MARCH FRACTURE: A SERIES OF 64 CASES.

BY MAJOR P. R. WILSON, M.A., M.R.C.S.
Royal Army Medical Corps,
Physical Medicine Specialist.

I.—INTRODUCTION.

In this present World War the syndrome known as March Fracture has once again become much in evidence. It first gained prominence during the Great War of 1914-1918 but the condition had been discussed by several authors during the latter half of the 19th century and Breithaupt [1], a Prussian Military Surgeon, described it as early as 1855.

Most authors have confined their studies to a relatively small number of cases, and it is hoped that, by analysing some 64 cases, further light may be thrown on the etiology, treatment and prevention of the condition.

The present series all occurred in young soldiers undergoing a course at an Army Physical Development Centre. It would be well at first to describe briefly the object of such a Centre and the type of training undertaken.

The object of a Physical Development Centre is to raise the fighting efficiency of the Army by specialized training of men who are under 30 years of age and, where possible, to raise their medical categories. The trainees fall into two main groups: First, newly joined recruits from Primary Training Units, mostly under 20, who, whilst properly placed in Category A1, are not “fighting fit” and are likely to break down if submitted to the full rigors of Basic Military Training.

These lads are mostly under-developed and under-nourished with here and there some minor remediable disability. The second group comprises men from Field Force Units, who are of a lower medical category on account of some such disability, are of poor physique, or men who have broken down as a result of training. This latter group consists very largely of foot defects.

Each course at the Centre lasts about two months. The essence of the work comprises graduated physical development. Most of the disabilities encountered are the results of muscular imbalance. The training, therefore, largely consists of progressive physical training with Remedial Training in selected cases. In addition, road work, running, obstacle training and activities of a military nature and graduated route marches complete the physical pro
gramme. The route marches take place once a week, starting in the first week with 3 or 5 miles, working up by small weekly increments to 18 miles in the last week but one, and in the final week, a 15 mile march on each of two consecutive days. For the first few weeks the trainee carries no pack or rifle but these are added to his load in the second month of training.

Men with foot disabilities are grouped separately and their route marching and other road work progression is slower than that for men of poor physique. This latter type is grouped according to body weight for all physical activity.

II.—Observations.

Only 4 of the 64 cases were originally placed in Foot Disability Groups—3 being Flat Foot and one Hallux Rigidus—the remaining 60 all being grouped as Under-developed or Poor Physique.

Table I shows the distribution of these cases according to their medical category, and Table II the average of age, height and weight.

<table>
<thead>
<tr>
<th>Category</th>
<th>Numbers</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>5</td>
<td>1</td>
<td>26</td>
</tr>
</tbody>
</table>

Table II.

<table>
<thead>
<tr>
<th>Average age</th>
<th>Height</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 years 11 months</td>
<td>5 feet 6 inches</td>
<td>116 lb.</td>
</tr>
</tbody>
</table>

Only 10 of the 64 cases came from units other than Primary Training Units and, of these 10, 1 had four years’ service, 1 two and a half years and the remainder under one year. Of the 54 men from Primary Training Units none had had more than three weeks’ service before arrival at the Centre.

The civilian occupation in each case can be classed as sedentary or semi-active. In no case was a man previously employed at a job involving any marked degree of physical activity, in particular involving the continued use of the legs in standing or walking, and none of the men had any previous athletic record of note.

The incidence of fracture involved either foot in about equal proportions but by far the most frequently injured bone was either the 2nd or 3rd metatarsal. Table III sets out the bones fractured.

<table>
<thead>
<tr>
<th>Metatarsal</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>IV</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>33</td>
</tr>
</tbody>
</table>

In addition, one man fractured the 2nd metatarsal of both the left and right foot, and another man fractured both the 4th and 5th right metatarsals.

History.

Unfortunately no accurate records were kept of the first 15 cases so that various data are not available.

The classical and typical history is given in 72 per cent of cases. A young under-developed soldier, in the middle of his course, sets out on a route march of 15 or 18 miles wearing field service marching order and carrying a rifle. After some 10 miles he feels an ache in the fore-foot, which gradually increases in severity and becomes strictly localized, the pain being accentuated each time the affected foot is put to the ground. In nearly every case the total march was completed.

Of the 64 cases, 46 (or 72 per cent) occurred during a route march, 34 of these being of
either 15 or 18 miles. Nine cases occurred during a 12-mile march and 3 during a 9-mile march.

In 9 cases a history of some trauma other than marching was obtained. Thus, 4 gave a history of pain suddenly coming on while jumping the obstacle course, 3 while jumping in the gymnasium, one while running a mile test in gym shoes and one stepping on a pebble in gym shoes. Two men sustained their injury before arrival at the Centre but had not been diagnosed before they were first seen at the Centre. In seven cases there are no available records of the history.

The majority of these fractures occurred in the middle of the course, 44 of the 64 occurring between the fourth and seventh weeks of training. This period corresponds to a general increase of activity in all training, including tests and, from the fifth week onwards, rifles are carried on all marches.

**Physical Examination.**

1. **General.**—The general physique of all trainees was broadly classified under the headings "Good," "Fair," or "Poor." Of the 64 cases of march fracture, 44 had physique classified as "Poor," 17 as "Fair," and only 3 as "Good." Similarly with general posture, 33 were "Poor," 26 "Fair," and 5 "Good." Thus over 90 per cent can be classified as being of poor or fair physique and posture. The main postural defects were Sway Back, Forward Slump, minor Kypho-Scoliosis, Flat Chest and general poor muscle tone. Fourteen (or 22 per cent) showed definite knock-knees of more than two inches separation of the internal malleoli but only one case had any marked degree of bow-leg.

2. **Feet.**—As has already been stated only 4 cases (6.2 per cent) had foot defects which warranted their being placed in Foot Disability Groups at the beginning of the course. Of the remaining 60 cases, 72 per cent had some minor foot defects not considered to require special attention but recorded on the original medical case sheet. These defects were mostly a low longitudinal arch which was readily restored, a spreading of the metatarsals and a dropping of the transverse arch. In only 5 cases was any defect of foot mobility found. From this it would be fair to state that the majority of these feet showed evidence of poor muscle tone which can well be considered as part of the general poor muscle tone of the rest of the body.

3. **Local.**—The physical signs in practically every case are typical. The man presents a foot which shows a small localized swelling on the dorsal aspect, usually over the 2nd or 3rd metatarsal near its distal end. There is slight pain on attempting to stand on tip-toe. The swelling is rubbery in consistency, is tender, but does not pit on pressure. The point of maximum tenderness is usually clearly defined and points to the site of the fracture. On the plantar aspect there is no abnormality to be seen and tenderness is not marked to any extent but passive flexion of the proximal phalanx on the affected metatarsal is usually painful.

In fractures resulting from trauma other than marching the local physical signs are usually more marked. The swelling is greater and may be red and feel hot and there may be slight pitting oedema. The tenderness in these cases is also more exquisite.

**Radiological Findings.**

1. **Of the Lesion.**—X-rays were taken as soon as possible after the man was first seen. In 34 cases (53 per cent) a definite fracture was visible at this early stage, corresponding in position with the clinical signs. It is, in most cases, difficult to make out a fracture line but, on careful scrutiny of the plate, a crack can be determined. In many cases this has the appearance of a chip or flake fracture, involving only one side of the metatarsal shaft, more frequently the medial side. In a few cases a definite hair-line crack extending right across the shaft of the bone is seen. In no case was there any marked displacement. The commonest site of the fracture is the middle or the distal half of the metatarsal shaft.

In 26 cases the earliest radiological sign was a periostitis, usually seen on the medial aspect of the shaft in the form of a linear streak or narrow fluffy irregularity, with no break visible in the continuity of the bone.
In only 4 cases was no abnormality detected in the first X-ray taken.

X-ray examination, in the majority of cases, was again made after two weeks. The picture at this stage is nearly always definite. There is considerable periosteal reaction at the site of the lesion, having a cotton-wool appearance, and in the majority of cases interruption of the bone is clearly seen. There is usually more callus formation on the medial and dorsal aspects of the shaft. In a few cases there appeared to be a tendency to osteoporosis of the distal fragment noticeable at this stage in comparison with the first X-ray picture.

In many cases a third X-ray was taken after a further two or three weeks, that is five or six weeks after the injury. At this stage the healing is well established, the fracture line is filled with callus and the surrounding callus is organizing into a more dense, regular, spindle-shaped mass. Characteristically no displacement is seen, the fracture clearly uniting in excellent position.

The final X-ray picture, obtained with the follow-up report some six months after the injury, shows the restoration of the normal architecture of the bone. A slight thickening of the cortex is seen but no evidence of a fracture line.

(2) Of the Foot.—Unfortunately, control X-rays of the feet were not made. Opinions still vary very much as to what are the radiological appearances of the normal foot. The general impression of this series of feet can be summarized as follows:

(a) General appearance suggests a broad fore-foot with a spreading of the metatarsals.

(b) The first metatarsal tends to be short—in no case was the 1st metatarsal equal in length to, or longer than, the 2nd and in all cases the 1st metatarsal segment showed the appearance of hypermobility.

(c) In many cases the 1st metatarsal showed a greater degree of abduction than would be expected in the so-called “normal” foot.

(d) If an imaginary line be drawn from the sesamoids to the articular surface of the head of the 5th metatarsal, in the majority of cases the heads of the 2nd, 3rd and 4th would lie wholly distal to this line and, in no case, would they be proximal to, or on a level with, this line.

Lateral radiographs are of no use in diagnosis but an oblique view in many cases showed the first evidence of fracture which was not visible in the antero-posterior view.

Diagnosis.—Provided the possibility of a march fracture be kept in mind the diagnosis presents no difficulty. The history, together with the physical signs, should provide adequate information and radiology will in nearly all cases (93.5 per cent) confirm.

III.—Investigations.

Treatment.—The 64 cases are divided into two series. Series A: Hospitalization, 15 cases; Series B: Retained at the Centre, 49 cases.

Series A.—These comprise the first 15 cases. Ten were sent to a Military Hospital or E.M.S. Hospital dealing with fractures when the diagnosis had been established. Each case was eventually placed on the “Y” list and no hospital notes are available.

Five cases lack adequate records and it is impossible to state what treatment they received, how long they were off duty or their ultimate disposal.

Series B.—It became clear that a great deal of training time was being lost by cases of march fracture as those sent to hospitals were immobilized in plaster for some six weeks, then transferred to Convalescent Homes and, eventually, to Convalescent Depots and, up to this point, could do no training of any kind. It was, therefore, hoped that by instituting ambulatory treatment at the Centre it would be possible to get a man back to training quickly and prevent his general physical condition from deteriorating. Forty-nine cases were, therefore, retained at the Centre. One case received no treatment as he never complained and the condition was only found during the course of a routine examination when the fracture was already five weeks old and X-ray showed it to be healing well although there was very slight displacement. This man had remained on full training all the time and had never had any pain. Forty-eight cases received the routine treatment detailed below:—
On first reporting sick the man is given "Attend C," that is, excused all duties; he is told to wear his Army boots all the time and is sent for X-ray. The next day he is seen again, with the X-ray available, when the diagnosis is finally established. An adhesive felt pad, 5/16 inch in thickness, is cut, shaped and bevelled and applied to the sole of the foot. The distal edge lies immediately proximal to the metatarsal head, the width of the pad being roughly 2 inches distally, tapering in a pear-shaped manner and being about 3 inches in length. Minor modifications to this plan are made depending on local conditions. The pad is kept firmly in place by six or eight strips of adhesive tape placed over-lapping from below up and the ends of each strip over-lapping each other by about 1 inch dorsally. The pad is thus completely encased by the strips. The man is told to wear his Army boots all the time, and is given "Attend B" (light duties, mostly of a domestic nature) for a period varying from three days to two weeks with an average of seven days.

The patient is free of pain when thus strapped and wearing boots but he still gets pain if he wears gym shoes.

Each case is seen every two or three days while on light duties, minor adjustments to the pad and strapping being made if necessary, and the whole pad and strapping are replaced about once a week.

After this short period of light duties the patient is put back to a modified full training or what is termed "Full training—Upper Body work only." This means that he rejoins his section for all training as far as possible but does no road work, running, jumping or obstacle course training. He continues to wear his boots on all occasions and to have the foot padded and strapped. The length of time he is kept on Upper Body work varies and depends on how the lesion progresses, the average time being nineteen days.

At the end of this stage he is free from all pain and can get about on his feet perfectly comfortably and without the pad or strapping. He then resumes completely full training, wearing the appropriate footwear, but is excused obstacle course training for a further week.

Nearly every case was retained for an additional two or four weeks training to make up for lost time but, more important, to ensure that the standard of training he goes back to is not too advanced. This particularly applies to route marching.

The average total time spent from receipt of the injury to the resumption of full training, for the 48 cases that have had this treatment and since left the Centre, is twenty-seven and a half days. The longest time was only forty-two days. There were no relapses in any of these cases.

Results and Prognosis.

1. Immediate.—On resuming full training the foot function has been normal in all cases and the trainee has completed the final two weeks training, which includes tests and route marches, entirely satisfactorily. No case has shown any tendency to develop a flat foot or other abnormality. In addition, great benefit has been obtained to the general physique and muscle tone by the continued upper body activity. It is thus seen that, while the affected foot is reasonably rested, as much as possible of the rest of the body is kept "in training."

2. Remote.—A follow-up system has been put into use. A pro-forma (see Appendix) is sent out to the man's C.O. approximately six months after the injury. At present 28 have been sent out and 20 have been completed and returned.

Eleven of these refer to the 15 cases in Series A. Seven are entirely satisfactory. One man still gets pain when in gym shoes but is quite comfortable in Army boots. Three men complain of aching feet on jumping, or marching more than seven miles, but one of these had sustained another march fracture but not of the same metatarsal. One man was declared a Deserter so details were not available. Nine follow-up reports refer to Series B. Seven of these were entirely satisfactory, including one man who was up-graded from A2 to A1 two months after leaving the Centre. One man complained of slight aching in the foot after very strenuous exercise on a forty-eight hour scheme and one had aching after a 20-mile march, this being the man who had sustained a fracture of both his 3rd and 4th metatarsals.
A Series of 64 Cases

IV.—Discussion.

(A) Etiology.—The etiology of march fracture is a subject that has received much consideration. The majority of authors stress the fact that the condition is seen particularly in soldiers undergoing training and, usually, in the recruit. The series of cases under discussion occurred in recruits who were substandard, undergoing a special carefully graded course of training. No figures are available for the incidence of march fracture occurring in other Recruit Training Centres where the men are of average or good physique.

That the etiology is obscure is well demonstrated by reference to the literature. Pauzat (1887) [2] suggested that a periosteal proliferation around the metatarsal shaft was produced by trauma from repeated bruising of the foot by the hard dorsal fold of the soldier’s boot. Mark Jansen (1926) [3] emphasized that the periosteal thickening is related to the insertion of the interosseous muscles, being most marked on the inner borders of the 3rd, 4th, and 5th metatarsals from which both plantar and dorsal interossei originate. This is borne out to some extent in the present writer’s series by the earliest radiological findings. That a muscle poor in tone is liable to produce spasm when subjected to severe strain is readily understood. Thus vascular obstruction may be produced in the periosteum, leading to decalcification, rendering the bone liable to fracture.

Morton (1927, 1928, 1930 and 1935) [4] and Dodd (1933) [5] both favour structural abnormality and stress the importance of a short first metatarsal, a hypermobile first segment, and that the metatarsal-heads lie forward to Morton’s line, from the sesamoids to the head of the 5th metatarsal. These conditions are also satisfied in the majority of feet in this series.

McMurray (1937) [6] pointed out that aching in a foot is a common feature for some time before the fracture is produced, thus inferring that metatarsalgia is a predisposing cause. This view is not supported by the present series in which no case gave a previous complaint of foot trouble. In all these cases the onset of pain was sudden and clearly coincident with the onset of fracture. Flavell (1943) [17] supports this in his recent series of cases.

Newell (1940) [7], in describing the condition, remarks that it is commonly found in soldiers, usually recruits, after long marches, carrying heavy packs and adds that there is no history of trauma and seldom of over-strain. Williams (1940) [8], described four cases in infantry soldiers and suggested standing rather than marching as the cause.

Brailsford (1935) [9], describing the radiological appearances, states that in its early stages there is merely ill-defined osteoporosis in the region of the metatarsal neck, later an appearance of fracture through this area, still later an amorphous deposit of calcium in what appears to be a subperiosteal haematoma and, finally, consolidated callus which becomes absorbed leaving the thickened shaft with a dense cortex.

Krause (1942) [10], comparing bone with metal, says that all solid material may lose its tensile strength through repeated strains. Ultimately a fracture may occur which is said to be due to exhaustion of material. Henschel has shown that “fatigue” fractures are preceded by changes in the crystalline structure of bone and lamellar bone is replaced by more fibrous bone with low calcium content.

The fatigue theory has been put forward by other authors in the etiology of apparently similar types of fracture of other bones. Thus, Von Deutoff (1940) [12] describes 4 cases, 2 of the lower end of the femur and 2 of the tibia, in which pain and disability arose at the site of fracture after about six weeks of training. He suggested as the cause continued rhythmic and unaccustomed strain, particularly to the metaphysis of the bone. Peterson (1942) [13] describes a case of fractured femur coming on eight days after the beginning of training. Radiologically a crack was seen at the lower end of the femur, later followed by typical callus formation. Hambley (1942) [14] described 14 cases of fracture of upper end of the tibia in children and adolescents the oldest being 20 years of age. He pointed out that the interest lies in recruits and that spontaneous cure resulted from rest.

Brandt (1941) [15] considers overloading of importance, and gives the best etiological summary by stating that march fractures are the result of rhythmically repeated sub-threshold
mechanical insults, acting by summation, to a point beyond the capacity of the bone to bear stress.

Wilhelm (1941) [16], describing 3 cases in men who were undergoing training, says they were not robust, had never played games nor done any athletic training and advises early athletic training and particular attention to strengthening exercises for the feet.

Flavell (1943) [17], in a recent article reporting 15 cases from the R.A.F., emphasizes the frequency of an atavistic anomaly of the foot, the absence of previous metatarsalgia, localization of pain to the affected area and complete cessation of pain after healing of the fracture. He further points out that X-ray diagnosis is unnecessary as the clinical syndrome is so characteristic and impresses the importance and success of ambulatory treatment.

The relation of footwear to aetiology has had very little consideration in the past. The Army boot differs in construction from the civilian shoe firstly in that it lacks flexibility in the sole. The action of the intrinsic muscles is thus altered, a heel-toe rocking movement occurring at the ankle-joint and movement at the metatarso-phalangeal joints being greatly limited. Secondly, the Army boot has a greater width anteriorly, thus allowing a considerably greater freedom to the fore-foot than in civilian shoes. Thirdly, the weight of the Army boot is much greater, which throws an increased amount of work on the tibialis anticus muscle with each step. In the substandard recruit, the poor-toned tibialis anticus readily tires on marching so that the fore-foot flaps heavily to the ground instead of there being an evenly-controlled roll forward from heel to toe as each foot comes to the ground. This flapping—a most noticeable feature when watching recruits marching—causes a considerable increase of the rhythmically repeated mechanical insults to the metatarsal heads.

The speed of marching is apparently of little importance. The average marching speed at this Centre was 3.9 m.p.h. During a three months period, as an experiment, no marching was done at a speed in excess of 3.0 m.p.h. but the incidence of fracture did not fall. Rather is it felt that the time spent on the feet is of greater significance, which is borne out largely by the fact that the majority of fractures occurred during the longer marches.

(B) Treatment.—The treatment of march fractures as described in the standard textbooks is immobilization in plaster for six weeks, followed by physiotherapy. According to most writers, weight-bearing should not be allowed for some eight to twelve weeks. The result of such treatment may produce sound healing of the fracture but what of the musculature of the foot and the rest of the body?

In the present war a welcome change in the treatment of most fractures is steadily gaining popularity, namely, the early use of movement and exercise. The treatment of march fracture is no exception. On the contrary, there is every reason for the institution of ambulatory treatment from the start. The treatment outlined under Series B has proved itself entirely satisfactory and the chief points in its favour are the rapid healing and early return to full duty, the fact that a great deal of the general physical and military training can continue uninterrupted, the complete elimination of hospitalization with its detrimental influence on a soldier and the satisfactory ultimate results. The average time spent away from completely full training by the 48 cases in this series thus treated was only twenty-seven and a half days as compared with some three months in hospitalized cases. This is a most important factor in these days of man-power problems.

Undoubtedly many cases of march fracture occur in the Army that are not diagnosed, being labelled foot-strain or metatarsalgia. This is probably because the pain is not severe and the majority of soldiers are not required to march continuously but have relatively long periods of comparative physical inactivity. It so happens that these cases of so-called foot-strain, which in reality may be march fracture, receive adequate treatment in their units by strapping and being excused marching and physical training for a short time.

V.—Conclusions.

(1) The incidence of march fracture in the present war is probably higher than recorded cases would indicate. This may be due to the fact that many cases are missed, being diagnosed as foot strain.
March Fracture: A Series of 64 Cases

(2) The main factors in aetiology would appear to be as follows: (a) A poorly developed recruit with poor muscle tone; (b) An unduly high ratio of weight of load carried to body-weight; (c) A tendency to atavism of the foot; (d) Prolonged and repeated foot strain; (e) Change to the Army boot.

(3) Ambulatory treatment should in all cases be instituted early. Its main advantages are an early return to full duty, completely satisfactory healing and ultimate foot function, the elimination of hospitalization and the continued uninterrupted application of most of the physical and military training.

(4) The possible prevention of the condition of march fracture appears to lie in the attention in early youth to the proper physical development of the body and in particular early athletic training, including special exercises to develop and strengthen the foot. An adequate diet, rich in vitamins and minerals, should be a sine qua non. The tempo and duration of the recruit's training should be geared according to his physical standard.

Sufficient time should be allowed for the recruit to accustom himself to the transition from civilian to Army foot-wear and accurate boot fitting at the outset is essential.

(5) In all cases of pain in the foot following prolonged strain, such as marching, the possibility of march fracture should be borne in mind. The diagnosis seldom presents any difficulty, the history and clinical signs being so characteristic. Radiology may at first show nothing and should be repeated in all doubtful cases after two weeks.

VI. SUMMARY.

(1) A brief outline of the object and training of an Army Physical Development Centre is given.

(2) A series of 64 cases of march fracture occurring at such a Centre is fully recorded, with statistical details.

(3) Physical and radiological findings are described.

(4) The aetiology is discussed and various views in the literature compared.

(5) Details of ambulatory treatment are given and the importance of this as the treatment of choice is stressed.

(6) Prevention would appear to lie along lines devoted to increasing sound physical development in early life.

I would like to express my thanks to Major A. N. L. Clark for his constant encouragement and help and to Major W. R. Playfair for his assistance and advice.

APPENDIX.

No. -- PHYSICAL DEVELOPMENT CENTRE.

Pro-forma for use in Follow-up cases of March Fracture.

Number. ............ Rank. ............ Name. ............ P.D.C. Serial. ............

The above named attended course No. ............ at No. ............ P.D.C. From / 44 to / 44 He sustained a March Fracture of ............ on / 44.

May the following information please be supplied:

PART A. To be completed by Company Officer.

1. What duties and training has he performed since / 44?

2. What are his present duties?

3. Record of Route Marches performed since / 44?

4. Record of other physical activities.

5. General Remarks.

Signed. ....................

O. i/c Coy.
PART B. To be completed by Medical Officer.

1. Patient's account of his foot condition since / / 44.

2. Has he reported sick since / / 44? If so, give details.

3. Has he had any period of light or modified duties because of foot condition?


5. Present Medical Category ......................

6. Any other relative remarks.

7. An X-ray plate, A-P view of the fore-foot would be greatly appreciated.

Signed ........................................ R.A.M.C.

M.O. i/c.

Remarks.

Signed ........................................ Officer Commanding.

Station: / / 44.

Date: / / 44.

REFERENCES.