ATHLETIC ACTIVITY IN ADOLESCENCE AS AN ETIOLOGICAL FACTOR IN DEGENERATIVE HIP DISEASE

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Degenerative hip disease (osteoarthritis) is common in this country. It may cause symptoms at any age in adult life, but the peak incidence is in the sixth decade, sex incidence being approximately equal. In men particularly, this age largely corresponds to the years of greatest productivity.

Osteoarthritis of the hip is known to be secondary sometimes to such disorders as acetabular dysplasia, Perthes' disease and epiphysiolsis. In most cases, however, no precipitating factor has been recognised. The descriptive terms "primary" or "idiopathic" were used in reports by Gade (1947), Lloyd-Roberts (1955), Adam and Spence (1958) and Nicoll and Holden (1961), who together recorded a total of 499 cases, of which 258 were so classified.

In a previous report (Murray 1965) on the etiology of 200 cases of so-called "primary" osteoarthritis of the hip the earliest antero-posterior radiograph was studied. Because lateral projections were seldom available these were disregarded. On the first detailed inspection of each a decision was made whether the hip architecture was fundamentally normal or abnormal. Whenever reasonable doubt existed, particularly when degenerative changes were already advanced, it was assumed that no basic anatomical abnormality had been present. The pre-existing anatomical configuration of the affected hips was concluded to have been completely normal in no more than 35 per cent. Serial radiographs of many cases in this group showed progressive changes comparable to rheumatoid arthritis and a subclinical form of this, or some allied disorder, was suggested as the cause of the degeneration of the hip. Some support for this was found in the sex incidence which was similar to that in established rheumatoid arthritis.

The remainder had minor anatomical abnormalities and the resultant incongruity of the hip was considered to be the precipitating cause of degenerative changes. These abnormalities were thought to be the least manifestations of the important predisposing factors mentioned above. Evidence of acetabular dysplasia was found in 25 per cent of the series, the sex incidence of 4:1 females to one male, corresponding to the incidence of true congenital dislocation, of which this condition may be regarded as a form fruste. Stigmata of unrecognised Perthes' disease, not seen in the original series, have occurred since in small numbers, probably less than 2 per cent of the total.

It became increasingly evident that the most common minor anatomical abnormality, occurring in approximately 40 per cent, was comparable radiologically to the appearance of previous epiphysiolsis. The remarkable contrast in sex incidence which was found, 5:6 males being affected for every female, required explanation. The abnormality consists of a medial angulation of the femoral head in relation to the femoral neck and, to define this, the term "tilt deformity" was proposed. The appearance was so common that it might easily be regarded as a normal variant, and to appreciate its nature it is necessary to consider the clinical aspects and radiological features of frank epiphysiolsis or slipping of the capital epiphysis.

EPHYSIOLYSIS

Clinical features—The patient, an adolescent, usually presents with a limp and a history of pain in the hip, or more commonly in the knee, of several weeks or months duration, frequently
having suffered a recent acute exacerbation. In most cases the affected femoral head tilts backwards and medially. The basic lesion is essentially a fracture-separation of the epiphysial plate, which is more often the result of chronic stress than a single injury. Boys are more often affected than girls, but this sex discrepancy has been considerably reduced during the last few decades. In 1926 Key found the male:female ratio to be 3:1, but Newman, investigating 108 cases in 1964, observed a slight female preponderance of 11:10. In the year 1967 one of us (R. O. M.) encountered twenty-four new cases, fourteen in boys and ten in girls. Some discrepancy may always be expected, since girls are at risk for approximately two years less than boys, because of earlier physiological fusion of their epiphyses. The predilection of this entity for males is emphasised in Figure 1, in which the incidence by age

![Graph showing sex incidence of epiphysiolysis.](image)

and sex is illustrated. This graph was obtained by compounding the incidence quoted by Torsten Jerre (1950), Burrows (1957) and Taillard et al. (1964).

The proximal epiphysial plate of the femur appears to be especially subject to disturbance by chronic stress. Such stress may be accentuated by the habitus of the individual. More than half these adolescents are overweight, and a few are tall and slender: the obesity may often be related to sex hormone deficiency, and a tall stature to excess pituitary growth hormone. The liability of an adolescent to develop this disorder is thus accentuated, because in each case additional strain may be expected to be placed on this site of potential weakness.

**Radiological features**—The pattern of the radiological changes provides the most convincing evidence of a traumatic origin. The metaphysis remodels to fit itself to the displaced femoral epiphysis; bone is resorbed from the outer side of the metaphysis and laid down on the medial side and can usually be identified at the first examination, indicating that the lesion is caused basically by chronic stress, even though an exacerbating incident may have caused sudden increase in displacement of the femoral head (Figs. 2 to 5). The final position of the femoral head in relation to the femoral neck is essentially the same as that recognised as the tilt deformity (Fig. 6) and in the development of this type of degenerative joint disease later in life (Figs. 7 to 9).

In this study a traumatic basis for the tilt deformity was therefore suspected and appeared worthy of further investigation. Interest had originally been stimulated by observation of
Epiphysiodesis—A 14-year-old boy suffered pain in the left knee for two months following a fall six months previously. The radiograph in March 1959 showed a slip of the left upper femoral epiphysis (Fig. 2). The femoral head was pinned in satisfactory position with no subsequent disability (Fig. 3), the final appearance being comparable to the tilt deformity described in the text (Fig. 4). Figure 5 is a tracing of the original film and illustrates: 1) apposition of new bone on the medial side of the metaphysis and absorption of bone from the lateral side, this remodelling process being indicative of the duration of the abnormality. 2) Extrusion of the medial third of the metaphysis from the acetabulum. 3) Extension of the line of the lateral aspect of the femoral neck fails to traverse the displaced femoral head. The femoral head ratio for the affected left hip was 2:06 whereas that of the normal right hip was 0:86. This coefficient cannot be established reliably until ossification of the lesser trochanter is complete.
many formerly distinguished athletes who had become lame through degenerative disease of the hip in middle life. In many, evidence of slight epiphysiolysis, now described as the tilt deformity, could be recognised. The mere fact that many patients first sought medical advice because of increasing limitation of activity—often in connection with golf—suggested that these active men had probably been active boys. Absence of symptoms earlier in life could probably be explained by the remarkably low-grade symptomatology of the gross lesion, when an adolescent might take as long as a year before presenting for examination. Minor injuries to the skeleton in children, such as avulsions of muscle attachments, may cause few symptoms or none at all, but still be responsible for radiological abnormalities. For example, Adams (1965) described such abnormalities in the epiphyses of the elbow in the throwing arm of adolescent baseball pitchers, almost all of whom had no complaint.

In the series investigated, men were much more often affected than women, possibly because in the first decades of this century girls participated in sport much less than today.

This type of degenerative joint disease appears to be common in Great Britain, the United States, Australia and New Zealand, but it is much less frequent—judging from a large number of personal communications—in Continental Europe, and is rare in the Latin countries. Among the coloured races it is virtually unknown, although their shorter life expectancy probably reduces the opportunity for degenerative change of this type to develop.

Because the radiological appearance of the tilt deformity so closely resembles that observed in the later stages of epiphysiolysis, it was thought to be the result of chronic stress during the years of adolescence. On this assumption the questions arose as to when such trauma occurred, to what type of activity it might be related, and whether any correlating history of such symptoms as “growing pains” could be established. A research study, the subject of this report, was therefore undertaken.

THE RESEARCH STUDY

Three groups of young mature males, aged seventeen to twenty-one, all volunteers and with parental consent, took part in the investigation. Each completed a questionnaire concerning his personal and athletic history, and a single antero-posterior radiograph of the
pelvis was obtained. These volunteers were derived from different sources in order to determine whether the hips of boys engaged in a highly athletic regime, often largely compulsory, were more affected than those in a more scholarly regime.

**Fig. 7**

**Fig. 8**

**Fig. 9**

*Osteoarthritis of the right hip secondary to the tilt deformity*—Mild symptoms of pain in the right hip caused a man to present at the age of 37 (Fig. 7). The femoral head ratio on the right was 1.45 and on the left 1.40. Degenerative change was characterised first by narrowing of the outer third of the joint space and new bone formation ("buttressing") on the lateral aspect of the femoral neck. Severe deterioration in the subsequent seven years (Fig. 8) was matched clinically by increased pain and disability. One year later, at the age of 45 (Fig. 9), the patient was virtually incapacitated.

*Group A* (ninety-four subjects) comprised pupils at a boarding school in the country, well known both for its intellectual standards and its athletic successes. Almost every form of sport was available. Educational standards for admission, which took place between the ages of thirteen and fourteen, were high. With only one exception all had attended preparatory boarding schools, mostly from the age of eight, where the regime was similar, compulsory games and exercise being the rule.
Group B (seventy-seven subjects) attended an equally famous school in a city where the intellectual standards were recognised to be unusually high and, although numerous opportunities for games and athletic activities existed, they were more voluntary and were practised less. About two-thirds were boarders, the rest attending daily. During the preparatory years approximately half had been boarders.

Group C (eighty subjects) comprised volunteers of the same age in industry. All had attended state schools in which games were to a large extent voluntary, but usually gymnastics and cross-country running had been compulsory. Many had left school at the age of fifteen, but most had continued with some athletic activity, the variety being extremely wide. The questionnaire was divided into parts: 1) the personal history, and 2) the athletic history. In the personal history were recorded details of age, height and weight at the time of examination and places of education both before and after the age of fourteen. Specific enquiry was made concerning any history of "growing pains" or of an unexplained limp or discomfort affecting the hips or knees. An enquiry was also made about any family history
of hip disorder. For the athletic history each subject recorded regular participation in games and sports before and after the age of fourteen, together with any distinctions achieved. Modesty was discouraged. Most activities were the subject of specific enquiry, but space was provided for any not definitely named. The dominant hand or foot for each activity was also recorded.

![Fig. 12](image)

**Fig. 12**

Tilt deformity of right femoral head, with secondary degenerative change, shown only in lateral projection—A 69-year-old man had slowly increasing pain and disability in the right hip for fifteen years (Fig. 12). The degenerative changes shown are often described as "primary" osteoarthritis. The lateral views (Fig. 13) show that the right femoral head is tilted backwards in relation to the femoral shaft. This relatively unusual variant of the tilt deformity corresponds to those cases of frank epiphysiodesis in which the femoral head displacement occurs purely in a backward form without any element of the much more common medial displacement. Such examples were not included in the present investigation, which depended entirely on frontal projections.

**Fig. 13**

*The pelvic radiograph—A single antero-posterior radiograph of each subject was obtained, using a standard technique. Large films were used so that the proximal ends of the femora could be included. The focal-film distance was one metre and the central ray was directed vertically to a point 2.5 centimetres above the symphysis pubis. All films were taken with the big toes touching and the heels 2.5 centimetres apart. This standard positioning was of considerable importance because the contour of the femoral heads and necks is altered if medial rotation or, more especially, lateral rotation of the femur is permitted.*

Although presence of the tilt deformity can usually be recognised by inspection alone, it was considered necessary both for the previous study of osteoarthritic hips and for the present enquiry, to employ a method of objective measurement.

**Technique of measurement of the tilt deformity**—The central point between the supero-lateral margin of the greater trochanter and the most prominent edge of the lesser trochanter was established. Similarly the central point of a line across the narrowest portion of the femoral neck was plotted. These central points were joined by a line, which was extended proximally to traverse the femoral head. On both the lateral and the medial sides of this line the vertical
distances to the most prominent point on the femoral head margin were measured. Division of the figure for the lateral portion into the figure for the medial portion produced a measurement designated as the "femoral head ratio". The application of this method to normal hips and to hips with tilt deformities is shown in Figures 10 and 11. In a normal femur the line traversing the head may be expected to bisect it, so that the femoral head ratio would be 1. In contrast the femoral head ratio for the residual deformity of the left hip shown in Figure 1 is 2-06. The mean ratio for osteoarthritic hips as previously reported was 1-58. In the present investigation a value of 1-35 was considered to indicate definite abnormality and was recorded as a tilt deformity. In the series of 100 normal control hips assessed previously, such a value was found in 10 per cent.

This technique, relying on a single antero-posterior radiograph, does not permit assessment of displacement of the femoral head in a purely backward direction, as may occur in a few cases of frank epiphysiodesis. Lateral projections are then necessary to demonstrate the

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>COMPARISON OF AGE, HEIGHT AND WEIGHT IN THE THREE GROUPS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td>Number of subjects</td>
<td>94</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>17.6</td>
</tr>
<tr>
<td>Average height (metres)</td>
<td>1.81</td>
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<tr>
<td>Average weight (kilograms)</td>
<td>69.6</td>
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<table>
<thead>
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<th>TABLE II</th>
<th>INCIDENCE OF TILT DEFORMITY (FEMORAL HEAD RATIO ≥1.35 ON EITHER SIDE) IN EACH GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total examined</td>
<td>Tilt deformity</td>
</tr>
<tr>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>Group A</td>
<td>94</td>
</tr>
<tr>
<td>Group B</td>
<td>77</td>
</tr>
<tr>
<td>Group C</td>
<td>80</td>
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</table>

abnormality clearly. Any tilt deformities of this type, therefore, could not be recognised in the present series. Those which were observed can thus only represent a proportion of the total which in fact existed. An example of degenerative changes due to this variant is illustrated in Figures 12 and 13.

RESULTS

The three groups were reasonably alike with respect to height and weight (Table I). The average age of subjects in group C was slightly higher than in the other two groups because of the inclusion of some marginally older subjects. The greatest age in group C was twenty-one years as against nineteen years in groups A and B. This did not appear to affect the measurements of the femoral head ratio.

Tilt deformity (femoral head ratio ≥1.35 in one or both hips)—Twenty-three cases of tilt deformity were found in group A, seven in group B and twelve in group C (Table II). The differing incidence of tilt deformity in the three groups is unlikely to have occurred by chance ($\chi^2 = 7.432; P < 0.05$).
Femoral head ratio—This was measured in both hips and the average of these two readings for each subject has been used as a measure of the femoral head ratio of that subject.

The mean femoral head ratios were 1.12 in group A, 1.05 in group B and 1.10 in group C. As can be seen in Figure 14, the distribution in group A showed a marked skewness. Group C also showed a slight skewness, whereas in group B the distribution was almost symmetrical. When subjects with a tilt deformity are omitted the femoral head ratio distributions become similar in the three groups. There is a suggestion, therefore, that subjects with a tilt deformity may form a separate, distinct group.

Effect of athletic activity—Since there were more cases of tilt deformity than would be expected at the school where emphasis is put on athletic success (group A) and fewer where athletic participation is largely voluntary (group B) a possibility arose that certain forms of sport, especially when undertaken compulsorily, might precipitate the abnormality.

This has been investigated in two ways. Firstly, the incidence of tilt deformity amongst subjects who regularly participated in a particular activity ("participants") has been contrasted with the incidence amongst subjects who did not record that activity ("non-participants"). Because the numbers involved were very small in many instances, the statistical significance of the difference between the two incidences has been evaluated by the exact method (Finney 1948); a two-tail probability was needed to test the hypothesis of no difference and this was obtained by doubling the one-tail probability. Secondly, for each activity the mean femoral head ratio for participants has been compared with the corresponding mean for non-participants using the t-test to evaluate the significance of the difference between the two means. Should an inapposite cut-off point in the definition of a tilt deformity have obscured the presence of a difference between the participants and the non-participants, the latter comparison might be expected to show this difference more clearly.

Athletics cover a wide range of activities. For the purposes of the analysis the long jump, high jump, pole vault and hurdling were grouped under the general heading of "jumping". Similarly, "track running" includes distance running from 100 yards to one mile.

Because information was available regarding athletic activities both before and after fourteen years of age, the results were further divided into participation before fourteen and participation at any time during school life. The results are summarised in Tables III and IV.

Compulsory cross-country running—The incidence of tilt deformity was greater amongst participants but not significantly so. This was most apparent in group A and group C subjects before the age of fourteen. The differences in mean femoral head ratio between participants and non-participants could have occurred by chance in all three groups. Overall the participants had a very slightly higher femoral head ratio.
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TABLE III

INCIDENCE OF TILT DEFORMITY (FEMORAL HEAD RATIO $\geq 1.35$ ON EITHER SIDE)

IN PARTICIPANTS AND NON-PARTICIPANTS IN ATHLETIC ACTIVITIES

All groups combined

<table>
<thead>
<tr>
<th>Athletic activity</th>
<th>Before 14 years</th>
<th>At any age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participants</td>
<td>Non-participants</td>
</tr>
<tr>
<td></td>
<td>Total Tilt deformity Number</td>
<td>Total Tilt deformity Number</td>
</tr>
<tr>
<td>Compulsory cross-country running</td>
<td>79 15 19-0</td>
<td>172 27 15-7</td>
</tr>
<tr>
<td>Voluntary cross-country running</td>
<td>37 7 18-9</td>
<td>214 35 16-4</td>
</tr>
<tr>
<td>Track running</td>
<td>105 15 14-3</td>
<td>146 27 18-5</td>
</tr>
<tr>
<td>Jumping</td>
<td>38 10 26-3</td>
<td>213 32 15-0</td>
</tr>
<tr>
<td>Compulsory gymnastics</td>
<td>140 24 17-1</td>
<td>111 18 16-2</td>
</tr>
<tr>
<td>Voluntary gymnastics</td>
<td>32 4 12-5</td>
<td>219 38 17-4</td>
</tr>
</tbody>
</table>

TABLE IV

MEAN FEMORAL HEAD RATIOS FOR PARTICIPANTS AND NON-PARTICIPANTS IN ATHLETIC ACTIVITIES

All groups combined

<table>
<thead>
<tr>
<th>Athletic activity</th>
<th>Before 14 years</th>
<th>At any age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participants</td>
<td>Non-participants</td>
</tr>
<tr>
<td></td>
<td>Number Mean</td>
<td>Number Mean</td>
</tr>
<tr>
<td>Compulsory cross-country running</td>
<td>79 1-10</td>
<td>172 1-09</td>
</tr>
<tr>
<td>Voluntary cross-country running .</td>
<td>37 1-12</td>
<td>214 1-09</td>
</tr>
<tr>
<td>Track running              . . .</td>
<td>105 1-09</td>
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</tr>
<tr>
<td>Jumping                    . . . .</td>
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<td>213 1-09</td>
</tr>
<tr>
<td>Compulsory gymnastics      . . .</td>
<td>140 1-10</td>
<td>111 1-09</td>
</tr>
<tr>
<td>Voluntary gymnastics       . . . .</td>
<td>32 1-10</td>
<td>219 1-09</td>
</tr>
</tbody>
</table>

Voluntary cross-country running—Mean femoral head ratios were observed to be higher for cross-country runners in group B and group C, but lower in group A. Subjects who voluntarily took part in runs had a slightly higher mean femoral head ratio when all three groups were combined, but in no instance was the mean ratio for participants significantly different from that of non-participants. This was a similar picture to that given by the incidence of tilt deformity.

Track running—Tilt deformities were more common in non-runners in all three groups but not to a statistically significant extent. Practically identical mean femoral head ratios were found for participants and non-participants in each group.

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Jumping.—Participants in jumping events in groups B and C showed a higher incidence of tilt deformity than non-participants, although only in group C was this effect significant at the conventional 0·05 level. Group A subjects on the other hand showed the opposite effect. For all groups combined the incidence was 26·5 per cent amongst participants and 14·4 per cent amongst non-participants, a difference which approaches statistical significance (P = 0·075; exact method). The mean femoral head ratio was also higher for all participants, but this may have occurred by chance. In group B, ten subjects who had taken part in these events at any time during school life had a mean ratio of 1·15, which differs significantly from the ratio of 1·04 found for sixty-seven non-participants (P < 0·05: t-test). Similarly in group C the value for fifteen participants was 1·18 compared with 1·08 for sixty-five non-participants (P < 0·05: t-test). Group A subjects again showed the opposite effect, the mean femoral head ratio being 1·09 for twenty-four participants and 1·13 for seventy non-participants, although this is not a statistically significant result.

Thus it appears that jumping in various forms might precipitate tilt deformity, but because this is not found in group A, in which most effect might have been expected, some doubt is cast upon this conclusion.

Compulsory gymnastics and voluntary gymnastics.—No significant differences could be detected between participants and non-participants.

Multiple regression analysis.—Because there was probably a high correlation between the various athletic activities whereby the effect of one athletic factor might be obscured by that of another, it was thought that a multiple regression analysis might bring any such factor to light. Height and weight were included with the six forms of athletic activity. The femoral head ratio was found to be correlated with participation in jumping events in group B (r = +0·249) and group C (r = +0·236), but not in group A (r = −0·098). When restricted to activities before fourteen years of age, only in group C was there a significant correlation (r = +0·267). Height was also correlated with femoral head ratio, negatively in group A (r = −0·276) and positively in group B (r = +0·227). In group C there was little or no correlation at all (r = +0·005). There was no correlation between height and participation in jumping events.

All the factors included in the regression analysis could only account for 11 per cent of the total variation in the femoral head ratio in group A, 15 per cent in group B and 13 per cent in group C. The regression analysis added little further to what has already been reported.

Athletic category.—An attempt was made to put each subject into one of three categories measuring his athletic ability by means of his interest and success in representing the school or house at sports both before and after fourteen years of age. Tilt deformity was not associated with this measure as such but there was a suggestion that those who started off being very athletic in early school life, and then became virtually non-athletic in later years, tended to have developed tilt deformities. In group A in particular, four out of six subjects who dropped from the most athletic category to the least had a femoral head ratio greater than 1·50 whereas only six of the remaining eighty-eight subjects had such high values. (P = 0·00185; exact method). It is tentatively suggested that a loss of success and interest in sports may in some cases arise from the development of a tilt deformity in the hip.

Growing pains.—A past history of growing pains was reported by forty-nine subjects (20 per cent), thirty-two referring to the knee. The incidence of tilt deformity in all was 22·4 per cent compared with 15·3 per cent in the remaining 202 subjects free of growing pains. When restricted to pains in the knee, the incidences are 25 per cent and 15·5 per cent respectively. The mean ratio for subjects reporting growing pains of the knee was 1·14 which is contrasted with 1·09 for subjects free of these pains. Although this difference is not statistically significant, the trend is present in all three groups, being most apparent in group C where femoral head ratios of 1·22 and 1·09 respectively were found for subjects with and without growing pains in the knee. (P < 0·05: t-test.)
DISCUSSION

The concept that minor anatomical abnormalities might be responsible, even in the absence of any appropriate history, for the development of osteoarthritis of the hip is not new. While this explanation is readily accepted in patients with mild acetabular dysplasia, little attention has been paid to joint derangement associated with slight epiphysiolysis in the past. Nevertheless, as early as 1933 Elmslie observed that a pre-existing deformity of the hip joint might be found in many patients developing osteoarthritis at a comparatively early age. Law (1952) firmly stated his belief that many of these cases were due to a slight degree of slipping of the epiphysis, which did not cause signs or symptoms during adolescence and which were masked by subsequent hypertrophic changes.

Because men, usually with an athletic background, are so largely affected, this investigation into this abnormality in young males and correlation with athletic activities appears to have been justified. The results offer some support for the hypothesis which has been proposed.

Statistically the evidence shows that the tilt deformity is significantly more common in boys exposed to a more active regime. This was especially evident in group A. In complete contrast was the very low incidence of the abnormality in group B. An attempt at correlation, however, with specific activities has been relatively unrewarding because so many boys take part in multiple forms of sport. A suggestion has been made, without firm statistical support, that activities involving jumping are related to the deformity. Nevertheless, particularly in unilateral cases, this would accord to certain clinical observations made in patients who were formerly fast bowlers at cricket; in them, the hip affected tended to be that on which the final strain had been taken immediately after delivery of the ball. The development of a distinctive style usually occurs during the years of susceptibility. In the case of bilateral involvement the obvious activity of suspicion was long-distance running, particularly on hard surfaces. Trainers of young horses are well aware of a potential hazard of lameness in similar circumstances. Nevertheless no statistical incrimination of activity of this type could be obtained.

Perhaps the most significant feature of this investigation, despite relatively small numbers, was the association between the presence of the tilt deformity and “growing pains”. This suggests an intermediate phase between the frank disorder of epiphysiolysis and the asymptomatic, minimal disturbance now under discussion. The fact that the majority of

Fig. 15
Bilateral tilt deformities in one subject who had been an outstanding all-round athlete before the age of 14, but whose performance was subsequently undistinguished except for proficiency at tennis. There was a history of “growing pains” in adolescence. The femoral head ratio was 1:45 on the right and 1:60 on the left.
these were referred to the knee rather than to the hip is again similar to the customary initial complaint in epiphysiolysis.

A number of the subjects with the tilt deformity exhibited no athletic prowess either before or after the age of fourteen. If the hypothesis is correct the damage must have been done before they had an opportunity to achieve any distinction. This does appear to be possible, since an intermediate group may be argued to exist, consisting of those who were outstanding at games and athletics before the age of fourteen, but whose subsequent performance was relatively or completely undistinguished, particularly in contact sports. For example, two subjects in group A, who had both achieved almost every sporting honour at their preparatory schools, terminated their school careers as captains of tennis and golf respectively. The severe tilt deformities in the former are shown in Figure 15. This subject had recorded “growing pains” in the hips.

The tentative conclusion obtained from this study is that excessive athletic activity in adolescence is likely to be an important cause, certainly in males, of subsequent degenerative hip disease. The keen boy will undoubtedly disregard this potential penalty, but by this conclusion some explanation for the remarkable geographical distribution of the disorder may be found. Those areas of the world in which middle-aged men are particularly afflicted by degenerative disease of the hip largely correspond to those in which competitive athletic activity is most encouraged. Similarly, the difference in racial distribution might to some extent be explained. Nevertheless, in this connection, emphasis must be placed on the fact that tilt deformities may be observed in normal adults at any age. The abnormality is in no way to be regarded as an inevitable precursor of degenerative joint disease. Observation and further investigation of many of these subjects may be possible in the future. Only then may a completely objective assessment be made.

Finally, some practical suggestions to reduce the incidence of the disorder during the decades to come may be made. “Growing pains” might be considered in relation to athletic activity, and when they affect the knees radiological examination of the hips may be advisable in order to exclude early epiphysiolysis. The merit of long-distance runs, particularly along hard roads, as a form of athletic training, whether compulsory or voluntary, might be reconsidered.

SUMMARY

1. In a previous investigation, approximately 40 per cent of so-called “primary” degenerative disease or osteoarthritis of the hip appeared to have been the result of an abnormal joint mechanism caused by minimal epiphysiolysis in adolescence. Males were affected much more commonly than females. The residual abnormality of this disturbance, recognised radiologically, was termed the “tilt deformity” of the femoral head.
2. Three groups of young adult males, with different athletic backgrounds, have now been examined to assess the incidence of this abnormality and its relationship to athletic regimes. The condition was found to be more common in subjects who had been engaged in more active regimes and was also related statistically to a history of “growing pains”. The deformity is compared with the gross disturbance of adolescent epiphysiolysis or slipped epiphysis, which is believed basically to be caused by chronic stress.
3. Degenerative disease of the hip of this type has a geographical and racial distribution corresponding to the degree of interest in and encouragement of competitive athletic activities. Many cases are therefore postulated to be the direct result of a minor and usually asymptomatic disturbance of this type, attributable to excess activity during adolescence.

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REFERENCES


NEWMAN, P. H. (1964): Personal communication.

