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.

REFERENCES

- Alford, A. F., and Gorrie, M. G. (1952). *Monthly Bull. Minist. Hlth, Lond.*, 11, 32.
 Burt, C., and Banks, C. (1947). *Ann. Eugen.*, 13, 238.
 Clements, E. M. B., and Pickett, K. G. (1952). *Brit. J. soc. Med.*, 6, 245.
 Dykes, R. M., Grundy, F., and Lee, H. E. (1952). *Med. Offr.*, 87, 223, 235.
 Emslie, M. (1939). *Lancet*, 2, 1260.
 Foot Health Educational Bureau (1949). *Foot Inspection in Childhood and Adolescence*. London.
 Lake, N. C. (1943). *The Foot*. Baillière, Tindall and Cox, London.
 Martin, W. J. (1949). *The Physique of Young Adult Males*. M.R.C. Memo. No. 20. H.M.S.O., London.
 Morant, G. M., and Gilson, J. C. (1945). Unpublished Report on a Survey of Body and Clothing Measurements of Royal Air Force Personnel. R.A.F. Institute of Aviation Medicine, Farnborough.
 Sheldon, J. H. (1948). *The Social Medicine of Old Age*. Cumberlege, Oxford Univ. Press, London.
 Wilkins, E. H. (1941). *Med. Offr.*, 66, 5, 13, 21, 29.

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 1½ in.—3.8 cm.) than among the men (average heel-height ¾ 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					
15- ..	2	17	—	19	—	3	4	8	6	47	50	12.2	15	15.7	—	—	33.3	27	16.7	44	16	36.4	
20- ..	9	28	—	16	—	5	20	13	29	62	37.7	23.1	11	18.1	22	40	45	33.2	10	33.2	17	50	
30- ..	5	11	—	6	4	1	14	5	23	23	33.2	21.7	21.7	21.7	5	21.7	23	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	43	50.7	31	50	51	60	
50- ..	8	7	1	3	8	4	8	11	25	25	44	32	32	43.4	24	32	43.4	48	36	41	48	60	
60+ ..	3	1	1	1	1	—	7	1	12	3	48	66.6	48	33.3	40	33.3	8	—	68	100	80	100	
Total ..	30	87	4	60	18	17	79	63	131	227	39.1	28.3	27	29.6	22.2	30	40.5	55	40	44	41.5	41	2 6.2 39.4

mean angle of 28 degrees at the metatarso-phalangeal joint. Table II shows the preponderance of cases of bunions in which this angle is 30 degrees or more.

TABLE II.—*Relationship of Bunions to the Angle of Deviation at the Metatarso-phalangeal Joint. The Figures are for Women Only*

Age Group	No. of Cases of Hallux Valgus			
	Angle of 10-29 Degrees		Angle of 30-50 Degrees	
	No Bunion	Bunion Present	No Bunion	Bunion Present
15-39 years ..	50	4 (8%)	19	13 (68.4%)
40-65 " ..	46	13 (28.2%)	47	32 (68.0%)

Survey II: Schoolchildren

The area under review covers both closely populated and semirural districts. About half the total school population was examined and all types of school were represented. The same two observers saw the children, and particular attention was paid to conditions likely to be precursors of adult foot trouble. Advice and treatment were given, where necessary at special sessions, and proved a valuable method of health education.

The results of the inspection of the 12,765 children are summarized in Table III.

TABLE III.—*Percentage of Certain Defects Found in Schoolchildren on Routine Foot Inspection*

Age Group	No. of Children	Proximal Hallux Valgus	Varus 1st Metatarsal	Cramped Toes	Valgus Ankles	Pes Cavus	Verrucae	Tinea	Unsatisfactory Footwear	Treatment Required	
										Chiropody	Minor Ailment Clinic
Infants, 5-7 years	{ Boys, 1,379 Girls, 1,364	4.3 4.7	12.2 12.95	12.0 13.7	7.4 4.5	0.2 0	0.3 0.3	0 0	17.1	0.4	3.0
Juniors, 8-11 years	{ Boys, 2,654 Girls, 2,700	6.1 11.7	10.7 12.6	11.9 18.2	6.4 4.8	0.13 0	0.8 0.75	0.2 0.2			
Seniors, 12-15 or 16 years	{ Boys, 2,898 Girls, 1,770	4.0 22.4	8.7 8.0	14.5 24.1	3.9 5.15	0.44 0.02	1.7 3.2	0.3 0.2	21.5 35.0	1.7 4.0	3.0 7.0

Hallux Valgus

This deformity is of two distinct types. The distal or interphalangeal type does not give rise to pain in adult life, and, while it appears to be congenital in some children, occurs with generalized cramping in association with short footwear (see Table IV). The proximal type is an important cause of pain in adult life, occurring most often in

TABLE IV.—*Percentage of Cases of Proximal and Distal Hallux Valgus in Boys and Girls in Relation to Age and Suitability of Shoes Worn*

Age Group	Good Shoes			Bad Shoes		
	No. of Children	Proximal Hallux Valgus %	Distal Hallux Valgus %	No. of Children	Proximal Hallux Valgus %	Distal Hallux Valgus %
<i>Boys</i>						
Infants, 5-7 years	378	0.25	4.64	69	0.4	16
Juniors, 8-11 "	619	0.17	4.04	171	0.72	14.7
Seniors, 12-15 "	978	1.9	5.72	268	4.4	12.2
<i>Girls</i>						
Infants, 5-7 "	346	0.29	5.49	81	1.25	25.0
Juniors, 8-11 "	661	1.21	8.47	205	2.5	27.5
Seniors, 12-15 "	891	2.70	5.95	381	14.2	47.9

TABLE V.—*Percentage of Cases of Proximal Hallux Valgus Found, and the Angle of Deflection, at Different Ages*

Age Group	% of Proximal Hallux Valgus	Mean Deviation of Hallux	Range of Deviation
Infants, 5-7 years ..	0.1	5.0 degrees	3-18 degrees
Juniors, 8-11 " ..	2.0	8.5 "	5-16 "
Senior boys, 12-15 years	2.4	10.7 "	5-28 "
Senior girls, 12-15 " ..	8.7	16.5 "	7-35 "

women. In schoolchildren this end-result can be seen in process of development (see Table V). A comparison of junior and senior children shows that three times as many girls had hallux valgus and with a greater mean angle of deflection. This implies that factors which result in many women suffering from bunions start to operate in the middle years of childhood and become fully active before the union of the metatarsal epiphyses.

In an attempt to assess the causes of this deformity various possibilities were considered: the intrinsic action of a short or a varus first metatarsal bone, or a pronated forefoot, and the action of extrinsic factors.

A short first metatarsal bone occurred in 39.4% of children and showed no age or sex differentiation; its presence was not closely related to hallux valgus. The intermetatarsal angle decreases with age (Keith, 1931) but a wider angle appears more common in females (Hardy and Clapham, 1952). Children with this variation from normal have difficulty in finding shoes broad enough for their feet, and, in order to eliminate this extrinsic factor, the combination of metatarsus primus varus and hallux valgus in children who wore good shoes was examined. These figures (Table VI) show no significant correlation. In other words, this suggests that metatarsus primus varus is not in itself an exciting cause of hallux valgus. It may, however, be a predisposing cause.

The pronated forefoot appears to be related to hallux valgus of both proximal and distal types. In children who wore good shoes the probability of association was 0.01, and therefore unlikely to have arisen by chance.

There is an increase in the number of children wearing badly fitting shoes with age, the senior girls being far the worst group. A study of Table IV shows that there is a great increase in both types of hallux valgus with bad footwear. This increases with age, and is maximal among senior girls. Examination of the shoes showed two patterns which appeared particularly detrimental: the first type had sharply pointed toes, and the second was the "flatie" or "casual," which gives no support to the instep and therefore increases any tendency to pronation as well as cramping the toes.

TABLE VI.—*Relationship Between Metatarsus Primus Varus and Hallux Valgus in Children Wearing Good Shoes*

Sex	No. Examined	No. of Cases Metatarsus Primus Varus Alone	No. of Cases Hallux Valgus Alone	No. of Cases Combined Defect	χ^2	Probability
Boys	1,875	445	85	34	0.611	0.80 (Not significant)
Girls	1,962	411	122	49	0.518	0.90 (Not significant)

Deformed Toes and Flat Foot

Hammer-toes and mallet-toes showed a constant percentage of 1.7 for all ages. While about 99% of the children over 10 years of age have some twisting of the fifth toe, this was symptomless in many cases. Cramping of all toes associated with signs of pressure was found in about 10% of the children and was closely associated with tight shoes.

Of the main types of flat-foot, the stable low-arched foot was very common and, as in the adult, it was symptomless. Pronation of the forefoot is, however, important as a potential cause of future pain. It is very common in the pre-school group, but only about 5% of cases persist into school life. Pronated forefeet are also closely associated with hallux valgus.

Pes Cavus

Pes cavus may be congenital or acquired, and of the latter type, as well as those secondary to neuromuscular causes, there are many idiopathic cases. These latter are of interest in that they, alone of all structural foot defects, are more common in boys than in girls. This pes cavus was not related to heel-height, but was associated with short shoes. (B.B.S.A.T.R.A. Research Report No. 107).

Survey III: Ealing Contributory Shoe Scheme

This scheme was open to all children attending one welfare centre and one school in the area. It was designed to be financially self-supporting. For a lump sum, payable in instalments before entry, the child was able to obtain three pairs of walking-shoes and one pair of sandals each year. Careful medical supervision of the feet was undertaken at intervals of ten weeks throughout the year, and a general physical examination was made on entry to the scheme.

The scheme was made possible by the co-operation and interest of Messrs. James Southall & Co., who supplied the shoes, and of their two agents in the area.

At the first examination it was decided whether the standard shoes should be worn or if any modifications were required; this was noted on the voucher with which the shoes were purchased. In special cases joint consultations were made with the shop managers or the technical adviser to Messrs. Southall. Assistants who had special training in children's fittings supplied the shoes from a full range of four fittings to each half-size.

The scheme ran for two years, fresh entrants being accepted for the second year, and 164 children were studied (Table VII). The information obtained may be divided into non-medical data and facts of more direct medical value. As had been estimated, three pairs of strong shoes were just enough for the needs of most children. The amount of repairs varied widely, and rubber composition appeared to be the most hard-wearing material. A

TABLE VII.—*Number of Children who Joined the Shoe Scheme, the Cost of the Scheme, and the Annual Expenditure on Shoes of a Sample of Children in the Borough, in the Previous Year*

Age in Years	No. of Children	Annual Cost of Scheme	Yearly Expenditure of "Average" Child
2-	88	£2 17s. 0d.	£2 18s. 0d.
5-	36	£4 17s. 0d.	£4 3s. 0d.
8-	32	£5 9s. 6d.	£5 11s. 0d.
11-15	8	£6 10s. 0d.	£6 14s. 0d.
Average ..	164	£4 18s. 4½d.	£4 16s. 6d.

TABLE VIII.—*Number and Kind of Defects Found in the Feet of Shoe-scheme Children*

Defect	No. of Cases		
	At Start	After 6 Months	After 1 Year
Hallux valgus	31	26	12
Cramped toes	46	20	8
Metatarsus varus ..	30	23	13
Pronated forefoot ..	29	17	16
Corns and callouses ..	30	8	3
Out-toeing	18	5	3
In-toeing	8	2	—
Knock-knees	21	7	3
Verrucae	6	—	—
Other (blisters, chilblains, etc.)	31	9	11
Total	250	117	69

FIG. 1.—Graph showing the average angulation of the great toe at the metatarso-phalangeal joint at various ages.

record of the fittings required showed that at least three fittings to each half-size were necessary to obtain an accurate fit.

Pedograph Records.—A pedograph was made on entry to the scheme and after one year; it proved a useful measure for demonstrating decreasing pronation of the forefoot and the redistribution of weight in the foot.

Defects and Deformities

Table VIII shows the decrease in number of defects during one year and illustrates the rapid decline in foot troubles when expert advice is available. Certain conditions showed a spontaneous recovery without treatment other than well-fitting shoes and socks. The younger the

FIG. 2.—Histogram showing the mean annual increase in length and width of the foot for each year of age.

child the quicker was the return to normal. These defects were corns, callosities, cramped toes, and proximal hallux valgus. The angle of the hallux was studied, and 48 children showed a deviation of more than 2 degrees in either direction. There was a marked decrease in the angles of deviation after one year (see Fig. 1).

Growth Rates

Measurements were made of the rate and periodicity of growth, and the results in 107 children who attended regularly for at least one year are shown in Fig. 2. The rate

FIG. 3.—Graph showing two types of growth in length of children's feet. The shaded background shows the range of measurements found in the shoe-scheme children of the same age.

in girls and boys was fairly close, the average increase in length being just under $\frac{1}{2}$ in. (1.3 cm.) a year; this corresponds to one whole size in shoes. The periodicity of growth is interesting, and Fig. 3 shows the types which occur. The commonest type was a curve showing alternating periods of growth and quiescence. This may be an annual or a biannual spurt. Child A shows both types over the two years; a regular slow growth, illustrated by Child B, was less common. The period of the year at which most growth occurred was the summer (June–August), while the autumn (September–November) was the usual quiescent period.

Discussion of the Three Surveys

Many adults suffer from pain in their feet. This is borne out by the demand for chiropody treatment in private practice and by the first survey on adult factory workers. Such discomfort must have an appreciable effect on the general health, temper, and work of the sufferer, while the final result on the country's economics is an interesting imponderable. This survey also suggests that the principal causes of pain are hallux valgus and bunions, pain in the long and transverse arches, and corns. The first-named occurs chiefly in women.

The results of the school survey show that these defects begin to develop during the years of childhood and increase progressively with age. While no single cause for the predominance of hallux valgus in girls is apparent, the figures shown suggest that both valgus ankles and bad footwear, which are more common in girls than in boys, play a part in producing this deformity, but the preponderance of valgus ankles is not in itself sufficient to account for the greater number of cases of hallux valgus in girls. That idiopathic clawed foot is more common in boys than in girls is probably related to the predominance of metatarsalgia in men. One theory of development may be suggested: that the rounder shape of a boy's shoe, when short, exerts equal pressure on all toes, causing retraction and dorsiflexion, while a girl's more pointed shoe presses mainly on the fifth and first toes.

The experimental contributory shoe scheme has shown that it is both possible and practicable to run such a scheme for supervising the care of children's feet and, by so doing, to diminish the amount of foot trouble in children. While its inherent principles are sound, the scheme has certain disadvantages. First, that while prices are unstable it may be impossible for manufacturers to budget accurately for a year ahead; secondly, it is a pity to limit the scheme to one firm only; and, thirdly, comparatively few parents have taken advantage of it, as many felt that the prices were beyond their reach. This assumption was not entirely reasonable, for the prices in the scheme compared very closely with the average amount spent on footwear in the preceding year in the same district (Mayers, 1950). Nevertheless a modification of this scheme suggests a line of approach to the problem of the great number of painful and defective feet in the adult population.

Conclusions

A survey to study the main causes of foot trouble in the adult suggests that bunions and hallux valgus, metatarsalgia, long-arch pain, and corns are the chief types of foot disability in healthy adults. An examination of schoolchildren has shown that these defects begin in the later years of childhood. An attempt to maintain foot health by providing children with good footwear and by supervising their feet during the growing period showed that it is possible to

prevent deformities and that certain early defects will correct spontaneously, given freedom for normal growth.

It is my pleasure to thank the Health Department of Middlesex County Council for facilities to carry out this research; in particular, Dr. W. G. Booth, area medical officer, Area 7, Middlesex County Council, to whom the Ealing Contributory Shoe Scheme owes its origin; also the British Boot, Shoe, and Allied Trades Research Association for loan of instruments; the Managing Director and Technical Adviser of "start-rite" shoes; to Mrs. Murton, S.R.N., for help in examination of the subjects.

REFERENCES

- British Boot, Shoe, and Allied Trades Research Association, Research Report No. 107.
- Clapham, J. C. R., and Hardy, R. H. (1951). *J. Bone Jt. Surg.*, 33B, 376.
- Craigmile, D. A. (1950). *Med. Offr.*, 83, 229.
- Dykes, R. M., Grundy, F., and Lee, H. B. (1952). *Ibid.*, 87, 223, 235.
- Hardy, R. H., and Clapham, J. C. R. (1952). *Lancet*, 1, 1180.
- Keith, A. (1931). *New Discoveries Relating to the Antiquity of Man*. Williams and Norgate, London.
- Mayers, J. R. (1950). *Med. Offr.*, 83, 231.
- Morton, D. J. (1935). *The Foot*. New York.

"It is regrettable that the position in relation to the institutional care of mental defectives has steadily worsened over the past four years. There is now a waiting-list of more than 420 patients for admission to institutions, as compared with 170 in 1948. The county council provides domiciliary supervision for all mental defectives in the county, and there are eight occupation centres where defectives may go daily for training and occupation, but this is no adequate substitute for institutional accommodation in many cases. There are numerous households where the defective child or adolescent is an intolerable burden and where only segregation in an institution will meet the case. The need for additional institutional beds for such patients is most urgent and should have a high priority in planning the use of available resources in manpower and money."—From the Report for 1952 of the Essex County Medical Officer of Health, Dr. H. K. Cowan.