Other modes of production of the apparent folic-acid deficiency in cases of malignant disease that merit consideration are deficient intake due to anorexia with resulting primary malnutrition, and diminished absorption produced by widespread metastases or some other means.

It seems unlikely that either of these mechanisms could operate without significant weight loss occurring, and there was little or no weight loss in Cases 74, 76, 77, 81, 84, 88, 90, 95, and 114. Moreover, in Cases 77 and 114 there was no evidence at operation of any cause for intestinal malabsorption. This was true also at post-mortem examination in Cases 88 and 95.

In contrast, there was very severe primary malnutrition of many years' duration in Cases 40, 41, and 42, as established by a detailed dietetic investigation. An important source of calories for Case 40 was whisky. Case 41 weighed only 4 st. 12 lb. (30.8 kg.): a fat-balance test in this patient revealed normal fat absorption. A post-mortem examination of Case 42 revealed no abnormality other than generalized wasting.

Nevertheless these patients, while excreting less of the administered folic acid than did most of the other control cases, were able to excrete 1.5 mg. or more.

It is, of course, possible that several factors operate to give a diminished folic-acid excretion in some patients with malignant disease. Thus it would be reasonable to assume that intestinal malabsorption was an important cause in Case 79. Recently a folic-acid-absorption test has been devised for measurement of absorption of folic acid from the alimentary tract (Girdwood, 1953), and it may be that the application of this test to cases similar to those in Table II will be of value.

The data given do not indicate whether the result of the folic-acid-excretion test is of help in assessing the prognosis or of value in considering the best method of treatment to adopt, especially in patients with leukaemia or some form of reticulosis. Case 63 had a normal folic-acid excretion and died within three months. Case 87 had a very abnormal excretion, but is alive and well following x-ray therapy.

Summary

A test dose of 5 mg. of folic acid was given subcutaneously to 148 patients. The urinary excretion of folic acid usually exceeds 30% of the test dose, and an excretion of less than 1.5 mg. is recorded as a "positive" test.

The test may be positive in megaloblastic anaemia, but there is no evidence that anaemia in itself gives a diminished excretion.

Where renal function is good and the patient does not suffer from megaloblastic anaemia, intestinal malabsorption, generalized oedema, a large effusion, or severe infection of long duration, a positive test is likely to indicate the presence of advanced malignant disease. It is, however, possible to have advanced malignancy with a negative folic-acid test.

This work was made possible by the kind co-operation of many physicians, surgeons, and nursing sisters in numerous hospitals in Edinburgh and district. I wish to thank them, Mr. Robert Brown, for performing many of the assays, and Professor L. S. P. Davidson for helpful advice. Financial assistance was obtained from the John Risk Bequest. Dr. A. T. Mennie, of Lederle Laboratories Div., Cyanamid Products Ltd., kindly supplied the folvite.

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THE PREVALENCE OF FOOT DEFECTS AMONG WARTIME RECRUITS

BY

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There is a general, if unconfirmed, impression that foot defects are common, painful, and incapacitating enough to justify more attention than they have hitherto received from epidemiologists. A recent survey in Luton has indicated the number of persons who themselves complain of foot trouble (Dykes, Grundy, and Lee, 1952), but assessments of incidence based on clinical observations are mainly confined to children (Emslie, 1939; Wilkins, 1941), young women (Alford and Gorrie, 1952), and aged persons (Sheldon, 1948). In the present investigation the registers of Civilian Medical Boards, which are more fully described elsewhere (Martin, 1949; Clements and Pickett, 1952) have been used to obtain an estimate of the prevalence of foot defects in men of working age and, where possible, to identify predisposing factors.

The registers used in the present survey relate to men who were called up in 1941 and examined in Leicester. According to the official instructions circulated to the Medical Boards, "special attention should always be drawn to the defects which may cause a man to be classified in one of the lower grades of fitness for military service, or which may influence decision on possible claims for pension in the future: these should be described as in a clinical report." The instructions stress the importance of recording all types of foot defect and state that a detailed examination of the feet may be omitted only if a man is so severely disabled in other respects as to be totally unfit for military service. There were 358 such cases in the Leicester records. After the exclusion of these, and of a further 93 over 45 years of age, there remained 22,843 men between the ages of 17 and 44, of whom 3,287 (14.4%) shared 4,160 foot defects.

Age Distribution and Interrelation of Foot Defects

The distribution of foot defects by age and diagnosis is shown in Table I. The two categories of flat-foot distinguish cases in which the arch could be restored by standing on tip-toe (mobile, or A cases), and cases in which the

TABLE I.—Foot Defects Recorded at Specified Ages: Men Examined at Leicester in 1941

Defect	Cases per 1,000 Examinees Aged						Total No. of Cases
	17-19	20-24	25-29	30-34	35-39	40-44	
Of longitudinal arch:							
Flat-foot (A cases)	38.9	38.6	36.7	39.0	36.6	45.6	880
" (B ")	8.5	11.6	20.4	24.6	34.8	38.2	502
Pes cavus . . .	5.2	7.9	10.7	11.2	14.4	12.7	233
Of forefoot:							
Hammer-toe . .	20.5	32.5	44.1	48.4	61.9	67.1	1,003
Hallux valgus . .	13.9	15.1	26.0	33.5	40.0	46.9	640
" rigidus . .	2.3	1.8	7.4	7.3	8.4	6.0	126
Overlapping toes . .	12.0	12.7	17.2	21.1	22.7	20.1	405
Other:							
Callosities . .	5.0	5.5	10.7	21.1	25.8	26.2	356
Miscellaneous . .	0.8	0.5	0.9	1.0	0.4	0.0	15
No. of examinees . .	4,835	3,786	2,153	5,082	5,496	1,491	22,843

longitudinal arch had permanently disappeared (rigid, or B cases).* The category "miscellaneous" includes deformed nails (5), extra toes (3), skin pedicles (2), webbed toes (1), and four undiagnosed cases.

According to Table I the A cases of flat-foot showed a fairly level age incidence, but the B cases increased steadily with age to become four times as common in the early forties as in the late 'teens. In theory this discrepancy can be accounted for in several ways, but the most likely explanation (which assumes that the A cases represent a stage between normality and total extinction of the longitudinal arch) is that new cases were occurring between the ages of 17 and 44 at roughly the same rate as established cases were progressing to an irreversible stage. If, however, the A and B cases of flat-foot are two distinct clinical entities then the figures in Table I can be explained only by assuming that (1) mobile as well as rigid flat-foot is an irreversible condition; (2) regularly throughout the age group 17 to 44 years new cases of rigid flat-foot continued to develop *de novo*; and (3) virtually all the cases of mobile flat-foot were manifest before the age of 17.

Table I also shows the incidence of metatarsal and related defects at various ages. The two most common conditions in this group show a rising age incidence, and by the early forties nearly 7% of men had hammer-toes, and nearly 5% had hallux valgus. A similar though less noticeable increase with age is seen in the case of callosities and overlapping toes, but the incidence of hallux rigidus shows little variation within the age range 17-44. There was also a distinct tendency for foot defects, especially when severe, to occur together. A measure of this tendency is shown in Table II,

TABLE II.—Frequency of Multiple Foot Defects

<i>r</i>	No. of Men with <i>r</i> Defects	Expected No. of Men with <i>r</i> Defects, on the Assumption that Defects Occur Independently
0	19,564	18,970
1	2,554	3,594
2	584	267
3	129	12
4	11	
More than 4	1	
All	22,843	22,843

which gives the actual number of men having 0, 1, 2, 3, 4, and more than 4 defects and the numbers to have been expected if each defect had occurred independently.

The expected figures were obtained by multiplying the appropriate proportions and summing when necessary. For example, the expected proportion with exactly one defect

$$\text{was } \sum_i \left\{ \frac{p_i}{1-p_i} \left[\frac{11(1-p_i)}{i} \right] \right\} \text{ in which } p_i \text{ stands for the}$$

proportion of men with the *i*th defect. In this calculation both categories of flat-foot are, of course, treated as one defect, since by definition they cannot occur together.

It will be seen that isolated defects occurred with less than three-quarters, pairs of defects with over twice, and three or more defects with nearly twelve times their expected frequency. The following list shows the extent to which particular defects tended to be associated, the figure beside each defect being the ratio of the number of times it was found in conjunction with other defects to the expected number, in the sense defined above: callosities, 4.75; flat-foot (B cases), 3.59; hallux valgus, 3.54; hallux rigidus, 3.10; overlapping toes, 3.05; hammer-toe, 2.80; pes cavus, 2.76; flat-foot (A cases), 0.64. The position of callosities at

the head of the list reminds us that these painful skin lesions are apt to accompany every variety of bony displacement. The list also shows that mobile flat-foot is rarely and rigid flat-foot commonly found in association with other deformities. This suggests that by the time other lesions have developed in flat-footed persons the longitudinal arch has usually disappeared.

The analysis of multiple defects was carried one stage further by calculating "association" ratios for specific pairing of defects. The two most frequent pairings were hammer-toe and callosities (121 times) and hallux valgus and hammer-toe (104 times), but for several other well-known combinations the excess relative to the "expected" number of cases was even greater. Thus hallux valgus and overlapping toes were eight times, hallux rigidus and flat-foot seven times, and pes cavus and hammer-toe four times, as common as they would have been if they were independent lesions.

The tendency for bony deformities of the foot to be found in association with diseases which affect other parts of the skeleton was also studied and foot defects were found to be especially common in persons who had had the paralytic form of poliomyelitis. There were also significant associations for lower limb injuries, curvature of the spine, rheumatoid arthritis, and for a mixed group of skeletal conditions mainly composed of operations on the lower limb and undiagnosed wasting of leg muscles.

Relation of Foot Defects to Body Size and Build

According to Lake (1943) the human foot is, still imperfectly adapted to the extra strain imposed upon it by the upright posture. Since this strain is related to body build it was thought worth while to examine the association between overt foot defects and certain measurements recorded at the time of the medical board.

In Table III the number of men ($\times 100$) with foot defects who fall into eight weight groups has been compared with the number to have been expected if the risk of foot troubles were independent of weight. The corresponding analysis for height is shown in Table IV. In both tables the age distribution of the different groups has been taken into consideration. The numbers on which the ratios are based have also been subjected to a statistical test which measures the likelihood of obtaining so large a departure from expectation as a result of chance fluctuations only. The results of these χ^2 tests are shown in the right-hand column of the table.

For foot defects as a whole (bottom line of Table III) there was no perceptible association with body weight, but a few specific conditions revealed statistically significant departures from expectation. The most definite of these associations were the exceptionally high ratios for rigid flat-foot, pes cavus, and overlapping toes in men weighing less than 110 lb. (49.9 kg.). The findings for A cases of flat-foot were inconclusive, but the highest ratio was at the heavy end of the weight scale, whereas for B cases it was at the lowest end.

For all types of foot defect taken together the association with height was much stronger than that with weight, and there were also significant associations for several individual lesions (see Table IV). Once again, however, the findings were not straightforward. Thus, overlapping toes were less common among medium-sized men than among either tall or short men; both categories of flat-foot had a maximum incidence in short men, and all the metatarsal deformities gave high ratios at or near the top of the height scale. In the extreme case of hammer-toe the risk for men of 70 in. (178 cm.) or taller was over twice as great as for men of 64 in. (162.5 cm.) or shorter. There are no measurements of foot length in civilian medical board records, but Morant and Gilson (1945), who studied men in the Royal Air Force, found that the coefficients of correlation between foot length and height, and foot length and weight, were +0.700 and +0.557 respectively. This may account for the departures from level incidence associated with variations in height being greater than those associated with weight.

*According to the official instructions, all A cases were automatically placed in the top fitness category (Medical Grade I) and B cases in Medical Grade IIa (feet), but in the presence of more disabling conditions the medical grade no longer serves to distinguish the two groups. These cases had to be "placed" at the time of coding and the convention was adopted that, in the absence of fuller clinical descriptions, all cases of "mild" or "slight" flat-foot should be coded A and all cases of "severe" or "disabling" flat-foot coded B.

TABLE III.—*Relation Between Body Weight and Incidence of Foot Defects. Standardized for Age (Standard Incidence=100)*

Foot Defect	Weight (lb.)										Probability (P) that the Observed Departures from Standard Incidence could have Arisen by Chance
	< 100	< 110	< 120	< 130	< 140	< 150	< 160	< 170	< 190	190 +	
Flat-foot (A cases)	76		100	108	102	86	111	100	112		0.20 > P > 0.10
" (B " ")	151		105	88	88	109	76	106	138		0.01 > P > 0.001
Pes cavus	160		96	85	123	87		80			0.05 > P > 0.02
Hammer-toe	89		91	98	105	105	99	133	84		0.30 > P > 0.20
Hallux valgus	118		107	104	95	97	100	89	77		0.80 > P > 0.70
" rigidus		120		114	89	69		101			0.50 > P > 0.30
Overlapping toes	143		115	104	102	176	86		82		0.10 > P > 0.05
Callosities		98		96	107	99	81		120		0.80 > P > 0.70
One or more of the above ..	110	104	103	99	99	95	98	110	105	102	1.00 > P > 0.90

TABLE IV.—*Relation Between Standing Height and Incidence of Foot Defects. Standardized for Age (Standard Incidence=100)*

Foot Defect	Height (in.)							Probability (P) that Observed Departures from Standard Incidence could have Arisen by Chance
	< 62	< 64	< 66	< 68	< 70	< 72	72 +	
Flat-foot (A cases) ..	145	110	102	102	88	102	92	0.20 > P > 0.10
" (B " ") ..		123	103	93	96		98	0.50 > P > 0.30
Pes cavus ..		83	105	91	96	134		0.30 > P > 0.20
Hammer-toe ..		62	79	86	128	154	135	0.001 > P
Hallux valgus ..		97	89	99	101	112	148	0.20 > P > 0.10
" rigidus ..			106	98		96		0.90 > P > 0.80
Overlapping toes ..		113	96	86	97	130		0.10 > P > 0.05
Callosities ..		68	94	87	115	144		0.01 > P > 0.001
One or more of the above	106	96	94	95	102	118	121	0.01 > P > 0.001

Considering the close association between weight and height (the coefficient of correlation for the present set of records was +0.725) there were remarkably few examples of contrasts between light and heavy men appearing again as contrasts between short and tall men. On the other hand, there were several examples of the same risks for short men and heavy men—for example, flat-foot—and for tall men and light men—for example, hammer-toe. It is clear, therefore, that certain foot defects are as closely related to general build as to absolute size.

An attempt was made to measure the relationship between foot defects and body shape, but only three measurements were available for the purpose—namely, height, weight, and chest circumference.

Chart showing relation between body shape and incidence of foot defects, standardized for age. (Standard incidence=100.) Probability that observed departures from standard incidence could have arisen by chance: Flat-foot (broken line), $0.01 > P > 0.001$; forefoot defects (continuous line), $P < 0.001$.

root of the weight in pounds) has a minimum value for a perfectly spherical body, and increases with increasing linearity of build. In adult males the normal range of variation of this index is from $11\frac{1}{2}$ to $14\frac{1}{2}$. Since the index tends to fall with age, the incidence ratios plotted in the Chart have been standardized for age in the same way as the separate ratios for height and weight. The diagram traces the relationship between the body-build index and the incidence of two groups of foot defect—namely, tarsal (that is, both grades of flat-foot) and metatarsal (that is, hallux valgus, hallux rigidus, overlapping toes, and hammer-toe, either alone or in combination). The

figure shows that for stocky men, with low values of the body-build index, flat-foot occurred in excess. It is possible, therefore, that overweight, or some associated condition, predisposes to this type of foot defect. The incidence of metatarsal defects, however, rose continuously with increasing linearity of build, and the risk appeared to double within the observed range of the index. For these cases, therefore, it is more reasonable to look for causes associated with underweight or slender build.

Relation of Foot Ailments to Economic Circumstances and Occupation

According to the Foot Health Educational Bureau (1949) "Exact figures are hard to come by, but, though as yet we have no unselected random sample of foot conditions among adult groups in Great Britain, it is probably correct to say that ailments of the feet . . . are distributed irrespective of income level." From an analysis of the civilian medical board records, however, it appears that this statement is almost certainly incorrect (see Table V).

TABLE V.—*Relation Between Social Class and Incidence of Foot Defects. Standardized for Age (Standard Incidence=100)*

Foot Defect	Social Class (according to Registrar-Gen.)					Probability (P) that the Observed Departures from Standard Incidence could have Arisen by Chance
	I	II	III	IV	V	
Flat-foot (A cases)	70	104	110	94		0.02 > P > 0.01
" (B " ")	79	96	107	139		0.01 > P > 0.001
" (total)	73	101	109	111		0.01 > P > 0.001
Pes cavus ..	82	99	115	106		0.70 > P > 0.50
Hammer-toe ..	82	99	115	106		0.10 > P > 0.05
Hallux valgus ..	68	98	108	132		0.01 > P > 0.001
" rigidus ..	149	91		103		0.20 > P > 0.10
Overlapping toes	68	98	122	118		0.05 > P > 0.02
Callosities ..	74	96	110	139		0.05 > P > 0.02
One or more of the above	60	80	100	108	112	0.001 > P

The age-standardized ratios for all foot defects except hallux rigidus showed a marked social class gradient, with the highest incidence among unskilled and semi-skilled workers. But a separate analysis of the two varieties of flat-foot showed that it was only the B cases which tended to concentrate in the lower-income groups. A possible explanation of this difference is that economic factors are more potent to aggravate pre-existing conditions than to initiate new lesions.

The relatively level social class and age distributions of hallux rigidus are in marked contrast with the corresponding gradients for hallux valgus and rigid flat-foot. The contrast between hallux rigidus and hallux valgus corresponds to known differences between the aetiology of these two conditions, but that between hallux rigidus and rigid flat-foot is at first sight difficult to reconcile with the orthodox view that a flat-footed gait predisposes to osteoarthritis of the first metatarso-phalangeal joint. Provided, however, a majority of cases of hallux rigidus are due to causes other than flat-foot, there is no contradiction between the findings of the present investigation and accepted clinical opinion.

Table VI summarizes the results of an attempt to relate the risk of foot defects to strictly occupational influences, as distinct from risks associated with low economic status. Table VI abounds with examples of significant departures from standard incidence, but it is clear that many of these only reflect the earlier analysis by social class. There are, however, a few findings which cannot be accounted for on this score and suggest the possibility of more specific occupational influences. For instance, (1) shoe operatives had an exceptionally low incidence of hammer-toe but a high incidence of overlapping toes; (2) the group of lathe operators and testers had a high incidence of flat-foot and an unusually low incidence of hammer-toe; (3) transport workers had a high incidence of foot defects in general, and of flat-foot in particular; and (4) workers in farming and building had a large excess of pes cavus. With the data available it was not possible to explore these relationships further, but they offer promise that survey of footwear and "foot work" in selected industries would yield some interesting results.

Discussion

In the case of a disease, such as tuberculosis, which has been intensively studied from the statistical angle, even the minutiae of survey findings can usually be seen in their proper perspective. When, however, an epidemiologist attempts to use survey data for a study of foot defects he soon discovers that there is no ready-made context for his findings. The present study has resulted in a collection of miscellaneous facts which, like the pieces of a jigsaw puzzle, are tantalizingly rich in detail but lacking in general coherence. Nevertheless a start must be made some time, and, though the present investigation has left nothing fully proved, it does suggest some new lines of inquiry.

It is possible, for instance, that the variations in incidence of foot defects which have been found to be associated with variations in body build and social class reflect the fact that there is not, in this country, a wide enough range of shoe shapes and sizes to cope with the general need. Or that, if there is, the need remains unsatisfied because the public does not realize the dangers of ill-fitting shoes. This

theory rests on two basic assumptions. The first is that the relationship between foot shape and body shape is such that persons of stocky build have feet which are disproportionately broad, and persons of slender build have feet which are disproportionately narrow. If this is so, then the fact that stocky men have emerged as bad risks in respect of flat-foot, and slender men as bad risks in respect of pes cavus and metatarsal deformities, may be due to the former being forced to wear shoes which are too long for the necessary width and the latter shoes which are too short.

The second assumption, which is introduced to explain the contrasts between tall and short men, is that the feet of tall men grow faster (as well as longer) than the feet of short men. The argument runs as follows: parents of children whose feet grow exceptionally slowly or exceptionally fast tend to misjudge the time taken to outgrow a new pair of shoes. As a result the slow growers (who are destined to be short men) spend most of their youth in shoes which are too big, and the fast growers in shoes which are too small. Finally, the social class gradient is accounted for by supposing that cheap shoes do more harm than expensive shoes, and that working-class parents find it particularly difficult to keep pace with the needs of growing children.

This is a highly speculative theory, and it is doubtful whether it would ever be possible to test it at all points, even if it proved acceptable to orthopaedic specialists. It will, however, have served its purpose if it shows how valuable it would be to know more about the relationship of body build to foot shape and the relationship of shoe habits to foot defects.

Summary

In a sample of 22,843 men aged 17 to 44 who were examined at Leicester in 1941, it was found that:

1. There was an increase with age in the incidence of rigid flat-foot, hammer-toe, hallux valgus, callosities, overlapping toes, and pes cavus. Hallux rigidus and mobile flat-foot showed a relatively even age incidence.
2. There was a real tendency for foot defects to occur in association with one another and with certain other skeletal defects.
3. Tall men suffered more often than short men from metatarsal defects (hallux rigidus excepted), but flat-foot more commonly affected short than tall men.
4. The risk of metatarsal defects increased continuously with increasing "linearity" of body build (as measured by the index $Ht \div \sqrt[3]{Wt}$). Flat-foot, on the other hand, was more common among men of stocky build.

TABLE VI.—Relation Between Occupation and Incidence of Foot Defects. Standardized for Age (Standard Incidence=100)

Occupational Group	Main Social Class Represented	One or More Defect of Any Kind	Longitudinal Arch				Forefoot				Callosities
			Flat-foot			Pes Cavus	Hallux valgus	Hallux Rigidus	Hammer-toe	Overlapping Toes	
			All	A	B						
Professional and administrative. . .	I and II	74§	68†	62†	77	E	76	} 115	83	D	D
Commerce and finance	I .. II	93	94	84	109	D†	78*		103	92	63†
Clerks and typists	I .. II	79‡	65§	67†	D†	D	92		111	D*	D
Textile operatives	III	103	104	107	99	93	96	} 99	102	99	98
Boot and shoe operatives	III	102	109	110	107	112	95		79†	125†	111
Engineers	III	100	97	113	60†	D	111		115	88	D
Lathe operators, testers, etc. (undefined)	III	95	123†	129†	111	D	96	} 92	58‡	D	D
Warehousemen, packers	III	109	97	96	99	D	131*		130†	D	134
Transport workers	III	116†	123†	120	130	E	93		119	128	128
"Other occupations "	IV	102	98	94	105	93	112	} 92	104	105	108
Farming, building, etc.		111	115	124*	100	155†	98		97	111	110
Unskilled	V	110	96	78*	128*	151†	132†		111	127	153‡
Probability (P) that observed departures from standard incidence could have arisen by chance		P<0.001	P<0.001	0.01> P>0.001	0.10> P>0.05	0.10> P>0.05	0.20> P>0.10	0.70> P>0.50	0.01> P>0.001	0.20> P>0.10	0.02> P>0.01

Where the contribution to the sum of χ^2 for all occupations made by any individual occupation would have been significantly large in a test based on one degree of freedom this is indicated by means of: * P<0.10; † P<0.05; ‡ P<0.01; § P<0.001.

5. Men in the lower social classes suffered more often than others from foot defects. The erroneous impression (which pre-dates the National Health Service) that all social classes are equally affected may have been due to a tendency on the part of well-to-do persons to seek medical advice for minor ailments more often than members of the working classes.

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INCIDENCE, ORIGIN, AND PREVENTION OF CERTAIN FOOT DEFECTS*

BY

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As the public know well, and hospitals' and chiropodists' reports confirm, many otherwise healthy adults suffer from foot trouble. A preliminary investigation in schools in Ealing (Craigmile, 1950) showed that many of the causes of adult foot disability were already present in the older schoolchildren. As a result of this, a routine foot inspection was begun in all maintained schools in the area. Until recently (Dykes *et al.*, 1952) there was no published report of the foot health of a normal population, and a survey of a factory in the area was made to determine the extent and chief causes of foot trouble in a normal working population. The results of this survey are in many respects confirmatory of the report of this survey at Luton, although undertaken on a different population and by different methods.

It soon became apparent that many foot troubles, while not present in the infant, began early in life and were due to stresses and strains imposed on an otherwise normal foot by modern conditions. Many of these

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lesions should be prevented, and an experiment, called the Ealing Contributory Shoe Scheme, was started in order to see how far good feet could be kept from developing defects and whether early defects already present would correct if the foot were given the best conditions for free growth.

This paper reports on these three surveys, which were made in an attempt to assess the most important foot defects in adults, their mode and time of origin in the child, and a suggested scheme to minimize their development.

Survey I: Factory Workers

The factory employed men and women of all ages and in a wide variety of work. In the volunteer survey 358 employees were examined by two observers. Questions were asked about past and present foot trouble and an examination of the feet and shoes was made. The position of the employee at work was included in the record.

Table I shows the classified results. Rather surprisingly, the proportion of those with present foot discomfort was almost equal in the two sexes (29.6% of women and 27% of men). Both sexes showed an increase of complaints with age, and those who sat at their work had less trouble than the others. Women aged 40-49 had much more foot trouble than men of this age, and this was not related to obesity. The chief causes of pain in men were metatarsalgia (10%) and an ache in the long arch associated with a pronated forefoot (6.9%). In women the principal causes were bunions and hallux valgus (11.6%), metatarsalgia (5.8%), and a generalized ache in the long arch (3.1%). Corns caused pain in only 2.2% of both men and women, but this factory had a well-attended chiropody clinic.

Chief Causes of Pain

Metatarsalgia.—This was associated with increased callous formation and clawed toes. It was twice as common in men and was not related to position at work. Increasing the height of the heel can be shown to increase the thrust on the metatarsal heads. A 1-in. (2.5-cm.) heel gives an increased thrust of 18% of the body weight, and a 2-in. (5-cm.) heel gives a 41.5% increase. If, then, metatarsalgia were related to heel-height, it would be expected to occur more often in the women (average heel-height $1\frac{1}{2}$ in.—3.8 cm.) than among the men (average heel-height $\frac{1}{2}$ in.—1.9 cm.), but the contrary was found.

Ache in the Long Arch.—This was related to forefoot pronation and is more common in the older age groups, in whom an increasing descent of the head of the talus has been shown (Hardy and Clapham, 1952).

Hallux Valgus and Bunions.—Hallux valgus occurred much more frequently in women, and the angle of deviation of the great toe, which appeared to be related to bunion formation, was in the region of 30 degrees. This external measurement corresponds closely to the radiographic measurements of the "critical angle of bunion formation" made by Hardy and Clapham, who found a

TABLE I.—*Distribution and Type of Foot Defects among Factory Workers*

Age Group (years)		Position at Work. No. of Persons						Type of Defect Found (Percentage)																				
		Standers		Sitters		Walkers		Mixed		Total		Past Trouble		Present Pain		Hallux Valgus		Bunions		Crooked Toes		Valgus Ankles		Callouses		Corns		
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
15—	..	2	17	—	19	—	3	4	8	6	47	50	12·2	15	15·7	—	—	—	—	33·3	27	16·7	44	16·7	44	16	36·4	
20—	..	9	28	—	16	—	5	20	13	29	62	37·7	23·1	11	18·1	22	40	4	7·5	23	49	45	33·2	10	33·2	17·5	30	
30—	..	5	11	—	6	4	1	14	5	23	63	33·2	21·7	21·7	21·7	21·7	21·7	5	21·7	32	50·8	43	50·8	56	50·8	15	56·6	
40—	..	3	23	2	15	5	4	26	25	36	67	20	49·4	24	38	12	24	5	39·4	43	50·7	31	50	51	60	20	53	
50—	..	8	7	1	3	8	4	8	11	25	25	44	32	32	43·4	24	32	12	43·4	43·4	48	36	41	48	60	43·4	30	
60+	..	3	1	1	1	1	—	7	1	12	3	48	66·6	48	33·3	40	33·3	8	—	68	100	80	100	68	—	50	33·3	
Total	..	30	87	4	60	18	17	79	63	131	227	39·1	28·3	27	29·6	22·2	30	12·2	20	40·5	55	40	44	41·5	41	2	6·2	39·4