EXERCISE PAIN IN THE LOWER LEG

CHRONIC COMPARTMENT SYNDROME AND MEDIAL TibIAL SYNDROME

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The aetiology of pain in the lower leg during exercise has been studied in 110 athletes by monitoring intracompartmental pressure during exercise and by technetium bone scans. Patients were assigned to three diagnostic groups: chronic compartment syndrome, medial tibial syndrome and those with non-specific findings.

Our results indicate that subcutaneous fasciotomy of the affected compartment(s) is the treatment of choice for chronic compartment syndrome. The treatment of patients with medial tibial syndrome, either by operation or conservatively, has been unsuccessful; non-specific symptoms have been treated conservatively with success.

Pain in the lower leg brought on by exercise but relieved by rest is a common complaint amongst athletes, particularly after an unaccustomed increase in activity or at the start of the season. Symptoms often subside after a few weeks of training; in some instances, however, they persist and become more severe until exercise becomes either extremely painful or impossible.

Diagnosis is difficult because there are no specific clinical signs. A history of pain on exercise, beginning after shorter and shorter distances and relieved by rest, may have a number of causes which include stress fracture, chronic compartment syndrome caused by raised intracompartmental pressure and medial tibial syndrome. All these conditions may be referred to by athletes, trainers and doctors alike as "shin splints" or "fresher's leg", neither term being specific.

Excluding bony disorders, these symptoms in athletes seem to originate from the anterior and deep posterior compartments of the lower leg (Fig. 1). Varying names have been given and aetiological factors ascribed (Table 1) but it is now generally agreed that the anterior compartment syndrome is due to a rise in intracompartmental pressure during exercise and that treatment should be by subcutaneous fasciotomy.

However, the reason for similar pain in the deep posterior compartment is less certain. Suggestions include an increase in intracompartmental pressure during exercise (Puranen 1974; Puranen and Alavaikko 1981), and an inflammatory reaction of the nature of periostitis or insertion fasciitis (Wallensten 1983; Mubarak et al. 1982). Opinions vary as to the best treatment, whether by operative decompression (Puranen 1974; Wallensten 1983) or by conservative means (Mubarak et al. 1982).

Even among authors who agree that pain from both the anterior and deep posterior compartment syndrome is caused by increased pressure during exercise, the diagnostic significance of these pressures is still disputed. It is generally agreed that, by themselves, pre-exercise resting pressures do not conclusively demonstrate compartment

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Table 1. Review of the literature on compartment syndromes, showing number of patients, diagnosis and treatment

<table>
<thead>
<tr>
<th>Author</th>
<th>Diagnosis</th>
<th>Number of patients*</th>
<th>Cause</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayor 1956</td>
<td>Anterior tibial syndrome</td>
<td>1 (2)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>French and Price 1962</td>
<td>Anterior tibial pain</td>
<td>2 (4)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Puranen 1974</td>
<td>Medial tibial syndrome</td>
<td>11 (12)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Reneman 1975</td>
<td>Anterior compartment syndrome</td>
<td>80 (116)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Puranen and Alavaikko 1981</td>
<td>Chronic compartment syndrome</td>
<td>32 (48)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Mubarak et al. 1982</td>
<td>Medial tibial stress syndrome</td>
<td>12</td>
<td>Periostitis</td>
<td>Conservative</td>
</tr>
<tr>
<td>Qvarfordt et al. 1983</td>
<td>Chronic anterior tibial compartment syndrome</td>
<td>102</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Rorabeck et al. 1983</td>
<td>Exertional compartment syndrome</td>
<td>12 (24)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td>Wallensten 1983</td>
<td>Medial tibial syndrome</td>
<td>9 (9)</td>
<td>Not pressure</td>
<td>Fasciotomy</td>
</tr>
<tr>
<td></td>
<td>Chronic anterior compartment syndrome</td>
<td>8 (8)</td>
<td>Pressure</td>
<td>Fasciotomy</td>
</tr>
</tbody>
</table>

* Number of limbs shown in parentheses

syndrome, and significant differences between normal and abnormal compartment pressures have been found only by statistical analysis.

Most emphasis has been placed on the time it takes for the post-exercise pressure to return to the pre-exercise level. Reneman (1975), Mubarak et al. (1982), Wallensten (1983) and Rorabeck, Bourne and Fowler (1983) all used this index, and although all concur that pressure in pathological compartments takes longer to return to its pre-exercise level, there is no agreement about precise criteria of pressure and time. Although it is generally agreed that higher pressures are found during exercise in cases of compartment syndrome, only Puranen and Alavaikko (1981) consider that this raised pressure is the most important diagnostic factor.

This paper describes a technique of accurately and continuously measuring the intracompartmental pressures in the lower leg during exercise and discusses the clinical relevance of this measurement in three distinct diagnostic groups of patients.

**MATERIALS AND METHODS**

One hundred and ten patients presenting with exercise-related pain in the lower leg were studied; 24 were women (average age 20, range 12–31) and 86 were men (average age 25, range 16–44). All had a full clinical examination, with particular attention being paid to the site and duration of pain, the presence of tenderness along the medial border of the tibia, any muscle herniae and the peripheral pulses. Plain radiographs of the tibia were taken and a technetium bone scan of the leg was imaged at three hours. Special note was made of any history of progressive increase in severity of pain and of the duration of exercise before pain started. Any previous fractures, stress fractures or operation were also noted.

For inclusion in this study a patient's symptoms had to have persisted for at least six months despite physiotherapy, rest and the use of shoe inserts where appropriate. Patients with stress fracture, popliteal entrapment syndrome, spinal stenosis, or other bony pathology were excluded.

The technique described by Barnes et al. (1985) was used to measure the compartment pressure. Slit catheters (Rorabeck et al. 1980) filled with heparinised saline were inserted through 16-gauge cutting needles (Medicut) into the anterior compartment and the deep posterior compartment of both legs midway between the patella and the malleolus. Each catheter was attached directly to a pressure transducer and both were securely taped to the leg. The transducers were connected to amplifiers and a chart recorder (Fig. 2).

The patency and correct location of the catheters was checked by squeezing the leg and noting the response on the chart recorder. At any time during a test that a blocked catheter was suspected, it was flushed with 0.2 ml of heparinised saline; this was done only if absolutely necessary to avoid producing an artificial increase in the compartment pressure.

![Fig. 2](image-url)  
Technique of measuring intracompartmental pressure during exercise.
Resting pressures were recorded with the patient lying supine as well as sitting with legs hanging over the side of the couch; the latter position was used to record baseline levels to which pressures should return after a period of exercise. The patient was then asked to run on the spot for one minute while pressures were continuously recorded. Both direct and mean pressures were monitored to provide diagnostic values and to give a clearer picture of catheter function. Three one-minute runs were recorded, the patient returning to the sitting position between each run to allow pressures to return to pre-exercise level. The average of the two closest, stable, mean pressure values during exercise was used for diagnostic purposes.

If the diagnosis of a compartment syndrome was made, that is, if pressures were raised during exercise, it was recommended that the patient have a subcutaneous fasciotomy of the affected compartment(s). The same operation was recommended for patients whose compartment pressures were borderline if their symptoms had been long-standing or severe, or if the contralateral limb showed definite signs of a compartment syndrome.

Fasciotomy was carried out under general anaesthesia. A one-inch incision was made midway between the ankle and the knee, the fascia was identified and split with a fasciotome for the length of the compartment. After operation the patient was encouraged to mobilise and to begin gentle exercise as soon as pain permitted, so as to help keep the fascial split open. Most patients who had fasciotomies for chronic compartment syndrome were reassessed clinically and had repeat pressure measurements three months after operation.

RESULTS

Resting pressures taken before and after operation are summarised in Table II. These measurements were found to be of no diagnostic significance, although averaged values did show slightly higher pressures in the pathological compartments which were subsequently reduced by operation. The pressures in the anterior compartment were also consistently higher than those in the deep posterior compartments in both normal and pathological limbs; this finding was in agreement with those of Qvarfordt, Eklöf and Ohlin (1982) and Wells, Youmans and Miller (1938) who all found higher pressures in the anterior compartment.

Exercise pressures in all groups of patients reached a stable level within a few seconds, suggesting that exercise prolonged until the onset of pain was unnecessary for diagnosis. In those patients whose onset of pain was almost immediate, no relationship was found between the time of onset or intensity of pain and the pressure measured. It was also found that the speed of running did not affect the pressure unless the patient sprinted flat out; when this was done the pressures decreased in the normal compartments and increased in those with already high pressures. When exercise stopped and patients returned to a sitting position, pressures in all groups rapidly returned to the pre-exercise levels. Figure 3 illustrates a typical pressure recording before, during and after exercise.

Diagnostic pressures

Anterior compartment syndrome. Those patients with exercise pressures above 50 mmHg were diagnosed as having chronic anterior compartment syndrome; this threshold value was based on previous work carried out by Allen et al. (1985) and Gibson et al. (1986) in which clinical signs and pressure were closely correlated. Puranen and Alavaikko (1981), with a similar clinical protocol, used the same exercise pressure threshold value.

A compartment syndrome was excluded if the exercise pressure was below 30 mmHg. For the purposes of this study, compartments giving this result are referred to as normal, though the group includes both symptomatic and asymptomatic legs. Compartments showing an exercise pressure between 30 and 50 mmHg were designated as borderline, and other factors were also considered when making a diagnosis and prescribing treatment.

Deep posterior compartment syndrome. Those patients with exercise pressures above 40 mmHg were diagnosed as having chronic deep posterior compartment syndrome. A lower value was taken than that for the anterior compartment, as it has been shown that the anterior compartment has a consistently higher pressure.

We have also found, by infusing known volumes of liquid into the two compartments of amputated lower limbs, that the deep posterior compartment was more compliant than the anterior; that is, for a given volume increase, the pressure will rise more in the anterior compartment. Two factors may account for this difference in compliance. First, radiographic contrast studies have shown that the deep posterior compartment is considerably larger than the anterior one. Secondly, the anterior compartment is bounded on three sides by comparatively rigid structures (tibia, fibula and interosseous membrane), whereas the deep posterior compartment is surrounded by more elastic structures, in particular being covered by the superficial posterior compartment (see Fig. 1).

Those patients with exercise pressures between 30 and 40 mmHg in the deep posterior compartment were
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Fig. 3

Typical pressure recording for a chronic compartment syndrome, showing rapid rise and fall of pressure before and after exercise.

also designated as borderline, while legs below 30 mmHg and with tibial tenderness were designated as showing medial tibial syndrome.

For the purposes of this paper, a deep posterior compartment with an exercise pressure of less than 30 mmHg and no medial tibial tenderness was designated as normal.

These diagnostic groups are not mutually exclusive and it has been found that a chronic compartment syndrome may occur in both the anterior and deep posterior compartments of the same leg. Similarly, anterior compartment syndrome and medial tibial syndrome may occur together (Table III). Both bilateral and unilateral involvement is possible, with bilateral cases being slightly more common.

Table III illustrates that the anterior compartment syndrome was most frequent, affecting 88 legs in 66 patients (33 patients with unilateral involvement). Of the 88 legs, 28 also had medial tibial syndrome and 13 had an accompanying deep posterior compartment syndrome. Chronic deep posterior compartment syndrome was the least common, affecting only 30 limbs in 20 patients.

Medial tibial syndrome. This was much more difficult to assess as the diagnosis depended solely on the patient’s history and the clinical finding of tenderness at the medial border of the tibia. Many patients were able to continue sporting activities despite this pain, which often occurred after, rather than during, exercise and was more of an irritation than a physical handicap. A medial tibial syndrome on its own was diagnosed in 28 limbs: in six patients this was found to be bilateral. Only four of these patients had pain which was severe enough to prevent exercise. Medial tibial syndrome was associated with anterior compartment syndrome in another 28 limbs and was often an incidental finding on examination, rather than a specific complaint by the patient. In all these cases it was pain from the anterior compartment which affected exercise tolerances.

Treatment

At least one type of chronic compartment syndrome was diagnosed in 105 limbs of which 12 were treated conservatively, either because symptoms had been present for less than six months or because the symptoms were not sufficiently disabling to prevent exercise or to interrupt a training programme. One patient gave up running altogether.

Another 20 limbs which were diagnosed as having a chronic compartment syndrome and were treated by operation were not available for follow-up; these have been listed separately in Table III. This left a total of 73 limbs treated by operation for a chronic compartment syndrome and reviewed three months later.

Typical pressure tracings of a bilateral deep posterior compartment syndrome before and after operation are shown in Figure 4. Exercise pressures before and after operation for 60 patients with anterior compartment syndrome are shown in Figure 5. Of these, 40 had pre-operative pressures greater than 50 mmHg while 20 were borderline, with pressures between 30 and 50 mmHg; most of the latter were found in the less affected leg of patients with bilateral involvement. After operation pressure remained unchanged in one case, four pressures actually increased, four were reduced but still remained above 50 mmHg, and the remaining 51 all returned to normal levels with exercise pressures below 50 mmHg.

There were no complications and all patients returned to full activity between 6 and 8 weeks after operation. All but three patients had improved. One of
Examine the pressure recordings before and after operation in 24 patients who had decompression of the deep posterior compartment are shown in Figure 6. In 17, pressures were reduced from above 40 mmHg to below this level, and four borderline values were reduced. One pressure value originally above 50 mmHg was unchanged, one borderline value increased slightly, and the pressure in one compartment was reduced only to 60 mmHg from a pre-operative level of 130 mmHg. Complications in this group included calf haematomas in two legs, one of which required further operation. As in the anterior compartment group, all patients returned to full activity after 6 to 8 weeks.

Medial tibial syndrome was diagnosed in 56 limbs, occurring in combination with anterior compartment syndrome in 28 (50%) (Table III). Four limbs with a medial tibial syndrome alone were treated by fasciotomy at the medial border of the tibia; in every case the result was disappointing and the symptoms persisted. The remainder of this group were treated conservatively by physiotherapy, steroid injections to the tibial border and shoe inserts. The results were inconsistent but generally unsatisfactory.

Nineteen legs with medial tibial syndrome as well as anterior compartment syndrome were treated by decompression of both the deep posterior and the anterior compartments, as suggested by Wallensten (1983). Most patients noticed an improvement, but this was largely due to relief of the anterior compartment and not to reduction in tenderness at the medial border of the tibia.

Biopsy specimens of periosteum and fascia were taken at all operations but these were normal with no evidence of inflammation, even on electron microscopy. Plain radiographs were normal in all groups, apart from occasional periosteal thickening, but this was rare and did not correlate with any diagnosis.

**Bone scans.** Technetium bone scans were used to exclude stress fractures, although the length of history was such that fractures would have been visible on plain radiographs. Apart from obvious focal uptake at "hot spots"
indicative of a stress fracture, most patients showed some general or patchy increase in uptake in the affected legs, with very few completely normal scans. Puranen (1974) observed increased strontium uptake in four out of 11 patients, and Mubarak et al. (1982) found a mild, diffusely increased uptake of technetium in two out of eight patients with medial tibial stress syndrome. By contrast, Wallensten (1983) and Rorabeck et al. (1983) found all technetium scans to be normal.

It was not unexpected that most scans were abnormal since extra stress from intensive exercise increases bone turnover and causes an increased uptake of the radiopharmaceutical agent. At present we are unable to show any diagnostic significance in these results, except that an abnormal bone scan is common in medial tibial syndrome and in both chronic compartment syndromes.

DISCUSSION

In order to make a definitive diagnosis it is recommended that patients presenting with exercise pain in the leg should first be treated conservatively, that is, with a period of rest, followed by physiotherapy and by shoe inserts if these are indicated. If there is no improvement and symptoms have persisted for at least six months, then intracompartmental pressure should be measured during exercise.

In our study three diagnostic groups were identified:

1. Those with exercise pressures greater than 50 mmHg in the anterior compartment or greater than 40 mmHg in the deep posterior compartment but without tenderness of the medial border of the tibia may be diagnosed as having a chronic compartment syndrome and will usually respond to subcutaneous fasciotomy.

2. Those with exercise pressures of less than 30 mmHg in the deep posterior compartment as well as medial border tibial tenderness may be diagnosed as having medial tibial syndrome, for which there is at present no satisfac-

tory treatment. Further research is needed into this group.

3. Patient with normal pressures and no tibial tenderness generally respond to conservative treatment by physiotherapy. The cause of their pain is unclear.

Patients with increased pressures in both compartments and tibial tenderness may respond to decompression, but medial border tenderness is likely to persist even if operation includes release of the deep posterior compartment. However, tibial tenderness is usually minimal and patients are often able to resume full athletic activities. In our experience bone scans are unhelpful, only confirming stress fractures which are already visible in plain radiographs.

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REFERENCES


