Risk factors associated with exertional medial tibial pain: a 12 month prospective clinical study


Objective: To investigate in a military setting the potential role of intrinsic biomechanical and anthropometric risk factors for, and the incidence of, exertional medial tibial pain (EMTP).

Methods: A prospective clinical outcome study in a cohort of 122 men and 36 women at the Australian Defence Force Academy. Each cadet underwent measurements of seven intrinsic variables: hip range of motion, leg length discrepancy, lean calf girth, maximum ankle dorsiflexion range, foot type, rear foot alignment, and tibial alignment. Test–retest reliability was undertaken on each variable. A physician recorded any cadet presenting with diagnostic criteria of EMTP. Records were analysed at 12 months for EMTP presentation and for military fitness test results.

Results: 23 cadets (12 men, 11 women) met the criteria for EMTP after 12 months, with a cross gender (F/M) odds ratio of 3.1. In men, both internal and external range of hip motion was greater in those with EMTP: left internal (12°, p = 0.000), right internal (8°, p = 0.014), left external (8°, p = 0.042), right external (9°, p = 0.026). Lean calf girth was lower by 4.2% for the right leg (p = 0.040) but by only 2.9% for the left leg (p = 0.141). No intrinsic risk factor was associated with EMTP in women. EMTP was the major cause for non-completion of the run component of the ADFA fitness test in both men and women.

Conclusions: Greater internal and external hip range of motion and lower lean calf girth were associated with EMTP in male military cadets. Women had high rates of injury, although no intrinsic factor was identified. Reasons for this sex difference need to be identified.

METHODS

Subjects

This study was conducted at the Australian Defence Force Academy (ADFA). Before being accepted into ADFA, applicants must undergo a medical examination. Those applicants with a past or current history of tibial stress fracture, compartment syndrome, or significant medial tibial pain are denied entry. Of those who passed this examination and who were accepted into ADFA training, 164 (126 male, 38 female) of the 167 first year cadet cohort (98%) agreed to participate in the study. As the pre-entry medical examination can precede the start of ADFA training (and baseline measurement in this study) by up to four months, we again asked participants about current symptoms of exercise induced lower leg pain, as a study exclusion criterion (no cases found).

The study was approved by the Australian Defence Medical ethics committee.

Measurement protocol

We measured height (by stadiometer, to 0.5 cm) and weight (by electronic scale, to 0.1 kg), and recorded use of orthotics (yes/no). Fitness level was estimated from each subject’s timed 2.4 km run at baseline measurement. The timed run was repeated six months later to note any change in fitness characteristics. Subjects also underwent a series of static bilateral lower limb anthropometric measurements, conducted by two physicians (SB, ET), three physiotherapists (RM, PN, LS), and one podiatrist (PB). Each tester was responsible for one measure (except the podiatrist, who...
recorded both foot variables), according to the following protocol.

**Hip range of motion**
The hip and knee were flexed at 90° in the supine position; each hip was rotated internally and externally to a firm end feel; range of motion, relative to the initial position, was measured in degrees.\(^7\)

**Leg length discrepancy**
The absolute leg length was measured using a tape measure (nearest 0.5 cm), in the supine position, from the anterior superior iliac spine to the superior surface of the most prominent aspect of the medial malleolus.\(^8\)

**Lean calf girth**
With the subject standing relaxed and upright, a measuring tape was manoeuvred to obtain the maximum perimeter (mm) of the relaxed calf. A skin caliper was applied at this point, 10 mm distally to the left thumb and index finger used to raise a vertical fold on the relaxed calf. A corrected calf girth was obtained by subtracting the appropriate skinfold thickness from the girth measurement.\(^9\) \(^10\)

**Ankle dorsiflexion**
In the upright position the feet were held parallel, and the subject was then asked to extend the hip, keeping the knee straight and the heel on the ground. A goniometer was set at the mid-point of the lateral malleolus and the angle recorded.\(^11\)

**Foot type**
The subject's foot type was assessed visually while bearing weight, and classified as cavus, planus, or neutral according to the method described by Dahlé\(^12\) and also used by Bennell, where correlation coefficients of reliability were acceptable.\(^13\)

**Rear foot alignment**
With the subject prone, the calcaneus was palpated at the medial and lateral borders. A dot was placed on the perceived middle of the calcaneus superiorly and inferiorly. With the subject then standing, the podiatrist placed the subtalar joint into the neutral position. An inclinometer was placed with the straight edge parallel to the two dots, keeping the instrument in the frontal plane. The calcaneal position was determined in degrees of inversion and eversion.\(^14\)

**Tibial alignment**
Each leg was measured using a single leg standing position. The examiner palpated the medial and lateral aspects of the distal third of the leg, then visually determined the posterior medial–lateral bisection and placed a strip of adhesive tape along the bisection of each leg. The tape was 10 cm long and 0.5 cm wide, and extended from a point just proximal to the malleolus. Tibial alignment relative to the flat surface of the floor was measured using a goniometer marked in degrees.\(^15\)

**Intratest reliability**
Fourteen volunteer controls were tested on two occasions, one week apart. Intratester reliability was established with intraclass correlation coefficients (right/left): hip external rotation (0.75/0.89), hip internal rotation (0.82/0.80), leg length (0.97/0.97), calf girth (0.96/0.93), skinfold (0.89/0.92), ankle dorsiflexion (0.82/0.80), rear foot angle (0.80/0.81) and tibial angle (0.53/0.59); and \(\kappa\) coefficient (right/left) for foot type (0.74/0.86). An acceptable intraclass correlation coefficient, or \(\kappa\) coefficient, was determined as >0.6 at the outset of our study.

**Cadet training**
There were four male and one female divisions of 35 to 40 cadets. Military training included regular sessions of marching, parade drill, and weapons handling. In addition, cadet divisions undertook compulsory two hour, twice weekly sessions of supervised physical training (PT), aimed at improving and maintaining upper and lower body endurance, strength, and flexibility. All cadets were issued with standard military boots for marching and other military training, and standard non-branded proprietary Australian Defence Force cross training shoes for their PT classes. Supervised running was no greater than 4 km, and high impact loading was not emphasised. Cadets undertook baseline and six month fitness assessments, including a 2.4 km timed run within a set time period. To prepare for the components of this test, cadets undertook rigorous training outside their study hours. Cadets were all provided with a standard training guide (three to four hours of running training per week) to assist them meet the acceptable level for the 2.4 km test, as failure to meet the standard required repeat testing and potential discharge from ADFA.

**Diagnostic criteria**
All injured cadets unable to attend PT required a doctor's certificate excluding them from that session. This was obtained from a specific health facility from a single physician, blinded to the results of anthropometric measurements. Comprehensive clinical details were entered into the cadet's medical file. Twelve months after induction, a separate physician scrutinised all subject's clinical records and included those cadets who met the following criteria as having EMTP:

- An atraumatic history at least one week of medial tibial pain, exacerbated by running.
- The presence of at least 10 cm of diffuse palpation tenderness at the distal two thirds of the posteromedial tibial border.
- At least one training session lost because of the tibial pain.

The individual medical files provided data on side of symptoms, date of diagnosis (time from baseline measurement), details of subsequent tibial pain and other clinical presentations, results of further investigations, and physical restrictions placed on the cadet. We recorded the details of any injury that prevented ADFA fitness assessment participation.

**Statistical analysis**
Statistics were analysed using the Statistical Package for the Social Sciences (SPSS Inc, Chicago, Illinois, USA). Separated by sex, EMTP subjects were compared with non-EMTP subjects using univariate \(t\) tests (continuous variables) and \(\chi^2\) tests (categorical variable) at a two tailed significance level of \(p<0.05\). For bilateral variables, means were compared against the respective side of injury.

**RESULTS**

**Subjects**
Throughout the 12 month period, six subjects (four male, two female) resigned (not included in analysis), none of whom had presented with tibial pain. The remaining 158 subjects consisted of 122 men and 36 women (table 1). There were significant differences between men and women for run times, height, weight, and lean calf girth.

**Diagnosis**
Twenty three subjects (12 male, 11 female) presented with EMTP over the 12 month period. Presentation rates did not
Table 1  Subject characteristics: mean (range) for men with and without exertional medial tibial pain

<table>
<thead>
<tr>
<th></th>
<th>EMTP men</th>
<th>Non-EMTP men</th>
<th>EMTP women</th>
<th>Non-EMTP women</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>12</td>
<td>110</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Dx time (days)</td>
<td>46 (9 to 78)</td>
<td>–</td>
<td>118 (9 to 291)</td>
<td>–</td>
</tr>
<tr>
<td>Age (years)</td>
<td>18.7 (17.8 to 20.8)</td>
<td>18.4 (17.1 to 21.8)</td>
<td>18.0 (17.1 to 19.34)</td>
<td>18.2 (17.1 to 20.0)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.79 (1.70 to 1.92)</td>
<td>1.79 (1.65 to 1.96)</td>
<td>1.67 (1.59 to 0.82)</td>
<td>1.68 (1.56 to 1.79)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74.4 (62.0 to 90.0)</td>
<td>74.5 (69.0 to 91.0)</td>
<td>61.0 (51.0 to 79.6)</td>
<td>60.2 (49.0 to 77.2)</td>
</tr>
<tr>
<td>BMI</td>
<td>23.0 (20.4 to 26.3)</td>
<td>21.3 (19.2 to 27.8)</td>
<td>21.8 (19.4 to 24.1)</td>
<td>21.4 (17.8 to 27.6)</td>
</tr>
<tr>
<td>Using orthotics at baseline (yes)</td>
<td>2</td>
<td>–</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Baseline 2.4 km run time (s)</td>
<td>561 (512 to 608)</td>
<td>584 (495 to 646)</td>
<td>769 (727 to 840)</td>
<td>708 (579 to 843)</td>
</tr>
<tr>
<td>Run time 6 months after baseline (s)</td>
<td>570 (508 to 634)</td>
<td>576 (460 to 645)</td>
<td>733 (673 to 820)</td>
<td>701 (568 to 823)</td>
</tr>
<tr>
<td>Failed run test</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>LLD (cm)</td>
<td>0.0 (0.0 to 1.0)</td>
<td>0.3 (0.0 to 2.0)</td>
<td>0.0 (0.0 to 0.5)</td>
<td>0.34 (0.0 to 1.5)</td>
</tr>
<tr>
<td>(R) LCG (mm)*</td>
<td>344 (319 to 390)*</td>
<td>359 (316 to 429)</td>
<td>329 (305 to 385)</td>
<td>338 (291 to 380)</td>
</tr>
<tr>
<td>(L) LCG (mm)*</td>
<td>347 (323 to 98)</td>
<td>357 (311 to 413)</td>
<td>335 (293 to 333)</td>
<td>337 (298 to 378)</td>
</tr>
<tr>
<td>(R) ADF (˚)</td>
<td>32 (25 to 45)</td>
<td>31 (18 to 52)</td>
<td>29 (20 to 38)</td>
<td>26 (18 to 42)</td>
</tr>
<tr>
<td>(L) ADF (˚)</td>
<td>32 (25 to 42)</td>
<td>31 (18 to 48)</td>
<td>28 (20 to 35)</td>
<td>27 (20 to 40)</td>
</tr>
<tr>
<td>(R) RA (˚)</td>
<td>inv 1 inv 6 to ev 4†</td>
<td>inv 2 inv 11 to ev 6</td>
<td>inv 2 inv 6 to ev 2</td>
<td>inv 3 inv 8 to ev 4</td>
</tr>
<tr>
<td>(L) RA (˚)</td>
<td>inv 3 inv 10 to ev 2</td>
<td>inv 2 inv 10 to ev 8</td>
<td>inv 1 inv 6 to ev 4</td>
<td>inv 1 inv 8 to ev 2</td>
</tr>
<tr>
<td>(R) IHR (˚)*</td>
<td>48 (32 to 70)</td>
<td>40 (10 to 64)</td>
<td>41 (34 to 52)</td>
<td>40 (24 to 54)</td>
</tr>
<tr>
<td>(L) IHR (˚)*</td>
<td>64 (42 to 90)†</td>
<td>55 (16 to 88)</td>
<td>61 (42 to 76)</td>
<td>61 (40 to 76)</td>
</tr>
<tr>
<td>(R) EHR (˚)</td>
<td>48 (28 to 72)†</td>
<td>36 (10 to 60)</td>
<td>40 (24 to 56)</td>
<td>39 (26 to 54)</td>
</tr>
<tr>
<td>(L) EHR (˚)</td>
<td>59 (32 to 66)†</td>
<td>51 (18 to 90)</td>
<td>58 (32 to 70)</td>
<td>55 (32 to 84)</td>
</tr>
</tbody>
</table>

*Significant mean differences (p < 0.05) existed between men with and without EMTP presentation: p = 0.040; p = 0.014; p = 0.026; p = 0.000; p = 0.042.
†Inv, vastus medialis; ev, vastus lateralis.

Risk factors

Concerning EMTP presentation, in either sex there were no statistically significant differences for body mass index, leg length discrepancy, foot type, rear foot angle, ankle dorsiflexion range, use of orthotics at baseline, run times at baseline, or change in fitness levels from baseline. For men only, there were significant differences for the other variables: hip range of motion (internal and external) and lean calf girth.

Greater internal (IHR) and external (EHR) mean hip ranges of motion were observed (fig 1): left IHR, 12° (p = 0.000); right IHR, 8° (p = 0.014); left EHR, 8° (p = 0.042); right EHR, 9° (p = 0.026). In men with EMTP, mean lean calf girth was less (fig 2), a difference that was statistically significant for right sided injury only: 15 mm, right (p = 0.040); 10 mm, left (p = 0.141).

DISCUSSION

Clinically relevant inclusion criteria to capture the syndrome of EMTP

Before discussing the implications of our findings, we will explain the rationale for using the clinical syndrome of EMTP as the primary focus of the study. In clinical practice, patients most often present with early EMTP, particularly in settings where military personnel, or elite athletes, are closely monitored by medical staff. Early in the course of their condition it can be difficult to differentiate the various tissue pathologies that can contribute to their shin pain at that time. The clinical syndrome that we have labelled EMTP for this study is likely to include precursors to stress fractures, or frank stress fractures, as well as MTSS. Whereas most differ between male cadet divisions. Twenty one cases were bilateral. The remaining two cadets (one male, one female) had symptoms limited to the left leg only. The incidence of 30.6% in women and 9.8% in men represents a cross gender (F/M) odds ratio of 3.1. Three subjects (one male, two female) were diagnosed subsequently with four tibial stress fractures (two unilateral, one bilateral) following the initial diffuse pain, confirmed in all cases by radionuclide bone scan (27, 43, and 54 days after the initial EMTP diagnosis).

Inability to participate in ADFA fitness assessment run component

Failure to attempt or pass the fitness test run components because of tibial pain (following EMTP presentation) occurred in five of 12 (42%) and four of 11 (36%) male and female EMTP subjects, respectively. In addition, five of 25 female non-EMTP subjects (20%) were also unable to attempt the run, with all five suffering from other chronic lower limb overuse injuries.

Risk factors

Concerning EMTP presentation, in either sex there were no statistically significant differences for body mass index, leg length discrepancy, foot type, rear foot angle, ankle dorsiflexion range, use of orthotics at baseline, run times at baseline, or change in fitness levels from baseline. For men only, there were significant differences for the other variables: hip range of motion (internal and external) and lean calf girth.
established stress fractures show focal tenderness, and almost 100% are positive on triple phase bone scan, early cases may present with more diffuse medial tibial pain consistent with EMTP, as defined here.

We chose not to limit our study to what is commonly referred to as MTSS in clinical practice, as there are no agreed diagnostic criteria for MTSS, and no investigation can currently provide an established gold standard. The sensitivity and specificity for triple phase bone scan and magnetic resonance imaging in symptomatic "acute shin splints" are reported to be 84%, 33%, and 79%, 33% respectively; furthermore, the majority of asymptomatic legs tested in that study showed abnormalities on both magnetic resonance imaging and triple phase bone scan. The use of these investigations as entry criteria for our study would have excluded an unacceptable number of symptomatic cases on the basis of a negative scan, and might have failed to discriminate for the presence of symptoms. Given the challenges of diagnostic specificity, we examined a clinical syndrome and attempted to be as inclusive as possible, while acknowledging the potential multiple pathology of the cohort. The important point is that our study population represents the group that presents to clinicians, seeks advice, and may require time off from work or sport. Thus we sought to identify risk factors that could be targeted to reduce the clinical burden of EMTP. This has particular relevance to the military setting, but is important also in the setting of recreational sport.

Risk factor analysis

In men, greater external and internal ranges of hip motion were associated with EMTP presentation. Internal range of motion has not previously been found to be associated with medial tibial pain presentations. External hip range of motion of more than 65° has been shown to predict tibial stress fracture in (male) Israeli Army trainees, but has not been linked to other causes of EMTP. Our study was not designed to explain the mechanism that might underlie a specific risk factor causing tibial pain. However, it could be speculated that available hip ranges of motion may be associated with specific running style patterns, possibly a risk factor causing tibial pain. Despite this, it may be important to reduce the risk of overpronation by increasing traction on the soleus origin, commonly attributed to MTSS pathology.

Clinical implications

Thus the clinical syndrome of EMTP is common in a military setting, and women appear especially prone to injury in the current military training environment. Medical personnel and training organisations should consider carefully the particular risk factors in women that account for their relatively higher rates of medial tibial injury. We found few intrinsic factors that may predict EMTP, although men with increased range of hip motion or low lean calf girth may be at increased risk.

Strengths and limitations of the study

This is one of very few prospective studies of EMTP in athletic populations. The very high recruitment and retention rate is a study strength, as are the use of common, clinically relevant, easily performed measures that require little equipment, and the blinded protocol for EMTP diagnosis. We excluded this biomechanical variable from the outcome analysis, as test–retest reliability showed an intraclass correlations of less than 0.60 for the two legs.
addressed more easily in future studies. The potential multiplicity of pathology related to our entry criteria reduces the external validity of our results to specific pathological conditions (for example, stress fractures). The small number of women compared with men may account for the lack of any intrinsic risk factor association in this group. Optimally, a power analysis of sex (not undertaken in our study) would assist planning in future studies. Furthermore, static measures such as foot type do not necessarily correlate with dynamic measures. Future studies analysing intrinsic risk factors for EMTP in both women and men would include the use of dynamic measures of gait biomechanics (for example, with a kinematics multicamera biomechanical analysis system). Such studies would require substantial funding for equipment, data collection, and analysis. Finally, we also note that military studies do not immediately generalise to a civilian setting.

In summary, in male cadets greater internal and external ranges of hip motion and lower lean calf girth were associated with the clinical syndrome of EMTP. No intrinsic variable was associated with EMTP in women, although future studies with more power are required. For men and women in this military setting, the presentation of exertional medial tibial pain frequently preceded an inability to complete training standards owing to ongoing disability, thus placing their occupation at risk.

Conclusions

We found that some biomechanical factors were associated with male EMTP presentation in this military setting. However, the increased incidence of EMTP in women, without any identifiable risk factor, requires the attention of military training organisations. Further research is required to understand why these sex differences exist.

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REFERENCES