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ARMY FOOT SURVEY

AN INVESTIGATION OF FOOT AILMENTS IN CANADIAN SOLDIERS

By
COLONEL R. I. HARRIS, M.C., R.C.A.M.C.
AND
MAJOR T. BEATH, R.C.A.M.C.

PRICE \$2.00

FIRST EDITION, 1947
SECOND EDITION (ABRIDGED) 1952

REPORT OF A PROJECT SPONSORED
BY THE ASSOCIATE COMMITTEE
ON ARMY MEDICAL RESEARCH

NATIONAL RESEARCH COUNCIL OF CANADA

OTTAWA

N.R.C. No. 2888

SECOND EDITION

The first edition of this publication was published by the British Research Council in London, England, in 1947. It was published in two volumes, one in English and one in French. The second edition, published in 1957, is a revised and enlarged edition of the first. It consists of two volumes, one in English and one in French. The English volume is 1,100 pages long and the French volume is 1,000 pages long. The second edition is a revised and enlarged edition of the first. It consists of two volumes, one in English and one in French. The English volume is 1,100 pages long and the French volume is 1,000 pages long.

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"And Asa in the thirty and ninth year of his reign was diseased in his feet, until his disease was exceeding great: yet in his disease he sought not to the Lord, but to the physicians.

And Asa slept with his fathers".

11 Chronicles, XVI:12,13.

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Ottawa, Canada
November, 1957

FOREWORD TO SECOND EDITION

The Army Foot Survey was a project sponsored by the National Research Council's Associate Committee on Army Medical Research during World War II. The first edition of the report on this project was published in 1947 shortly after the Committee had been disbanded. The report, complete with tables, graphs and many illustrations, consisted of two volumes, comprising 417 pages, bound in one cover.

Copies of this publication were made available to many research centres and individuals known to be interested in the subject, and the remainder of the issue was disposed of by sale. Despite the fact that the report has now been out of print for some time, there has been a continuing demand for it because of its value as a reference work. Accordingly, at the request of the senior author, and with the approval of the President of the National Research Council, a second edition, somewhat abridged, has now been prepared.

In the second edition, the Main Report has been reprinted in full, and as before, it constitutes the first volume of the report. The second volume contains Appendices A, B, C and D, each printed in full.

Appendix E has been shortened by omitting the tables, but the captions have been included in order to indicate the nature of the tabular material on which the text of the report was based. Three pages of explanatory matter have been retained in Appendix F but here again the tables and graphs which appeared in the first edition have been omitted, as a measure of economy in printing, and in order to keep the size of the book within reasonable limits.

Appendices G, H, I and J consisted of ancillary material such as routine Army training orders, now out of date, and miscellaneous observations on individual cases. These four appendices have been omitted from the second edition.

The second edition, in its present abridged form, has been prepared under the direction of the Officer-in-Charge of the Public Relations Branch of the National Research Council, who was formerly Executive Secretary of the Associate Committee on Army Medical Research.

Ottawa, Canada.
November, 1952.

S.J.C.

CONTENTS

Volume I - Main Report

Introduction.....	1
Notes on Canadian Army organization in relation to Army foot problems.....	2
Outline of Army foot problems.....	5
The foot problem at the Army reception centre.....	5
The foot problem at military training centres.....	13
Plan of treatment of Army foot disabilities.....	16
Boots - design and fitting.....	17
Summary.....	17
Plan of study.....	19
Technique of the examination conducted at the Army reception centre.....	21
Items in the examination conducted by the foot survey at the Army reception centre.....	22
Technique of examination conducted at basic and advanced training centres.....	26
Collection of other data.....	27
Presentation of data.....	29
Incidence and nature of foot defects found at Army reception centre.....	29
The problem of flat foot.....	29
Hypermobility flat foot with short tendo achillis....	31
Discussion of data.....	42
Hypermobility flat foot with short tendo achillis....	42
Peroneal spastic flat foot.....	44
All other cases of low arch.....	47
Problem of pes planus.....	48
Pes cavus (mild or severe).....	49
Accessory tarsal scaphoid and/or prominent scaphoid tubercle.....	52
Hallux valgus.....	55
Hallux rigidus.....	57
Hammer toe.....	60
Spurs and exostoses.....	61
Skin lesions.....	64
Atavism of first metatarsal segment.....	68
Findings of survey in relation to shortness of first metatarsal.....	75
Findings of the survey in relation to thickening of the second metatarsal.....	79
Findings of the survey in relation to the position of the sesamoids.....	80
Findings of the Survey in relation to hypermobility of the first metatarsal segment.....	80

(ii)

The problem of calluses	81
Incidence and nature of foot defects found by survey at training centres	85
Lesions overlooked at the reception centre or lesions whose functional capacity was over- estimated	85
Footwear	
Boot fitting	91
Used boots	99
Boot design	102
Socks	104
Discussion of hypermobile flat foot with short tendo achillis in relation to support of the head of the talus by the os calcis	107
Discussion of significance of atavism of first metatarsal segment	111
The management and treatment of foot disabilities in the Army	118
Recognition of foot disabilities and proper assess- ment of their functional capacity	118
Treatment of foot disabilities which develop during military service	122
Problems relating to boot fitting	124
No. 1 boot rebuilding depot - Montreal	125
Principal conclusions and recommendations	
Conclusions	130
Recommendations	133
Acknowledgments	143

Volume II - Appendices

Appendix "A" - Data for record card and descriptive key	A1-40
Appendix "B" - Method of foot printing	B1- 3
Appendix "C" - Technique to obtain standardized radio- graphs	C1- 4
Appendix "D" - Method of studying x-rays	D1- 8
Appendix "E" - Tables	E1-50
Appendix "F" - Graphs	F1-38
Appendix "G" - Canadian Army Routine Orders	G1-16
Appendix "H" - Miscellaneous observations and illustrated case histories	H1-34
Appendix "I" - Suggested revisions of "Physical Standards and Instructions" for Canada	I1-12
Appendix "J" - Lasts	J1-68

ARMY FOOT SURVEY

VOLUME I - MAIN REPORT

INTRODUCTION

The existence of an "Army Foot Problem" has long been recognized. It is a complex and somewhat mysterious condition which affects all departments of army activity. Every army struggles with soldiers' foot problems, for in spite of Napoleon's experience, an army marches, not upon its stomach, but upon its feet. Even a modern mechanized army demands much of its soldiers. They still must be able on occasion to march far and fast, to slog through mud and snow and to hold defense positions unharmed by incapacitating foot problems.

When Canada embarked upon total war it was not surprising perhaps that difficulties with feet should constitute one of the problems involved in transforming her citizens into trained soldiers. No nation was less prepared for war or less militant in its attitude than Canada. Physical fitness, general and good foot function in the past had little direct interest for the average Canadian. But with war these things became important. Ability to march is one of the essential assets of a soldier. It became necessary therefore to develop within the army organization measures which would: 1. eliminate at enlistment centres recruits with unsound feet, 2. plan military training to develop the maximum fitness of feet as of other parts of the body and 3. devise methods of treatment for soldiers' foot problems which would be effective and at the same time would conform to the exigencies of the military situation.

INTRODUCTION

INTRODUCTION

The existence of an "Army Foot Problem" has long been recognized. It is a complex and somewhat confused field in military surgery which manifests many and varying aspects in all departments of army activity. Every army struggles with soldiers' foot problems, for in spite of Napoleon's aphorism, an army marches, not upon its stomach, but upon its feet. Even a modern mechanized army demands much of its soldiers. They still must be able on occasion to march far and fast; to slog through mud and snow and to hold defense positions unhampered by incapacitating foot problems.

When Canada embarked upon total war it was not surprising perhaps that difficulties with feet should constitute one of the problems involved in transforming her citizens into trained soldiers. No nation was less prepared for war or less militant in its attitude than Canada. Physical fitness in general and good foot function in particular had little direct interest for the average Canadian. But with war these things become important. Ability to march is one of the essential assets of a soldier. It became necessary therefore to develop within the army organization measures which would: 1. eliminate at enlistment centres recruits with unsound feet, 2. plan military training to develop the maximum fitness of feet as of other parts of the body and 3. devise methods of treatment for soldiers' foot problems which would be effective and at the same time would conform to the exigencies of the military situation.

1(a)

These are problems peculiar to military medicine. Upon them civilian medical teaching and experience from civilian practice throw all too little light. Lack of knowledge of the nature of certain foot problems and lack of any uniform practice in assessing the function of feet and in treating foot disabilities are handicaps to the efficient management of the problem in the army. There is need for information upon (1) the extent of foot disablement among the male population of enlistment age, (2) the various types of foot disabilities and their relative incidence, (3) the significance of various foot lesions in terms of function, (4) what foot problems may develop during military training and (5) what can be done to minimize wastage from foot disabilities by preventing their occurrence or by salvage after they have developed.

The present survey was undertaken to obtain such information, the objective being to develop a uniform and improved policy with respect to Foot Problems in the Canadian Army.

NOTES ON CANADIAN ARMY ORGANIZATION IN
RELATION TO ARMY FOOT-PROBLEMS

For the information of those dealing with Canadian Army organization, who may read this report, certain details are here outlined to enable them to understand better certain **Project - Army Meds. - No. 22** aspects of training for **Project - Army Meds. - No. 22** in relation to foot problems.

For military administrative purposes Canada is divided into numbered geographical areas known as Military Districts. Enlistment of a soldier takes place at an Army Reception Centre (A.R.C.) of which there is one for each Military District. The procedure of enlistment involves a complete and detailed medical examination carried out by a team of Medical Officers of whom a proportion are specialists in various fields. Enlistment or rejection is dependent, in large part, upon the outcome of this physical examination. On enlistment the new soldier goes first to the District Depot (D.D.) of which the Reception Centre is a part. There he is outfitted and received, with his other equipment, socks, two pairs of army boots (boots, socks, gaiters) and one pair of exotics (shoes, leather, black).

When a soldier is allocated to a particular Military District he is sent to a Basic Training Centre (B.T.C.) where he undergoes elementary military training (including obstacle course, route marching). As the conclusion of Basic Training the soldier goes to an Advanced (or Corps) Training Centre. There he receives special training for eight weeks in the branch of the army to which he has been allocated (i.e. Infantry, Artillery, Armoured Corps, Engineers, Signals, etc.). He then is a trained soldier and is allocated to the Trained Soldiers Company of his particular corps and continues training in his own field until he is drafted overseas as a reinforcement. Overseas he continues his training in Corps Reserve Units until posted to a field unit as a replacement.

The medical examination at an Army Reception Centre is designed to ensure that only physically fit men will be enlisted. Carefully compiled instructions (Physical Standards and Instructions) guide the Medical Officers in their assessment of the recruit's physical fitness and

NOTES ON CANADIAN ARMY ORGANIZATION IN
RELATION TO ARMY FOOT PROBLEMS

For the information of those unfamiliar with Canadian Army organization, who may read this report, certain details are here outlined to enable them to understand terms more clearly and to appreciate the general plan of training for a Canadian soldier, especially in relation to foot problems.

For military administrative purposes Canada is divided into numbered geographical areas known as Military Districts. Enlistment of a soldier takes place at an Army Reception Centre (A.R.C.) of which there is one for each Military District. The procedure of enlistment involves a complete and detailed medical examination carried out by a team of Medical Officers of whom a proportion are specialists in various fields. Enlistment or rejection is dependent, in large part, upon the outcome of this physical examination. On enlistment the new soldier goes first to the District Depot (D.D.) of which the Reception Centre is a part. There he is outfitted and receives, with his other equipment, socks, two pairs of army boots (boots, ankle, black) and one pair of oxfords (shoes, leather, black). When a sufficient number of recruits have accumulated at the District Depot to constitute a draft, they are sent to a Basic Training Centre for eight weeks of elementary military training (arms drill, platoon drill, company drill, obstacle course, route marching). At the conclusion of Basic Training the soldier goes to an Advanced (or Corps) Training Centre. There he receives special training for eight weeks in the branch of the army to which he has been allocated, (i.e. Infantry, Artillery, Armoured Corps, Engineers, Signals, etc.). He then is a trained soldier and is allocated to the Trained Soldiers Company of his particular corps and continues training in his own field until he is drafted overseas as a reinforcement. Overseas he continues his training in Corps Reserve Units until posted to a field unit as a replacement.

The medical examination at an Army Reception Centre is designed to ensure that only physically fit men will be enlisted. Carefully compiled instructions (Physical Standards and Instructions) guide the Medical Officers in their assessment of the recruits' physical fitness and

of their presumed functional capacity. It should be emphasized that the object of this examination is to assess the functional capacity of the recruit. Hence, not only must there be recognized the obvious foot lesions which are causing definite disability, but also lesions that heretofore, in civil life, have given little or no trouble but which will not stand up to the stress of army training (potential unfitness).

The Pulhems system of assessment and recording is used. In this the record of the examination is broken down into seven subdivisions (Physique, Upper extremity, Lower extremity, Hearing, Eyesight, Mentality and Stability). In each subdivision a grading is given, from one to five, indicative of the functional capacity of the man in each of these particular aspects of his ability to serve as a soldier. Grade 1 indicates perfect fitness and perfect function and Grade 5 indicates a degree of disability which interferes with function so greatly as to render the man unfit to function as a soldier. (He may of course be quite capable of performing many tasks in civil life). Foot disabilities are grouped under the subdivision L (Lower extremity). P U L H E M S is
 1 1 1 1 1 1 1
 a perfectly fit soldier. P U L H E M S indicates severe
 1 1 5 1 1 1 1
 functional incapacity of the lower extremity. If it be due to a foot lesion it is of such seriousness as to prevent the man from functioning as a soldier.

Insofar as it refers to feet, the guidance contained in "Physical Standards and Instructions" may be summarized as follows:-

- L 1. Normal feet; able to march twenty miles per day.
- L 2. Minor and unimportant foot troubles; able to march five miles and in an emergency to walk up to twenty miles.
- L 3. Flat feet; mild hallux valgus, not severe, loss of one toe.

- L 4. Flat feet moderately severe but painless, moderate grade bunions, hallux rigidus if not too severe, mild pes cavus, loss of great toe, mild grades of club feet; able to do sedentary work only.
- L 5. All the severe deformities and disabilities of the foot.

During the training of a soldier there may arise occasion to re-assess his functional fitness. This is accomplished by examination by suitable specialists who may change the Pulhems grading which was given to him on enlistment, provided the findings of their examination justify such change. For instance, should the soldier, during training, manifest a foot disability which detracts from his functional efficiency and which does not respond to treatment, his Medical Officer refers him to a surgical specialist accompanied by a consultation form (MFB 1478). The specialist examines his disability, writes his report on the MFB 1478 and assigns him a new PULHEMS grading or reaffirms the old one.

The programme of training of a Canadian soldier is carefully graded to ensure that there is a gradual increase in the physical effort involved. This is to prevent needless breakdown of new soldiers who may not be completely fit physically when they enlist. However, the short time available for training necessitates rather rigid adherence to the graduated training syllabus and this pace may be too rapid for certain soldiers of low physique. To meet this difficulty provision is made for a period of physical fitness training for such soldiers in specially equipped and specially staffed Conditioning Centres. In this programme there is a special section for foot disabilities to which reference will be made later.

Project - Army Meds. - No. 22

OUTLINE OF THE ARMY FOOT-PROBLEM

Inexperience in foot problems and especially in their military aspects. The ability to take such a proper appreciation of reality is probably a broad knowledge of foot problems such as the history, causes, and proper handling of them. The knowledge of the foot problems of soldiers is the medical staff of an Army Reception Centre are concerned with the handling of special cases, gathered together into one unit for the purpose of conducting a more detailed examination and an assessment of the functional capacity of recruits. Many are recent graduates. Their basic training

OUTLINE OF THE ARMY FOOT PROBLEM

It is necessary for clarity to outline in some detail the various aspects of the Army Foot Problem. These group themselves into four divisions. (1) Problems related to the recognition of foot disabilities and the determination of how great is the interference with function they cause. Such problems are primarily the concern of the Army Reception Centre though they recur throughout the whole period of service of a soldier. (2) Problems arising during military training. (3) Problems concerned with effective methods of treatment and especially with therapeutic measures which are feasible for use within the restrictions imposed by army exigencies. (4) Problems related to foot-wear - especially the proper design and construction of boots.

The Foot Problem at The Army Reception Centre

At the Reception Centre during the initial examination of the recruit the particular aspects of the Foot Problem which are of basic importance are the recognition of foot disabilities and the proper assessment of them in respect to function. It is a useless waste of time, effort and money to enlist men whose feet will not permit them to undertake the duties of a soldier even though they may have succeeded in finding for themselves a niche in civil life in which they can compete on equal terms with their fellows. This skilful and accurate recognition of foot disabilities at the Reception Centre followed by the proper assessment of them in terms of function is beset by certain difficulties which are outlined below.

Inexperience in Foot Problems and Especially in Their Military Aspect. The ability to make such a proper segregation of recruits presupposes a broad knowledge of foot problems such as few doctors possess. Even orthopaedic surgeons of broad experience have difficulty in translating their knowledge drawn from peace time practice to the handling of the foot problems of soldiers. The medical staff of an Army Reception Centre are average doctors with an added sprinkling of specialists, gathered together into a team for the purpose of conducting a mass medical examination and an assessment of the functional capacity of recruits. Many are recent graduates. Their past training

and experience does not help them to recognize foot lesions any too well; still less to know their significance in terms of function. There is lack of written instruction from which they can make good the deficiencies in their knowledge. Consequently they are compelled to improvise and devise their own methods of handling foot problems and integrate them into the broad picture of physical examination:

Differences Between Military and Civilian Foot Problems.

The task of examining the feet of recruits at a Reception Centre for the purpose of determining their fitness for soldiering, differs greatly from the management of foot problems in civil life. Civilian patients with foot problems, for the most part, come with symptoms which are disablingly severe. The problem they present therefore, is the recognition of advanced foot pathology and its treatment. The approach to the soldiers foot problem is entirely different. In the Reception Centre the task is to examine large numbers of feet, (for the most part symptom-free) in a short period of time and determine which pairs of feet should be enlisted and which rejected on the basis of what they can or cannot accomplish of the effort required of a soldier. To do this the examining Medical Officer must have an assured knowledge of the type of foot disabilities which are present in the youth of the country, skill in recognizing them in his necessarily rapid examination; an efficient technique of examination; and knowledge of what each disability means in the matter of impairment of function. The question of treatment does not enter into the Foot Problem in the Reception Centre. The sole problem is one of selection. The importance of such a military approach to the problem must be emphasized as essential to its successful management.

Need of Uniform Standards for Examination and For Assessment of Functional Capacity.

The problem of selection, peculiar to this phase of Army medicine, requires a technique of examination which will ensure efficient and expeditious assessment and which can be made reasonably uniform across the country. Insofar as foot disabilities are concerned it has not been possible, up to the present, to accomplish this. There has been much variation in the method of examination of the feet of recruits in different Reception Centres and still wider divergence in the interpretation of the findings and the assessment of functional

fitness. The following summary of rejections of army recruits on account of foot disabilities indicates clearly the difficulties which arise from lack of uniform practice in examination and assessment. It has been compiled for this report by A.M.D.2 of the Directorate of Medical Services and shows the numbers of recruits who were rejected in 1944 at the Reception Centres across Canada for certain foot disabilities as listed in the Canadian Morbidity Code. The diagnosis "tarsalgia" is an ill defined term presumably meant to designate painful feet due to causes other than those which can be specifically recognized and defined. It invites loose usage. It is not surprising therefore that much variation exists in the numbers rejected for this disability. The totals, however, are insignificant. But under the diagnoses of hallux valgus, hammer toes, flat foot and pes cavus, the variation is surprisingly great. Under flat foot, for instance, it is impossible to believe that the incidence of disabling functional incapacity from this cause is nine times greater in one part of Canada (Military District No. 12 - 27.56 per 1,000) than it is in another (Military District No. 3 - 2.94 per 1,000). This discrepancy can only have resulted from differences of opinion as to what constitutes flat foot and still more, from differences of opinion as to what constitutes a disabling degree of flat foot. Similar discrepancies occur under the diagnosis of hallux valgus and hammer toe. Actually, experience in the training of soldiers has demonstrated that hallux valgus, unless very severe, is not incompatible with good function and that hammer toe need seldom, if ever, be a cause for rejection if the soldier is young and if shoes are properly designed and properly fitted. (1).

The need for improved knowledge of foot problems and the effect they have on function and the need for something approaching uniformity in examination and assess-

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1. The Incidence of Symptomless Deformities of the Foot in an Infantry Brigade. Director of Biological Research (Brit) paper No. 11.

Numbers of Army Recruits Rejected on Account of Certain Foot
Disabilities per 1,000 Recruits Examined in
Military Districts of Canada in 1944.

Military District	Tarsalgia	Hallux Valgus	Hammer Toes	Flat Foot	Pes Cavus	Total Rejections for All Foot Disabilities
# 1	0	3.00	2.00	16.77	3.38	25.16
2	0.12	1.61	0.40	5.99	1.61	9.72
3	0.	2.08	0.37	2.94	3.79	9.18
4	0.24	2.83	0.36	19.82	10.58	33.83
5	0.12	4.83	1.12	14.87	7.93	28.88
6	0.	2.40	0.40	13.05	2.26	18.11
7	0.	5.71	0.54	23.55	10.35	40.14
10	0.44	2.78	1.00	14.99	2.89	22.09
11	3.70	1.80	0.57	14.91	5.13	26.11
12	1.73	2.31	0.43	27.56	7.50	39.53
13	1.83	2.59	0.92	18.46	2.75	26.55
Totals for All Canada	0.64	2.64	0.64	14.60	5.41	23.93

NOTE: Military Districts 8 and 9 do not now exist. They have been absorbed into other Military Districts.

ment is very evident. Had these existed, the numbers rejected for flat feet probably would have been reduced to a level something like that of Military District No. 3 (2.94 per 1000) since there is no evidence that soldiers enlisted at the Reception Centre of Military District No. 3 suffered any greater wastage from foot problems than those from any other District.

Statistics supplied by the Medical Services of the Canadian Armed Forces show that there also were differences between the three Services in the numbers of recruits rejected for foot disabilities.

Period	<u>NAVY</u>	<u>ARMY</u>	<u>AIR FORCE</u>	
	May 1941 to Sept 1945	Jan 1944 to Dec 1944	Air Crew	Ground Crew
Total Examinations	105,553	63,125	102,536	131,798
Total with disqualifying Foot Conditions	366	990	341	1,323
Disqualification Rate per Thousand Examined	3.40	15.68	3.32	10.04

In considering the four frequency rates in this table it must be realized that the foot function requirements of the three Services are not the same. This fact is in part responsible for the differences observed in the table.

Value of Certain Technical Aids in Examination of the Feet of Recruits at Reception Centres. There is wide divergence in the extent to which technical aids are used in the examination of the feet of recruits and no general policy on the subject has been defined. Indeed there is no uniform opinion on this matter in the medical world at large. Often the initiative of an individual medical officer has resulted in the development of an original device which he has thought of value. The result has been the sporadic use of various pieces of apparatus, some of which have merit. When their inventor leaves the Reception Centre for other fields of military activity his invention usually soon gathers dust in a corner. In various Centres and at various times there have been in use the following types of apparatus; certain types of foot printing devices; plate glass viewing slabs with mirrors and illumination to permit the soles of the feet to be viewed from below while the patient bears weight upon them; various attempts at x-raying the feet by standardized techniques. This Survey will show that certain of these measures have merit and should be standardized and retained. It will be possible to show also that there is need for standardization in methods of examining and recording such elements of foot structure as dorsi-flexion of the great toe (hallux rigidus) and range of dorsi-flexion at the ankle (important in the hypermobile type of flat foot in which it is greatly limited), etc.

In the matter of assessment of function the only attempt at standardization are the meagre instructions contained in Physical Standards and Instructions. They have been referred to previously. Their brevity cannot be criticized too severely. There obviously is a limit to the minutiae into which standardized instruction can go without becoming so overwhelming as to defeat its own object. Nevertheless some uniform simple instructions based upon recognition of the significant types of foot disabilities and some assured statement upon the effect they exercise upon function with respect to service as a soldier would be of great use to the medical officers at a Reception Centre.

Need of New Information Regarding the Etiology and the Incidence of Foot Problems. Much of the complexity and confusion which surrounds the Army Foot Problem is the result of our genuine lack of knowledge of the fundamental nature of many foot disabilities. There is still much to be learned about the structure of the foot and its relationship to function. Certain deviations from the structural average are of great significance in terms of the load which the foot can carry. The presence of an accessory tarsal scaphoid, for instance, can so modify the insertion of the posterior tibial tendon as to materially diminish its power to lift up the inner side of the foot and so be a significant cause of diminished function, (weak, painful flat foot). There will be occasion later in this report to emphasize the importance of deviation from average structure as a cause of serious impairment of function when we discuss the type of flat foot which we have designated "hypermobile flat foot with short tendo achillis".

Any consideration of the problem of foot structure in relation to function is made complex by the facility with which compensatory mechanisms are developed, by the use of which a weak foot can be made to approach normal in function. One has to consider not only the structure of the particular pair of feet under consideration and the power of the muscles which move them, but also the manner in which the foot is used. An example is the increased use of the flexor hallucis longus to compensate for the lack of support by the head of a short 1st metatarsal. Increased use of this muscle transfers some of the thrust in walking and standing to the ball of the great toe, diminishing and often completely preventing any disability from the short first metatarsal.

These genuine deficiencies in our knowledge of the basic pathology of foot problems are not easily filled. There is a dearth of pathological material, study of which might add to our knowledge. Since foot disabilities after all are minor ailments in civil life, there has been a tendency to direct our researches to more interesting fields. But when war comes, foot problems are important, since they can cause wastage of personnel. So under the stress of war, there comes a tendency to fill

the gap in our knowledge by enthusiastic theorizing with the inevitable result that claims respecting the cause of foot troubles are advanced earnestly as statements of pathological fact when in reality they are little more than hypotheses.

In addition to our need for greater knowledge regarding the pathology of foot diseases, we lack information regarding the incidence of foot problems in the population at large and in particular in the male population of enlistment age (19 to 35 years). There are no surveys which record the nature and incidence of the various foot disabilities nor are there any sustained observations upon the functional capacity of feet under conditions resembling the training of a soldier. In consequence our knowledge of foot disabilities is based chiefly upon the treatment of individual foot problems. While this has given us a broad knowledge of the course and response to treatment of any particular foot problem, it tends to accentuate the disabling aspect of foot problems and gives no information whatsoever upon the incidence of these problems. Such information can only be obtained by a survey like that recorded here.

Need of Improved Instruction in Foot Problems. There is much need of improved instruction in foot problems to medical officers. The subject is neglected sadly in medical schools where it fares ill in the crowded curriculum. While it is not easily reduced to a simple form which can be taught to students, some earnest attempt should be made by medical schools to provide sound instruction in this field of surgery. In military medicine the essentials of the problem require clear definition and some standardization of methods of examination and assessment are needed. The military examination and re-examination of thousands of young men presents an unrivaled opportunity to add to our knowledge of foot problems information which should be incorporated into our programme of education.

Summary of the Foot Problem at Army Reception Centre. The Soldiers' Foot Problem presents its most difficult aspects at the Army Reception Centre. The essential problem there is the proper selection of recruits. Insofar as this concerns feet it means the rejection of those pairs of feet which will not stand up under training:

the proper grading of those feet which will stand limited effort but not the full activity of an infantry soldier and the stamp of full physical fitness upon those feet which are perfect. If this selection could be accomplished with some approach to perfection all the foot problems which might arise after enlistment would be simple. But the achievement of such perfection is beset by the difficulties which have been outlined above. Many of these could be removed or simplified by the accumulation of increased and more accurate knowledge and its dissemination to all medical officers. In addition there is needed the establishment of sound and uniform procedures of examination and assessment. It is the object of this Survey to provide the needed new facts and to indicate what procedures could be adopted with advantage.

The Foot Problem at Military Training Centres

The life of a soldier is perhaps the most strenuous that men are asked to undertake. Only the perfectly fit can stand the stress. The object of military training, in part, is to accomplish this fitness by a graduated programme of hard and steadily increasing effort. Ability to work at heavy labor in civil life is not necessarily a criterion of similar fitness for army life, and this is especially true of foot problems. In civil life, to a large extent, the workman accomplishes his task in his own way, by his own technique. By so doing he can accomplish much even with imperfect feet. It is otherwise in the Army. There he must conform to a fixed pattern of strenuous effort, the details of which are laid down in a syllabus. He must march in step with his comrades, precisely as they do, each pace of the same length, the same number of paces per minute and continued for the same number of miles. This can make a profound difference in his ability to perform heavy duties. Feet which have been symptomless in civilian life may give trouble in the Army. Basic and Advanced training therefore provide the real test of the functional capacity of feet.

Low Grade Feet which have Passed Through the Reception Centre Undetected. It is inevitable that the Reception Centre will enlist certain men whose feet are not wholly

sound. The rapidity of the examination; lack of precise knowledge of the incidence of foot defects; difficulties in assessing the functional capacity of feet and imperfections in the system of examination and assessment permits some, who should not, to slip into the Army. When put to the test these men will prove wanting. The strenuous activities of military training, even though carefully graded, will overtax the limited load capacity of their feet.

This group is the largest and the problems they present are the greatest of all the foot problems amongst enlisted soldiers. It must be recognized that the screen of the Reception Centre is not perfect. Some subnormal feet will slip through undetected and others which seemed satisfactory will prove to have a low functional capacity on test. Therefore it becomes the responsibility of training officers and especially of the medical officer of a Training Centre to recognize such unfit feet and deal with them appropriately. To a large extent this is a problem in assessment of functional capacity and is an extension of the responsibility of the Reception Centre. As such it involves an assured and accurate knowledge of the various types of foot disability and their significance in terms of function. If it can be recognized that the man has a foot lesion which impairs his capacity to continue as a soldier, he must be regraded. If the disability is severe he should be discharged, otherwise he should be down-graded and allocated to new duties compatible with the functional capacity of his feet. Occasionally such cases if not severe can be sufficiently improved by physical fitness training that they can be salvaged but this happens seldom.

Casualties from Over Rapid Progress of Military Training.

All recruits do not enter the army equally fit physically and though they make great strides in fitness under army regime, some cannot keep pace with the necessarily rapid progress of military training. The difficulty in maintaining the pace is accentuated, if for any reason the soldier loses time from training, especially if this be from illness. He then gets so far behind that he is constantly overtaxed. This overtaxing of a man's physique manifests itself by foot strain as well as in other ways.

Many such cases, if they have not structurally unsound feet, can be salvaged by arrangement for less steeply graduated training with particular emphasis on physical fitness. In the Canadian Army there exist for this purpose, units called Conditioning Centres. They were established originally to render fit again men whose training had been halted by illness and hospitalization. Later they were expanded to take in recruits, undernourished and of low physical fitness, who could be rendered fit for training by improvement of their physique.

In an effort to determine how best to salvage for further training soldiers who developed foot disabilities, groups of men with foot complaints were sent to these Conditioning Centres for special training designed to improve their foot function. This consisted of exercises specifically directed towards improving the power of the muscles controlling foot movements and especially those muscles which in their action tended to correct foot deformity (e.g. invertors of the foot in flat foot). Some good was accomplished by this but many foot disabilities were not improved by this programme of conditioning. It is obvious that only certain types of foot problem can be expected to benefit. If the basic cause of the trouble is structural weakness, improved muscle power may not accomplish complete compensation. Success in such a programme is dependent upon the selection of the proper cases for reconditioning. Broadly speaking, the types of foot problem suitable for reconditioning are infrequent. Most foot disabilities are the result of structural weakness and do not lend themselves to great improvement by methods of muscle development. For example, hypermobile flat foot with short tendo achillis, pes cavus, peroneal spastic flat foot, accessory tarsal scaphoid, hallux valgus, hallux rigidus and exostoses, none of which are amenable to correction by increase in muscle power, constituted two fifths of all the foot disabilities encountered at the Reception Centre in this Survey. Of the remaining three fifths, the great majority were cases of short first metatarsal, many of whom had no symptoms, while the others had symptoms due to localized pressure under the heads of the metatarsals and incapable of improvement by exercise. Only a small proportion were cases which might conceivably benefit by exercise.

Foot Disabilities Peculiar to Military Training. In Training Centres there develop a number of minor foot ailments which are the direct result of the strenuous programme of training. Lesions such as blisters, ingrown toe nails, callosities, spurs and exostoses become matters of importance because they interfere with training. To a large extent, they can be prevented by a training programme which makes provision for education of the soldiers in the care of their feet and their footwear and rigid insistence that they carry out an elementary programme of foot hygiene.

The Unwilling Soldier. Every army has its unwilling soldiers and often they feign disability to escape unpleasant or dangerous duty. A favorite complaint is painful feet. It is the medical officer's responsibility to recognize their true nature and deal with them firmly. He can accomplish this best by accurate knowledge of foot disabilities and the significance of these in relation to function. No medical officer can afford to be stern in the handling of a soldier unless he is sure of his ground. To be certain he must be able to recognize foot disabilities and to know whether or not they disturb function.

Plan of Treatment of Army Foot Disabilities

One of the difficulties which besets the Army Foot Problem is the fact that treatment which is entirely satisfactory in civil life usually is impractical in the army. Generally speaking, all treatment of weak feet with supports of any kind or by modifications of shoes is completely impractical in army life. It is virtually impossible to establish any form of supply which will ensure that a particular type of foot support or a particular modification to his boot will be provide to a soldier from the time he enlists, through all his training period in Canada and overseas and will follow him to whatever fighting front he may be assigned. Treatment of army foot problems, therefore, presents special difficulties. They are solved chiefly by reassessing the functional capacity of the man and assigning him a new "L" grading. Only the simplest forms of supportive treatment have any hope of proving practical throughout the whole of a soldier's life in the army.

Boots - Design and Fitting

The design of the present Canadian army boot was determined without the benefit of medical advice. This was not so in the American army. It is true that few doctors give thought to the boot requirements of normal feet and fewer still have any knowledge of the designing and manufacturing of lasts and boots. Nevertheless there seems good reason to believe that the special knowledge of anatomy and of foot function possessed by an experienced orthopaedic surgeon could be combined to advantage with the craftsmanship and manufacturing skill of boot-makers to design a boot which would be free from any imperfections.

The fitting of a soldier's boot is important. An appreciable number of foot disabilities are due to the imperfect fitting of boots. Some of this is due to organizational difficulties, all of which are capable of elimination (inadequate range of sizes in quartermaster's stores; lack of training of quartermaster's staff). Part is due to the complexity of the procedure necessary to fit a Canadian army boot. The last on which it is made is a special last which does not correspond to the designated sizes and widths on standard foot measuring rules. In consequence, rather complicated adjustments must be made to the measurements of the foot to determine the size and width of army boots which will fit such a foot.

Some simplification of the procedure of foot measuring and boot fitting would be highly desirable. Indeed there is reason to suggest that the whole of the present antiquated system of measurements by sizes and widths should be replaced by a more precise set of measurements of lengths and circumferences in centimetres. This would simplify and standardize foot measurements and boot fitting.

Summary

The Army Foot Survey was carefully planned to enquire into the aspects of the Army Foot Problem out-

lined above, with a view to enlarging our knowledge and improving our practice. It has extended over a period of eighteen months. During the survey many thousands of soldiers have been examined and re-examined. The initial examination of 3,619 recruits at Army Reception Centre No. 2, at Toronto, was followed by re-examination of 1,391 of these during their Basic Training and Advanced Training at a time when they were scattered in Training Centres across Canada from the Atlantic to the Pacific. Many hundreds of special foot problems were investigated in Camp Borden, Toronto and Ottawa. New improved and standardized methods of examination have been perfected. A standardized plan of mass examination in rather elaborate detail which permitted adequate examination of up to two hundred men daily. Investigations were conducted into certain distinctive types of structural abnormalities of the foot with particular reference to function. New information has been obtained regarding the pathology of certain foot lesions. Extensive investigations have been made into footwear and shoe fitting and into the care of feet and footwear.

Interim reports have been made to the Associate Committee on Army Medical Research at previous meetings. In this, the final report, the completed project is reported upon under the following subdivisions: Method of Study; Information Obtained from the Study; Army Foot Wear; Hypermobility Flat Foot with Short Tendo Achillis; Atavistic First Metatarsal; Management and Treatment of Foot Disabilities in the Army; Principle Conclusions and Recommendations; Acknowledgments; Appendices containing detailed, tabulated, statistical records and graphs.

PLAN OF STUDY

The general outline of the plan of the Survey was as follows:- to examine, at a Reception Centre, for foot defects, as large a group of recruits as might prove feasible, then to follow those who were selected through their Basic and Advanced Training to determine the nature and extent of foot defects which developed during training.

Project - Army Meds. - No. 22

A comprehensive examination of recruits presenting themselves for enlistment at the Reception Centre permitted accurate determination of the varieties of foot disabilities (and their frequency) existing in a specific cross section of the population of Canada. Various organizational difficulties prevented the inclusion of women soldiers in the scope of the Survey so that in the end the information which was obtained by the Survey deals with foot disabilities occurring in a group of Canadian males ranging in age from 18 to 35 years.

Examination during Basic Training of those enlisted from the group surveyed at the Reception Centre and re-examination of these during Advanced Training permitted the frequency and breakdown from foot ailments during training to be determined. Problems related to boot fitting, boot design and other forms of footwear also were studied and important information obtained.

PLAN OF STUDY

A valuable feature of the Survey was that it was conducted throughout upon the same group of men and by the same examiners; rather than upon different groups of men in various departments of Army activity and by different examiners. The careful examination at the A.R.C. of several hundred pairs of feet and their classification as to abnormalities permitted conclusions to be drawn regarding functional fitness when they were subsequently re-examined while subjected to the stress of military training.

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In order to ensure that the re-examination during Basic and Advanced Training might be conducted by the same staff who performed the initial survey, it was necessary to close the initial examinations at the

A.R.C. in about one month. By then those first examined were in the midst of their Basic Training and their re-examination was pending. By the time the survey of those undergoing Basic Training was completed it was time to commence the re-examination of the same men then undergoing Advanced Training.

The examination at the Reception Centre of as many men as possible in the time available involved planning and well integrated team work. The information which was to be sought by examination was decided upon by previous discussion. It included every item which seemed likely to be of value. Specific and standardized techniques of examination were devised and submitted to test. New apparatus necessary for those techniques was devised and made. A working team was organized consisting of an orthopaedic surgeon, an assistant orthopaedic surgeon and requisite clerical assistance and they were trained in the conduct of the examination. When organized, equipped and trained, the team opened the Survey and for the period of a month examined every recruit who came into the largest Reception Centre in Canada. This provided a reasonably large group of cases for study. The daily examination of recruits at the Reception Centre was then stopped and the team divided for separate duties. The orthopaedic surgeon, with suitable assistance, followed the enlisted men through their Basic and Advanced Training while the assistant orthopaedic surgeon commenced the analysis of the material obtained during the preliminary examination. When the last man had been followed through his Advanced Training the whole of the information obtained was submitted to statistical analysis and arranged in tables and graphs.

It chanced that while the Survey was being made in the Army Reception Centre in Toronto, the National Selective Service Board was desirous of determining the physical status of certain groups of men, exempted from military service because of war work, with a view to the possible future necessity of combing industry for manpower for the army. To obtain the information the exempted men within the age group of 18 to 35 years were passed through the Reception Centre along with the recruits and assigned a Pulhems grading. They then re-

turned to their war work. These men were also examined by the Foot Survey. In consequence the number of men surveyed at the Reception Centre is large when compared with the number enlisted, but this low proportion of enlistment is not a true index of rejections for physical unfitness.

The final accomplishment of the Survey is based upon information obtained from the examination of 3,619 recruits and war workers at the Reception Centre. From this group, 1,600 were enlisted and of these 1,391 were examined during Basic and Advanced Training.

Technique of the Examination Conducted at the Army Reception Centre

The details of the various steps in the examination which was conducted at the Army Reception Centre are described in full in the Appendices. It will suffice here to outline briefly what was done and to give the reasons for doing it.

The items of information of value, which it was thought might be obtained by examination of the recruits in a Reception Centre, were carefully decided upon by conference and discussion before the Survey started. This was necessary to enable the procedure to be so planned that no changes would be necessary after the examinations commenced and also to ensure the most expeditious handling of the men as they passed through the Reception Centre. This plan proved entirely satisfactory. The experience of the Survey showed that all the desired examinations could be conducted without holding up the flow of men through the A.R.C. and that no item of any great importance had been left out, though several items included in the Survey proved of little value and might well have been omitted.

The routine physical examination of recruits at the Reception Centre is carried out on a production line basis. Each man follows the man before him in an orderly sequence of steps of physical examination and documentation until his record is complete. By careful planning and the organization of a skilled team it was

possible to interpose into the enlistment stream the examination steps necessary to obtain the information desired by the Foot Survey without delay or interference with the flow of recruits through the Centre. The examinations of the Foot Survey team were carried out independently of the examinations being carried out by the Reception Centre staff. There were, therefore, two sets of examinations of feet: that conducted by the Reception Centre staff, this of necessity was brief but it was the official examination on which the recruits' "L" grading (for feet) was set; that conducted by the Foot Survey, much more elaborate and detailed, the record of which played no part in the grading of the recruit but was used solely for the purposes of this project.

Items in the Examination Conducted by the Foot Survey at the Army Reception Centre

Each of the 3619 men who passed through the Army Reception Centre during the period of the Survey was examined in respect to the following items and the whole of the information so obtained was recorded upon a card specially designed to permit sorting for statistical purposes. Full details will be found in Appendix "A" - "Data for Cards".

1. History. A brief but orderly enquiry was made into the existence of symptoms of foot disability with indication as to whether the symptoms occurred chiefly on standing or on walking and whether they were situated in heel, midfoot or forefoot. Enquiry was made also into the previous occurrence of disease such as rheumatism which might have a bearing on foot diseases.

2. Clinical Examination. Each case was submitted to a clinical examination which was conducted by one examiner (T.B.). The examination consisted of inspection of the feet from in front to visualize the arch, the degree of pronation and any other features which might be detected by this view (Fig. 1). The man was then asked to stand on tip toe though this did not consistently yield very important information (Fig. 2). If there was any question of the degree of pronation

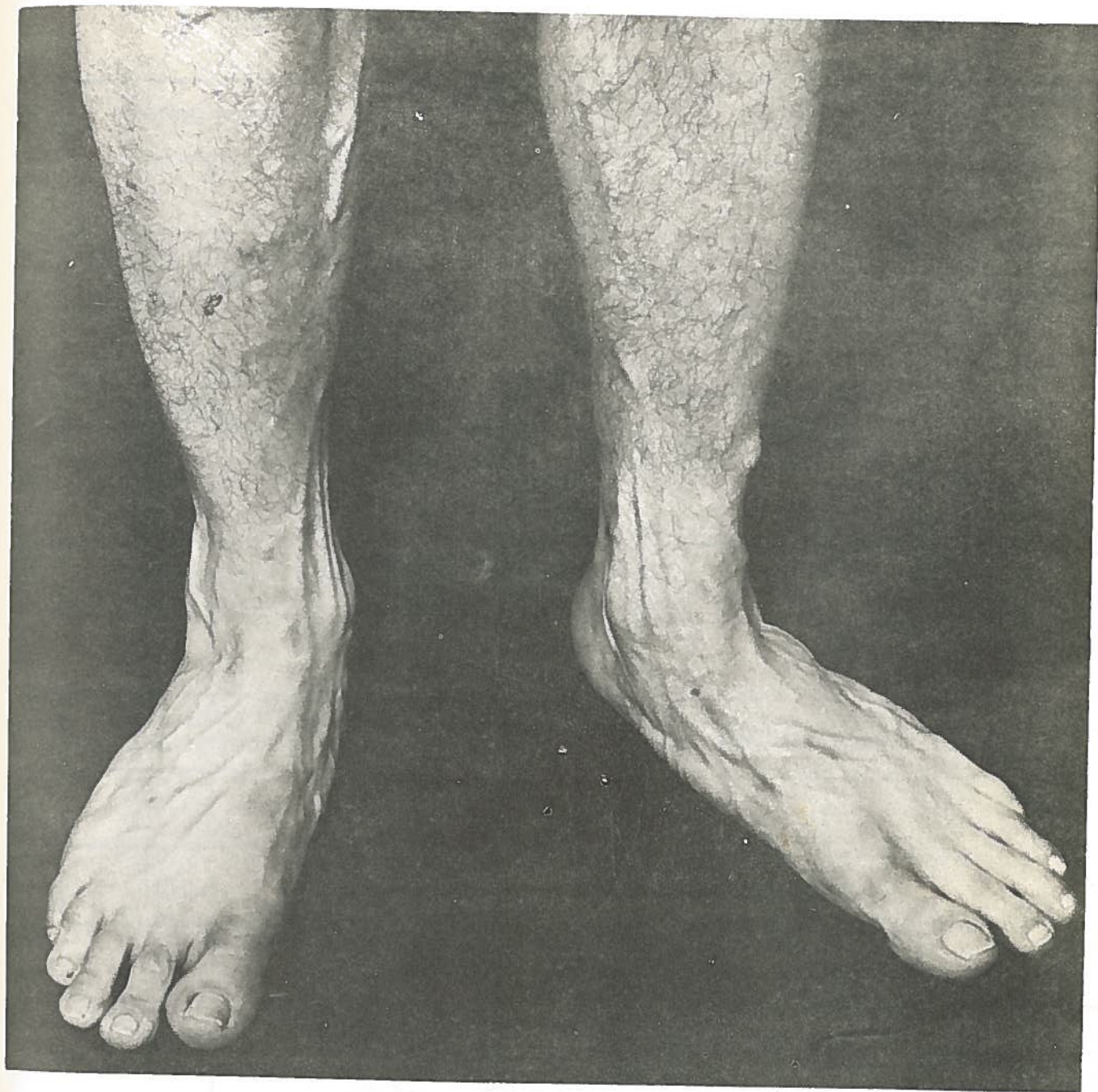


Fig.1 - Examination of the recruit's feet; from the front a moderately severe case of hypermobile flat foot with short tendo achillis. Same case as illustrated in Figs.2 to 10 inclusive.

FLOW SHEET OF STEPS IN RECEPTION CENTRE PROCEDURE

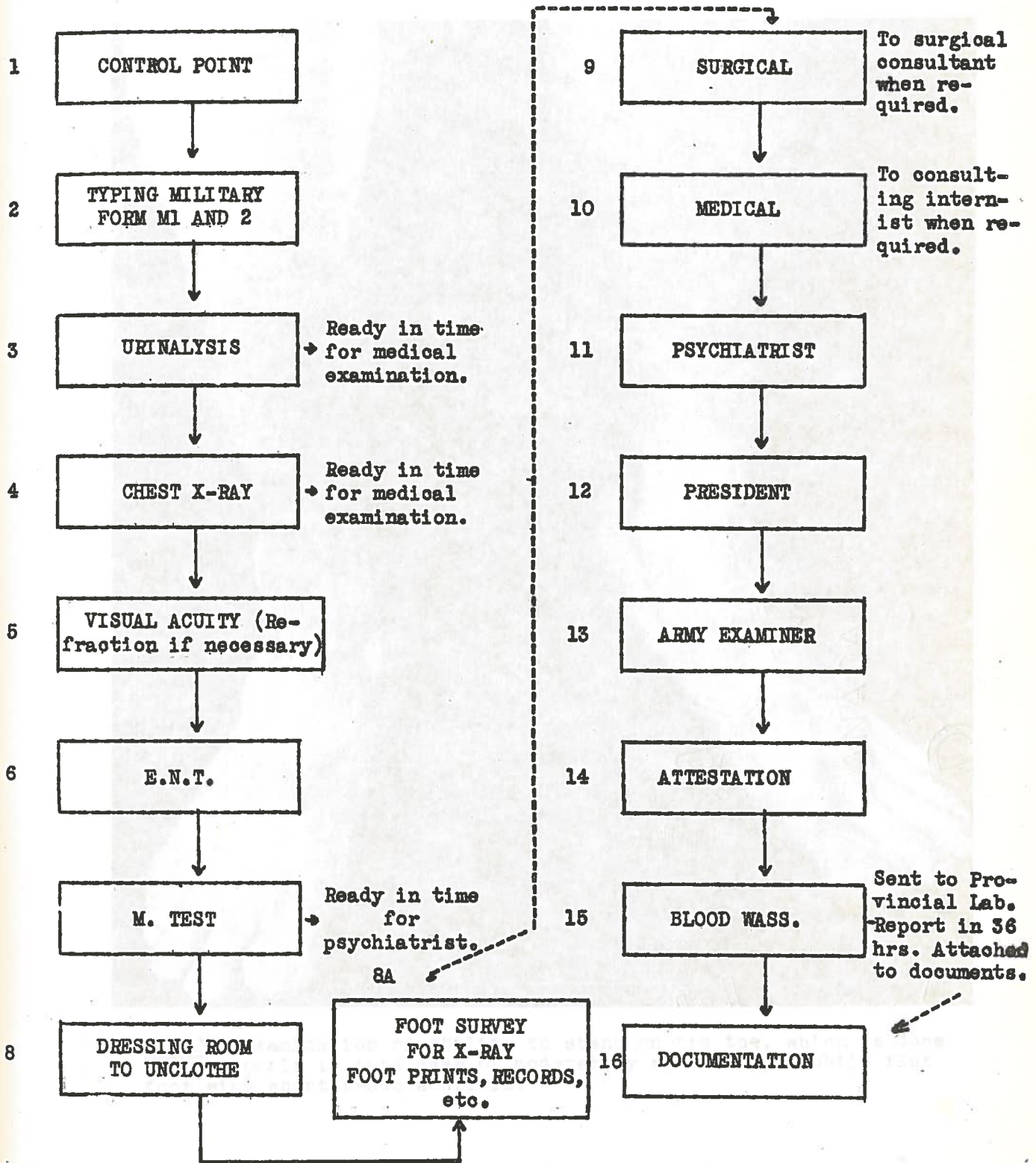




Fig.2 - Examination of ability to stand on tip toe, which is done rather poorly in this case of moderately severe hypermobile flat foot with short tendo achillis.

his feet were examined from behind (Fig. 3). The man was seated and his foot placed on the examiner's knee. The sole of the foot was examined for callosities, etc. (Fig. 4). The skin between the toes was examined (Fig. 5). The foot was then grasped and the range of movement of the subastragalar and mid-tarsal joints estimated from manipulation (Figs. 6 and 7). The range of passive dorsi-flexion of the ankle was determined by pushing the foot upwards, the knee being fully extended and the foot held in such a manner as to prevent movement at the subastragalar and mid-tarsal joints and permit only movement at the ankle joint. This item in the examination proved of great value in recognizing the very disabling type of flat foot, to be discussed later, characterized by hypermobility of subastragalar and mid-tarsal movement and limitation of dorsi-flexion at the ankle joint (Fig. 8). This range of dorsi-flexion at the ankle was estimated in degrees and recorded. The great toe was then dorsi-flexed to test for hallux-rigidus (Fig. 9). An attempt was made to estimate clinically the relative length of the 1st and 2nd metatarsals by flexing these toes sharply at the metatarso-phalangeal joint until the heads of these metatarsals could be seen (Fig. 10). Finally a record was made of the presence or absence of localized excess of pressure under the heads of the metatarsals (as evidenced by the existence of callosities). Further details regarding the items in this clinical examination and especially the method of recording them will be found in Appendix "A" - "Data for Cards".

3. Foot Prints. It was decided, after considerable discussion, that foot prints would be of some value if in addition to recording the outline of that portion of the foot which contacts the ground, they would also record graphically the relative distribution of weight on the sole of the foot. It was not easy to develop apparatus for this purpose but it was ultimately perfected and was productive of interesting and valuable information.

Morton (2) and Elftman (3) have both attempted,

-
2. Morton, Dudley J. The Human Foot. New York, Columbia University Press. 1935.
 3. Elftman, Herbert. A Cinematic Study of the Distribution of Pressure in the Human Foot. Anat. Rec. vol. 59, No. 4. July, 1934.

in different ways, to record graphically the weight distribution on the sole of the foot. We desired a simpler and more efficient method. It was ultimately achieved by the use of a rubber mat whose upper surface was covered with fine ridges running at right angles to each other and at different levels. The first successful type consisted of ridges at two levels alternating with one another in both directions. This type was used for nearly the whole of the Survey. Subsequently an improved pattern was made having ridges at three levels. Both types are illustrated in Appendix B - "Method of Foot Printing".

By inking the ridges and then covering them with a sheet of paper on which the man stood or walked, an imprint of the foot was obtained outlining the area of the foot in contact with the ground; those parts which bore least weight printing only the highest ridges. Where more weight was applied, the deeper ridges registered their imprint also on the paper. In the areas of greatest weight bearing all of the ridges print completely. The general effect is similar to that produced in a half tone print: areas of heavy pressure printing dark and areas of light pressure printing faintly.

Full details of the foot printing apparatus, its manufacture and method of use and reproductions of illustrative types of foot prints, will be found in Appendix "B" - "Method of Foot Printing".

4. Standardized Radiographs. No Foot Survey would be complete without provision for radiographs since many foot problems can be recognized only by their aid (accessory tarsal scaphoid; Freiberg's infraction of 2nd metatarsal). Certain other conditions can be assessed accurately only by means of x-ray study (short 1st metatarsal). In this Survey also it was hoped that by means of radiographs, valuable information would be obtained regarding deviations from normal structure and their relationship to diminished function. For these reasons much care was expended in devising a satisfactory method of obtaining good radiographs of each pair of feet examined. The detailed technique is described in Appendix "C" - "Technique to Obtain Standardized Radiographs". It will suffice here to state that by its excellent

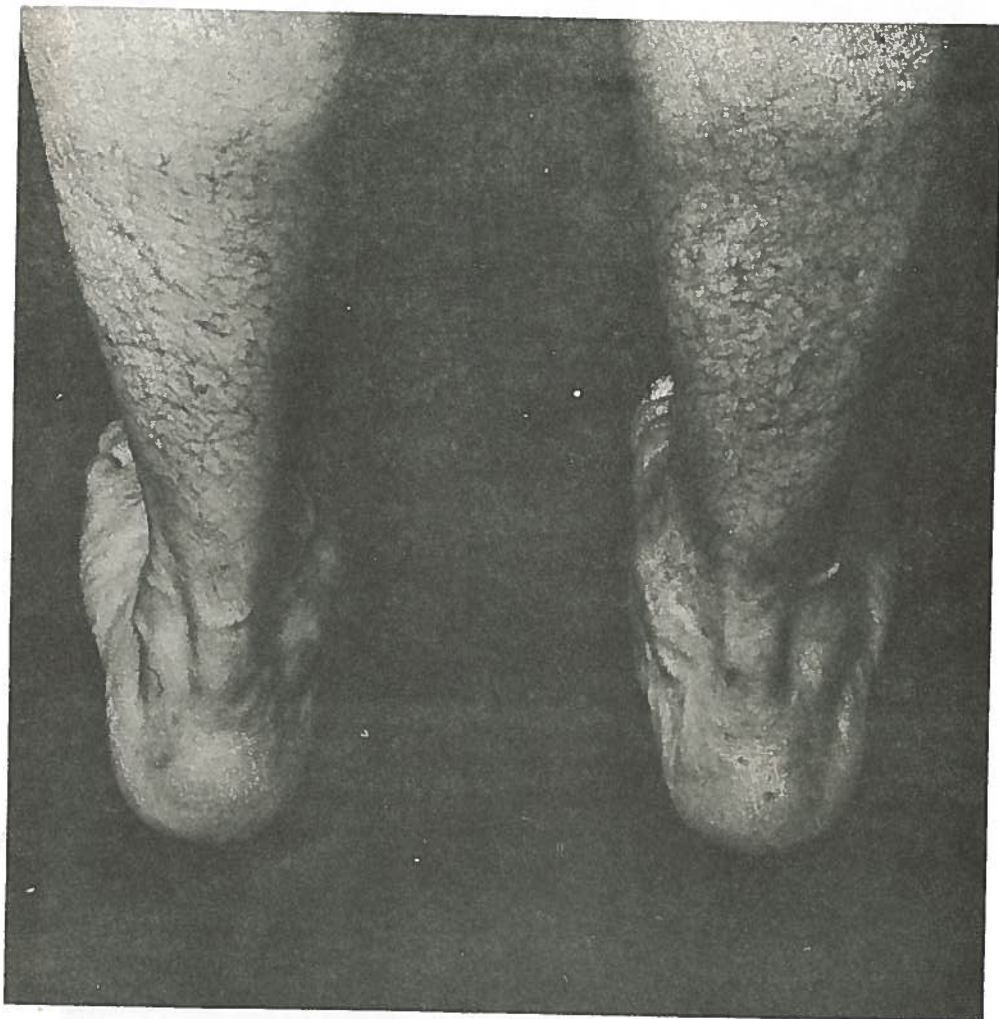


Fig. 3 - Examination from behind for pronation of os calcis. Minimal in this case of moderately severe hypermobile flat foot.

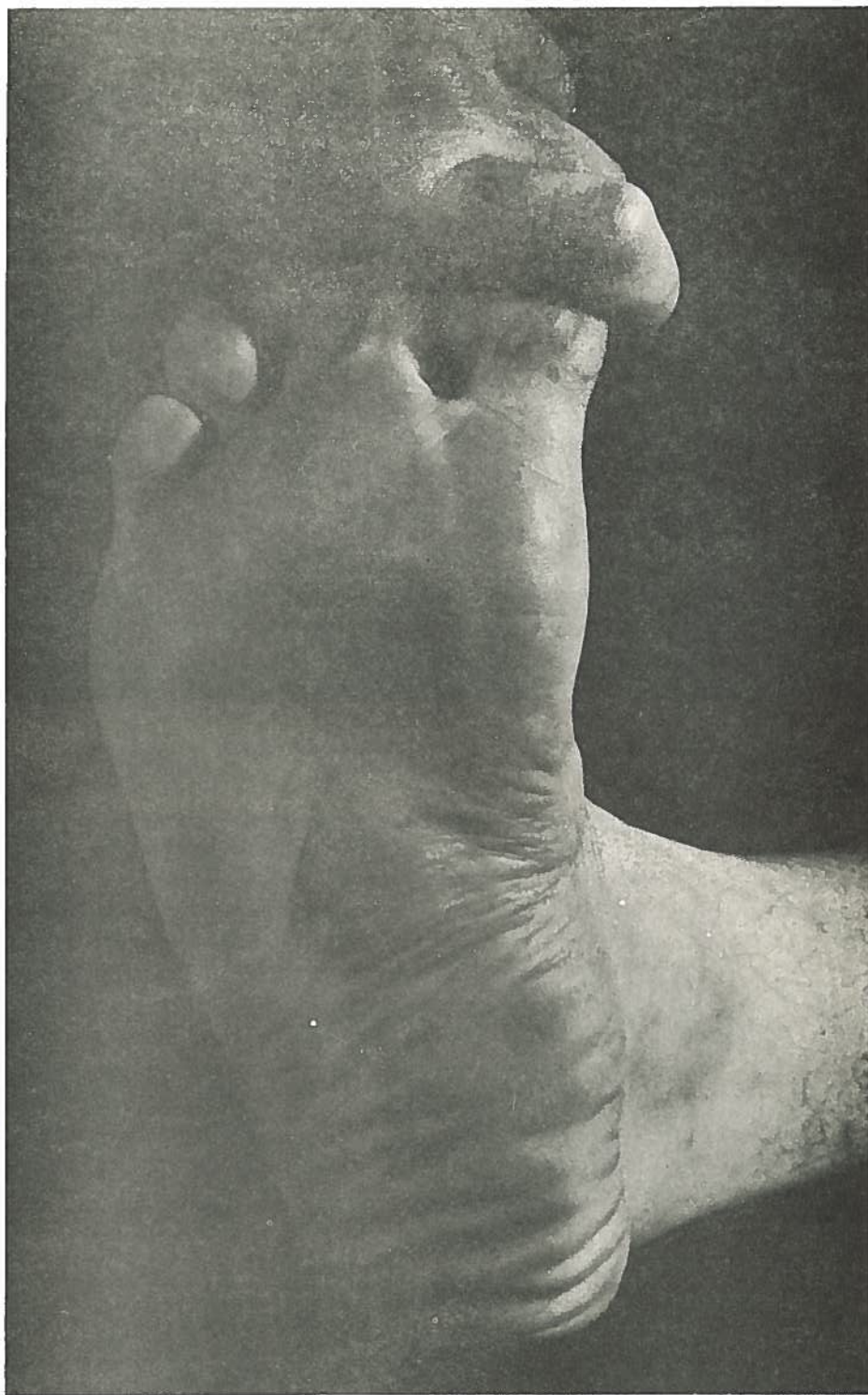


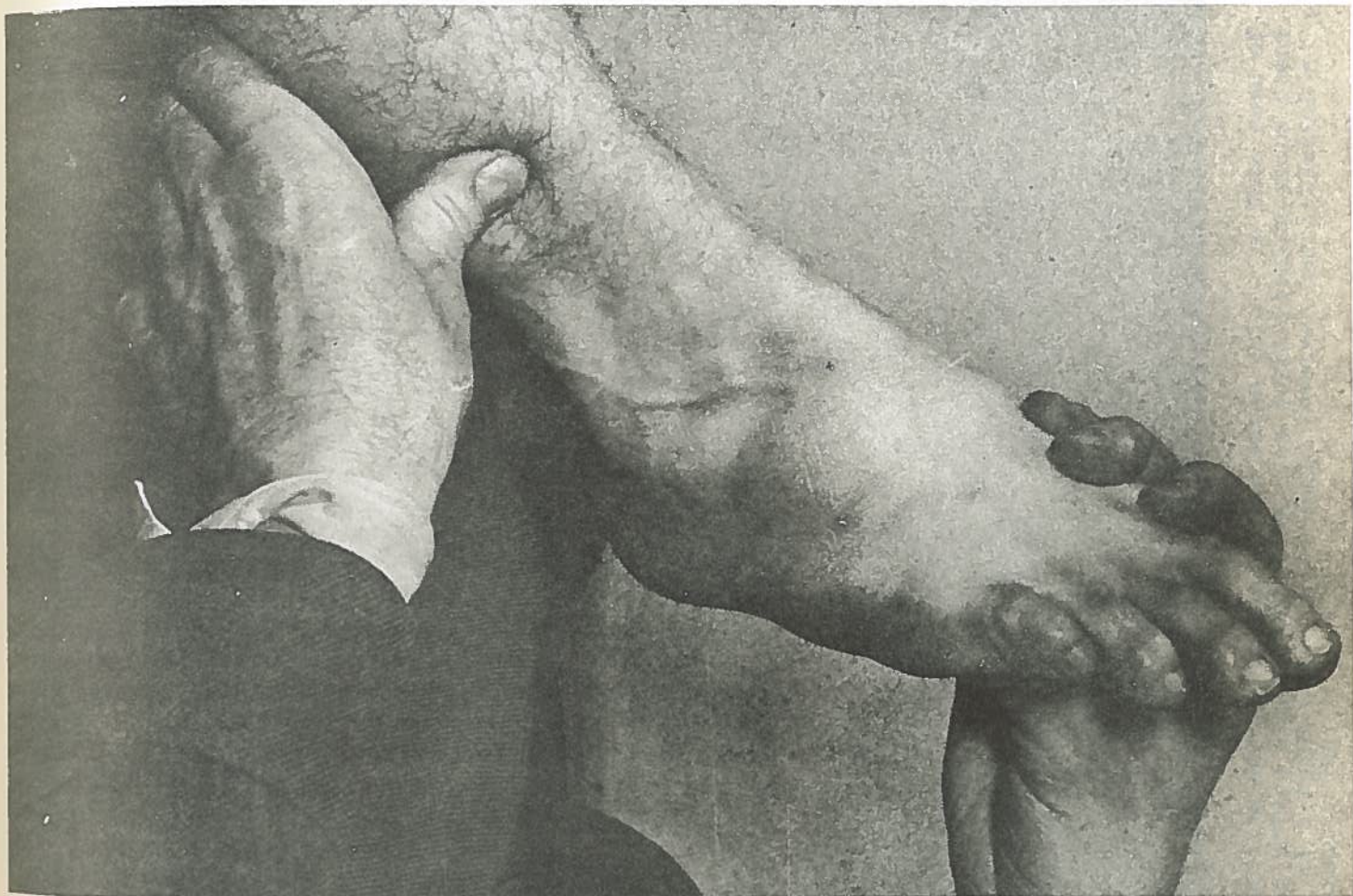
FIG.4 - Examination of the sole of
the foot for callosities, warts, etc.



Fig.5 - Examination of the skin between the toes for fungus infection, etc.



Fig.6 - Testing for movement of mid-tarsal and subastragalar joints - Inversion.



**Fig.7 - Testing movement of mid-tarsal
and subastragalar joints - Eversion.**

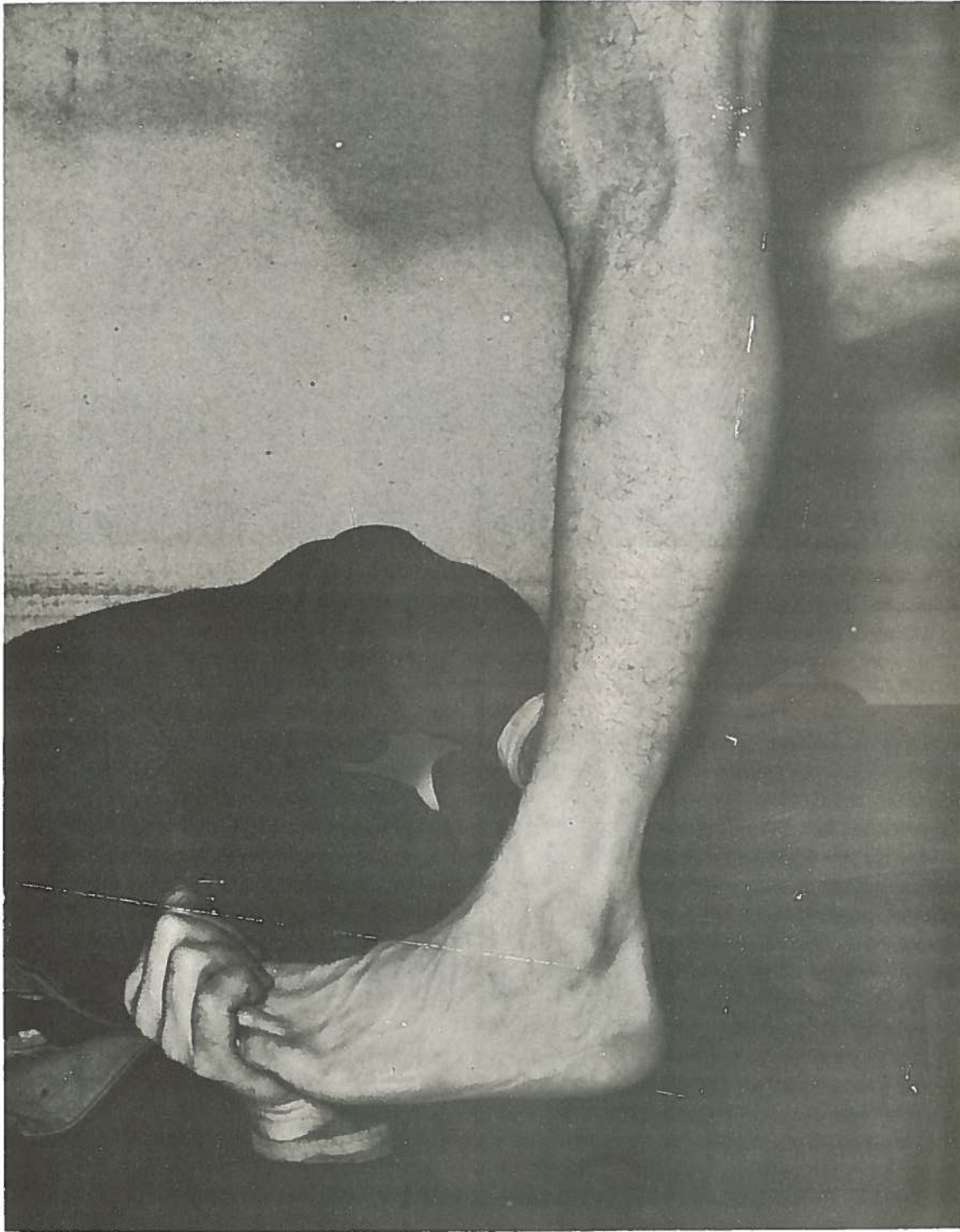


Fig. 8 - Testing dorsi-flexion at the ankle joint. In this case of moderately severe hypermobile flat foot dorsi-flexion stops about 120 short of a right angle, i.e. angle greatest dorsi-flexion = 1120 - Normal = 750.

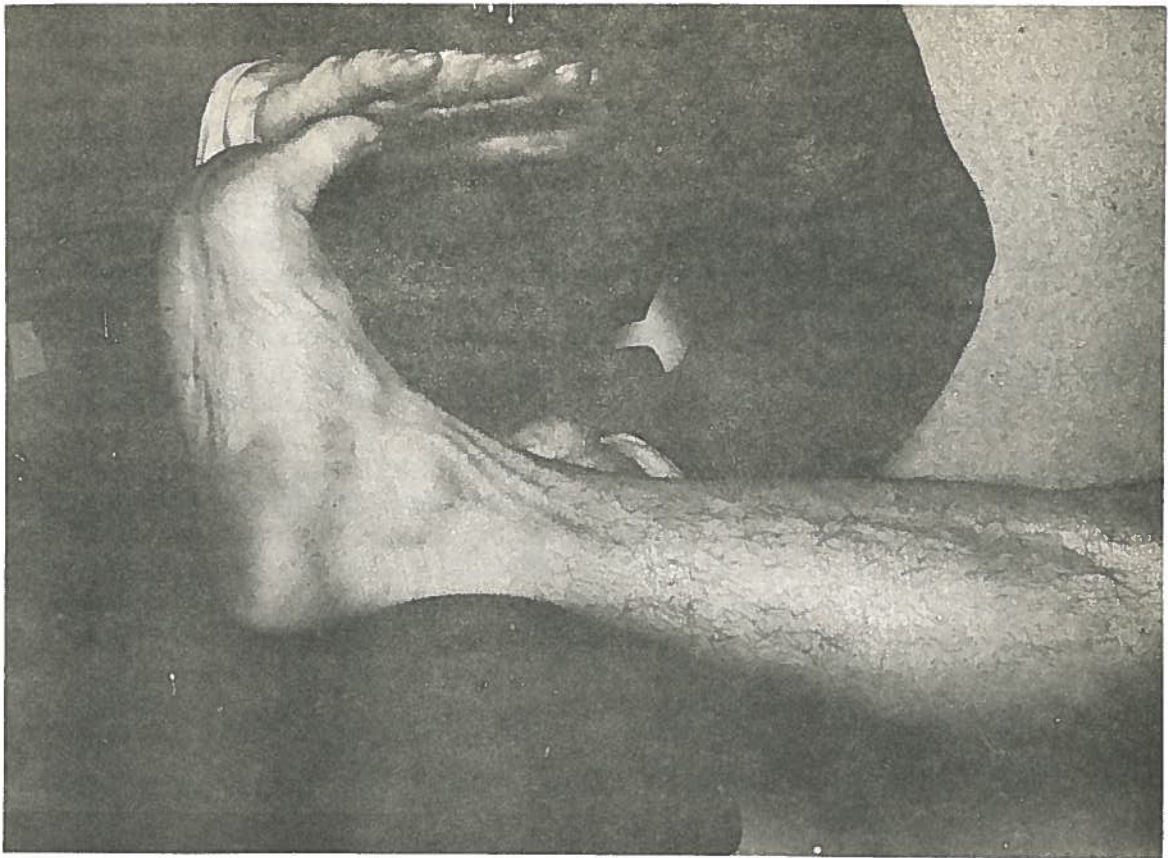


Fig.9 - Testing for range of dorsi-flexion of metatarso-phalangeal joint of great toe - and for presence of hallux rigidus.

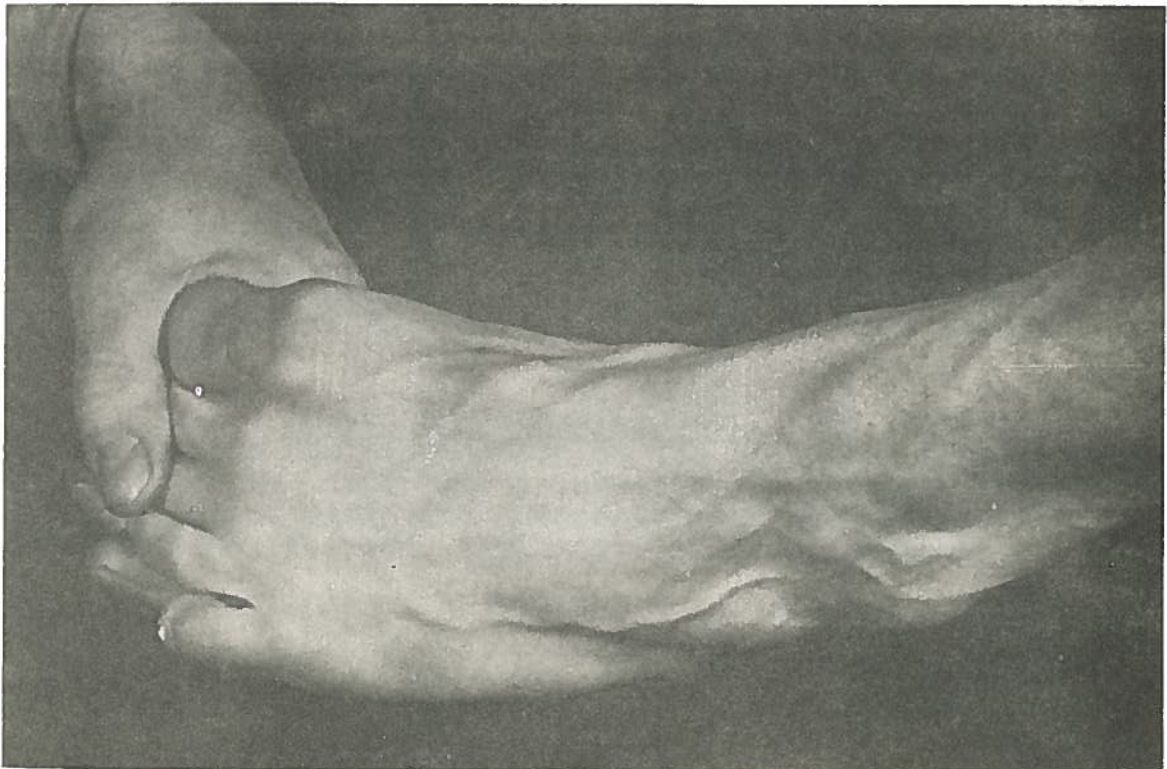


Fig.10 - Examining the length of the first metatarsal as compared with the second.

supero-inferior (dorsi-plantar), oblique and lateral views were obtained. The technique is completely standardized so that each set of films is strictly comparable to all the others. The films obtained were so satisfactory and the information they yielded so valuable that the technique is worthy of adoption in every hospital as the standard practice for foot x-rays. See Appendix "C".

By reason of the standardized technique, these films are strictly comparable one with each other. In addition to the information regarding foot structure and abnormalities which could be obtained by visual examination of them, they provided the opportunity to study measurements and compare these with clinical examination and with function (as determined by study at Training Centres) with a view to deciding whether certain types of foot disability might not be assessed by measurements taken from standardized radiographs. The list of these measurements and the technique of conducting each measurement is described in Appendix "D" - "Method of Studying X-rays".

It was necessary to determine, before the Survey commenced, exactly what measurements would be undertaken. The face of the Record Card is printed from an engraved block and changes are not possible once it is made up. In consequence, every measurement which offered any possibility of yielding information was included for analysis. Many of the measurements yielded information of the greatest value (e.g. measurement of the length of the 1st metatarsal in comparison with the 2nd). Other measurements proved of dubious value in correlating structure of the foot with function. Nonetheless, the plan of utilizing comparable standardized radiographs for anthropometric analysis proved valuable and is strongly recommended for such studies. The films of this Survey have been carefully stored away in the Records Office in Ottawa where they will be available for further study of the bony structure of the foot.

5. Method of Recording Data. The information obtained from the examination at the Reception Centre together with the information subsequently obtained from examination at Basic and Advanced Training Centres was recorded upon Keystone "Kwiksort" statistical Cards,

(Fig. 11). This proved an admirable arrangement for purposes of record and subsequently for analysis of the material. Values are recorded by converting specified holes in the margin of the card into notches. This provides a simple means of sorting which requires no more machinery than a punch and a bodkin and permits the analysis of up to 5000 cards.

The face of the card is divided into rectangles in each of which is to be recorded the facts in respect to a certain item in the examination. The nature of this item is indicated in its appropriate rectangle by a title, often abbreviated. Each item has a corresponding hole on the margin of the card. In conducting the examination the presence or absence of a particular item is indicated in its appropriate rectangle by a "plus" or "zero" sign or sometimes by a word. Subsequently this information is transferred to the margin of the card by converting the appropriate hole into a notch. The card is then filed away for subsequent analysis.

The designation of the values within the rectangles on the face of the card, because of limitation of space, are necessarily abbreviated. These abbreviations represent clearly specified items which had previously been decided upon and defined precisely in writing. It was found extremely important to be undeviating in the interpretation of the meaning of each item. The details of the significance of each item is recorded in "Appendix A" - "Data for Cards".

Technique of Examination Conducted at Basic and Advanced Training Centres.

The examination during training of the soldiers who had been enlisted from the original group examined at the Reception Centre, was arranged to take place during the latter half of their training period to ensure that the soldier had been submitted to sufficient stress of training to justify conclusions. Machinery was set up to trace the men to their Training Centres and to trace any moves from Training Centre to Training Centre. It was possible to trace the movements of virtually every man who was enlisted but it was not possible to see quite

AGE											HISTORY											ALPHABETIC SORT											FACTORS IN FOOT STRAIN (3)											PES PLANUS CAUSAL																																																																																																																								
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ELSEWHERE (SPECIFY)											UP TO 4 INC. (ENTER)											5-9 INC. (ENTER)											10-19 INC. (ENTER)											20+ (ENTER)											RHEUMATISM																																																																																																													
MILD											SEVERE											CLAWING											EXCESS WT.											MORTON'S											OTHER DISTURBANCE											SHORT											VARUS											HYPER-MOBILE											EXCESS WT. HEADS 2,3											SEVERE GRADE											HALLUX VALG. MILD											HALLUX VALG. SEVERE											HAMMER TOE											HALLUX RIGIDUS										
M-C (9) HEEL (10)											EXOST.											INJURIES (11)											CALLUS OR CORN											ONYCH OR INGROWN											FUNGUS OR SWEAT											WARTS											SEVERE SKIN											VASCULAR											ARTHRITIS											OTHER CONDITIONS OF FEET (SPECIFY)											SYMMETRY (14)																																											
MILD ATAVISM											SEVERE ATAVISM											1ST SHORTER THAN 2ND											FIRM SUPPORT											MODERATE SUPPORT											OVERLAP S-1 (MM.)											WIDTH TAL. S-1 (MM.)											HEAD MEDIAL											HEAD LATERAL											OVERLAP LAT. (MM.)											HEIGHT TAL. LAT. (MM.)											ELEVATED HEAD TAL.											POSITION OF SESAMOIDS (MM.)																																
THICKENED 2ND METAT.											LENGTH 1ST CP. 2ND (MM.)											LENGTH OF FOOT (CM.)											DEPRESSED HEAD TAL.											LENGTH SPR. LIS. (MM.)											SHORT SPR. LIS.											LONG SPR. LIS.											POSITION SUSTENT. (MM.)											SUSTENT. POST.											SUSTENT. ANT.											SUB. NOTCH OBLITER.											ANTERIOR FACET											FWD. POSITION											POST POSITION																					
1ST SHORTER THAN NORMAL (MM.)											TOO OBLIQUE M-C JOINT											OBLIQUITY M-C JOINT											PROJEC. HEAD DECR FWD TALUS (MM.)											INCR. FWD. PROJ. HEAD											ANGLE (DEGREES)											DECREASED ANGLE											INCREASED ANGLE											SLOPE-SUST. (DEGREES)											DECREASED SLOPE S											INCREASED SLOPE S											UNUSUAL (SPECIFY)																																											
ANGLE 1ST METAT. 2ND.											METAT. PRIMUS VARUS											OTHER ATAV FEATURE											SPURS: EXOST. ETC. (18)											ACCESS. SCAPH. (19)											WIDTH (CM.)											NARROW											WIDE											HEIGHT (CM.)											LOW											HIGH											M-T ANGLE											M-T VALGUS											M-T VARUS																					
TEST PREVENTED											TOLERANCE TESTED											MISSED DEFECTS (SPECIFY)											MY L 1											MY L 2 OR 3 (SPECIFY)											A.R.C. L 1											A.R.C. L 2 OR 3 (SPECIFY)											ANGLE											GRY. ANGLE											DECR. ANGLE											LENGTH (CM.)											SYMMETRY (22)																																											
NEW TROUBLE (SPECIFY)											ABILITY LESS THAN B (SPECIFY)											ABILITY S-B (SPECIFY)											L LOW OTHER THAN FEET											REJECTED A/C FEET											REJ. OTHER MEDICAL											REJECT. ON ADMINIST.											A											1											2											B											RIGHT											LEFT																																
ABILITY 10-19 (SPECIFY)											LOST TIME 5 OR LESS (SPECIFY)											LOST TIME OVER 5 (SPECIFY)											B-T NOT COMPLETED (FEET)											UPWARD REGRADE											DOWN REGRADE											BOOTS NOT WELL MAINTAINED (SPECIFY)											UNSATISFACTORY AT D. DEPOT (STATE WHY)											GROUP 1											GROUP 2											GROUP 3																																																						
CONTROLLABLE DISABILITY NOT CONTROLLED (SPECIFY)											STABILIZED GRADE B/R											STABILIZED GRADE L I											SOCKS NOT WELL MAINTAINED (SPECIFY)											THREE OR MORE FITTINGS (STATE WHY)											1											2											3																																																																																							
STABILIZED GRADE L 2 OR 3 (SPECIFY)											M & S AT A.R.C.											M & S AT REVIEW											LACKS MOTIVATION											SKIN NOT WELL MAINTAINED (SPECIFY)											FINAL FIT UNSATISFACTORY (STATE WHY)											WEEKS 1ST											WEEKS LAST											DATE LAST																																																																												
MEDICAL SUMMARY											SYM-METRY											CALC-ANEUS											MISCELLANEOUS MEASURABLE ITEMS (X-RAY)											SESAMOIDS											SUPPORT OF HEAD OF TALUS											EXTRA HOLES (29)											BASIC											ADVANCED											INFANTRY											MED. OR ENG.											NAME OTHER CORPS																																											

Fig. 11 - Keystone Kwick-Sort statistical card used in the foot survey.

all of them during their training. There were many reasons for this. They were scattered through thirty-five Training Centres across the whole of Canada. Some Training Centres had poor train connections serving them and to visit such Centres to examine only a few men would have consumed so much time that other Centres, of necessity, would have been neglected. In the main, however, the following programme was carried out and the great majority of the men enlisted were examined during their Basic and Advanced Training.

Such examination of the men during training was accomplished by notifying beforehand the Commandant of the Training Centre of the date the examination was to be carried out and the names of the men it was desired to examine. These were paraded at the Medical Inspection Room and were examined there jointly by the Training Centre medical officer and the Foot Survey officer (T.B.). The items in this examination were: 1. An enquiry into the occurrence of foot troubles during the man's training and the nature and severity of such foot troubles. 2. Examination of the man's feet for foot lesions. 3. Examination of the fit of the man's boots. This is a comparatively simple procedure since the Canadian army boot has no toe cap and the toes can be readily felt through the leather. 4. The condition of the boot and socks was determined in relation to proper care of feet and footwear. 5. Enquiry was made into methods of treatment and management of foot disabilities with particular reference to methods of dealing with weak feet. 6. The information obtained was entered upon the man's survey card which had been brought by the Foot Survey examiner for that purpose. When necessary, further foot prints and x-rays were obtained.

The Regimental Medical Officer and the records of the Medical Inspection Room were available to provide pertinent information.

Collection of Other Data

Boots. During the course of the Survey the problem of the fitting of boots was given considerable attention. It obviously is a matter of importance in

any Army. The information obtained from observations made during the Survey was enlarged by discussion with Quartermasters responsible for issuing of boots and with the civilian boot fitting instructors employed by the Ordnance Corps. Four Boot Repair and Reconditioning Depots were visited and No.1 Army Boot Rebuilding Plant in Montreal was visited on more than one occasion. The special fitting centre in Boston maintained by the United Shoe Machinery Corporation and the Unit developed from this for the American Army in the Quartermasters' Depot in Boston, were visited and studied especially with reference to the fitting of boots to abnormal or deformed feet.

This problem of shoe fitting led finally to an enquiry into the design and manufacture of lasts on which comments are made in Appendix "J".

A programme for the mass survey of the measurement of feet has been set up by the American Army at Fort Knox under the direction of Major Freedman. During the later stages of this Canadian Army Foot Survey Major Freedman came to Canada to enquire into our Survey and to examine its results. As an outcome, D.G.M.S., Canadian Army was invited to send Major Beath to Fort Knox to collaborate with Major Freedman in the planning of their survey and in the early phases of the examination and the measurements of the men. This contact yielded much interesting and valuable information. (4)

Reports and Directives - Reports relevant to foot problems which from time to time have reached National Defence Headquarters and various Instructions and Routine Orders were all read and analysed. Comment will be made on them in the proper place.

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4. Foot Dimensions of Soldiers - Project No. T-13 SGO No. 611. Survey of Foot Measurements and the Proper Fit of Army Shoes - Armored Medical Research Laboratory. Fort Knox. Kentucky.

PRESENTATION OF DATA

The information obtained from the various phases of the Survey has been analyzed and tabulated in as great detail as seemed informative. The analytical tables will be found in Appendix "B". They represent accurate sources of statistical information, deserving of careful study. A more general picture of the findings of the Survey will be given here, the statistical facts being drawn from the tables.

Project - Army Meds. - No. 22

INCIDENCE AND NATURE OF FOOT DEFECTS FOUND AT ARMY RECEPTION CENTRE

The 5,619 men examined by the Foot Survey at the Reception Centre were found to have the following defects. (Figures abstracted and condensed from Tables I and II, Appendix "B").

	<u>Number</u>	<u>Percentage</u>
Hypermobile Flat Foot with Shaft Tendo-Achillis (mild or severe).	217	6.0%
Personal Spastic Flat Foot.	74	2.0
All other Cases of Low Arch.	324	14.5
Pes Cavus (mild or severe).	427	11.8
Accessory Tarsal Scaphoid and/or Prominent Tub.	178	4.9
Hallux Valgus (mild or severe).	79	2.2
Hammer Toe	22	0.6
Hallux Rigidus	135	3.7
Exostosis	42	1.2
Skin Lesions	392	10.8
First Metatarsal shorter than Second (Norton)	1282	35.5

PRESENTATION OF DATA

The Problem of Flat Foot

At the outset of the Survey there was encountered the problem of defining what is meant by the term pes planus (Flat foot). In any attempt to define this condition two aspects are involved: concerned respectively with structure and function. There may be no association between them. It is common practice to interpret literally the term pes planus and regard it as meaning lowering of the longitudinal arch and increase in the area of the

PRESENTATION OF DATA

The information obtained from the various phases of the Survey has been analysed and tabulated in as great detail as seemed informative. The analytical tables will be found in Appendix "E". They represent accurate sources of statistical information, deserving of careful study. A more general picture of the findings of the Survey will be given here, the statistical facts being drawn from the tables.

INCIDENCE AND NATURE OF FOOT DEFECTS
FOUND AT ARMY RECEPTION CENTRE

The 3,619 men examined by the Foot Survey at the Reception Centre were found to have the following defects. (Figures abstracted and condensed from Tables I and II, Appendix "E").

	<u>Number</u>	<u>Percentage</u>
Hypermobile Flat Foot with Short Tendo-Achillis (mild or severe).	217	6.0%
Peroneal Spastic Flat Foot.	74	2.0
All other Cases of Low Arch.	524	14.5
Pes Cavus (mild or severe).	427	11.8
Accessory Tarsal Scaphoid and/or Prominent Tuberosity of Scaphoid.	178	4.9
Hallux Valgus (mild or severe).	79	2.2
Hammer Toe	22	0.6
Hallux Rigidus	135	3.7
Exostosis	45	1.2
Skin Lesions	392	10.8
First Metatarsal shorter than Second (Morton)	1282	35.5

The Problem of Flat Foot

At the outset of the Survey there was encountered the problem of defining what is meant by the term pes planus (flat foot). In any attempt to define this condition two aspects are involved: concerned respectively with structure and function. There may be no association between them. It is common practice to interpret literally the term pes planus and regard it as meaning lowering of the longitudinal arch and increase in the area of the

of the medial margin of the sole which is in contact with the ground. This is the convenient acceptance of visible and obvious deformity which lends itself to ready appreciation and even to recording by means of foot prints but it bears no constant or certain relationship to impaired function. Feet may have marked depression of the longitudinal arch, marked increase in the area of the sole in contact with the ground and marked valgus tilt of the os calcis and still be free from symptoms and be capable of sustaining prolonged and strenuous effort. A conspicuous example of such a type of valgus foot is that which exists as a compensatory measure to bow legs, Fig. 12. Here to compensate for the incurve of the tibia and permit the sole of the foot to be applied to the ground, it is necessary for the foot to be tilted out into valgus. Even when of severe degree this compensatory valgus is not associated with disability. Conversely, feet may display minimal evidence of flatness and be grossly limited in their capacity to bear weight or to walk long distances.

It is evident therefore, that we cannot be content merely to recognize the deformity of flat foot. Our concern is with function. If this is good it matters little whether or not the longitudinal arch is depressed. Further, more than one type of flat foot exists and each type of flat foot can occur in varying degrees of severity with corresponding variations of functional capacity. Much of the confusion in regard to foot problems arises from two causes: 1. acceptance of flatness of the foot as an index of functional incapacity and 2. failure to distinguish between the different types of flat foot.

In this Survey we have recognized three classifications of flat foot: 1. hypermobile flat foot with short tendo achillis (abbreviation HFF-STA), 2. peroneal spastic flat foot and 3. all other cases of low arch. The first group, while not very common (6% overall incidence: 27% of all low arch cases) is important because it is always associated with some degree of functional incapacity, often severe. The second group is rare, (2% overall incidence: 8% of all low arch cases) but it also is important because of the constancy and severity of the functional incapacity it causes. The third group while large (14.5% overall incidence:



Fig.12 - Valgus foot compensatory to bowlegs.

64.4% of all low arch cases) is of little significance since it causes little or no incapacity. It represents variations in normal structure whereas the first two may be regarded:- one the result of a serious structural abnormality and the other the result of pathological changes in the foot associated with reflex muscle spasm. Discussion of the various types of flat foot follows.

Hypermobile Flat Foot with Short
Tendo Achillis (HFF-STA)

We have given the descriptive designation "hypermobile flat foot with short tendo achillis" to a clearly defined and severely disabling type of flat foot which heretofore has not been definitely recognized. Several authors (5.6.7.) have noted the association of a short tendo achillis with a severe and disabling type of flat foot and some have regarded the short tendo achillis as the cause of the flat foot (5). As far as we are aware no one has recognized and described the condition as a distinct entity with a characteristic history and characteristic physical findings and no one has suggested that the cause of the condition is a structural abnormality in the relationship of the talus to the calcaneus. This we feel is the basis of the condition. Our studies in the Foot Survey and elsewhere have yielded evidence to support such a contention. A detailed description of this type of flat foot therefore is necessary.

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5. Hibbs, R., Muscle Bound Feet. New York Medical Journal, Oct. 1914.
 6. Schultz, F. Die Behandlung des Statischen Plattfusses Millelst des Redressement Force und der Sehnen Plastik. Zeitschrift fur orthopaedische chirurgie, vol. 13, p. 302. 1904.
 7. Gocht, Halle, H. Sehnenoperation Beim Pes Planus. Zeitschrift fur orthopaedische chirurgie, vol. 14, p. 619. 1905.

History. Hypermobility flat foot with short tendo achillis is a severe and disabling type of flat foot based upon a congenital structural anomaly in the relationship of the talus to the calcaneus. It is the common severe bilateral flat foot of childhood, adolescence and young adult life. Since the structural abnormality is congenital, the flat foot appears early in life. Many cases and perhaps all are manifest in childhood by flatness of the feet but for a varying period of time the condition gives rise to no symptoms and will only be recognized if an alert and observant parent notices the flatness of the feet. Sooner or later there appear symptoms of pain and aching in the feet and tiredness on standing or walking. Symptoms may appear at an age as early as five years but perhaps they more commonly appear in the early teens. From the first appearance of symptoms there usually is a continuous history of foot disability and limited capacity for foot effort. The boy learns to avoid strenuous sports and heavy activities and by this means adjusts himself to a regime of activity which falls within the limits of his capacity. The characteristic history, therefore, is one of flat feet since childhood with some degree of incapacity observed first in late childhood or early teens and continuous since then. It should be emphasized however, that the disablement in youth usually is not as great as might be expected from the degree of flatness of the feet. Also there are wide gradations in the basic abnormality and consequently wide variations in the severity of the deformity and in the degree of functional incapacity.

Clinical Features. Clinical examination of such feet reveals distinctive features. The flatness of the feet is manifest only when the patient bears weight upon them. Fig. 13. The degree of flatness usually is severe, though there are exceptions to this statement. When weight is completely removed from the feet they assume a shape which seems completely normal. Fig. 14. To demonstrate this feature it is necessary that the feet be completely relieved of weight and this can best be accomplished by seating the patient on the edge of a table and permitting his legs and feet to dangle freely from the knees. The disappearance of the flatness when the feet are relieved of weight bearing is an evidence of the mobility of the feet and of the elimination of the action of the short tendo-achillis, a factor to be discussed now.



Fig.13 - Hypermobile flat foot with short tendo achillis. Severe flat foot on weight bearing.



Fig.14 - Hypermobile flat foot with short tendo achillis. The feet assume normal shape when they are relieved of weight bearing.

If movement at the ankle joint be examined carefully, it can be demonstrated that its range in dorsiflexion is greatly limited. To obtain comparable results in this test, it is necessary that the knee be fully extended while the ankle joint movements are being carried out, otherwise variations in the tension of the gastrocnemius will modify the range of dorsiflexion at the ankle. It is of equal importance to ensure that only movement at the ankle joint is permitted. For this purpose movement at the subastragalar and mid-tarsal joints must be eliminated by the manner in which the foot is held. Fig. 15. When examined with careful observance of these details (knee fully extended - movement at subastragalar joint eliminated) the hypermobile flat foot with short tendo achillis displays a remarkable limitation of the range of dorsiflexion. Fig. 16. This never reaches a right angle and frequently falls short of a right angle by 25° (i.e. the angle of greatest dorsiflexion is 115°).

Table 12 of Appendix "E" shows clearly the nearly constant existence of a considerable amount of limitation of dorsiflexion at the ankle joint in cases of hypermobile flat foot with short tendo achillis. Of the severe cases of HFF-STA 80% fail to dorsiflex to a right angle (zero reading of Table 12). For mild cases the proportion is 48.8% while of normal feet all but 2.8% dorsiflex past a right angle.

The limitation of dorsiflexion in movement of the ankle joint is concealed and may be overlooked on casual observation by another and equally characteristic feature of the hypermobile flat foot with short tendo achillis: viz. an unusual degree of mobility of the subastragalar and midtarsal joint (talo-calcaneal, taloscapho-calcaneal and calcaneo-cuboid joints). Normal movement in these related tarsal joints is complex and results in valgus of the heel, abduction of the forepart of the foot at the mid-tarsal joint and eversion of the forepart of the foot. These elements of the complex movement are all greatly increased in range in the type of flat foot under discussion and particularly the element of eversion of the forepart of the foot. Because of the greatly increased range of movement of the subastragalar and mid-tarsal joints, it is possible for the forepart

of the foot to swing upwards and outwards to an unusual degree although it accomplishes this by an accompanying valgus of the heel and bulging (mid-tarsal valgus) of the inner margin of the foot. The increase in the sweep of the forepart of the foot upwards and outwards is sufficient to permit the heel to come down on the ground in spite of the short tendo achillis. Therefore, as far as the forepart of the foot is concerned movement upwards (dorsi-flexion) consists of dorsi-flexion at the ankle joint to which is added as a final element, an upward and outward swing which takes place in the subastragalar and mid-tarsal joints and is accompanied by valgus of the heel and abduction at the mid-tarsal joint. Up to the limit of dorsi-flexion at the ankle the foot can remain normal in shape, but as soon as the limit in dorsi-flexion at the ankle is reached, further dorsi-flexion of the forepart of the foot, necessary to permit the heel to reach the ground, can only be accomplished by a movement which, at the same time, tilts the heel into valgus and breaks the foot inwards and downwards at the mid-tarsal joint, in other words, produces flat foot.

It should be noted here that the phrase "with short tendo achillis" in the descriptive title, while describing accurately what is found in these cases, does not necessarily imply that the short tendo achillis is the cause of this type of flat foot. Indeed, we believe that the cause of the trouble is a structural bony fault and that the short tendo achillis and the hypermobility of movement at the subastragalar and mid-tarsal joints are the result of stresses which are placed upon these joints by reason of the structural weakness. We would have preferred a simpler term to designate this type of flat foot, but since above all else a descriptive term is necessary, we have chosen one which indicates the chief clinical features of the condition.

A further clinical feature characteristic of hypermobile flat foot with short tendo achillis is the instability of the subastragalar joint. This is constantly demonstrated when examining the range of dorsi-flexion of the ankle joint by the technique previously described. It is not easy to eliminate movement at the subastragalar and mid-tarsal joints because with every

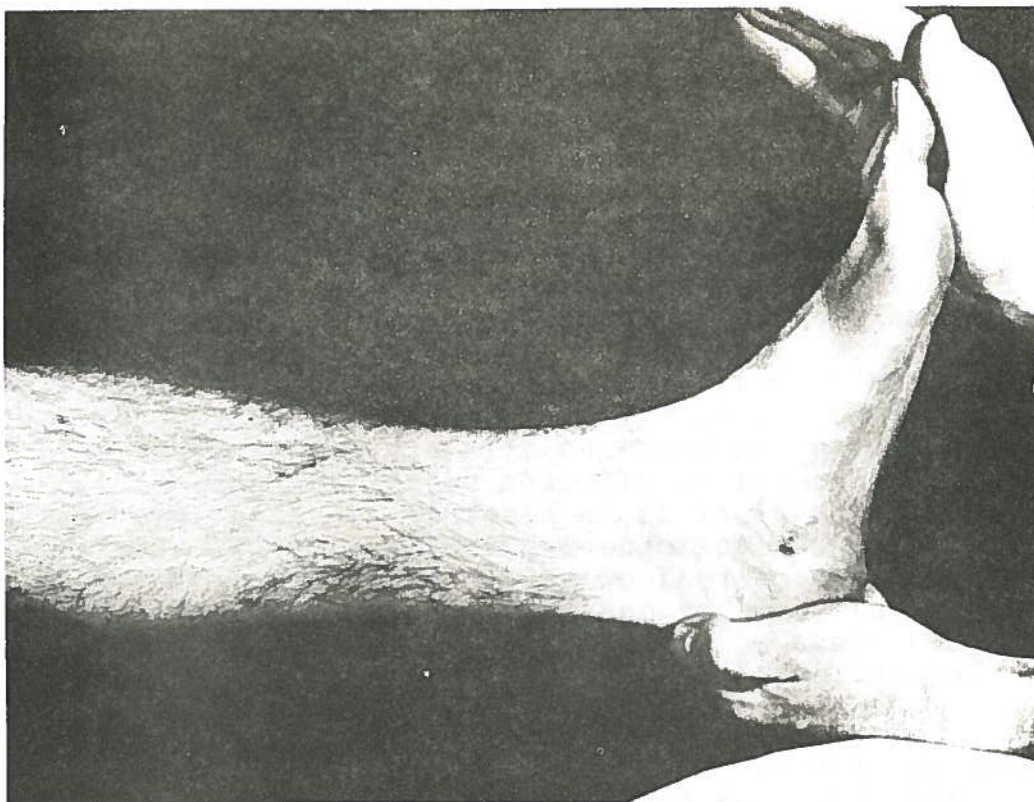


Fig.15 - Hypermobile flat foot with short tendo achillis. Examination to determine the range of dorsi-flexion at the ankle joint. The heel is grasped in such a manner as to prevent movement at the subastragalar joint and the foot is dorsi-flexed by upward pressure on the ball of the foot.

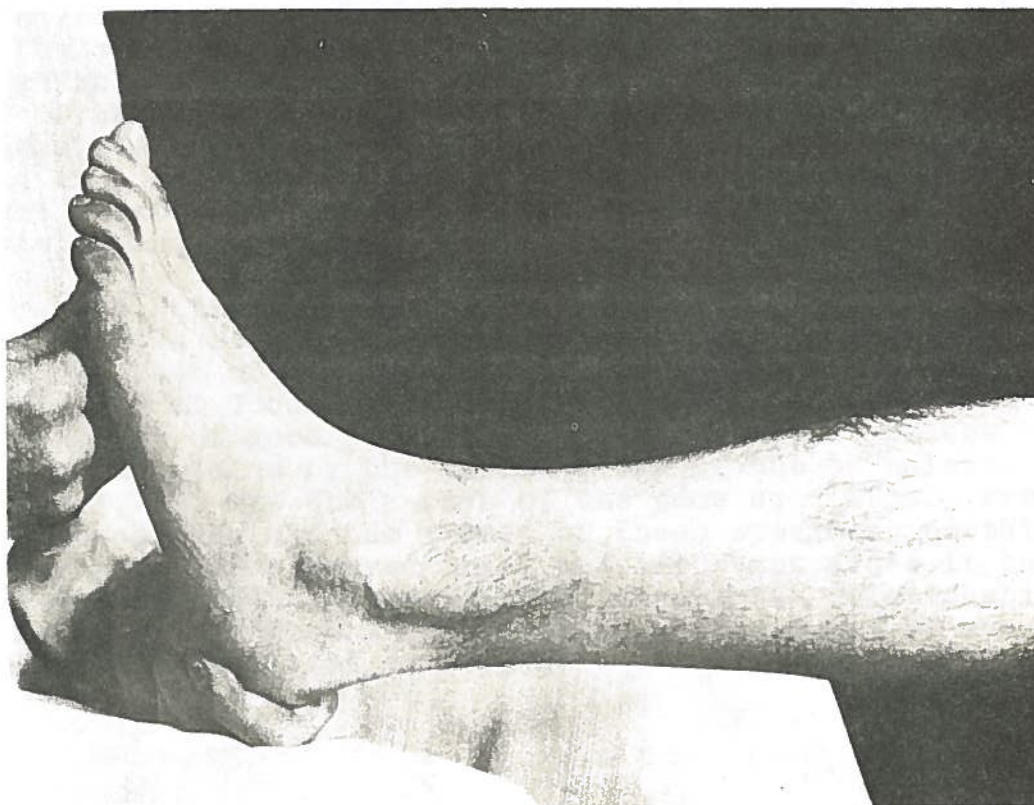


Fig.16 - Hypermobile flat foot with short tendo achillis. This illustrates the limit of dorsi-flexion which is obtained by movement solely at the ankle joint. Further dorsi-flexion of the forefoot is accomplished by movement at subastragalar and mid-tarsal joints and is accompanied by valgus.

attempt to dorsi-flex the foot the forefoot tends to slip out into valgus. There is only one narrow segment in its range of movement in which pressure against the ball of the foot produces only movement at the ankle joint. So precise is the position in which the foot must be maintained to limit movement at the ankle joint, that the slightest movement to one side or the other permits the forefoot to slip off either medially or laterally (most commonly the latter). It feels as if it were balanced on a point. If it is maintained at exactly the correct point, considerable force can be applied to the ball of the foot. When the point of balance is lost, the forefoot suddenly flips up and out through its whole range of movement without any resistance until the limit of valgus is reached.

Anatomical Features. Previous studies on this type of foot by one of us (R.I.H.) had suggested the possibility that its primary basis might lie in the bony anatomy of the foot. Through the courtesy of Prof. J.C.B. Grant and the interest of Prof. H.A. Cates of the Department of Anatomy of the University of Toronto, studies in the tarsal bones were undertaken by Prof. Cates which revealed wide variations in the relationship of the talus to the calcaneus especially with reference to the manner in which the head of the talus is supported by the anterior end of the os calcis. Since the weight of the body is transmitted to the ground in considerable part through the head of the talus, the manner in which it is supported might greatly influence its range of movement and its position under stress.

Figs. 17, 18, 19, 20 illustrate four different views of two sets of talus-calcaneus. These were selected from the feet of 200 cadavers in the Department of Anatomy, University of Toronto to illustrate the extremes within this group, of good support and of poor support of the head of the talus by the anterior end of the os calcis. Figs. 21, 22, are the x-rays of the same specimens. From the photographs and the x-rays of these specimens certain features can be observed which are important since it has proven possible to reveal similar structural relationships by means of clinical x-rays. These features may be summarized and tabulated as follows:

chosen from 200 cadavers to illustrate the extreme examples of firm support and weak support of the head of the talus by the anterior end of the os calcis. This is the structural basis for the disabling type of flat foot characterized by hypermobility of the subtalar and metatarsal joint and limitation of dorsi-flexion at the ankle joint. See description in text.

	<u>Firm Support of Head of Talus</u>	<u>Weak Support of Head of Talus</u>
Figs. 17 & 21		
Superior view	Sustentaculum tali	Sustentaculum tali
Bones separated	broad, rounded and runs forward to anterior margin of calcaneus. Articular facet on anterior margin of calcaneus is continuous with sustentaculum tali.	a narrow tongue like process springing from the medial side of the calcaneus far back and from a narrow base. No facet on anterior margin of calcaneus.
Figs. 18 & 22		
Superior view	Head and neck of talus short and thick. Head superimposed over anterior end of calcaneum. Calcaneus tends to be thick and short.	Head and neck of talus elongated and project forward and medially much beyond anterior end of calcaneum. Head of talus lies anterior and medial to anterior end of calcaneum and is not superimposed upon it.
Fig. 20		
Anterior view	Centre of head of talus lies nearly over the centre of the anterior end of calcaneus and nearly flush with it.	Centre of head of talus lies far medial to centre of anterior end of calcaneus. Head of talus projects forward from anterior end of calcaneus. There is no contact between head of talus and anterior end of calcaneus, no articulation and no support.



Fig. 17

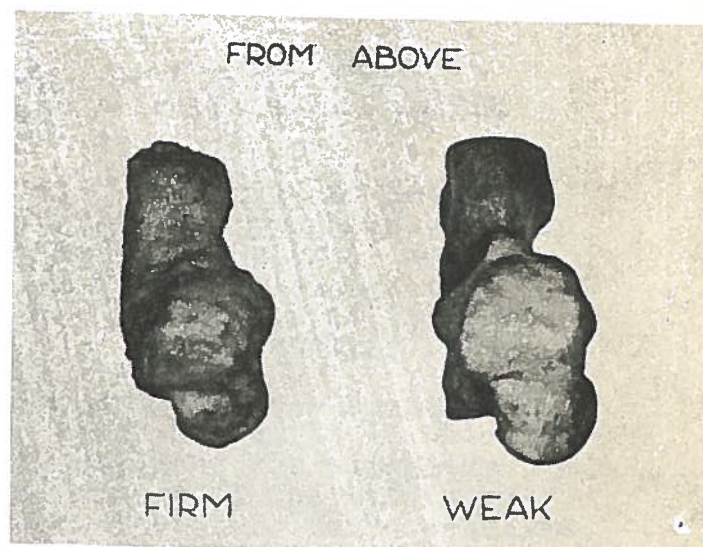


Fig. 18

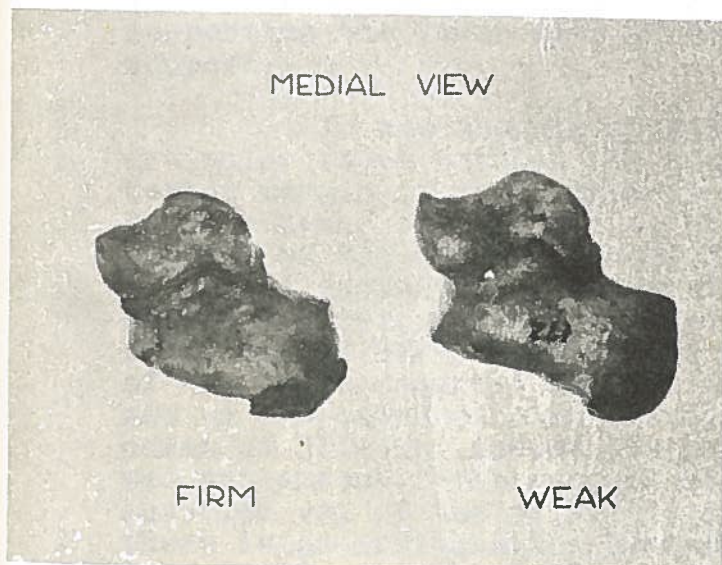


Fig. 19

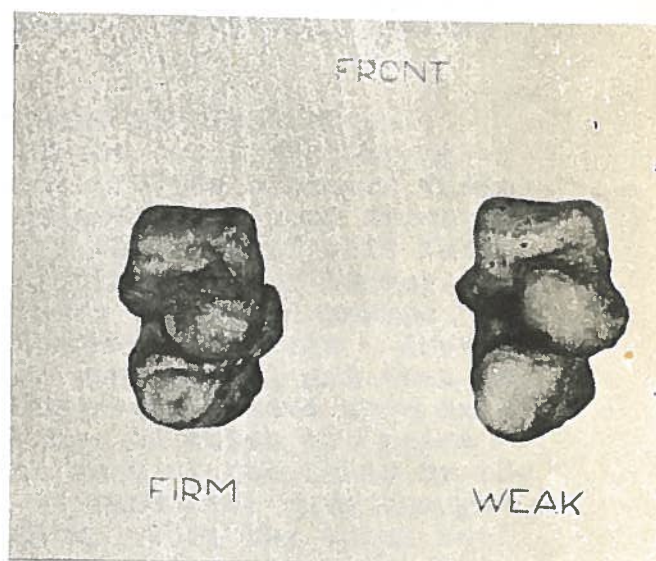


Fig. 20

Anatomical specimens from Dept. of Anatomy, University of Toronto, chosen from 200 cadavers to illustrate the extreme examples of firm support and weak support of the head of the talus by the anterior end of the calcis. This is the structural basis for the disabling type of flat foot characterized by hypermobility of the subastragalar and metatarsal joint and limitation of dorsi-flexion at the ankle joint. See description in text.

Firm Support
of Head of Talus

Weak Support
of Head of Talus

Fig. 21

Oblique View

Head of talus articulates with anterior end of calcaneus by a well defined facet which supports the talar head.

There is no facet in this specimen between the anterior end of the calcaneus and the head of the talus (rare anomaly).

The clear evidence provided by these anatomical specimens of the wide variation which may exist in the support provided to the head of the talus by the calcaneus offers an explanation for the existence of the entity we have called hypermobile flat foot with short tendo achillis. When the talar head lies medial to the anterior end of the calcaneus the weight of the body is transmitted through the talus and through the anterior pillar of the foot in a manner which tends to press the foot downwards and inwards at the talo-navicular joint. The body weight acts as a great force to flatten the inner margin of the foot which is only resisted by the spring ligament and by the muscles supporting the inner side of the foot, there being no bony support.

It was thought at first that the lack of an articular facet between the head of the talus and the anterior margin of the calcaneus might provide a simple radiographic means of recognizing the existence of poor structural support of the talus. Unfortunately the lack of this facet is a rare anomaly. It occurred 187 times in our Survey. While, generally speaking, these cases presented marked evidences of HFF-STA, such was not always the case. Absence of the facet occurred in feet which were normal and even on one or two cases of claw foot. Conversely, there were many cases of HFF-STA, indeed the majority, in which the facet was not absent. The support of the head of the talus by the anterior end of the os calcis can be imperfect even though there is an articulation between them. When the talar head is medially displaced in relation to the calcaneus the anterior facet is oblique and is not disposed in such a manner as to provide direct support. Its obliquity invites downward displacement of the head of the talus when it is loaded with the body weight.

The condition we have designated hypermobile flat foot with short tendo achillis is therefore a clinical syndrome characterized by: 1. Flat Foot when weight is borne upon the foot and disappearance of deformity when the foot hangs free. 2. Limitation of dorsi-flexion at the ankle joint. 3. Increased mobility at the subastragalar and mid-tarsal joints. 4. Instability of the subastragalar joint. It may exist in every gradation of severity from the mildest case which is barely detectable to the most obvious deformity and severe disability. Moreover, two major elements of the syndrome (limitation of dorsi-flexion at the ankle joint and hypermobility of the subastragalar joint) may not run parallel to each other. The occasional case is seen in which there is definite limitation of dorsi-flexion at the ankle joint with little or no hypermobility at the subastragalar joint. (Figs. 23, 24 and 24A). Also there may be little limitation of dorsi-flexion at the ankle joint but well marked hypermobility of the subastragalar joint.

The feature of hypermobility of the subastragalar and mid-tarsal joints which is so characteristic of this condition tends to be replaced slowly by stiffness with advancing years. In the later decades of life the foot becomes fixed in the deformed position by the development of osteo-arthritic changes by reason of undue strain upon the joints. It becomes a rigid flat foot.

Incidence of HFF-STA in Survey. In the 3,619 men examined at the Reception Centre there were 217 cases of hypermobile flat foot with short tendo achillis. Of these 192 were mild in degree and 25 severe. Five of the severe cases were enlisted - (they had been given an L1 grading by the Army Reception Centre staff though the grading of the Foot Survey was L3 and L4). The accuracy of the Foot Survey's estimate of their functional capacity was borne out by their performance during training. All five were unable to complete the syllabus of marching and training and had to be downgraded. Of the mild cases 64 were enlisted (presumably the least severe) and of these 16 (25%) were unable to meet all the requirements of the syllabus. In this group of mild cases the condition again was recognized and its significance ap-



Fig.21 - Radiographs of the anatomical specimens illustrated in Figs.17, 18, 19 and 20. Specimens illustrating firm support of the head of talus on the left: that illustrating weak support on the right.

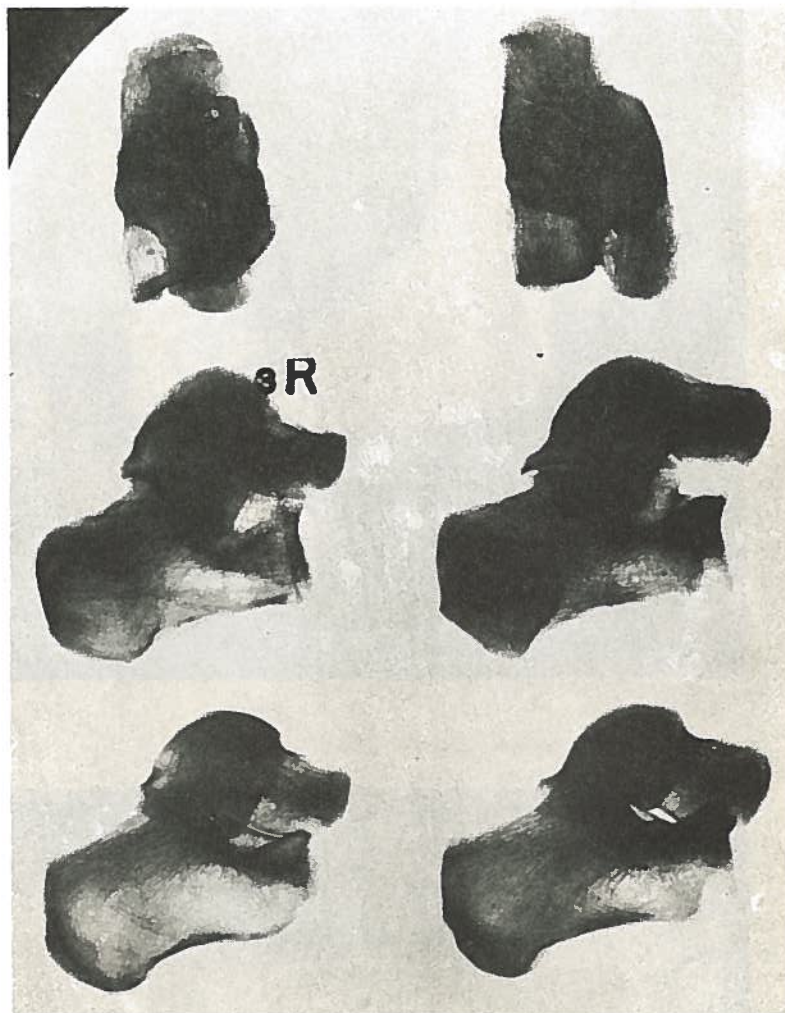


Fig.22 - Radiographs of anatomical specimens illustrated in Figs. 17 - 21. In this figure the talus and calcaneus are articulated. That of firm support is on the left and that of weak support is on the right. Supero-inferior - top. Oblique - centre. True lateral - below. X-ray technique for these radiographs was identical to that used in clinical cases for the whole Survey.

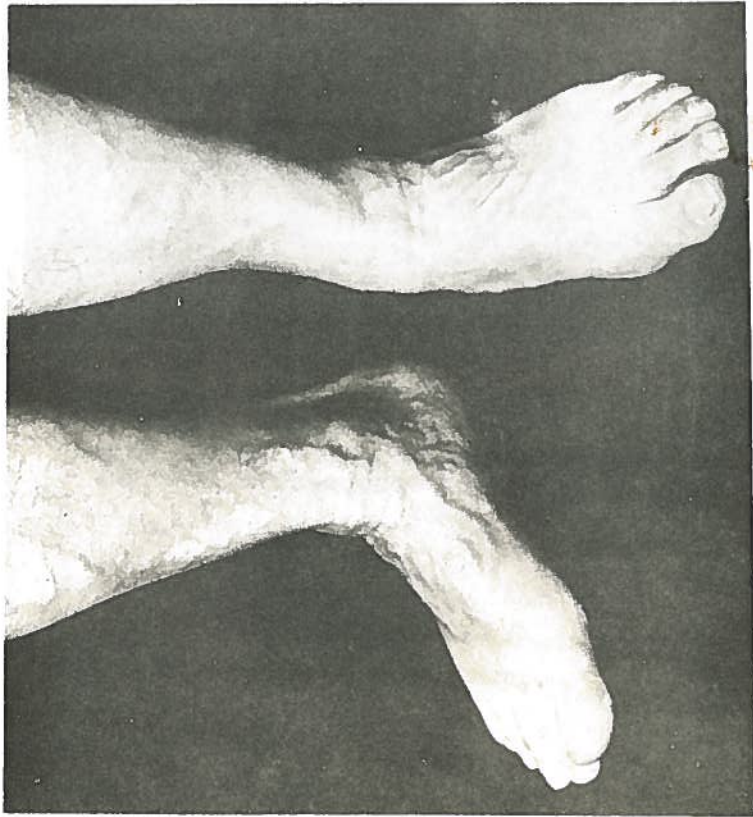


FIG.23 - To illustrate that the basic elements of HFF-STA may exist in varying degrees of severity. In this case the element of shortness of the tendo achillis is marked but there is little hypermobility of the subastragalar and mid-tarsal joints and hence little flattening of arch. The arch is good on weight bearing.

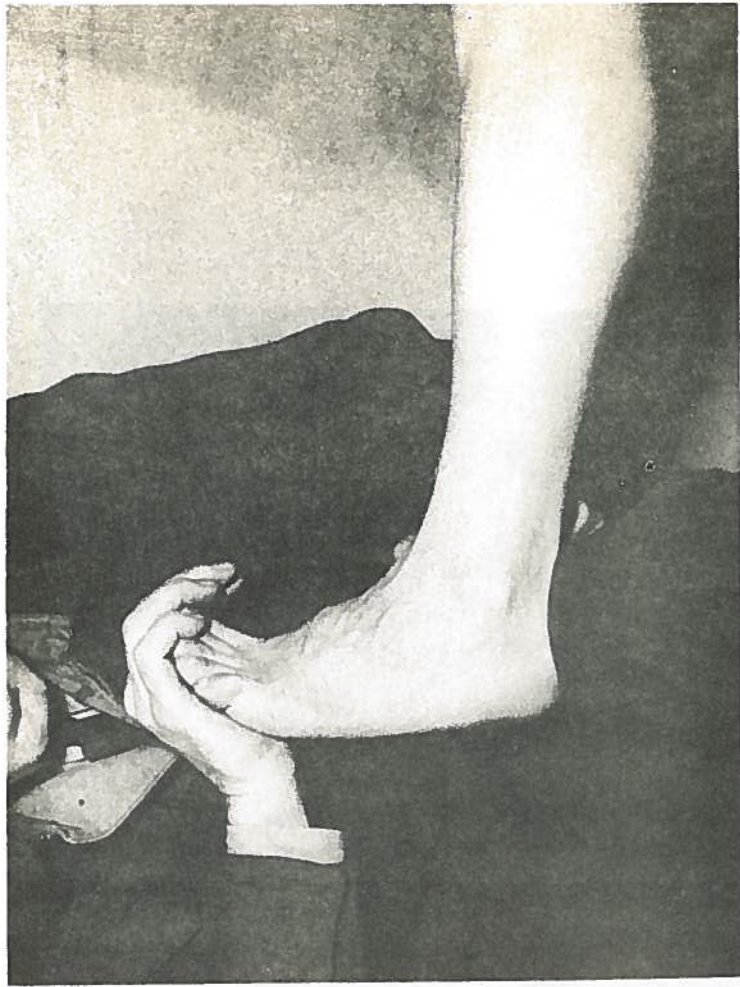


Fig.24 - Same case as in Fig.23 to illustrate the shortness of the tendo achillis. Dorsi-flexion at ankle stops at -7° (i.e. angle of greatest dorsi-flexion = 93°).

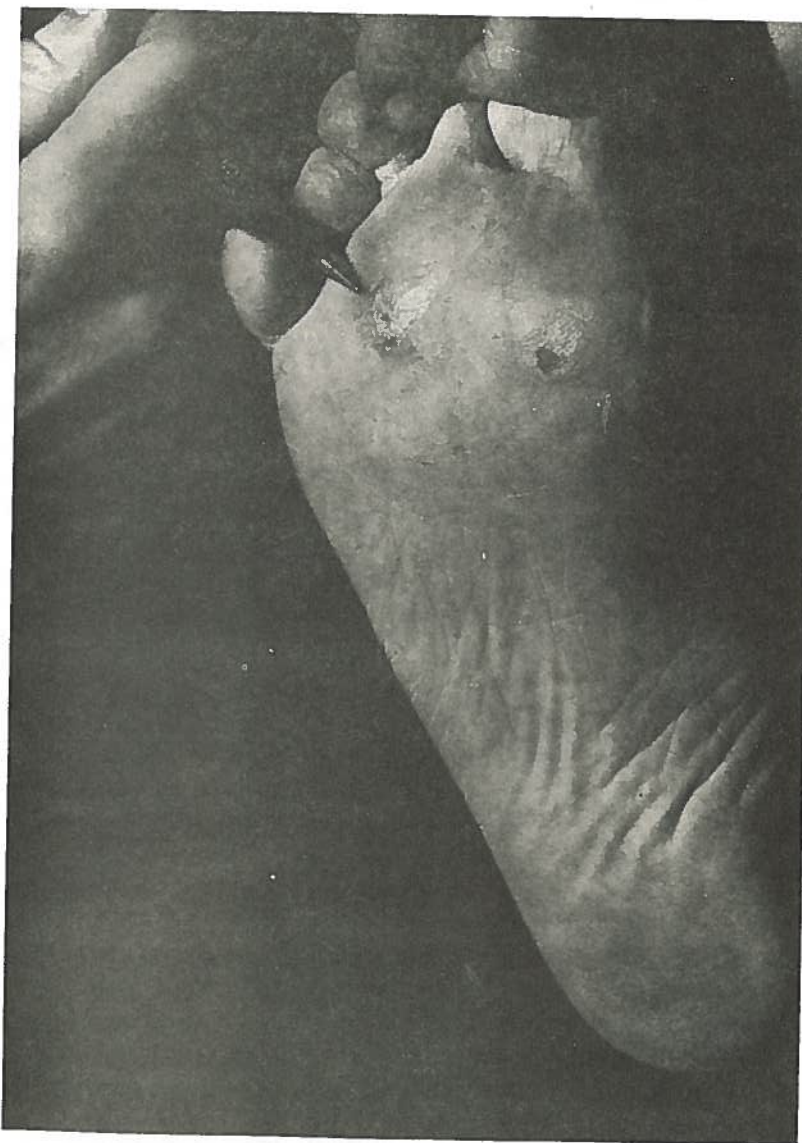


Fig.24a - Same case as in Fig.23. Because of short tendo achillis and a firm arch much stress comes on heads of metatarsals which in consequence develops calluses.

preciated more clearly by the Foot Survey team than by the Reception Centre staff. The former gave no L1 gradings; 72 gradings of L2 or 3 and 2 gradings of L4. The corresponding figures given by the Reception Centre staff were L1 - 62; L2 - 12. The significance of this is that this particular type of flat foot is not generally recognized nor is its effect upon function appreciated. These cases were regarded as mild cases of flat foot, if they were recognized at all, and their limited capacity for heavy loading was not appreciated.

X-ray Studies of HFF-STA. Part of the purpose of the detailed and somewhat elaborate series of measurements from the standard x-ray films was the hope that we might by this means develop a technique for the simple and ready recognition of the condition. The standardized x-ray technique did provide films of good and uniform quality in which the basic structural features present in the anatomical specimens could be readily recognized (medial displacement of head of talus, tongue like shape of sustentaculum tali which does not reach to anterior end of os calcis). But on the whole, a considerable number of measurements proved disappointing, since they did not show variations which were statistically significant from which one could, with certainty, recognize from the x-ray the existence of hypermobile flat foot with short tendo achillis. The general conclusion we have drawn from study of this problem based upon several hundred cases is that diagnosis is best made upon the findings of history and clinical examination. It would have been satisfactory to have developed an x-ray technique which would infallibly demonstrate this condition but our failure to do so is no great loss and is perhaps an advantage. The history is so characteristic, the clinical features are so distinctive that the diagnosis can be made on these grounds much more simply than upon radiographs which would necessitate special equipment and technique.

The measurements which were made upon the standardized x-rays in the hope of proving the existence by radiography of HFF-STA were as follows:

1. The angle between the axis of the talus and the axis of the calcaneus. Supero-inferior view. See

Appendix "F", Graph 1. Because of the medial displacement of the head of the talus in hypermobile flat foot with short tendo achillis, it was thought that there might be a significantly greater divergence between the axis of the talus and the axis of the calcaneus. In the standardized x-ray it was easy to visualize the two bones and to draw in their long axes. Graph 1 is the analysis of these measurements separated into four groups: (a) HFF-STA. (b) Flat foot other than HFF-STA. (c) Cavus feet. (d) All other cases. There is not sufficient divergence of this x-ray measurement in the case of HFF-STA to make it of significant value in the recognition of this type of foot disability.

2. Forward projection of the head of the talus in front of the calcaneus. Supero-inferior view. See Appendix "F", Graph 2. By grouping the cases as for Graph 1 it is possible to demonstrate that, in general, this measurement is greatest for HFF-STA and least for claw foot. There is however, a wide range of variation within each group. Great overlapping therefore occurs which makes distinction between the groups difficult and impractical.

3. Slope of the sustentaculum tali. See Appendix "F", Graph 3. There is a consistent variation in the angle of the slope of the sustentaculum tali; greatest in severe HFF-STA and least in severe cavus feet. It can be regarded as an essential part of the structural picture of this type of flat foot. It is possible to recognize that the HFF-STA as a group are characterized by a high angle though in an individual case there might be difficulty in recognizing the condition from this measurement alone.

4. Length of spring ligament in millimetres. See Appendix "F", Graph 4. This measurement is longest in the group of HFF-STA and shortest in the cavus group.

5. Distance of the sustentaculum tali behind the anterior end of the calcaneus. See Appendix "F" Graph 5. This measurement is the most distinctive of all the measurements undertaken in the Survey to distinguish flat feet from normal feet from cavus feet. As might be anticipated from the photographs and x-rays

(Figs. 17, 18, 19, 20, 21, 22) which are discussed on pages 35 to 37, the measurement is greatest in HFF-STA and least in normal and cavus feet. Though this measurement is significant and important, the simple recognition in the x-ray of the tongue-like shape of the sustentaculum tali is of even greater practical importance. It is so shaped in nearly all severe cases of HFF-STA.

6. Proportion of the diameter of the head of the talus which overlies the calcaneus in the superoinferior view. See Appendix "F", Graph 6. This is a measure of the medial displacement of the head of the talus as displayed by the x-ray - the greater the medial displacement the less the head of the talus overlaps the anterior end of the calcaneus. Analysis of this measurement shows the overlap least in flat feet and greatest in cavus feet.

7. Proportion of the diameter of the head of the talus which overlaps the calcaneus in the lateral view. See Appendix "F", Graph 7. There is a measure of the downward displacement of the head of the talus in depression of the longitudinal arch (flat foot). The measurements vary with the grading from flat foot to cavus. In flat foot the head of the talus is depressed and the overlap is greatest; in cavus the head of the talus is elevated and the overlap is least. This is an important measurement since it demonstrates that an important part of the shifting of the tarsal bones, which occurs in flat foot, occurs between the talus and the calcaneus. The measurement also is an accurate index of the degree of planus which is present.

8. Length of the calcaneus in millimetres. See Appendix "F", Graph 12. This was an attempt to confirm or disprove the apparent fact observed in the anatomical specimens, viz. that hypermobile flat foot with short tendo achillis is associated with a long slender calcaneus. The measurements indicate that there is a gradual trend for the calcaneus to be shorter in the higher arch cases. The differences however are not great and consequently they are not of great value in the x-ray recognition of the condition. The significance which can be attached to them is that they add one further item of

confirmation to the conception that the shape of the arch of the foot is intimately related to its bony structure.

Graphs 8,9,10,11,13,14,15,16 and 17 in Appendix "F" are of measurements related to flat feet including HFF-STA but not specifically concerned with the latter.

The radiographs are of great value in anthropometric studies since they permit a wide variety of measurements to be correlated with clinical manifestations. Being standardized, measurements from them are strictly comparable. Much can be learned of the relationship of bony structure to clinical foot types and to function. As a means of diagnosing specific foot types from measurements, they are of less value especially in individual cases. There is sufficient overlapping of the range of measurements from type to type to make it impossible to define precisely the limits of normal and hence impossible to state that beyond a certain point measurement is abnormal. An equivalent problem which illustrates the difficulties of such measurements would be an attempt to determine the mid position of rotation of the hip joint by means of radiographs. By observation of a significant number of radiographs it would be possible to establish a range of measurements which would mark the boundaries of the mid position for the individuals of the group. But to read a single film and determine from it whether the hip was in its mid position would be impossible, only probabilities could be stated.

On the other hand, the revelation by the x-ray of certain distinctive features in bony structure (the tongue-like shape of the sustentaculum tali and the long and slender os calcis) is valuable information.

DISCUSSION OF DATA

Hypermobile Flat Foot with Short Tendo Achillis

The observations made during this Survey, together with previous studies, lead us to believe that there exists, as a distinct clinical entity, a disabling type of flat foot presenting a characteristic history

and clinical findings. It has not been clearly recognized or defined heretofore though there have been references to certain of its clinical features in discussions upon flat feet, particularly the limitation of dorsi-flexion at the ankle joint. Because of the clinical features which characterize it we propose to designate it by the descriptive title of hypermobile flat foot with short tendo achillis.

The basis of this type of flat foot is a structural alteration of the normal relationship of the talus to the calcaneus such that the head of the talus lacks the normal bony support provided it by the anterior end of the calcaneum. These deviations from normal structure of the bones are demonstrable by suitable radiographs and by anatomical specimens.

The condition is best recognized and distinguished from other types of flat foot by: 1. The history of foot flatness extending back into childhood and of foot disability commencing in late childhood or early teens. 2. The clinical demonstration of limitation of dorsi-flexion at the ankle joint, hypermobility of the subastragalar and mid-tarsal joint and instability of the mid-tarsal joint.

It exists in every gradation of severity from mild to extreme. It is the most disabling type of flat foot though in youth the disability often is less than might be anticipated from the severity of the deformity. Nevertheless, there is a greatly diminished load capacity in this type of foot. In later life it tends to become rigid by the occurrence of osteo-arthritic changes.

Its incidence in the male population of Canada between the ages of 18 to 35 years, as determined by this Survey, is 6% and it constitutes 25% of all the cases of flat foot and low arch encountered in this age group.

It is a serious bar to military training. All the more severe cases encountered in this Survey who were enlisted failed to complete their syllabus of training and 25% of the mild cases also broke down during training.

Peroneal Spastic Flat Foot

A distinctive and disabling type of flat foot of obscure etiology is that which is designated peroneal spastic flat foot or spastic flat foot. It is characterized by eversion of the foot chiefly at the subastragalar joint, by reason of spasm of the peroneal muscles. Flattening of the longitudinal arch occurs but not to the intense degree which is seen in hypermobile flat foot with short tendo achillis and often the element of flat foot is minimal and sometimes is absent. The distinctive feature is peroneal spasm. This is intense and unremitting.

Clinically the condition is often unilateral. On examination the foot presents a degree of flat foot varying from mild to moderate severity. The deformity is eversion at the subastragalar joint rather than depression of the longitudinal arch. The deformity remains unchanged whether or not weight is borne upon the foot. Moreover it is impossible to change the position of the foot by manipulation. The spasm of the peroneal muscles holds the foot in the extreme position of eversion and no amount of manipulation will overcome the eversion. Forceful manipulation is painful. Anaesthesia, either general or local, which causes relaxation of the peroneal muscles, permits correction of the deformity, though often this correction is incomplete.

There are some cases in which the element of peroneal spasm is minimal or even absent. It may be that these are not true cases of peroneal spastic flat foot. At any rate, they are characterized by fixed eversion of the foot and inability to invert the foot. In this Survey we have grouped both types together. This may be equivalent to classifying them together as "rigid flat foot" but in our opinion, most cases which are called rigid flat foot are examples of peroneal spastic flat foot. The few exceptions occur in later life as the result of the development of arthritic changes.

The etiology of peroneal spastic flat foot is obscure and in this Survey we have not been able to advance our knowledge regarding its cause. There is much evidence to support the belief that the primary lesion is in the tarsal joints and is of such a nature as to give rise to stimuli which initiate reflex spasm of the

peroneal muscles. If such be the case, the site of the initial lesion is not clearly known - neither is its nature (inflammatory or traumatic). The limitation of muscle spasm to one group of muscles also is difficult to explain. None the less, the appearance of peroneal spasm in certain chronic strains and also in such frank inflammatory lesions of the tarsal joints as rheumatoid or gonorrhoeal arthritis is the best evidence we have that peroneal spastic flat foot is caused by reflex spasm of the peroneal muscles initiated by lesions in the larger tarsal joints.

It seems evident that more than one etiological factor can cause the tarsal lesion which initiates the reflex which gives rise to the muscle spasm. Thus certain cases of hypermobile flat foot with short tendo achillis are accompanied by peroneal spasm during a phase of acute disability. It is well known also that acute inflammatory lesions of the tarsus such as rheumatoid and gonorrhoeal arthritis are accompanied by eversion due to peroneal spasm.

Peroneal spastic flat foot is a rare condition. Amongst the 3,619 cases examined at the Reception Centre 74 were found - an overall incidence of 2%. It constituted 9% of all the cases of flat foot and low arch from all causes. Many of the cases were mild.

Tables 1 and 2 in Appendix "E" show the incidence of peroneal spastic flat foot in relation to other disabilities found in the Survey. Table 5 in the Survey shows the L grading which was given to the 74 cases, both those which were enlisted and those which were not enlisted. Forty-two were given gradings of L3 or lower; 32 were graded L1 or L2. These were the milder cases.

Table 6 in Appendix "F" analyses the 74 cases into their various groups dependent upon their association or otherwise with flat foot and related conditions. It also separates those with peroneal spasm from those with rigid eversion without peroneal spasms.

Only 17 of the peroneal spastic cases were enlisted (7 severe, 10 mild). All encountered difficulties

in training - especially marked in the more severe cases.

An opportunity recently has occurred to study carefully a case of peroneal spastic flat foot with the aid of an electromyograph. This instrument offers new and unique opportunities to examine problems in neuro-muscular physiology. The results of the examination of the case may be summarized as follows:-

1. Clinical examination - the foot was held rigidly in marked eversion and this position could not be changed by manipulation or force.

2. Electromyographic examination of the muscle showed that it behaved as does a normal muscle - i.e. when at rest, though the foot was in valgus, the peroneal muscles were silent, which means that they were not in continuous contraction. However the moment that an attempt was made to invert the foot, the muscles were instantly bombarded by a great burst of impulses which appeared more quickly and in greater number than normal.

3. Novocaine block of the subtalar joint; of the mid-tarsal joint or of both combined, did not result in any abatement of the spastic valgus.

4. Complete novocaine block of the peroneal nerve at the neck of the fibula so as to cause paralysis of the anterior tibial and peroneal muscles and anaesthesia of the area of peroneal supply results, nearly, though not quite completely, abolishes the deformity. Presumably the prolonged fixation in valgus results in periarticular changes which permanently limit movement.

One concludes from this examination that the deformity is due to muscle spasm initiated by movement of the tarsus and presumably due to some irritative lesion of the tarsal joints though the nature and location of this lesion could not be demonstrated. The condition which is termed "muscle spasm" is demonstrated to be ready response by muscle contraction to stimuli induced by movement of the foot; movement which normally does not initiate this contraction. In "muscle spasm" the muscle is not in continuous contraction. (See Lapidus's recent paper. (8).

8. Lapidus, P.W. Spastic Flat Foot. J. Bone and Joint Surg. Vol.28, No.1, p.126, Jan. 1946.

All Other Cases of Low Arch

(i.e. Cases with low arch exclusive of HFF-STA and peroneal spastic flat foot)

The majority of men with flat foot (pes planus, low longitudinal arch) do not manifest the distinctive features of hypermobile flat foot with short tendo achillis or of peroneal spastic flat foot. They display merely varying degrees of lowering of the medial margin of the foot with increase in the area of the inner half of the sole which is applied to the ground. Table 2, Appendix "E" shows that there were 524 such cases (488 mild, 36 severe) compared with 217 cases of HFF-STA and 74 cases of peroneal spastic flat foot.

This group of cases is characterized by an appearance of deformity but with comparatively little associated disablement. Their feet are not rigid as in peroneal spastic flat foot; on the other hand, they are not hypermobile as in HFF-STA. For the most part they are stable normal feet except for the fact that a greater than normal proportion of the inner margin of the foot is applied to the ground. They may be regarded as variations from normal shape which are stable and strongly supported and because of this have little serious dysfunction. That this is so is evidenced by Table 16, Appendix "E" which shows that only 13.3% developed symptoms associated with the defect during training and of these less than one-third had serious symptoms. This incidence of symptoms is one-half that which developed in mild HFF-STA and questionable HFF-STA and one-sixth that which developed in severe HFF-STA during training.

Evidence that this defect is minor is the fact that most cases were given an L1 grading and there arose no occasion to change this.

This is the type of foot around which stories have gathered of good function in spite of the appearance of flatness; for example, the Indian who tramped 200 miles out of the bush in order that he might reach Edmonton to enlist and then tramped back again the 200 miles to his trapping ground after he had been rejected because of his flat feet. Doubtless these stories are apocryphal - at

any rate we have never been able to track down any such story to a specific individual. Nevertheless, they express the experience of examining surgeons who have learned that not all feet which appear flat are necessarily impaired in function.

Perhaps into this group fall also the anthropological types, Negroes, Indians, South Pacific Islanders, with feet which are flat when compared with Caucasian standards. Attention has frequently been called to the flatness of the feet of such people without evidence of impaired function.

Summary Problem of Pes Planus

In assessing the function of feet it is not possible to adopt the simple expedient of associating dysfunction with flatness of the foot. No strict parallelism exists between lowering of the longitudinal arch and impairment of function. Feet may be flat from a variety of causes and some of these are more disabling than others. It is necessary, therefore, to determine carefully the type of flat foot which is present before function can be assessed. The two disabling types of flat foot are 1. peroneal spastic flat foot and 2. the type which we have designated hypermobile flat foot with short tendo achillis. Nearly all other cases of flat foot cause little dysfunction. For the most part, they are stable and strong feet whose contour happens to deviate from the normal standard in the direction of lowering of the longitudinal arch.

For military purposes therefore, the important point is to recognize the existence of HFF=STA and of peroneal spastic flat foot. If these exist in any degree of severity, the man is of no value as a soldier and should be rejected or discharged. If the lesions are mild, he may be given a lowered L grading compatible with his functional capacity. If doubt exists as to the presence of HFF=STA or of peroneal spastic flat foot, or if the man has flatness of the foot which presents none of the features of these entities, he should be enlisted and submitted to the test of training. He can be regraded later should this prove necessary.

Pes Cavus - (Mild or Severe)

We have regarded pes cavus as a foot disability related to the arch. It may or may not be accompanied by claw toes. The etiology is obscure. Many cases seem to result from neuro-muscular disease (e.g. Charcot-Marie-Tooth myopathy) and indeed muscle imbalance appears to be an important factor in the causation of many cases of pes cavus. The Survey, however, has yielded information which associates pes cavus with the structural picture we have designated "firm support of the head of the talus". Pes cavus indeed may be regarded as the anti-thesis of hypermobile flat foot with short tendo achillis. (Observations upon which this statement is based are recorded in the Table on page 109, and in Appendix "E" Tables 8, 11 and 12; and Appendix "F" graphs 1, 2, 3, 4, 5, 6, 7, 8, 10, 12 and 17.)

The deformity occurs at the mid-tarsal joint and is such that the axis of the hind foot in the lateral x-ray, meets the axis of the fore foot at a less obtuse angle than normal. The relationship of the hind foot to the ankle joint and to the tibia is normal and when the hind foot is held in its normal relationship to the ankle, it can be seen that the fore foot drops sharply at the mid-tarsal joint often forming nearly a right angle to the hind foot. This would put the metatarsal heads at a much lower plane than the heel. There is compensation for this by increased dorsi-flexion at the ankle joint so that the heel and the metatarsal heads come to lie on the same level. The centre of the foot then is high; the weight is borne upon the back end of the heel and the heads of the metatarsals. The backward projection of the heel disappears because of the increased pitch of the calcaneus. This last feature is of importance since it makes it difficult for the boot to grasp the foot. In consequence, there is a tendency for the heel of a claw foot to ride up and down inside the boot in walking and marching.

Pes cavus, mild or severe, is relatively common. There were 427 cases amongst the 3,619 men examined at the Reception Centre. This constitutes 11.8% of all cases

examined. As might be expected in the age group examined (18 to 35 yrs) mild cases (396) predominated greatly over severe cases (31) (see Table 11, Appendix "E"). Clawing of the toes accompanied the pes cavus in comparatively few cases, but proportionately much more often in severe cavus (32.3%) than in mild cavus (11.1%). The nearly equal number of men enlisted with pes cavus (severe 14, mild 177) by the staff of the Reception Centre compared with those not enlisted (severe 17, mild 219) suggests that this is a disability which is not commonly recognized or if recognized is not regarded as significant. Acceptance or rejection is based on other factors. Certainly the less severe degrees of claw foot can easily be overlooked by the inexperienced examiner.

This is a convenient point to state that the clinical features by which it can be recognized are: 1. the humping of the foot at the mid-tarsal joint, often referred to as a "high instep", 2. the loss of posterior projection of the heel due to the increased perpendicularity of the os calcis and 3. the pattern of the area of contact of the sole of the foot with the ground obtained either by foot print or by examination of the sole of the foot after walking on a dirty floor. Figs. 25-26.

Tables 17 and 18, Appendix "E" record the manner in which severe and mild cavus feet stood up under training stress. Generally speaking, cavus feet as seen in young adult males do not cause great functional incapacity even when severe in degree. Of 10 severe cases enlisted, whom it was possible to examine during training, only 2 (20%) had symptoms (inability to march 10 miles). Of 151 mild cases enlisted; 27 (17.9%) had symptoms due to the lesion but in only two of these were the symptoms graded as severe.

The review of cavus feet by the Survey during the period of training justifies the conclusion that the cavus foot, unless particularly severe, is not an important cause of symptoms in the soldier. This finding is compatible with all of our knowledge of claw foot. It is a stable foot capable of bearing at least an average load, sufficiently strong for all ordinary purposes. Disability when it occurs, comes in middle life and is due to

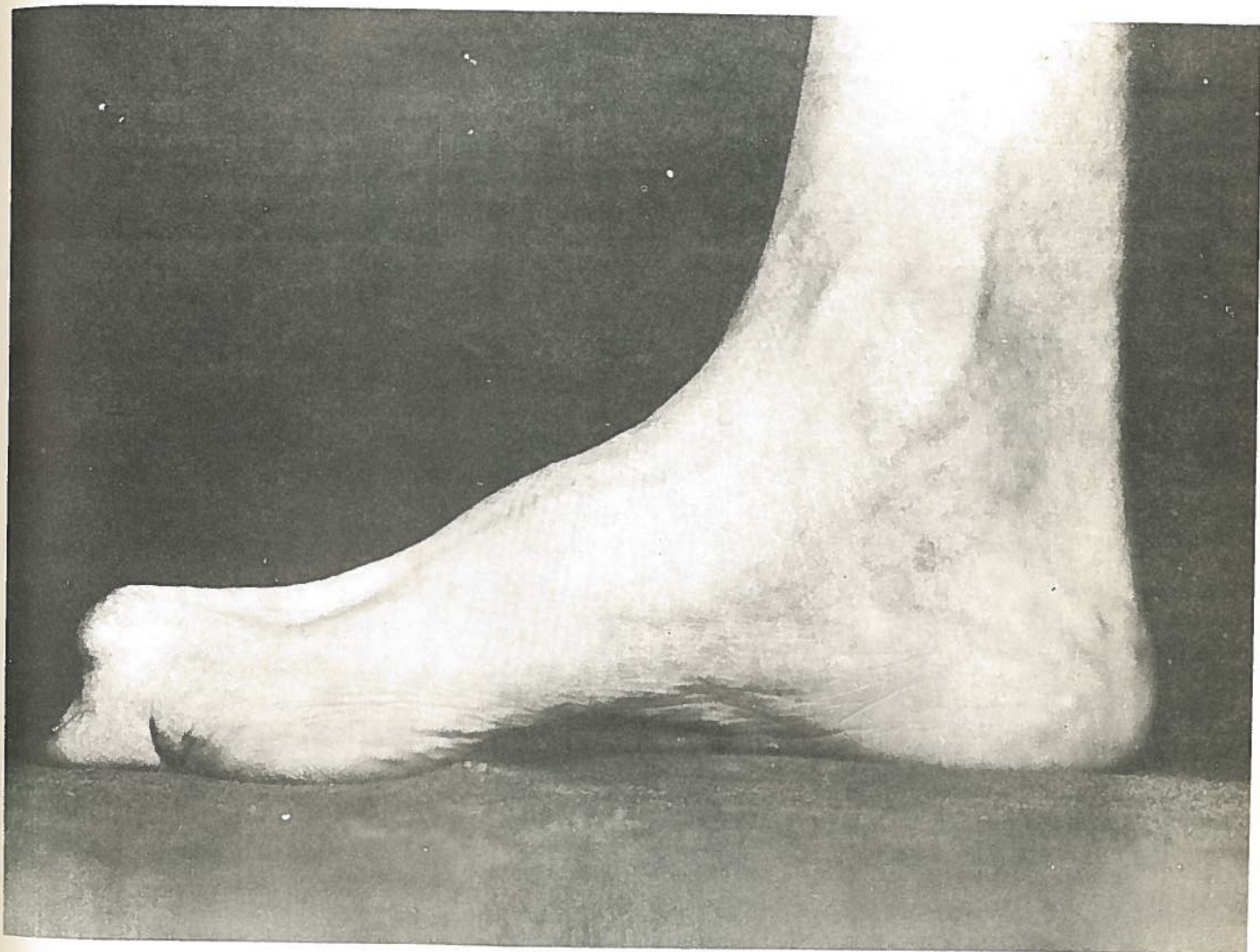


Fig.25 - Pes cavus - moderately severe cavus of foot with marked clawing of toes. This patient's deformity was due to myopathy of the Charcot-Marie-Tooth type. His son has the same disease in even more severe form.



Fig.26 - Imprint of the cavus foot shown in Fig.25. Note the concentration of weight upon the heads of the metatarsals and the heel. The toes bear scarcely any weight.

localized pressure under the heads of the metatarsals with callus formation.

Table 12 of Appendix "E" records the relationship between the various types of feet and the range of dorsi-flexion at the ankle joint. In this table a considerable proportion of cavus feet fail to dorsi-flex at the ankle beyond 90°. This feature, which seems to put severe cavus in a class approaching hypermobile flat foot with short tendo achillis, must be interpreted with caution. The measurement recorded in Table 12 is the angle between the sole of the foot and the mid-line of the tibia. In claw foot when this angle measures 90° (zero reading for Table 12) the talus must actually be in a position of marked dorsi-flexion in order to compensate for the humping of the tarsus at the mid-tarsal joint. Though the position of the whole foot in relation to the tibia may not pass 90° this falls short of being a true measure of the range of dorsi-flexion at the ankle joint by amount of the claw foot deformity at the mid-tarsal joint.

Summary Cavus Foot.

Some degree of cavus (mild or severe) is relatively common amongst the young adult males of Canada: - 427 cases (mild 396, severe 31) were found in the 3,619 men examined in the Reception Centre. This is an overall 11.8%. Concomitant clawing of the toes was present in 32.3% of the severe cases and 11.1% of the mild cases.

About equal numbers of cavus feet were enlisted and rejected which would seem to indicate that the condition is not commonly recognized by the Reception Centre staff or that it is disregarded as a source of functional incapacity.

The clinical features of claw foot by which it may be recognized are: 1. increase in the height of the mid-tarsal arch, 2. loss of posterior projection of the heel, 3. weight borne by the foot only at the heel and at the ball of the foot. The net result is to make the foot short from anterior to posterior end, thick from top to bottom and relatively broad since width has not diminished in proportion to the length. They tend to

be difficult to fit with boots. Boots which are of the correct length are too narrow and lacking in height, while boots which will accommodate the width and thickness of the foot are too long.

Pes cavus in the young adult male does not cause any considerable degree of functional incapacity. Casualties during training were few in number and even the number having symptoms was small. For Army purposes all but the most severe cases of pes cavus may be enlisted and the L grading adjusted in accordance with the functional capacity displayed during training.

It is certain that the claw feet of many soldiers will become worse with the passage of time since the disease is one which tends to progress slowly. Consequently it is conceivable that a certain number may ultimately claim pension for late foot disablement due to pes cavus said to be due to service. This makes the recognition of the condition on enlistment and its recording in the man's documents on discharge a matter of importance.

Accessory Tarsal Scaphoid and/or Prominent Scaphoid Tubercle

The presence of an accessory tarsal scaphoid (os tibiale externum) in the tarsus is known to be the cause of disability. Its presence modifies the insertion and the action of the tibialis posterior tendon in such a manner that it functions less efficiently in elevating the inner margin of the foot. Such clinical information as we possess regarding this entity is derived chiefly from the surgical treatment of cases presenting disabling symptoms (9). It is possible and there is reason to believe it is a fact, that the presence of an accessory tarsal scaphoid may not always cause disability. The Survey planned therefore to discover the incidence of the occurrence of accessory tarsal scaphoid and in particular,

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9. Kidner, F.C. J. Bone and Joint Surg. Vol 11, p. 831. 1929.

to determine the degree of functional incapacity caused by its presence. The standardized x-ray films provided a ready means of finding accessory tarsal scaphoids and the review of the enlisted men gave the opportunity to determine how often and how severe was the disablement they might cause.

Certain feet present an accessory tarsal scaphoid on one side and a scaphoid with a much enlarged tubercle on the other side as though this might represent fusion of an accessory tarsal scaphoid with the scaphoid. Also, much enlarged scaphoid tubercles are themselves the cause of occasional disability by reason of the pressure of their prominence against the boot and apparently also by reason of their interference with the insertion and action of the tibialis posterior tendon. The Survey therefore recorded the presence of enlargement of the tibial tubercle and grouped this with accessory tarsal scaphoid.

By clinical examination (prominence at inner end of scaphoid visible and palpable, Fig. 27) and x-ray finding (Figs. 28 and 29) there were 178 cases in this group found amongst the 3,619 men examined at the Reception Centre. They were distributed as follows:-

Prominent tuberosity of scaphoid <u>with</u> accessory tarsal scaphoid.	18
Prominent tuberosity of scaphoid <u>without</u> accessory tarsal scaphoid	28
Accessory tarsal scaphoid without prominent tuberosity of scaphoid	132

Of these 88 were enlisted and 91 were not enlisted. It may be assumed that failure to enlist the 91 cases was due, in every case, to reasons other than the accessory tarsal scaphoid since the staff of the Reception Centre did not examine for accessory tarsal scaphoid.

It was possible to follow 73 of the enlisted men throughout their training. Table 23 of Appendix "E" summarizes the small amount of disability which could be attributed to accessory tarsal scaphoid and/or prominent tuberosity of scaphoid. Four cases only had symptoms

during training and these symptoms were mild. One of the four cases had an associated prominent tuberosity of scaphoid. The symptoms were related predominately to the arch i.e. mild arch strain; but occasionally at least this lesion gives rise to moderate disability by reason of pressure upon the prominence at the tuberosity of the scaphoid by the boot.

Summary

Accessory Tarsal Scaphoid.

It is evident from this Survey that the presence of an accessory tarsal scaphoid and/or prominence of the tubercle of the scaphoid seldom gives rise to any disability. To have identified 178 cases of this lesion and to have followed 73 of them throughout training without finding a single case of severe disablement means that serious disability, if it ever occurs, occurs rarely. But the experience of civil life indicates that there are causes of major disability from this cause which are benefited by surgery directed toward the lesion. The only interpretation which can be put upon this is that such cases are the few with major symptoms culled from a large population.

As far as Army administration is concerned it is evident that accessory tarsal scaphoid and/or prominent tubercle of the scaphoid need not be taken into account during the examination of recruits at the Reception Centre. The number of cases who have this lesion and who develop symptoms from it during training is small. The symptoms they develop, on the whole, are mild and present no bar to continuation of training and of service as a soldier. To attempt to determine its presence would necessitate rather elaborate equipment and procedure for the x-ray survey of the feet of all recruits. This would be not only costly, time consuming and difficult: it would accomplish nothing save the demonstration of the presence or absence of the accessory tarsal scaphoid. There is no certain means of determining functional capacity except by the test of training.

The first occasion on which the lesion may need consideration is during training and then only if symptoms



Fig.27 - Prominence at the tuberosity of the scaphoid. X-rays showed a rather large accessory tarsal scaphoid. No particular depression of the arch. Only symptoms were pressure of the tuberosity on the shoe.



Fig. 28 - Accessory Tarsal Scaphoids. - No disability.

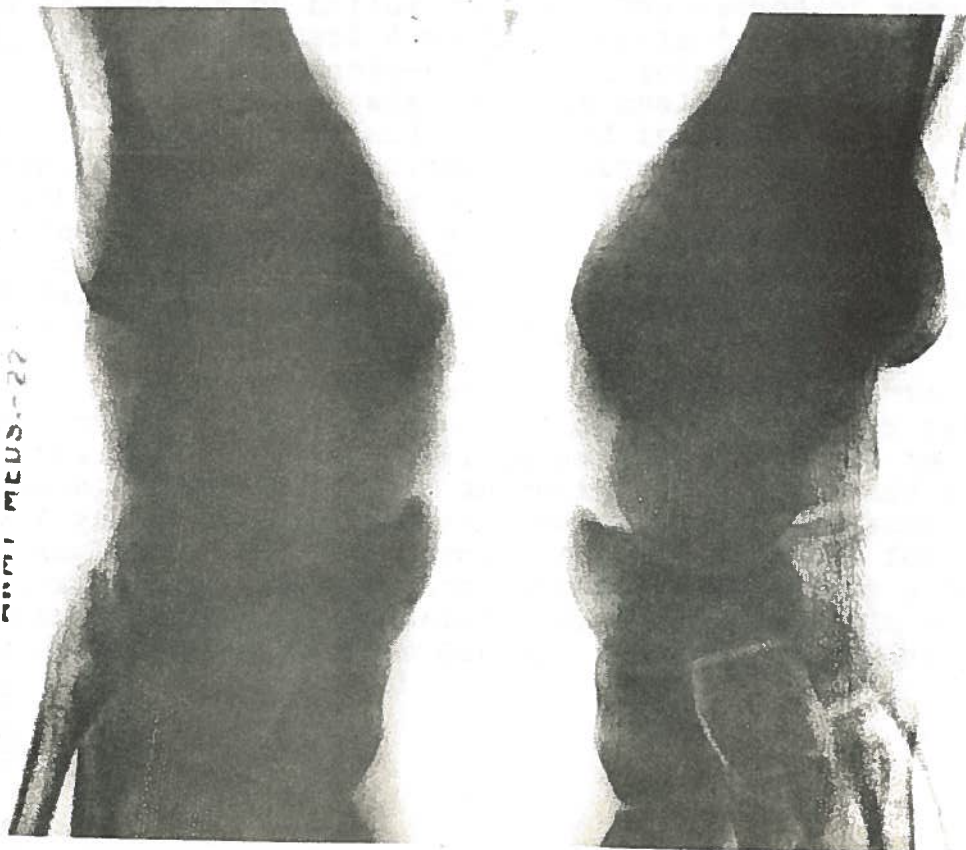


Fig. 29 - Enlarged and prominent tuberosities of scaphoids. No disability.

occur under the stress of training which with the visible prominence at the inner end of the scaphoid suggest the lesion. X-ray is necessary to confirm the diagnosis. Disposal will be dependent upon the degree of disablement which is present. Downgrading rarely will be necessary.

Hallux Valgus

As might be expected this is not a common lesion amongst young adult male Canadians. There were 79 cases (66 mild - 13 severe) amongst the 3,619 men examined at the Reception Centre. This is an overall percentage of 2.2%. For various reasons only 24 of these were enlisted (20 mild - 4 severe). (See Appendix "E", Table 29). There frequently were associated with hallux valgus other lesions and especially hallux rigidus and hammer toe. This relationship is tabulated in a small table as a footnote to Table 29.

An attempt was made in the x-ray studies of the Survey to determine what influence, if any, obliquity of the first metatarso-cuneiform joint had upon the occurrence of hallux valgus. The method of measuring the angle is laid down in Appendix "A", Sect. 15-C, (obliquity of metatarso-phalangeal joint) and Appendix "D" (obliquity of metatarso-phalangeal joint). The results are analyzed and tabulated in Graph No. 32, Appendix "F". The findings indicate that there is no relationship between the obliquity of this joint and the occurrence of hallux valgus. The mean of this angle for normal great toes falls between that for mild hallux valgus and severe hallux. It would seem that this angle has no etiological bearing upon hallux valgus.

On the other hand it has been possible to demonstrate a definite association between hallux valgus and the angle between the long axis of the first two metatarsals. Graph No. 32 in Appendix "F" records and analyzes the figures obtained for this measurement. It shows that the angle is least for normal feet and greatest for severe hallux valgus. One may conclude that metatarsus primus varus is definitely associated with severe hallux valgus. The observations of this Survey, however, do not permit

us to state unequivocally that metatarsus primus varus is the cause or even a cause of hallux valgus. The only statement which can be made from the findings of the Survey is that severe degrees of hallux valgus are associated with wide divergence of the first metatarsal from the second (metatarsus primus varus). To prove that metatarsus primus varus is a causative factor in the development of hallux valgus, and not merely the result of hallux valgus, would necessitate an x-ray survey of the feet of children to locate those having metatarsus primus varus and then the following of these and of controls to adult life to determine the incidence of hallux valgus developing in both groups.

Hallux valgus as seen in young Canadian males is not a serious handicap to military training. The Survey of such cases during training showed almost no symptoms save the occasional case of irritation of the exostosis by the boot. Fortunately the Canadian Army boot is particularly suitable for hallux valgus. It has no toe cap; the leather of the upper is supple though strong and the fore part of the boot swings inwards in such a manner as to provide ample room for the great toe even if it does cramp the fourth and fifth toes. With properly fitted shoes there need be no serious incapacity from hallux valgus per se. The hallux rigidus which may accompany it may complicate the picture.

Summary Hallux Valgus

In male Canadians of military age (18 - 35 yrs) hallux valgus is comparatively rare (2.2%) and more than four fifths of such cases as do occur are mild in degree.

There is a definite relationship between hallux valgus and metatarsus primus varus. That the latter causes the former cannot be proven from this Survey. There is no definite relationship between obliquity of the first metatarso-cuneiform joint and hallux valgus.

If boots are properly fitted, hallux valgus, except in the most severe degrees, is not a barrier to military service and need not be a cause for rejection

at the Reception Centre. The hallux valgus which occurs in young men most often is mild in degree. Even when moderately severe or severe the disability it gives rise to most often is the result of pressure upon the exostosis by the boot and can be avoided by careful boot fitting. It is not until the later decades of life that the increasing deformity causes loss of function due to a painful osteo-arthritic joint and to loss of the spring of the great toe as well as to the increasing size of the exostosis.

The significant importance of the statement which can be made from this Survey that hallux valgus, unless very severe, need not cause rejection at the Reception Centre can be appreciated by examination of the Table on page 8. The rejection for hallux valgus per 1,000 recruits examined in the various Reception Centres across Canada varied greatly ranging from 1.61 in M.D. 2 to 5.71 in M.D. 7, i.e. 3 1/2 times greater. This can only be explained by lack of uniform opinion as to the degree of functional incapacity caused by hallux valgus.

At the Reception Centre most cases of hallux valgus should be enlisted and submitted to the test of training. If, in training, they develop symptoms which cannot be relieved by properly fitting boots they can then be regraded or discharged. There is no satisfactory place for surgery in the management of hallux valgus in the Army. If the deformity gives no symptoms it should be left alone. If it gives symptoms which cannot be relieved by simple measures the man should be regraded.

Hallux Rigidus

The term hallux rigidus is commonly applied to a lesion of the metatarso-phalangeal joint of the great toe, usually the result of trauma and characterized by limitation of movement of this joint and the development of an exostosis on the dorsum of the metatarsal immediately behind the articular surface. The adjective rigidus is misleading. The joint is seldom rigid - and great disablement can exist in joints which have a fair range of movement. The principal disabling element (though not

the only one, e.g. exostosis) is the inability of the great toe to dorsi-flex sufficiently at the metatarso-phalangeal joint to accommodate itself to stride in walking or marching. In this Survey we have therefore accepted limitation of dorsi-flexion at the metatarso-phalangeal joint of the great toe from any cause as the criterion for the diagnosis of hallux rigidus. While this lumps together cases of diverse etiology, it has the advantage of a simple functional classification.

Since hallux rigidus is to be recognized by limitation of dorsi-flexion of the great toe, it is necessary to define how much limitation of this movement constitutes hallux rigidus. In this Survey we have arbitrarily chosen to regard inability to dorsi-flex beyond 45° from the straight line as constituting hallux rigidus. This may be an unduly broad classification but we were anxious to include all cases which had even a minor degree of hallux rigidus (i.e. limitation of dorsi-flexion). It probably has resulted in the inclusion of some cases which all surgeons would not concede should be called hallux rigidus, but it has the advantage that every degree of limitation of dorsi-flexion of the great toe which could be of any possible significance has been included.

Under this definition there were 135 cases of hallux rigidus recognized amongst the 3,619 men examined at the Reception Centre (3.7%).

By accepting limitation of dorsi-flexion as the criterion for the diagnosis of hallux valgus we found we had included examples of the disability due to at least two different causes:-1. Changes within the metatarso-phalangeal joint itself usually the result of injury - either a single trauma or a frequently repeated trauma as from the pressure of a boot. 2. No changes present within the joint but a tight plantar fascia limiting dorsi-flexion by means of the strands which run forward into the great toe.

The cases due to changes within the metatarso-phalangeal joint are the more disabling. In young males

the most common cause of the intra-articular type is traumatic osteo-arthritis following a single injury such as the dropping on the foot of a heavy weight or a horse stepping on the joint. Sufficient damage is caused to interfere with the structure of the joint and continued use of the damaged joint results in the development of traumatic osteo-arthritis. In addition to limitation of dorsi-flexion this type is characterized by exostoses at the margin of the articular surface, especially on the dorsal surface, and by osteo-arthritic changes within the joint. In this type pain and disablement are more severe and occur more frequently than in the second type.

Those due to tension of the plantar fascia show no changes in the metatarso-phalangeal joint. There is limitation of dorsi-flexion and it can easily be seen and felt that this is due to tension of the medial margin of the plantar fascia. Fig. 30. There is no evidence that there is anything abnormal about the plantar fascia except its tightness. It causes little disability but is of some anatomical interest. We have not been able to discover any previous observation that tight plantar fascia can cause significant limitation of dorsi-flexion of the great toe.

Hallux Rigidus is disabling out of all proportion to the anatomical changes which are present. This is especially true when the extreme of movement is painful. Free dorsi-flexion of the great toe at the metatarso-phalangeal joint is a vitally essential element in marching. Any interference with it causes an abnormal gait and can greatly limit the capacity of the foot to march. Some adaptation to the defect is achieved sometimes by using the flexor hallucis longus to take an increased amount of the thrust in walking. Generally speaking however, limitation of dorsi-flexion of the great toe at the metatarso-phalangeal joint, especially if it is painful, is a serious handicap to function.

In addition to the limitation of dorsi-flexion a considerable number of cases of hallux rigidus show varying degrees of osteo-arthritis. This is manifested by thinning and erosion of the articular cartilage and by the development of exostoses about the margin of the articular surface especially on the dorsum of the joint. This element of the deformity is the cause of disablement from painful pressure by the boot upon it.

The effect of training upon the foot with hallux rigidus is indicated in Table 30, Appendix "E"; 27.5% of all enlisted cases of hallux rigidus developed symptoms during training and nearly three quarters of these were serious symptoms. Cases with intra-articular changes more frequently caused symptoms and their symptoms were more severe. Even a moderate degree of hallux rigidus interferes with the last movements of the stride. Prolonged marching therefore is a particularly severe strain upon a hallux rigidus which may have given no trouble in civil life. Degrees of hallux rigidus which are not very severe cannot stand prolonged marching such as is demanded of a soldier. This is particularly the case with the intra-articular lesions.

Summary Hallux Rigidus

Hallux rigidus even under the broad definition laid down by the Survey is not of very frequent occurrence (3.7%). It is due to two principal causes: 1. Changes in the first metatarso-phalangeal joint due to trauma and 2. tightness of the plantar fascia. The former more often causes symptoms and the symptoms are more severe.

In training, particularly marching, even a moderate degree of hallux rigidus (especially the intra-articular type) gives rise to symptoms and often these necessitate regrading. It is therefore a disability which should, if possible, be recognized at the Reception Centre. Examination of the range of dorsi-flexion of the great toe should be part of the routine examination of the foot. The more severe degrees, especially when due to intra-articular lesions, should be given a low grading. During training such cases as display symptoms should be regraded if the symptoms are severe and persistent.

Hammer Toe

Hammer toe proved to be rare finding amongst the 3,619 men examined by the Survey. Only 22 cases were found (0.6%). For various reasons, unconnected with the hammer toe, only 8 of these were enlisted. It proved to be a factor of no importance as a handicap to training. This is as might be expected. The disability which is



Fig. 30 - Moderate limitation of dorsi-flexion of hallux due to tension of the plantar fascia. On the right the medial margin of the plantar fascia stands out under tension on attempted dorsi-flexion.

potential in hammer toe is that it may require more height than is available in the rigid toe cap of the shoe. The deformity per se has no influence upon function of the foot provided there is space for it without pressure in the boot. The problem of its management therefore is one of the shoe design and shoe fitting. The Canadian Army boot is well designed to meet the needs of hammer toe. It has no toe cap and the leather of the upper is supple and can be made to adapt itself to the hammer toe reasonably easily.

In the Army hammer toe need not be the cause of functional incapacity. Any disability it causes can be overcome by proper shoe fitting. Therefore its recognition at the Reception Centre need not be regarded as cause for rejection.

Spurs and Exostoses.

Exostoses arising from certain of the tarsal bones are an occasional cause of foot disability. Provision was made to determine the frequency and nature of this lesion during the Survey. In all, 45 cases (1.2%) were found.

Exostoses occur in the foot as the result of trauma and as the result of certain inflammatory lesions. The trauma may have been a single injury but much more characteristic is the small daily repeated trauma which comes from ill fitting boots or from boots which cause friction in certain spots. This localized boot pressure may be caused by bony abnormality of the foot itself, the result of previous injury or abnormality. Whatever may be the particular combination of circumstances which cause it, once localized boot pressure on a bony point is established it inevitably leads to bony irritation and to the deposition of periosteal new bone. This enlarges the bony point which is being pressed upon and makes boot pressure greater. The condition becomes a vicious circle and self perpetuating.

Both hallux valgus and hallux rigidus (intra-articular) are almost always associated with exostosis. It is initiated and progresses in size in the manner described above. Each new pair of boots has to be

"broken in" to accommodate the exostosis. This means that the exostosis, by pressure, must mould the leather of the boot to stretch and form a pocket for it. In so doing the exostosis is still further traumatized and as a result develops more subperiosteal new bone and becomes larger, perpetuating and aggravating the situation.

Because the exostosis of hallux valgus and hallux rigidus are each part of a larger syndrome we have not included them in this section on spurs and exostoses. They are included under hallux valgus and hallux rigidus as an integral part of those syndromes. We have reserved this section on spurs and exostoses for lesions arising in other parts of the foot.

Certain inflammatory diseases, notably gonorrhoea and rheumatoid arthritis, can cause bony spurs to develop in the foot by lesions which attack the attachment of ligaments and the insertion of tendons. Two common sites are: 1. under the heel at the point of attachment of the long plantar ligament to the calcaneus and 2. at the postero-superior corner of the heel anterior to the insertion of the tendo achillis into the calcaneus.

There is a certain type of calcaneus in which the postero-superior corner is broad and high and projects on either side of the tendo achillis, but chiefly the lateral side. (Fig. 31) This does not correspond to the last from which a modern boot is made. Pressure, therefore, develops over the upper posterior corner of the calcaneus which causes irritation and finally enlarges the already prominent corner of the bone into an exostosis - usually the postero-superior-lateral corner.

A further common site for the development of an exostosis by boot pressure is on the dorsum of the foot over the metatarso-cuneiform joint (10). Usually the dorsal margins of the bones forming this joint develop lipping which projects sufficiently under the skin to

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10. Maisonnave - Tarso Giboso (Tarsal Gibbus) Boletín de Sociedad de Cirugía del Uruguay. XIII. 362.1942. (Abst. J. Bone & Joint Surg. Vol. 26, No. 1, p. 216. Jan. 1944.)



Fig. 31 - An extreme example of exostosis at the postero-superior lateral angle of the os calcis and of abrasion of the skin over it from boot rubbing.

cause localized pressure.

Excluding the exostoses which are associated with hallux valgus and hallux rigidus the common sites for spurs and exostoses in the foot are:-

1. On the dorsum of the foot at the metatarso-cuneiform joint - from boot pressure.
2. Under the heel at the attachment of the long plantar ligament to the calcaneus (calcaneal spur) due to inflammatory lesion.
3. At the postero-superior corner of the heel under the tendo achillis and at its attachment to the calcaneus, from an inflammatory lesion.
4. At the postero-superior-lateral corner of the calcaneus lateral to the tendo achillis, from boot pressure upon a calcaneus abnormally broad at this point.

Table 33 of Appendix "E" gives the information which was obtained in this Survey regarding spurs and exostoses. It will be seen that there were 14 1/2 cases (i.e. one had one heel only involved) of prominent postero-superior-lateral corner of heel, 2 1/2 cases had calcaneal spur and 28 cases had exostosis elsewhere.

In training the disability caused by spurs and exostoses was not great. Of thirteen cases enlisted - four had symptoms but in all, these were mild. Exostosis as seen in young males does not interfere seriously with military training. Good shoes of good design and properly fitted will accommodate virtually every case.

The discovery of spur or exostosis during the Reception Centre examination is not cause for rejection unless it is unusually severe. When severe the condition is easily remediable by operation so that the man should be enlisted with a remediable disability and operated upon for its cure after enlistment.

Skin Lesions

Under this heading we have grouped various foot problems manifesting themselves as lesions of the skin including its appendages. We were, in part, concerned to determine the possible field of usefulness for chiropodists in the Army and for that purpose desired to know the incidence and the disability caused by such lesions as corns, calluses, ingrown toe nails, etc. Under the heading of skin lesions we have included seven classifications. Their designation and the number of cases which occurred in each of them is as follows. (Summarized from Table 32, Appendix "E").

Callus	88	
Corns	72	
Warts	24	
Fungus	38	
Ingrown toe nail	36	
Otherwise deformed nails	3	
Excessive sweating	<u>131</u>	
	<u>392</u>	- 10.8% of <u>3619 cases.</u>

It is evident from this table that there are a sufficient number of skin lesions to make the services of a chiropodist of value to the medical officer. This will be discussed further under the section on treatment of foot disabilities.

Some discussion of the various types of skin lesions will be valuable at this point.

Callus and Corn. There is some difference of opinion as to the meaning which should be attached to the terms callus and corn. Many define a corn as a lesion which has a core while a callus is a diffuse thickening of the skin without any localized increase. This seems to group thickenings of the skin into those which are pathological (corn) and those which are physiological (callus). Actually our terminology is very loose. It is well to recognize this and also to realize that all lesions of this type are varying manifestations of the same physiological response to pressure.

We are dealing here with skin lesions which cause foot disability. We have chosen to distinguish two such lesions because of the somewhat different clinical problems they present. We have arbitrarily designated these; callus - a localized lesion upon the weight bearing surface of the foot and corn - a lesion of non-weight bearing skin. Such use of the terms callus and corn may be at variance with the usage of others but it serves a useful clinical purpose. Apart from the distinction in the matter of the site at which they occur, they are essentially the same type of lesion. Both result from localized increase of pressure on the skin often against an underlying bony prominence. In both the resulting lesion is the same, viz. a great increase in the thickness of the cornified layer of the skin which because of pressure is forced down into the underlying cutis. The lesion is an inverted dome or cone. The level of the surface of the callus or corn is not much above that of the surrounding skin but this is no indication of the thickness of the lesion because this is concealed by its intrusion into the underlying tissue. It is this intrusion which makes the lesion painful. It accentuates localized pressure until the effect produced is that of walking on a pebble.

The increase in the cornified layer of the skin which characterizes callus and corn is the result of a change produced by pressure upon the normal process of desquamation of the skin. Instead of separating in flakes under the influence of normal wear and tear, the dead epithelium under the influence of pressure, becomes cemented together into a tough horny mass growing thicker with continuation of the local pressure.

Much of the nature of callus can be learned by observation of the feet of patients who have been in bed for some time and who had corns or callus before they were confined to bed. After approximately two months in bed (which means two months of freedom from the localized pressure which has caused the lesion) the normal growth of the skin has reached a point of desquamation at which the callus separates. The margins first curl away from the underlying skin and finally the whole corn or callus can be lifted off. When this is done it reveals

its conical shape, the surprising thickness of the centre, and the deep depression it has excavated in the underlying tissues.

Corns are most frequently seen upon the dorsum of the toes and are most frequently due to boot pressure from tight or ill fitting boots. But localization of the boot pressure may be determined by toe deformity which presses the toe against the boot or by bony spicules and prominences (frequently the cause of interdigital corns). Because of localized pressure determined by bony prominences, corns can appear elsewhere than on the toes; for example - over the exostosis of a bunion or the exostosis on the dorsum of the metatarso-cuneiform joint.

Calluses are most common under the heads of the metatarsals due to sharply localized pressure. This syndrome will be discussed at some length under atavism of the first metatarsal segment with which it is frequently associated. Callus may of course appear elsewhere in the foot than under the heads of the metatarsals; for example, under a calcaneal spur.

We have been inclined to reserve the term callus for sharply localized areas of cornification which are painful on pressure or on weight bearing. Mention should be made of broader and less sharply defined areas of cornification which appear in certain areas. A good example is the under surface of the great toe when the flexion function of this digit is used to supplement the flexors of the foot in the last movements of the stride. Callus and cornification indeed tell the story of the distribution of the body weight upon the sole of the foot; where it is sharply localized and intense, calluses are produced; where it is more diffuse, appreciable increase in cornification is present; where it is widely diffused as in a normal heel or ball of the foot, there is only a thickened epidermis.

There is reason to believe that certain skins respond to the application of localized pressure by callus formation more readily than do others. It is difficult otherwise to explain the extremely numerous and severe calluses which are observed in certain feet whose boot problem does not seem unduly abnormal. It may well be

that certain skins respond more readily to pressure and more easily develop cornification than do others. (11).

Plantar Wart. This perplexing and troublesome lesion presents exactly the same problems in the Army as it does in civil life. First, a certain degree of difficulty in diagnosis. Second, the unusual degree of disablement it causes when the wart is on a weight bearing surface. Third, the magnitude of the problem of treatment.

Diagnosis is not really difficult if one realizes the possibility of warts as foot lesions. The small size and the demonstration of the frond-like ends of the papilloma suffice. It is disabling because it causes intense localized pressure when weight is borne upon it.

Treatment is difficult and often unsatisfactory. No method assures a high percentage of success. If the first attempt at treatment fails other methods must be tried. It is well to recognize that a proportion of cases will only be cured by repeated attempts and that both the soldier and the surgical specialist should appreciate this before they embark upon a programme of treatment.

In the Army major therapeutic measures for verrucis plantaris are not to be lightly undertaken. The danger of making the lesion worse is not small. Radiotherapy is not readily available.

A contribution to the therapy of plantar wart which has been made in the Army has been the induction of necrosis of the lesion by the injection of vasosclerotics following novocaine into the base of the wart. (12).

11. Montgomery, R.M. and Montgomery, A.H. Common Hyperkeratotic Lesions of the Foot. J.A.M.A., Vol. 124, p. 756. Mar. 1944.

12. Ross, J.W. J. Can. Med. Services. Jan. 1946.

One form used to some extent in Camp Borden consisted in the injection of two minims of quinine and urethane into the base of the wart under novocaine anaesthesia. In a fair proportion of cases this produced dry necrosis of the lesion and ultimately it fell out. It has the merit of simplicity and the man remains ambulatory.

Ingrown Toe Nails. This is a rather common lesion in youth and in the Army it was fairly common in training. All that needs to be said of it here is that its treatment is simple and operation hardly ever is necessary. All cases will be cured when the ingrown corner of the nail grows out sufficiently far to be beyond the nail bed. During this period of growing out it is wise to elevate the corner of the nail by packing so as to lift it from its bed and prevent further injury by digging into the soft tissues. If severe infection is present, it may be wise to remove the nail completely to allow the infection to subside and the ulcer to heal. Then as the nail grows out it can be prevented from causing ulceration by packing. Hospitalization and elaborate operations are unnecessary for the treatment of ingrown toe nails. The soldier himself can be taught to look after the lesion and a good foot orderly or chiropodist can be of immense help to the Medical Officer in carrying out whatever programme of foot hygiene has been decided upon.

Excessive Sweating. This is part of the physiology of youth. It can be of importance in the Army because feet which sweat easily do so more readily in army boots. Wet feet develop sodden skin which blisters easily because of increased friction. Clean socks changed often and formaldehyde baths to the feet will do much to diminish this condition.

Atavism of First Metatarsal Segment
First Metatarsal Shorter Than Second

Dudley Morton (2) has advanced the hypothesis that the factor of greatest importance in disabilities of

the forefoot and also in many arch disabilities is some degree of atavism of the first metatarsal segment. By this he means the existence in the human first metatarsal segment of some one or all of the elements which characterize this segment in anthropoids and which presumably are derived from a common remote ancestor. First metatarsal segment means great toe + first metatarsal + first cuneiform. According to Morton the atavistic elements are: 1. Divergence of the first metatarsal from the second, 2. Hypermobility of the first metatarsal segment, 3. Shortness of the first metatarsal, 4. Posterior displacement of the sesamoids.

Morton has advanced his hypothesis with ingenuity and energy and has convinced many surgeons that his views are correct. It is of importance to determine to what extent atavism of the first metatarsal segment exists and if it exists to what degree does it cause disablement. The Survey therefore included extensive plans for the investigation of this lesion and its effect upon function.

Morton's contention may be summarized thus:-

1. When the first metatarsal is shorter than the second less weight than the normal proportion is carried upon the short first metatarsal head because it then does not reach the ground as readily as does the head of the second metatarsal or the head of the third metatarsal. Distribution of weight borne on the forefoot is disturbed by the shift of part of the load from the head of the first metatarsal to the head of the second.

2. In an attempt to make the head of the first metatarsal reach the ground the forefoot tends to roll out into valgus and this produces arch strain.

3. The disturbed distribution of weight bearing is manifested by:

- (a) calluses beneath the heads of the second and third metatarsals.
- (b) x-ray evidence of thickening of the shaft of the second metatarsal in response to the increased amount of stress to which it is subjected.

4. Alternatively to the shortness of the first metatarsal, the same disturbance of the distribution of weight upon the fore part of the foot occurs;

- (a) when there is hypermobility of the first metatarsal segment as compared with the second. When this exists the head of the first metatarsal segment bears less than its normal share of weight because it is more easily forced into dorsi-flexion than the second,
- (b) when the sesamoids of the hallux are more posteriorly displaced than normal. This in effect is the same as a short first metatarsal since the sesamoids provide the effective point of weight bearing for the hallux.

5. Therefore, according to Morton a short first metatarsal (or hypermobility of the first metatarsal segment or posterior displacement of the sesamoids) is an important cause of foot disability both in the forefoot (calluses beneath the heads of the metatarsals, falling of the transverse arch, pronation of the forefoot) and in the longitudinal arch which is distorted and subjected to undue strain by the attempts to compensate for the diminished weight borne on the head of the first metatarsal.

Survey Measurements - Atavism of First Metatarsal Segment. An earnest attempt was made by the Survey to measure precisely all of the elements pertaining to atavism of the first metatarsal segment and to correlate these with functional capacity as demonstrated by the ability of the man to undergo military training. It often proved difficult to devise precise means of measurement and sometimes impossible. Nevertheless a great amount of data has been obtained from which can be drawn important conclusions. As far as we are aware, this is the first occasion on which such anthropometric methods have been applied to the problem. Since the results contradict Morton's hypothesis it is important that they be put on record. At one stage in its programme of military training, the American Army was pressed to accept Morton's hypothesis that a short first metatarsal is a cause of disability and to submit every soldier to examination for this defect and if found

to provide him with the compensating insole which Morton recommends for such cases.

The following is an outline of the Survey's attempts to devise means of measuring with some degree of accuracy, the various aspects of atavism of the first metatarsal segment.

Measurement of Length of First Metatarsal as Compared with Length of Second Metatarsal. At the outset the technique of measuring the length of the first metatarsal had to be decided upon and this proved to be a detail of some importance. Morton's procedure is to draw a line tangent to the head of the second metatarsal and at right angles to the axis of its shaft and to project this across the first metatarsal. The distance of the head of the first metatarsal from this tangent he takes as the measurement of the length of the first metatarsal in relation to the second. If it projects beyond the tangent it is longer than the second metatarsal by the measured amount. If it falls short of the tangent it is shorter than the second metatarsal by the measured amount. (Fig. 60). But it can easily be demonstrated that this measurement can be changed within wide limits by the varus-valgus position of the metatarsals. (Fig. 61). If the measurement is taken when the metatarsals are in valgus the effect is to increase the apparent shortness of the first metatarsal. Conversely the length of the first metatarsal can appear to increase relative to the second by assuming the varus position. This introduces an uncontrollable source of error since it is difficult to standardize the varus-valgus position of the metatarsals. Moreover, if Morton's hypothesis is correct, Morton's measurement does not provide the needed information. Indeed such information as it does provide may be fallacious. The measurements actually required are distance from the posterior point of support of the foot (heel) to the head of the first metatarsal and the head of the second metatarsal since these represent anterior points of support of the foot. Morton himself recognizes this as is evident from the following quotation from page 179 of the 1935 edition of his book "The Human Foot": "One of the requirements for ideal foot function is an equidistance of the heads of the 1st and 2nd metatarsal

bones from the heel". In the usual supero-inferior x-ray it is impossible to make such measurements since the posterior end of the calcaneus cannot be seen on account of the shadow of the tibia. In the x-rays obtained by the technique of the Survey the calcaneus and all the other bones of the foot are equally well visualized and measurements from calcaneus to heads of metatarsals are possible. It is true that the weight bearing point on the inferior surface of the calcaneus (tuber calcanei) cannot be visualized but an equivalent point can easily be chosen (middle of posterior margin of calcaneus).

Comparison of the two methods of measurement (Figs. 60 & 61) shows very considerable differences in the results obtained. Feet which by Morton's measurement display shortness of the first metatarsal, by the Survey method show no shortness and vice versa. Both methods were used in more than half the cases so that there is material for comparison of one method against the other. In all, 7222 feet were measured for relative length of first and second metatarsal by the Survey method and 3923 of them were also measured by Morton's method. The findings will be discussed in detail later.

The Survey measurements both by Morton's procedure and by that of the Survey record the actual length of the first metatarsal in relation to the second. They indicate not only shortness of the first metatarsal relative to the second, but also the amount of the shortening in millimetres. In addition to these careful measurements the Survey also recorded the existence or absence of shortness of the first metatarsal by visual examination of the x-ray without any attempt at measuring the amount of shortening (Appendix "A", Sect. 15 - 3). Much of the discussion which follows is based upon this visual recognition of shortness (without actual measurement of its amount). In effect, this is the determination of shortness by Morton's method.

Measurement of Hypermobility of the First Metatarsal Segment. Considerable effort was expended in an attempt to devise means which would display, in a graphic

manner, the relative mobility in dorsi-flexion of the first as compared with the second metatarsal segment. The procedure which we hoped would be most productive of result was to take a lateral x-ray when the patient stood upon a sponge rubber pad of half inch thickness. It was expected that if hypermobility of the first metatarsal segment did exist that standing upon the elastic pad, rather than upon a rigid level surface, would bring the metatarsal heads to rest at different levels as measured from a base line, the first higher than the second. This technique, though ingenious, failed because there was no way of calculating the thickness of the soft tissues between the inferior surface of the metatarsal heads and the rubber pad, nor were we able to devise any other method which would demonstrate hypermobility. Clinical examination also failed to convince us that such an entity as hypermobile first metatarsal segment really exists. We are definitely of the opinion that the x-ray evidence which Morton advances as indicating hypermobility (open space between first and second cuneiform bones) is not pathognomonic. It merely means that the central beam of the x-ray has chanced to be directed exactly through the joint space.

After much effort we have concluded that hypermobility of the first metatarsal segment does not exist as a clinical entity and in consequence, we feel no measurements of this feature are necessary. In any case, we did not succeed in devising any technique which displayed the feature.

Measurement of the Degree of Divergence of the Axis of the First Metatarsal from that of the Second - Metatarsus Primus Varus. This measurement has already been discussed under hallux valgus with which it is more closely concerned than it is with shortness of the first metatarsal. The measurement is easily obtained from the standard supero-inferior x-rays. (Fig. 63).

Measurement of the Posterior Displacement of the Sesamoids. A reading for this was easily obtained from the supero-inferior view. The mid-point of the sesamoids was chosen in accordance with the method laid down in Appendix "A", "Data for Cards" 17-A. The distance

of this point behind the most anterior projection of the head of the metatarsal was measured. (Fig.63).

Measurement of Thickening of the Shaft of the Second Metatarsal. It proved impossible to measure this by any method which would give figures which were comparable since the distance of the metatarsal bones from the film modified the size of the x-ray image and many unrelated and uncontrollable factors were concerned in this distance. But in each case an estimate was made as to the presence of thickening of the second metatarsal and this was recorded. An effort was made to be sure that thickening of the second metatarsal when recorded would be such as would be agreed upon by anyone.

Recording of Evidences of Disturbed Weight Bearing in the Forefoot. There was no accurate and simple means available to us of measuring in kilograms or pounds the distribution of weight upon the under surface of the forefoot. Consequently we were forced to rely upon indirect methods to investigate the altered distribution of weight bearing in atavism of the first metatarsal. Foot imprints made from the pad designed by the Survey (Appendix "B") gave a clear idea of the relative amount of weight borne upon various parts of the sole of the foot. Clinical examination of the sole of the foot for calluses and other evidences of localized pressure gave an accurate inventory of the existence of localized pressure and its position. These findings were sought and recorded in all cases.

Findings of the Foot Survey re Atavism of the First Metatarsal Segment and its Relationship to Function. The measurements obtained by the Survey have been compiled and analyzed in the following Tables and Graphs which should be consulted in connection with the discussion which follows.

Appendix "E" Table 25 - Incidence of atavism

Table 26 - Shortness of first metatarsal judged clinically compared with that shown by Morton's method of measurement.

Appendix "E" Table 27 - Relationship between excess weight on metatarsal heads and shortness of first metatarsal.

Table 28 - Incidence and distribution of excess weight on the heads of the metatarsals.

Appendix "F" Graph 20 } - These are analyses of the
 Graph 21 } differences in the forward
 Graph 22 } projection of the head of
 Graph 23 } the first as compared with
 Graph 24 } the head of the second meta-
 Graph 25 } tarsal in association with
 Graph 26 } various other factors out-
 Graph 27 } lined in the graphs.

Graph 28 } - Graphs of the distance of
 Graph 29 } middle of sesamoids be-
 Graph 30 } hind anterior end of
 first metatarsal in com-
 bination with various
 other factors.

Graph 31 - Angle between first metatarsal and second.

Findings of Survey in Relation to Shortness of First Metatarsal

If we define a short first metatarsal as one which is at least one millimetre shorter than the second, using Morton's method of measurement, Table 25 Appendix "E" shows that there were 1282 cases with this finding amongst the 3619 men examined.

If there is a reasonable amount of flexibility of the metatarso-phalangeal joints it is possible by strongly plantar-flexing the toes, to obtain an impression of the position of the heads of the metatarsals and hence of the relative lengths of the first and second. (Fig. 10). This method of estimating the presence of short first metatarsal is admittedly only approximate but since it is simple

and convenient, it would be useful if it approached reasonable accuracy. Unfortunately this is not the case. Actual measurement (Table 26, Appendix "E") shows such a poor approximation to the actual state of affairs that this method of clinical examination can only be used to obtain a general impression of the relative lengths of the metatarsals.

If we accept callus under the metatarsal heads as evidence of excess pressure upon them, our measurement and clinical observations lead us to the conclusion that there is little or no evidence to support Morton's hypothesis that shortness of the first metatarsal causes excess weight to be borne upon the heads of the second and third metatarsals or gives rise to disability. Table 27, Appendix "E" shows that of 1282 men with short first metatarsals, as determined by measurement, only 36 1/2 had calluses under any metatarsal head and only 14 had callus beneath the heads of the 2nd, 3rd or 4th metatarsals. Conversely, of 2337 cases in which the first metatarsal was not short by measurement, there were 50 cases with callus. These figures may be summarized in the following table which is abstracted and condensed from Table 27, Appendix "E".

	Excess Weight Bearing as Evidenced by Callus			Total With Callus	No Excess Weight Bearing as Evidenced by No Callus	Total
	Under 2 or 2-3	Under 3 or 3-4	Under Others			
First Metatarsal Short by Measurement	6 1/2	7 1/2	22 1/2	36 1/2	1245 1/2	1282
First Metatarsal Not Short by Measurement	13 1/2	7 1/2	29	50	2287	2337

Note:- Because of frequent assymetry each foot is counted as 1/2 case.

3619

The significance of this Table is that evidences of symptom producing disturbance of weight distribution in the fore foot are not associated solely with short first metatarsal and probably are not caused by it. They occur almost as frequently when the first metatarsal is longer than the second. Of special significance is the small number of cases presenting calluses beneath the heads of the 2nd and 3rd metatarsals which Morton postulated would be burdened with excessive pressure when the first metatarsal is short.

It should be appreciated that there are many variations in the manner in which the feet are used which can act as compensatory mechanisms of considerable efficiency. One such can easily compensate for lack of support normally provided by the head of the first metatarsal in standing or walking. It is the increased use of the flexor hallucis longus muscle. The keen observer will often see evidence of the use of the great toe in walking and the mark of this increased use is callus on the plantar surface of the great toe. If shortness of the first metatarsal really was a source of impaired function one would expect that the first attempt at compensation would not be pronation of the fore part of the foot as stated by Morton, but increased use of the flexor hallucis longus to maintain a due proportion of weight borne upon the first metatarsal segment. This compensatory mechanism has a high degree of efficiency and often is used to advantage.

The vast majority of cases with measurable shortness of the first metatarsal have no symptoms related to it and present no evidences of any disturbance in weight distribution. The lack of any association between shortness of the first metatarsal and disturbed function sometimes is very striking. An example is Fig. 32 which shows the x-ray of a very short first metatarsal and the photo of the sole of the same foot free from callus or other defects. He was also free from symptoms.

Graphs 20 to 27 inclusive of Appendix "F" are concerned with analysis of the measurements of short first metatarsal in relation to the classification of the feet in respect to planus. Morton postulated that shortness of the

first metatarsal results in pronation of the forefoot to permit the first metatarsal head to reach the ground and this in turn, is associated with planus and arch strain. There is a fallacy in Morton's method of measurement in that valgus of the forefoot makes the first metatarsal apparently short.

The graphs indicate, first, that the Survey method of measurement is more accurate and stable than Morton's and second, that no definite relationship exists between shortness of the first metatarsal and pes planus.

In the matter of functional capacity the experience of the Survey would indicate that short first metatarsal per se causes no interference with the training of a soldier. This is not to say that calluses beneath the heads of the metatarsals do not cause disability. They do; but the evidence that these are due to short first metatarsal is lacking. We shall discuss them later.

In summary, the findings of the Foot Survey in respect to shortness of the first metatarsal are as follows:-

Shortness of the first metatarsal is common (over $1/3$ of all cases) but over-length of the bone is almost equally common. (Graph 20 Appendix "F").

Measurement of the length of the first and second metatarsals by the Survey method is more accurate than by Morton's method.

The vast majority of cases of short first metatarsal have no disability of any kind even when the shortness of the metatarsal is great.

There is no certain evidence to associate short first metatarsal with undue weight bearing by other metatarsals. Evidence of excess weight borne by heads of second and

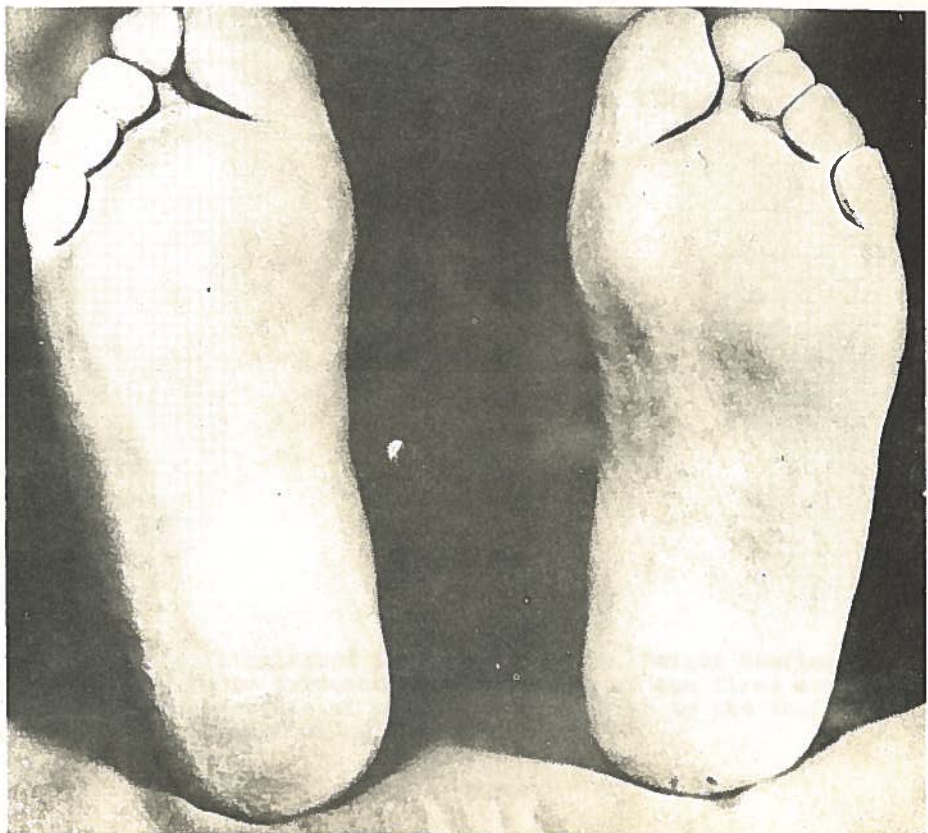
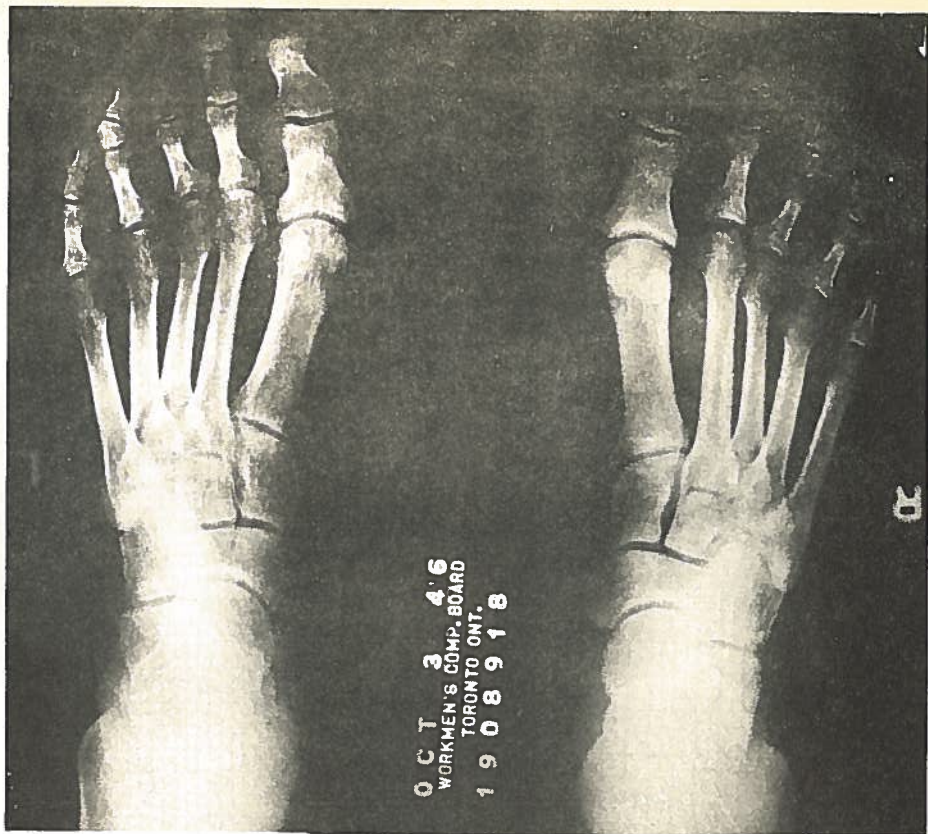


Fig. 32 - Short first metatarsal without symptoms or callus. The radiograph "A" shows very short first metatarsals. The photograph "B" shows no callus under heads of metatarsals. The man had no foot symptoms though the short first metatarsal was sufficiently severe to be obvious on clinical examination.



Fig. 32 C - Imprint of the base illustrated in Fig. 32 A and B. Weight bearing is uniformly distributed over the ball of the foot. Evidence that shortness of the first metatarsal does not always cause disability by transference of undue weight bearing to the heads of the second and third metatarsals and the development of callus.

third metatarsals occurs only occasionally in cases of short first metatarsal and it occurs almost as frequently in cases in which the metatarsal is not short. The evidence is that calluses beneath the heads of the 2nd, 3rd and 4th metatarsals are due to causes other than shortness of the first metatarsal.

Short first metatarsal per se does not cause functional incapacity and therefore need not be seriously regarded during examination at the reception Centre.

Findings of the Survey in Relation to Thickening of the Second Metatarsal

Our findings do not support Morton's statement that shortness of the first metatarsal is the principal cause of excess weight upon the heads of the second and third metatarsals. Nor can we find any direct association between shortness of the first metatarsal and thickening of the second metatarsal. On the other hand, when there is evidence of excess weight upon the second or second and third metatarsals (callus) there is frequently (44.7%) thickening of the shaft of the second metatarsal. It should be noted that in the converse many cases with thickening of the second metatarsal present no evidence of excess weight borne by the heads of second or second and third metatarsals. These features and others related to excess weight under the heads of the metatarsals are recorded in Table 28, Appendix "E". It may be assumed, with reasonable accuracy, that when, for any reason, the second metatarsal does bear excess weight and has done so since childhood, it will respond with increase in size. This is as might be expected. Increased stress on bone, especially in the formative years, manifests itself by structural changes in the direction of increased strength.

Our investigation therefore, indicates that a thickened second metatarsal usually means that it is subjected to greater than normal stress and usually this is associated with other evidences of increased stress particularly the presence of callus beneath the head of the metatarsal.

Findings of the Survey in Relation to
the Position of the Sesamoids

Our investigation of the position of the sesamoids in relation to the anterior end of the first metatarsal leads us to the conclusion that variations in their position play no part in the causation of symptom-producing alterations of weight distribution in the fore-foot. This is to be expected from our previous observation that Morton's basic contention respecting short first metatarsal is not supported by the observed facts. If short first metatarsal does not cause symptoms one would not expect posterior displacement of the sesamoids to do so.

Graphs 28, 29, 30 of Appendix "F" record our findings in regard to the position of the sesamoids.

The position of the sesamoids with relation to the anterior end of the first metatarsal varies within a considerable range. The extreme range is 16 mm. (7.5 to 23.5 mm.) but the great bulk of the cases fall within the range of 12.5 to 16.5 mm.

Whether the first metatarsal be shorter than the second or not has little influence upon the position of the sesamoids (Graph 28). This is an observation of importance since it might be thought that shortness of the first metatarsal could be compensated by more anterior position of the sesamoids. Broadly speaking, such is not the case. The position of the sesamoids follows a percentile curve which is essentially the same whether the metatarsal be long or short and whether or not there be evidence of excess weight under the second metatarsal.

We have been unable to satisfy ourselves that the position of the sesamoids bears any causal relationship to the bearing of excess weight upon the heads of the 2nd or 2nd and 3rd metatarsals.

Findings of the Survey in Relation to
Hypermobility of First Metatarsal Segment

As previously stated we have been unable to demonstrate that such a condition as hypermobility of

the first metatarsal segment exists and we have been unable to devise any means of measuring this movement. We do not believe this to be a factor of any practical significance in foot disability.

The Problem of Calluses

Beneath the heads of the metatarsals is a comparatively common place for calluses to appear. Most of the 88 cases (2.5% of 3619 men examined) were in this situation. This incidence is higher than expected in a group of young and healthy males. Such calluses cause a considerable amount of disability which is accentuated in soldiers since they must spend so much time on their feet in marching and drilling. A plan of management which would eliminate this disability would be of considerable value in military training.

We have previously discussed (page 64) the general problem of corns and callus and reserved for this place the discussion of the calluses which appear beneath the heads of the metatarsals. The investigation of atavism has enabled us to demonstrate that there is no clear association or causal relationship between short first metatarsal and calluses beneath the heads of the metatarsals. They occur equally often when the metatarsal is not short and the vast majority of short first metatarsals are not associated with such evidences of localized excess pressure.

The exact nature and causation of these calluses is not easy to determine. In general terms they are produced by excess pressure upon a small area of weight-bearing skin. When this pressure develops it causes characteristic changes in the cornified layer, cementing together the epithelium which normally would desquamate. As the cornified layer becomes thicker it intensifies the local excess pressure and perpetuates the lesion.

The manner in which local excess of pressure is developed is obscure. In all probability several factors may be involved singly or together. We have not been able to determine all of these factors with certainty

in spite of much thought and effort. Work on this problem is continuing. However, the following factors, on occasion, play a part in initiating the local pressure.

1. If the toes are clawed, even to a small degree, the long toe flexors no longer press the toes firmly against the ground so as to bear their share of the body weight and the thrust of the stride. This transfers more weight to the ball of the foot where sooner or later calluses develop under the heads of the metatarsals.

2. If the foot is clawed the metatarsals are directed more steeply downward and weight is concentrated upon the metatarsal heads because less is borne in the mid-portion of the foot. The area of the metatarsal heads probably is smaller when directed thus obliquely than when more horizontal. The pressure therefore is concentrated upon a smaller area.

3. It may be that the thickness and quality of the pad of subcutaneous tissue is diminished so that weight is less widely distributed upon the skin surface. Certainly when the tissues of the foot are fibrosed and contracted from scar following inflammation, calluses form with great facility.

4. When there is muscle weakness or paralysis there is a tendency to concentrate weight upon limited areas of the foot from which it cannot be shifted because of impairment of muscle power. Perhaps also the atrophy of soft tissues facilitates local concentration of pressure.

5. Change in the position of the heads of the metatarsals in relation to one another, "falling of the anterior arch". While this is a recognizable clinical entity, the mechanism of its production is not clear. Probably more than one factor is involved. The difference between a normal foot in which the ball is clothed in firm smooth weight bearing skin and a foot with

callus beneath the heads of the metatarsals is great. The outstanding impression is that the involved metatarsal head is closer to the skin than the others. Hence weight is not borne uniformly upon all the heads but is concentrated in an undue proportion upon the displaced metatarsal head, thus providing the concentration of pressure which gives rise to callus.

6. Probably certain skins respond more readily to pressure by callus formation than do others.

7. There is a time factor concerned with the development of calluses. In childhood they are rarely seen; in young adult life they are uncommon. Past middle age they are common. This can mean either that it takes a long time for the localized pressure to cause the development of callus or that the factors which develop localized pressure arise late in life. The latter is the most probable explanation since children with deformities due to poliomyelitis develop calluses rapidly enough. It seems likely that slow changes occur in the structure and shape of the foot as we grow older which in certain cases, can cause localized pressure and the development of calluses.

We feel that there is much need of investigation into the problem of callus and especially into that aspect of its etiology concerned with displacement of the metatarsal heads so as to cause unequal pressure upon them. The Foot Survey was able to throw little light upon this problem except to demonstrate that shortness of the first metatarsal per se seldom causes the lesion.

During training calluses beneath the heads of the metatarsals are apt to be troublesome lesions. They give rise to an appreciable amount of disability for which it is not easy to provide relief. A high proportion of men with callus on enlistment developed symptoms during training. (See Tables 32 and 36, Appendix "E"). The following figures are abstracted and condensed from Table 36, Appendix "E".

All important symptoms occurred in Infantry Training.

Symptoms during Training Related to Callus

<u>Site</u>	<u>Symptoms</u>		<u>Totals</u>
	<u>Mild</u>	<u>Severe</u>	
Callus under Heads of Metatarsals	35	5	40
Callus and Corn situated elsewhere	18	4	22
Totals	53	9	62 cases amongst 1391 soldiers examined during training.

The disability due to callus is more evident in the Infantry Corps than in any of the Corps in the Army. This is the direct result of the much greater amount of foot training there is for an infantryman than for any other soldier. The following figures are abstracted and condensed from Table 37, Appendix "E".

Incidence of Symptoms due to Callus
in various Corps of the Army

Effect of Type of Training on Symptoms

<u>Site</u>	<u>Types of Corps Training</u>			<u>Totals</u>
	<u>Infantry</u>	<u>R.C.A.M.C. and R.C.E.</u>	<u>Other Corps</u>	
Callus under Heads of Metatarsals	27	2	11	40
Callus and Corn (elsewhere)	13	3	6	22
Totals	40	5	17	62

Note: R.C.A.M.C. : Royal Canadian Army Medical Corps
 R.C.E. : Royal Canadian Engineers
 Other Corps: Provost Corps, Army Service Corps, etc.

All important symptoms occurred in Infantry Training.

INCIDENCE AND NATURE OF FOOT DEFECTS
FOUND BY SURVEY AT TRAINING CENTRES

In the previous section relating to the lesions found during the examination at the Reception Centre, occasional mention has been made of the behaviour during training of men suffering from certain foot disabilities in order that the general picture of each specific disability might be completed. It is necessary now to give in detail the findings of the Survey when it examined men during training.

Of the 1600 men who were enlisted, it was possible to examine 1391 both in Basic and/or Advanced Training. This provides a reasonably large amount of material from which to draw conclusions.

The disabilities found during this part of the Survey were of two types: 1. organic lesions of the foot, overlooked during the Reception Centre examination or overestimated as to their ability to bear up under stress. 2. lesions which developed during training and as the result of training.

Lesions Overlooked at the Reception Centre or Lesions
whose Functional Capacity was Overestimated

It has already been emphasized that some foot disabilities will slip through the screen of the Reception Centre examination undetected. This is inevitable and must be accepted. Still more are likely to be enlisted whose foot peculiarity is recognized but the degree to which it will interfere with function is underestimated or perhaps cannot be estimated until submitted to test. The examination of a recruit's foot is a small part of the examination he must undergo. We have shown (pages 8 & 9) how great is the divergence of opinion as to what constitutes certain foot disabilities or how seriously they may incapacitate a man for military training. There is much lack of accurate knowledge concerning foot problems. Most of the men presenting themselves at an Army Reception Centre have no symptoms. These only develop under the stress of training.

For all these reasons it is certain that foot disabilities will appear during training which might have been detected and eliminated at the Reception Centre. But on the whole it is better for the examiner at the Reception Centre to enlist a man about whose function he is uncertain rather than reject him. Wholesale rejection accomplishes no useful purpose and is wasteful of manpower. The test of service will quickly determine whether or not a man's feet will serve him as a soldier. The Training Centre staff therefore and particularly the medical officers should be alert to detect such foot disabilities and to deal with them by retraining or by regrading and reallocation as indicated.

Some indication of the incidence of these lesions can be obtained from Table 40, Appendix "E". Here is reviewed the development of symptoms during Training of men who were: 1. recognized at A.R.C. to have defects liable to dysfunction. 2. had defects which were recognized subsequently. The assessment of defects is based on the examination by the Survey Team and on the whole this was much more accurate than that of the ARC staff. What occurs to these groups during training will be seen from the following abstract from Table 40.

Occurrence of Symptoms during Training in Men
Enlisted with Defects Liable to Dysfunction

	<u>Symptoms occurred as expected</u>	<u>Unexpected symptoms occurred</u>	<u>No symptoms</u>	<u>Totals</u>
Defects liable to dysfunction considered present by Survey Team at ARC	127	53	225	405
Defects liable to dysfunction not noted at ARC, but found on subsequent examination	22	1	3	26
Totals	149	54	228	431

All important symptoms occurred in Infantry Training.

The feet which fell into these groups consisted mostly of longitudinal arch problems (often hypermobile flat foot with short tendo achillis) and of metatarsal arch problems (usually uneven distribution of weight with callus formation beneath the metatarsal heads). When such disabilities manifested themselves during training by the development of symptoms, it was necessary to re-examine them and often regrade them.

Lesions which developed during training and as the result of training. This group of foot lesions may be regarded as the result of the minor traumata of a strenuous life. Blisters, tendinitis, ingrown toe nail were the chief examples. The problem of management and prevention is not unduly great. Well fitted boots are the most important requirement. Brief comment on one or two items is necessary.

Tendinitis. This is a lesion which proved to be characteristic of military training. The sudden transition from a sedentary life to a strenuous military life and the enclosing of the feet in heavy boots produced minor injuries to the superficial tendons of the foot: - tendo achillis, anterior tibial tendon, peroneal tendons, posterior tibial tendon. The lesion usually is initiated by direct pressure of the boot upon the tendon against a bony background. The most obvious signs are distension of the tendon sheath with fluid and a fine silky crepitus due to rubbing together of the inflamed synovial surfaces. In many cases, however, the tendon itself presents evidence of trauma in the form of a localized thickening or nodule. (13) The lesion was particularly frequent in Officers Training Centres where cadets moved "at the double" on all their duties.

Treatment of the established lesion consists of rest until it subsides. The best treatment is prevention and this is dependent upon well fitting boots which are kept in good condition.

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13. Johnston, H.D. Peritendinitis or Foot Sloggers Nodule. Brit. Med. J., p.193. Feb. 1945.

March Fracture. This example of stress fracture of the metatarsals is very characteristic of military training. It is very rarely seen in civil life. Yet it is not common in the Army. Amongst the 1391 men followed through their period of training no proven case of march fracture was found and only two or three suspected cases were seen. The incidence in the American Army is 0.50 per 1000. (14).

The exact etiology of this and other types of stress fracture is obscure as is also the mechanism of its production. Presumably the quality of the bone is not sufficiently strong to withstand the repeated stresses of training. The elastic "give" of bone to the strain placed upon it results ultimately in buckling of trabeculae at the weakest point. Once this has occurred the stresses are concentrated upon this spot until the characteristic fracture occurs.

The incidence of march fracture varies greatly. In civil life it is extremely rare; amongst soldiers it is more common, though still not frequent. It appears to vary in frequency in different countries and in different parts of the same country. This in part may be only apparent. Certainly an alert medical staff and a good radiologist will detect cases which otherwise would be overlooked. The increased incidence amongst military personnel can be attributed to the increased stresses to which their bones are subjected by the strenuous life they had. The type of footwear may have some bearing upon march fracture. Boots with heavy and rigid soles probably are more protective than those with lighter and more flexible soles. It is conceivable that the nutrition of a district or a country may play some part in the occurrence of stress fractures (including march fracture). If diet has resulted in bone of poor quality stress fractures may more easily develop.

Ingrown toe nail. Strenuous foot activity predisposes to ingrown toe nail if the trimming of the nail has been such as to result in the distal corner being buried in

14. Peterson, Col. Orthop. Consultant to Surgeon-General.
A.U.S. (personal communication)

soft tissues. Forward growth of the nail then presses this corner into the soft tissues until ulceration is produced.

Treatment is simple and effective. Pack a pledget of cotton underneath the corner of the nail to lift it up from the ulcerated bed in which it lies. Continue this until the normal growth of the nail carries the corner beyond the soft tissues. Trim the nail so that the free corner always lies beyond the nail bed. The lesion can be prevented by proper nail trimming. If severe infection accompanies the lesion it may be necessary to deal with this by simple avulsion of the whole nail to give the ulceration an opportunity to heal before the nail again has grown out. While it is growing out the corner is kept elevated by packing to avoid damage to soft tissues by the advancing corner of the nail.

Blisters. These are due basically to friction between the foot and its coverings, especially the socks. Several accessory factors accentuate their development.

1. Any factor which localizes pressure on the foot invites blistering. The commonest cause of this is poorly fitting boots.
2. Dirty, stiff or inelastic socks.
3. Wet feet; especially from sweating. This macerates the horny layer of the skin and also increases friction.
4. A rough inside of the shoe. The Canadian Army shoe is not lined, and the rough surface of the leather may be a factor in developing blisters. One type of American Army shoe is manufactured with the dressed surface of the leather turned inside. While this does not improve the external appearance of the boot it does diminish friction inside the boot.
5. Malformation of the foot such that localized pressure and friction by the boot is made easy. e.g. the exostosis on the postero-superior lateral corner of the heel often develops a blister over it.

Summary.

The foot disabilities of consequence which developed during military training may be summarized thus:

Organic defects overlooked at the Reception Centre or overestimated as to their functional capacity

- Hypermobile flat foot with short tendo achillis
- Claw-foot
- Hallux valgus.

Lesions resulting from training

- Blisters
- Calluses
- Ingrown toe nail.

Problems related to shoe fitting

- Discussed in the following section.

14. Peterson, Col. Orthop. Consultant to Surgeon General. A. U. S. (personal communication)

Foot Fitting

Incidence - From Table #1, Appendix "E", it will be seen that 14% of men had misfitting of boots. The purpose of the survey into this matter was to attempt to show the degree to which misfitting of boots gave rise to foot problems in the Army.

Projects - Army Meds. - No. 22

Method of Fitting - The official method of fitting boots and shoes in the Army is given in G.A.R.C. 2804 - Appendix "G". The official relationship of the Medical Corps to boot fitting is given in G.A.R.C. 613 - Appendix "G". Routine Order 613 states, in short, that the Medical Corps shall have a supervisory role in the fitting.

The Directorate of Ordnance Stores (General Stores) maintains two civilian shoe fitters whose work consists of advising and instructing quartermasters on the method of fitting. These men travel continually across Canada for this purpose. They have served a most useful purpose in developing an organization which by and large has performed well the enormous task of fitting soldiers with the Army boot.

FOOTWEAR

Though the BOOTS - (FITTING AND DESIGN) the responsibilities of the Ordnance Stores and of the Medical Corps meet in the common project of SOCKS and DUBBIN. The responsibility of the Ordnance Corps is to provide the soldier with proper clothing - including boots - and for this purpose they must have skill in measuring his foot and providing the proper boot to fit these measurements. The responsibility of the Medical Corps is to prevent wastage from disease or injury and to eliminate their causes. Good boot fitting therefore is the concern of both though for different reasons.

Because of this common interest it was felt that there might be an advantage in having the shoe fitters of the Directorate of Ordnance Supplies (General Stores) accompany the Survey Officer on some of the review parades, for the following reasons:

(1) that if boot fitting instructors saw the judgments the Survey Officer was making in regard to boot

Boot Fitting

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Though they differ in their approach, the responsibilities of Ordnance Stores and of the Medical Corps meet in the common problem of shoe fitting. The responsibility of the Ordnance Corps is to provide the soldier with proper clothing - including boots - and for this purpose they must have skill in measuring his foot and providing the proper boot to fit these measurements. The responsibility of the Medical Corps is to prevent wastage from disease or injury and to eliminate their causes. Good boot fitting therefore is the concern of both though for different reasons.

Because of this common interest it was felt that there might be an advantage in having the shoe fitters of the Directorate of Ordnance Supplies (General Stores) accompany the Survey Officer on some of the review parades, for the following reasons:

(1) that if boot fitting instructors saw the judgments the Survey Officer was making in regard to boot

fitting and if they agreed to the general correctness of his judgment, more weight could be given to his report as to the incidence of misfitting (if any) and the factor it was as a cause of soldier inefficiency.

(2) that the Foot Survey parades would give an opportunity to the boot fitting instructors to see the fitting of boots as it had actually been done without their supervision.

(3) that it would give an opportunity for the exchange of information between the Medical Corps and the Ordnance Corps on this particular problem, and in particular between the Survey Officer and the boot fitting instructors.

Criterion of Fit - Our judgment of acceptable fitting was based largely on presence of ample width of the fore part of boot and sufficient length so that the toes did not impinge against the end of the boot. We have endeavoured to record as misfits only those cases in which the misfitting was sufficiently gross so that no reasonable likelihood of difference of opinion would occur among fitters. The standards of the boot fitting instructors were somewhat more critical than ours, and therefore, in the same group of soldiers their recorded misfits are distinctly greater than our own. Further, while there were many recorded by them as misfits who were not recorded as such by us, there were practically none recorded by us as misfits to which judgment they did not agree. We were all in general agreement on the points of judgment of good fitting. The importance of this is that of our compiled data showing the amount of misfitting present in the Foot Survey cases, we can at least claim it to be, if anything, an understatement of the amount. Our 14% of men misfitted is not more than 2/3 as many as would have been recorded by the boot fitting instructors on the same cases.

Rate of Symptoms - Of those misfitted approximately half (i.e. 7%) felt some subjective effects when seen during basic training. Of those with misfits who had no symptoms during basic training, about half complained before completion of advanced infantry training.

Types of Misfitting - Recognizing that our work was not primarily an inquiry into the state of boot fitting, we have made no detailed records as to how misfitting occurred. We can, however, observe that it was quite common to find a man fitted with a D-width boot which was too short. Bearing in mind that D-width is the narrowest carried in quartermaster's stores it is evident that a man with a narrow foot tends to be fitted with a boot either too wide or too short or too wide and too short. A few cases correctly fitted for length and with F-width were found to require still greater width. A scattered few cases had the ball of the foot crowded forward into the narrowing toe region of the boot. This occurs in some cases where the ratio of length of toes to length of foot is small. Commenting on this:- (a) it would appear that easy availability of widths narrower than D may appreciably reduce the misfitting, (b) the requirement of wider than F-width seemed so obvious in some cases that we felt driven to believe the quartermaster's fitter would have recognized the need but that widths H were not obtained for other reasons. These reasons, we think, are mainly a 'laissez-faire' attitude at the quartermaster's stores for H-widths were available at district ordnance depot. (c) It seems reasonable to think that of the soldiers requiring B-, C- or H-widths, those who would actually obtain them would be in proportion to the ease of availability of those sizes to the quartermaster. It seems important, therefore, to make them readily available.

Validity of C.A.R.O. 2804 - We did not personally (except occasionally) check on whether or not strict adherence to C.A.R.O. 2804 would have avoided all misfitting. It is our impression that adherence to this instruction will give correct fitting in the vast majority of cases. It is common knowledge, however, that where there was distinct shortness of the toes in proportion to the foot length, strict adherence to C.A.R.O. 2804 would lead to the wide ball of the foot being crowded forward into the narrowing toe of the boot. This gives the effect of too narrow a boot. This misfitting can be recognized readily when the boot is on the foot, if the fitter is aware of its existence. Its correction is to

fit with wider, longer, or wider and longer boots. This is perhaps the commonest case where benefit will result in examining the fit of the boot on the foot and fitting slightly at variance with the instructions if need be.

Ball of the Great Toe - It is well known that some boot fitters make much of positioning of the "ball of the great toe" in the boot. There is no evidence in this Survey to show that lack of exact positioning (e.g. with short toes and ball placed forward) has been a factor in foot inefficiency except in the matter of difficulty in getting a correct fit as noted just above.

Dividends from Good Fitting - We have concluded that increase in the percentage of correct fitting of soldiers will pay dividends in increased army efficiency. This Survey, however, has not concerned itself with the practical measures which might be employed to obtain this end.

Medical Officers not Well Informed - On the whole, it is felt that the boot fitting situation could be improved. In contacting many medical officers in training centres throughout Canada we are impressed that with few exceptions, they are not familiar with the criterion of correct fitting of boots nor are they familiar with the size range of boots and shoes available. For the most part, they are not aware of the existence of Routine Order 2804. Routine Order 2804 calls for the measurement of the feet by a rule which is used in the shoe trade that measures the length and width of the foot. It is interesting that medical officers in the last analysis are called upon to decide the question of misfitting in an individual with trouble in his feet yet no foot measuring rules are on the scale of issue for medical units. Some medical officers have obtained these by arrangement with the quartermaster but it is rather the exception to find such a rule in a medical unit.

R.O. 2804 Obsolete - It may be noted here that there are minor inaccuracies in Routine Order 2804, for example the range of sizes of boots and shoes is not correctly stated.

Size Markings - If a soldier presents himself with a fitting problem, one of the best ways of deciding what his correct fit should be is to note the size of his present

fitting and recognize how it should be changed. It is therefore of value to be able to determine the size of the boots even though partly worn. Occasionally it is difficult to determine from the label the correct size of new boots, though, for the most part, those in the boot and shoe trade can do so. Frequently in partly worn boots it is impossible to do so. The fitting of boots in the Army however, is not entirely in the hands of the boot and shoe tradesmen and when the size is difficult to determine from a pair of boots, confusion may arise. The final decision rests with determining the size stamped on the insole. This is placed rather far forward and is very difficult to see in many instances. The size stamp is then duplicated on the shank of the outsole but this may become illegible through use. It is, we believe, worth trying to devise a practical way of making the size markings more permanently legible. In one boot repairing depot, reconditioned boots were being stamped for size on the leather of the upper in a prominent way. Though we have not seen any example, it is possible theoretically for this upper leather to be built into a new pair of boots in the No. 1 Boot Rebuilding Plant. This new or rebuilt boot would then carry the stamp on the upper which would not correspond to the correct size of the boots. It is not always possible to be dead certain that the boots were made on the last corresponding to the label of the insole. We are told that when large orders are being filled in a plant, that plant may occasionally run out of lasts. They will be in the position of having the uppers prepared and insoles ready but no lasts of the correct size. Shop practice has coined a term "last up" or "last down". Under the circumstances mentioned the foreman may give his workmen an order to "last up" or "last down" by which is meant for "last up" that a one half size longer and one width narrower last is to be used instead of the correct last. This has the result that a shoe is produced of approximately the same width as the label but a half size longer. We are told that this practice is uncommon though it occurs.

Fitting Practices - For the most part, the impression was gained, though not based on systematic inquiry, that men were conscientiously fitted in most quartermaster's stores. Some quartermasters, indeed, considered correct fitting of boots as a most important function of the Q.M. stores.

They were, however, not infrequently handicapped by lack of a complete stock of all sizes. There seems no doubt that even in depot stores there is need at least occasionally for a size which is not available. This appears to result from unavoidable causes, among which might be mentioned the fact that one of the large depots was burned down during a time of short supply of boots and a large number of boots perished in the fire. Ordinarily, a training centre unit is supposed to carry a stock of boots equivalent to 10% of the personnel of the unit. As far as we were able to learn, there was no Headquarters guidance to show the optimum number of shoes of any given size which should be carried. A quartermaster without boot and shoe experience might well accumulate a greater proportion of boots of a given size than the likely demand for that size and thus the stock that he has might not be as effective in fitting the personnel as it should be. There is no doubt that if the size is not readily available, quartermaster stores (as a whole) tend to fit the individual with a compromise which might be available. We have seen cases supplied at depot with boots known to be the wrong size, with the advice to the soldier that he should get them changed to a correct size when at the Training Centre. While R.O. 2804 is an instruction in the fitting of boots, which is supposed to be adhered to, it is not hard to get examples of men being given boots without any measuring of the feet as a guide. It is not unusual to contact soldiers who have been fitted to the size of their own request - a method which is universally known to be fallacious. While this study did not pertain to C.W.A.C., some C.W.A.C. cases have been seen in regard to their shoe fitting and it can be stated that, at least, one C.W.A.C. Q.M. stores does not regularly measure the feet and attempt to fit the shoes in accordance with R.O. 2804.

Special Size Boots - The standard supply of boots by ordnance is in sizes from 5 to 12 1/2 in widths D, E and F. Until the middle of 1944 a stock of H-width boots was kept at district ordnance depot and supplied on demand to quartermasters. From personal contact with quartermasters, we know that at least some were not aware of the availability of width H. We were impressed that even among those who know of their availability, they did not use this service as much as indicated. The proof of this,

however, is virtually impossible as one would have to be certain that the fitter recognized the need for an H-width and did not obtain it and it is impossible for us to know when this recognition of the need was present. In the latter half of 1944, the No. 1 Boot Rebuilding Plant began making outside boots. Quartermasters submitted a nominal roll, of special sizes, which was sent to the ordnance depots and thence to No. 1 Boot Rebuilding Plant where the special size boots are made and delivered in a fortnight. A full range of lengths and widths is thus obtainable for the soldier. The stock of H-widths in district ordnance depots was withdrawn and sent to the No. 1 Boot Rebuilding Plant to use for supply when the special size roll indicated the need. As it now stands, all sizes beyond the range 5 to 12 1/2 in D, E and F are supplied from Montreal. The tracing of the outline of the foot is sent with the special size-roll and when this or the measurements indicate minor bulges in the foot, leather is tacked on to the last and the boots made accordingly. This additional service borders on the field of orthopedic footwear and is not encouraged at the Montreal plant as this is not one of the recognized functions of the plant. It does, however, indicate the potentialities of the plant and that such a plant in a production stream may make minor variables of an orthopedic nature from the standard boot.

Shoes, Leather, black - Shoes, leather, black (oxfords), are available in size 5 to 12 with widths C, D, E and F. So far as we know no mechanism is available for the supply of these shoes in other than these sizes.

C.W.A.C. Shoes - Shoes, leather, brown - C.W.A.C. are available in:-

- S - Slim 5 - 10 inc.
- N - Narrow 4 - 10 inc.
- M - Medium 3 1/2 - 10 inc.
- W - Wide 3 - 9 inc.

There is a mechanism by which authority may be obtained by the Quartermaster from the District Ordnance Officer to purchase shoes for C.W.A.C. on the civilian market where the quartermaster's stores are unable to correctly fit the individual. The District Ordnance Officer keeps

a list of merchants for this purpose. It is interesting to note that R.O. 2804 gives the width measurement as A, B, C etc., while the C.W.A.C. shoes are listed as S, N, M and W. As far as we can find there is no indication showing the correlation between the width stamped in the C.W.A.C. shoes and the width reading as obtained according to R.O. 2804. Actually the correlation between the reading on the measuring stick and the size labels is S=AA; N=B; M=D; W=E.

A Serious Effect of Misfitting - There becomes a sizable problem in the quartermaster's stores, particularly in training centres, if the rate of misfitting of boots is great. If a training centre is fed by a depot in which the misfitting is considerable, the soldiers at the training centre return their boots to the quartermaster for better fitting after they have been worn considerably. There can be no doubt that a soldier who is misfitted at the depot has in practice, very little opportunity for changing the boots at that level. The soldier after being fitted at the depot wears his boots for some two weeks there and by the time he is sufficiently organized in a training centre to know the means for changing his boots, they have been worn another three to five weeks. He is now returning a pair of boots worn about seven weeks and on the average the outsole will be more than half worn through. This brings these boots into the class of partly worn boots. While it was not within our province to inquire to what degree these are returned for repair and reconditioning, we are impressed that not infrequently partly worn boots are simply put on the shelf in exchange for another pair and that the original cause of this largely hinges on the question of fitting. The more the quartermaster has to refit soldiers the greater the number of instances in which this will occur.

Original Aim Not Consummated - The original purpose in examining feet for misfitting was to determine whether this might be a factor in giving rise to disability. The factors giving rise to disability are so complicated and overlap so much that it became very difficult to attribute a certain degree of disability as being due to misfitting of boots. For example, if a man had hallux valgus, the presence of misfitting of boots might aggravate the symptoms

present, but the proportion of the disability caused by the misfitting of boots is almost impossible to determine. There was no opportunity, in such a case, to see the man properly fitted and then see what disability he had. However, the impression gained is that about 40% of men with misfitting boots complained of the fit during Basic Training; of those who did not complain during Basic Training and went on to Corps Training with the same fit of boots, about half complained during Corps Training.

Lacing of Boots - As far as we were able to determine no standard method for lacing of boots has been laid down for the Army. There were some instances of irritation under the eyelets. In other instances, the lacing was needlessly unsightly. The continuous lacing from one end to the other results in a fairly even pressure on the tongue in the average person. However, in cavus cases where there is prominence in the region of the tarsometatarsal joints, pressure on the top of the foot occurs. There is need of a new method of closure such that the tension at the top, middle and bottom of the closure could be controlled independently. This would greatly help these cavus cases in standard boots.

Used Boots

Reconditioned Boots - Not infrequently, for one reason or another, used boots are returned to the quartermaster's stock. One reason for this is the demand by the Medical Officer for new boots to correct symptoms he believes due to misfitting. In the ordinary case these boots are sent to the local boot repairing plant which is operated by the Army Salvage and Disposal Board. There (if it can be salvaged) the boot is repaired by thoroughly soaking, putting on a last and hammering the insole as smooth as possible, repairing the sole and heel, and ironing out the uppers. They are then labelled for size. There was a time when boots had between the insole and slip-sole, a layer of tar and cork which in use moved and resulted in a bumpy insole. It was virtually impossible to hammer the insole of these boots to a smooth surface and indeed, it is sometimes impossible to do so with the tar and felt filler that is now being used. In any case, a number of these boots have been issued to soldiers and during the

course of visits to training centres we have seen two or three pair with a very bumpy insole. It is, of course, possible that these boots never went from the Q.M. stores for reconditioning but were issued as if they had. Another alternative may be that the boots seen by us had been, in fact, sent to the repair shop but long before the present method of reconditioning was developed. We have, however, seen at least one case of boots returned from the repair depot which the quartermaster thought had been reconditioned, in which the insole was far too bumpy to warrant issuing to a different soldier. However, even here, an accident may have occurred in the handling - the repair depot may have thought that the boots were returned for repairing to be worn by the same man rather than reconditioning to be worn by another. This problem in the reconditioning, however, is certainly unusual and there can be no question that the reconditioning of boots is a highly satisfactory procedure as it is now done and that very little trouble arises to the soldier who has to wear reconditioned boots. We recognize that reconditioned boots were a cause of occasional instances of justifiable complaints. These were few in number, may have been in boots reconditioned by now obsolete methods or may have been partly worn boots which had got back on the quartermaster's shelves without actually having been reconditioned. In the Survey we have seen no reason to think that the use of reconditioned boots as now being done (as against the use of new or rebuilt boots) gives undue difficulty in relation to their salvage value.

Size Determination in Used Boots - When boots are sent to the repair plant for reconditioning, it is sometimes impossible to read the size label. In that case the size of the boot has to be established and stamped on it after reconditioning. This did not convince us that it was always possible to find the size accurately. It was done in one of two ways or both, (1) on the outside of the boot, measurements were made of the length from the heel to the toe and of the breadth of the sole, and the size of the boot was determined from this and (2) the boot was fitted with the largest last in width and length that it would hold. This seemed to be somewhat more accurate and it would suggest that even if the boot had been slightly smaller before the last was inserted that it

would be stretched to the last size and therefore the boot size could be determined. If, however, the boot had to be unnaturally stretched to insert the last, it seems reasonable to think that it would shrink a little from that size. However, on the whole, we think that the size determined after reconditioning probably is within a half size of the true size and one width of the true width.

Conditioning of Leather - The leather in the reconditioning process is treated to soften it and to sterilize it to some extent, I am told that in one repair plant 2% phenol is the antiseptic used and in another a mixture of izol and lexol is used. Reports would indicate that formalin is a more reliable antiseptic for the elimination of fungus (epidermophyton). We did not, however, inquire with great detail into the method being used.

Rebuilding of Boots - The Army Salvage and Disposal Board in Montreal operates the No. 1 Boot Rebuilding Plant. At this plant used boots which cannot be salvaged in the district repair depots are taken apart and the usable leather built into otherwise new boots. The boots made are on the standard last No. 470. There is no fault to find with this procedure and only the highest commendation for those who have developed and are operating the plant. We understand that some formalin, though a small amount, is being used in the solution for sterilizing. No information has come to our attention to indicate the development of fungus infection from the use of used or rebuilt boots.

Repair - The repair of boots appears to be splendidly carried out. A few instances have been seen in which the sole was roughened by a nail having been put through the back of the half sole near the corner and which pulled a deep dimple down into the insole leaving a projecting edge of the insole which was irritating. Another instance was seen in which the insole appeared torn away from the welt during repairing. We are told that this does occur and is one of the few weaknesses of the Good-year welt construction.

Boot Design

Boots, Ankle, Black - Canadian Army service boots are built on last 470. This is a semi-rocker design and appears to be in its characteristics intermediate between the American Army boot and the English Army boot. It appears to have been basically a copy of the Munson last with some necessary, though minor, modifications. A metal heel plate and a metal toe plate have been put on to prevent wear. The full rocker shape of the Imperial Army last was considered not necessary because (1) the lack of the toe cap allows more flexibility in the front of the boot and (2) the sewing construction of the sole also allows more flexibility. Most boots now have a so-called clump sole which is a half sole added to the slip sole (mid-sole) and ordinary outsole. The boot must certainly be considered a very satisfactory one on the whole. It is easily fitted and even soldiers who have never worn boots and have never marched before like them. The clump sole, in particular, is popular.

There are, however, points which should be taken into consideration as to the possibility of improvement. The lack of toe cap allows some shrinking and closing down of the toe region in storage after removal of the last, and a few men have been seen who complain of the pressure of the leather on their toes. The question of whether the toe region of the last should be built up more should be investigated. The decision to have a heel plate seems not to rest on any sound physiological investigation and there seems room to study the question of composition or rubber heels. There was shown to be a fairly high rate of tendinitis occurring and an association between excessive use of the tendon in an untrained soldier and the occurrence of tendinitis was shown. With the boot having a stiff sole as present in the clump sole boots, it is a question whether a greater rocker action should be incorporated into the design in order to decrease the pull necessary on the tendon in walking. Unfortunately, it is impossible in this study to correlate the occurrence of tendinitis with the type of boot. The forepart of the boot swings in needlessly, so much that the fourth and fifth toes tend to be cramped and there is more space than necessary for the great toe.

Shoes, Leather, Black - The shoes, leather, black, are the oxford shoes or dress shoes for soldiers and are built on last No. 800. This last is a smaller size for the corresponding labelled size with a view to wearing lighter socks than are worn with the boots, ankle. In this Survey we have not made any inquiry as to the background for the design of these shoes. It appears on the whole to be a very good one.

C.W.A.C. Shoes - This inquiry did not concern itself with C.W.A.C. personnel, However, in the course of the Survey, a number of cases of C.W.A.C. have been observed. Women in civilian life have not been required to any great extent, to do much walking, and it appears that they have been accustomed to wearing shoes that are tight. This may be because of the inadequate lacing of many civilian designs, hence they depend for their security on a snug fit at the heel and a certain amount of compression of the toes. Difficulty occurs in fitting these women with shoes which are loose enough to walk in with comfort. If enough room is allowed in the fore part of the foot they complain of looseness in the region of the heel. Our observations, which are admittedly very cursory, suggest that the design of the shoe might be improved to make the waist and heel region smaller in proportion to the breadth of the fore part of the shoe. This observation is supported by those of Captain Freedman, Fort Knox, U.S.A. (15).

Officers' Shoes, Brown - By regulation, Canadian Army officers are required to wear boots, ankle, black in training, manoeuvres and combat. At other times, in the mess and on the street and in offices they wear brown oxfords. They are dependent on the civilian shops for the supply of these shoes. At the present time, the civilian shop-keepers recognize that the demand per shop is slight and they have poor stocks of sizes, it being now (1944) almost impossible to obtain such shoes. It never was easy to obtain the infrequently used sizes. The Navy, in contrast, undertakes to supply officers as

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15. SPMEA 727-3; Armored Medical Research Laboratory
Project No. T-13 SGO Project No. 611.

well as ratings on a repayment plan. This has the effect of making it possible to maintain an adequate stock of sizes.

Socks

Quality - Our observations would confirm the fact that the standard woollen socks issued are an excellent product. For a time it became impossible to obtain sufficient supply of these and an inferior quality had to be issued. The characteristic of these second choice socks was that the toe instead of being closed by knitting was sewn leaving a transverse seam at the toe. This seam had a tendency to pull under the toes in use and in approximately one third or one quarter of the cases supplied with them, some minor complaints resulted. The complaints were surprisingly few and unimportant. We understand that the only troops supplied with such socks were those in Canada.

No Instructions for Fitting - We have seen a number of instances in which grossly incorrect sizes of socks were issued and thus far have not been able to locate any clear cut instructions guiding quartermasters as to the size of socks to be issued to the troops.

Replacement - In one Advanced Training Centre a group of soldiers was seen just at the end of their training and many of these presented with socks rather seriously worn out. They complained to us that it was difficult to get a re-issue. On further inquiry at the camp, however, this was found to be a deliberate policy of the unit, in order that men would have their socks thoroughly worn out at the end of the training and then they could and would be issued with completely new ones before proceeding overseas. Even at this centre we did not observe any harm resulting from this practice though it gave rise to discontent among the soldiers. The practice at this unit, we think, is commendable.

Maintenance of Socks - On the whole repair of socks was poorly done. Some evidence of foot inefficiency, due to this cause, was observed, but even this was not great. Socks, on the whole, were not very clean and we saw them being worn and attention may be called to the lack of

facilities for laundering and in particular for laundering of socks in training centres. A percentage of individuals were wearing socks that had become somewhat felted and shrunken though the incidence of this was rather less than might have been expected. On the whole, we are under the impression that some actual benefit might be obtained by developing better laundering facilities and having available, in training centres, sock stretchers for drying. It does not seem practical to issue soldiers with sock stretchers and have them burdened by that much more equipment but it does seem conceivable to have sock stretchers as a fixture in huts.

Dubbin - Reference is made to Routine Order 2984 - Appendix "G" which requires the application of dubbin during the winter and encourages it during the summer though permitting the use of polish during the summer. In practice the soldier would have a somewhat disagreeable time with most N.C.O.'s were he to depend on washing and dubbing boots to the exclusion of polish. We are told by experienced officers that if too much dubbin is used it oozes through the leather to the inside and is disagreeable on socks, and this occurs particularly in the summertime. This problem is mentioned as one that might benefit by some further study.

Type of Soles for Boots - The Directorate of Inter-Service Research & Development of the Canadian Army undertook user trials of synthetic out sole material. This was undertaken by using synthetic outsoles on standard army boots and having soldiers march in them. They studied the subjective symptoms resulting from this and made a study also of the wearing qualities of this material. This was a most extensive user trial and the report covering it is not yet available. We understand, however, in general, that the wearing qualities of the synthetic material were excellent, that soldiers had a minor increase in subjective discomfort when the material was used as an outsole though very little when used as a clump sole. We understand that their conclusion is that the small amount of increased discomfort did not offset the increased wearing qualities and ready availability of the synthetic material if used for outsoles or clump soles. A comparison was also made between the discomfort in boots with a mid-sole and an

outsole only as against that without the addition of a clump sole. We understand that they found no difference between the ease with which a man accustomed himself to new boot with clump soles and new boots without clump soles. The preference of users was, with few exceptions, for the clump soles.

Fitting of Boots - A study of the criterion for the fitting of boots has been conducted at the Armoured Medical Research Laboratory at Fort Knox, Kentucky, by Captain Arthur Freedman. This was reported on the 12th June, 1945 (The Report on Project No. T10 - The Design and Fit of Army Shoes). Those interested in this subject should certainly consult this excellent study. As a result of this study, Captain Freedman has become skeptical that the American Army boot is made on the best possible design of last. He points out that the critical part of fitting is not the width of the fore part of the boots nor the over all length of the boot, but is the capacity of the mid and rear section of the boot. The boot may be too long or too wide in the fore part but if it is snug in the waist and heel no discomfort results. He is proposing to conduct another and more extensive study covering the measurements of the feet with a view to deciding the rightness or otherwise of the present lasts and with a view to having available measurements upon which to base any alterations in last design. It is probable that one of us (T.B.) will take part in such a study in the role of clinical advisor.

DISCUSSION OF HYPERMOBILE FLAT FOOT WITH SHORT
TENDO ACHILLIS IN RELATION TO SUPPORT OF THE
HEAD OF THE TALUS BY THE OS CALCIS

This section is presented as a collection of
observations and interpretations of our inter-
Project - Army Meds. - No. 22
preliminary studies which have already
been considered through the report there in an attempt to re-
sult in a more complete understanding of the condition. Nevertheless we hope that this may be of
some value.

Characteristics of Flat Foot with Short Tendo Achillis Defined

Some flat feet have the following characteristics:
The metatarsals and sesamoid bones are excessively
flexible. When the weight bearing on the foot tends to assume
a comparatively normal shape. If the foot is passively
inverted at the ankle, with maintenance of slight inver-
sion and reasonable sweep of the arch, there is limited
large flexion of the ankle due to the position of the tendo
achillis (the knee must be kept fully extended). This type
of foot is associated with marked disability. For purpose
of research and pure study, it has been given the
designation of "hypermobile flat foot with short tendo achillis."

DISCUSSION OF HYPERMOBILE FLAT FOOT

WITH SHORT TENDO ACHILLIS

IN RELATION TO

SUPPORT OF THE HEAD OF THE TALUS

BY THE OS CALCIS

Particulars in the normal foot are based upon the
comparative anatomy of the foot. The diagrams which show
the variation in the shape of the talus and calcaneus.
The position of the talus is variable and
the angle of the talus is variable as well as
the size. There is variation in the length to width
of the talus and calcaneus. As far as we have found, these
variations have not been studied in relation to any great ex-
tent. The relationship of variations to disability in the
condition has not been studied to our knowledge.

Normal tarsus - In the normal, the calcaneus carries a
sesamoid bone which is strongly placed slightly behind the
front end of the calcaneus and the front margin tends to
merge with the front end of the calcaneus. The front end
of the calcaneus has a facet for the head of the talus. The
talus when articulated with the calcaneus and looked at from
above, overlaps the front end of the body of the calcaneus.
The head projects a little in front of the front end of the
calcaneus.

DISCUSSION OF HYPERMOBILE FLAT FOOT WITH SHORT
TENDO ACHILLIS IN RELATION TO SUPPORT OF THE
HEAD OF THE TALUS BY THE OS CALCIS

This section is presented as a collection of pertinent data on the subject of HFF-STA and as our interpretation of this data. Since much of this is already scattered through the report there is an element of recapitulation. Nevertheless we hope that this may be of some value.

Hypermobile Flat Foot with Short Tendo Achillis Defined

Some flat feet have the following characteristics: the mid-tarsal and subastragalar joints are excessively mobile. When not weight bearing, the foot tends to assume a comparatively normal shape. If the foot is passively dorsi-flexed at the ankle, while maintaining slight inversion and reasonable shape of the arch, there is limited dorsi-flexion of the ankle due to the tension of the tendo achillis (the knee must be kept fully extended). This type of foot is associated with marked disability. For purpose of emphasis and more clear cut study, it has been given the designation hypermobile flat foot with short tendo achillis. See Figs. 33, 34, 35 and 13, 14, 15, 16.

Variations in the Tarsus - A review of papers upon the comparative anatomy of the foot reveals diagrams which show marked variation in the shape of the talus and calcaneus. The position of the sustentaculum is obviously variable and its slope in a coronal or saggital plane varies as well as its size. There is variation in the relative length to width of talus and calcaneus. So far as we have found, these variations have not been studied in humans to any great extent. The relationship of variations to disability in the human has not been studied to our knowledge.

Normal Tarsus - In the normal, the calcaneus carries a sustentaculum which is strong, placed slightly behind the front end of the calcaneus and the front margin tends to merge with the front end of the calcaneus. The front end of the calcaneus has a facet for the head of the talus. The talus when articulated with the calcaneus and looked at from above, overlaps the front end of the body of the calcaneus. The head projects a little in front of the front end of the calcaneus.

Professor Cates, at the instigation of one of us (R.I.H.), investigated the tarsus looking for variations which might explain or be associated with flat feet. He conceived that the head of the talus is supported in part by bone and in part by ligaments - the greater the support by bone, the less the support by ligaments. If great stress was put on the ligaments by decreasing the support of the head of the talus by bone, symptoms might result. He, therefore, ranged the feet from two hundred cadavers in series to illustrate firmness of support of the head of the talus by the os calcis. The two extremes found are shown in Figs. 17 to 20. It is noted that in the case of the weak support of the head of the talus, the sustentaculum is placed far back; the anterior margin is almost at right angles with the long axis of the calcaneus and with these two factors there develops a distinct notch between the front of the sustentaculum and the side of the calcaneus when viewed from above. It can be noted that the front end of the calcaneus carries no facet for the head of the talus. The talus has a long neck and both bones seem long in proportion to their width. When the specimens are articulated, it is noted that the whole of the head and most of the neck of the talus lie completely free from underlying bony support of the calcaneus. The pair of bones taken from the opposite end of the series show diametrically the opposite features. The same features may be studied in x-rays. See Figs. 21 and 22.

Reason to Study Support of the Head of the Talus - It has long been stated that some normal looking feet develop arch strain when used, while some abnormal, flat looking feet do not develop symptoms. At the inception of this study, it was thought that the variation in the support of the head of the talus in two similar cases might explain this. Since it was uncertain what was the meaning in clinical terms of this variation and how often the variation occurred, it was felt to be important to study the feature in clinical cases.

Relationship of Support of Head of Talus to Hypermobile Flat Foot with Short Tendo Achillis - Emerging from the study is the evidence that the hypermobile flat foot with short tendo achillis is associated with weak support of the head of the talus. A table to bring out this feature follows:

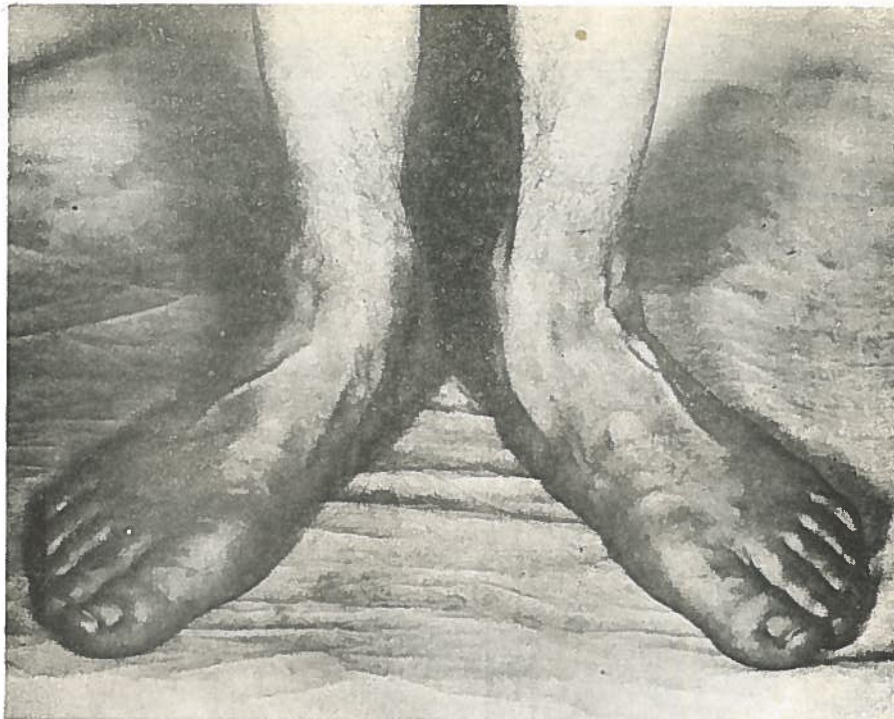


Fig. 33 - Severe hypermobile flat foot with short tendo achillis.

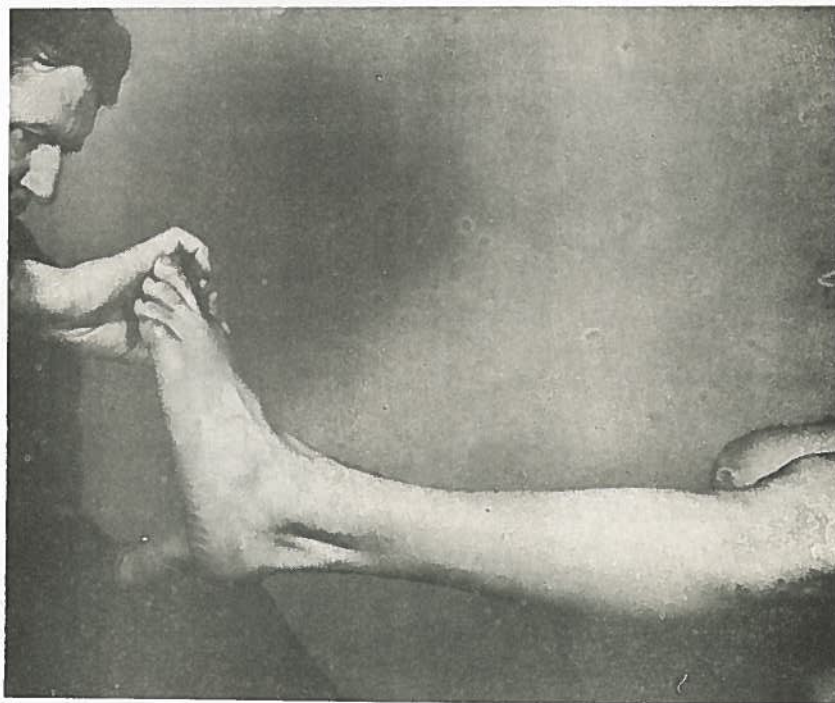
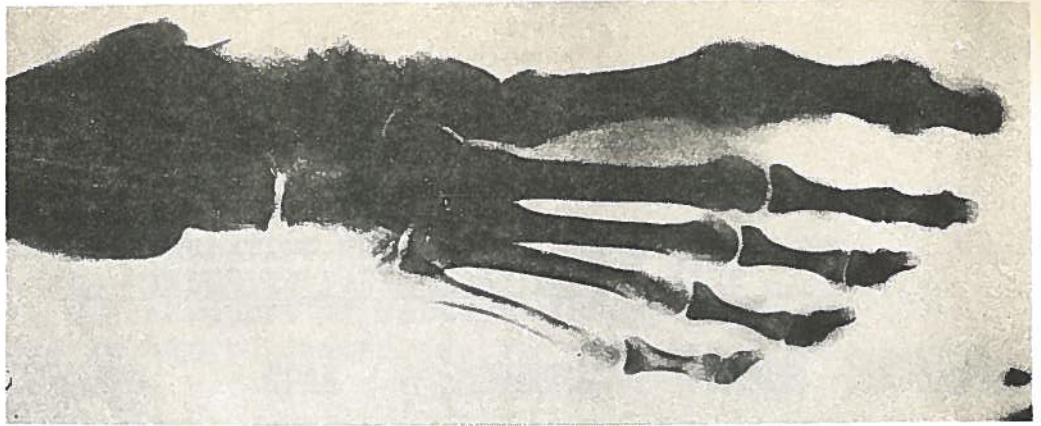


Fig. 34 - Hypermobile flat foot with short tendo achillis. Dorsi-flexion limited to -18° (i.e. angle greatest dorsi-flexion = 108°). Same case as Fig. 33.



3739

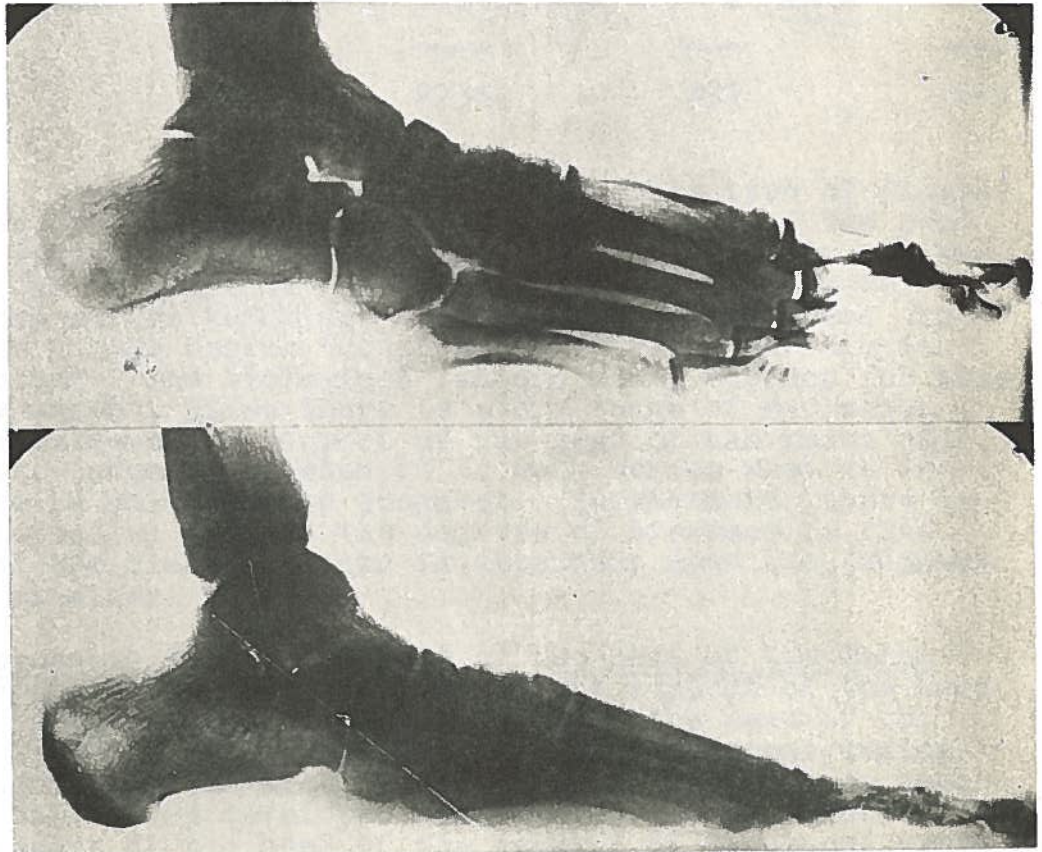
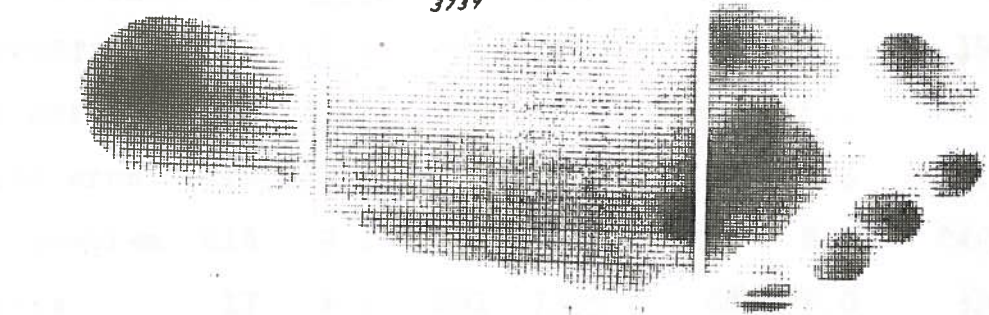


Fig. 35 - Moderately severe hypermobile flat foot with weak support of the head of the talus.

TABLE RELATING SUPPORT OF THE HEAD OF THE
TALUS TO VARIATIONS OF THE ARCH
Support of Talus by Calcaneus

<u>CLASSIFICATION</u> (in respect to arch)		<u>WEAK</u>		<u>MODERATE</u>		<u>FIRM</u>		<u>TOTAL</u>
Severe HFF-STA	19	<u>76.0%</u>	6	24.0%	0	0.0		25
Mild HFF-STA	101	<u>52.6</u>	85	44.3	6	3.1		192
Dubious HFF-STA	88	<u>45.6</u>	94	48.7	11	5.7		193
Other low arch	109	28.9	252	<u>68.8</u>	16	4.3		377
No arch problem	218	9.1	1984	<u>82.5</u>	203	8.4		2405
Mild cavus	17	4.3	291	<u>73.5</u>	88	<u>22.0</u>		396
Severe cavus	0	0.0	23	74.2	8	<u>25.8</u>		31
TOTAL	552		2735		332			3619

It becomes obvious then that this type of disabling flat foot is associated with weak support of the head of the talus. When the association was first seen, it was hoped that it might have been more clear cut. However, with more mature thinking, it might better have been expected that a high degree though not a complete correlation would occur. The biological factors would account for this, to some extent, since there is every stage of variation between extremes of support of the head of the talus and since the judgment of when it is weak versus when it is moderate is only a human judgment. Furthermore, there is every variation between the degrees of hypermobile flat foot and the classification is dependent upon the judgment of the examiner.

Symptoms in Varying Support of the Head of the Talus -
The association of the symptoms to the support of the head of the talus is that in weak support of the head of the talus, 16.8% of those enlisted developed symptoms during training due to the arch; in moderate support of the head of the talus 5.8% developed symptoms due to the arch; in firm support of the head of the talus 2.8% developed symp-

toms due to the arch. When it is appreciated that less cases with, than without weak support of the head of the talus seen at the Reception Centre were enlisted and that those which were, probably had the lesser degree of aberrance, the 16.8% becomes impressive.

X-rays not Imperative - Neting the fact that there is a high degree of association between lack of support of the head of the talus and a type of flat foot which is reasonably easy to detect, the importance of x-rays as a key factor in deciding disability decreases.

377	4.3	16	68.8	252	28.9	109	Other low arch
2405	8.4	203	82.2	1984	9.1	218	No arch problem
396	22.0	88	73.2	291	4.3	17	Mild cavus
31	25.8	8	74.2	23	0.0	0	Severe cavus
3619		355	2752	2752		222	TOTAL

If becomes obvious that this type of disability flat foot is associated with weak support of the head of the talus. When the association was first seen, it was hoped that it might have been more clear cut. However, with more mature thinking, it might better have been expected that a high degree though not a complete correlation would occur. The biological factors would account for this to some extent, since there is every stage of variation between extremes of support of the head of the talus and since the judgment of when it is weak versus when it is moderate is only a human judgment. Furthermore, there is every variation between the degrees of hypermobile flat foot and the classification is dependent upon the judgment of the examiner.

Symptoms in Varying Support of the Head of the Talus - The association of the symptoms to the support of the head of the talus is that in weak support of the head of the talus, 16.8% of those enlisted developed symptoms during training due to the arch; in moderate support of the head of the talus 5.8% developed symptoms due to the arch; in firm support of the head of the talus 2.8% developed symptoms.

DISCUSSION OF SIGNIFICANCE OF ATAVISTIC
FIRST METATARSAL SEGMENT

Project - Army Meds. - No. 22

Morton's thesis on the significance of the first metatarsal on comparison to the second. He showed that this variation was a natural expectancy of aversion. He also recognized the widening of the angle between the 1st and 2nd as a feature of staving. He considered that separation of the base of the 1st metatarsal segment from the rest of the foot represented associated hypermobility of the 1st metatarsal segment. Shortness or hypermobility of the 1st metatarsal or a posterior position of the sesamoids was considered to lead to decreased weight bearing by the head of the 1st metatarsal. The weight which should have been borne by the head of the 1st metatarsal was thereupon carried by the 2nd and perhaps in part, by the 3rd. He studied the weight distribution clinically by means of foot prints. The thickness of the 2nd metatarsal shaft as seen on x-rays, was stated to be proportionate to the weight load carried by the 2nd metatarsal head. He conceived that the effects of this lack of proper weight bearing by the head of the 1st, in addition to causing calluses under the 2nd, allowed pronation of the foot with resulting support of the

DISCUSSION OF SIGNIFICANCE

OF

ATAVISTIC FIRST METATARSAL SEGMENT

It also... trauma to the segments of the base of the 2nd metatarsal with secondary inflammation and even an abscess of the inflammation to involve the... the peri-neuritis... described as Morton's (T.G. - not Dudley) metatarsalgia. This conception might explain symptoms in many cases which were otherwise obscure and therefore we felt that it was necessary to investigate Morton's thesis with care.

Foot Survey Study - The x-rays of all cases were examined for shortness of the 1st metatarsal by a scale in accordance with Morton's method. This method is to determine whether the head of the 1st metatarsal projects beyond or recedes behind the line which is tangent to the head of the 2nd metatarsal at right angles to its shaft (this being studied in the supero-inferior x-ray projection). In order that all would agree on the cases determined to be short 1st metatarsal as compared with the 2nd, trifling degrees of shortness were not recorded as such. Such

DISCUSSION OF SIGNIFICANCE OF ATAVISTIC
FIRST METATARSAL SEGMENT

Morton's Thesis - As is well known, Dudley Morton recognized variations in the length of the 1st metatarsal on comparison to the second. He showed that this variation was a natural expectancy of atavism. He also recognized the widening of the angle between the 1st and 2nd as a feature of atavism. He considered that separation of the base of the 1st metatarsal segment from the rest of the foot represented associated hypermobility of the 1st metatarsal segment. Shortness or hypermobility of the 1st metatarsal or a posterior position of the sesamoids was considered to lead to decreased weight bearing by the head of the 1st metatarsal. The weight which should have been borne by the head of the 1st metatarsal was thereupon carried by the 2nd and perhaps in part, by the 3rd. He studied the weight distribution clinically by means of foot prints. The thickness of the 2nd metatarsal shaft as seen in x-rays, was stated to be proportionate to the weight load carried by the 2nd metatarsal head. He conceived that the effects of this lack of proper weight bearing by the head of the 1st, in addition to causing calluses under the 2nd, allowed pronation of the foot with resulting strain of the ligamentous support of the arch. It also was thought to cause chronic trauma to the ligaments of the base of the 2nd metatarsal with secondary inflammation and even an extension of the inflammation to involve the contiguous medial plantar nerve. The perineuritis, in turn, gave neuralgic symptoms previously described as Morton's (T.G. - not Dudley) metatarsalgia. This conception might explain symptoms in many cases which were otherwise obscure and therefore we felt that it was necessary to investigate Morton's thesis with care.

Foot Survey Study - The x-rays of all cases were examined for shortness of the 1st metatarsal by a scale in accordance with Morton's method. This method is to determine whether the head of the 1st metatarsal projects beyond or recedes behind the line which is tangent to the head of the 2nd metatarsal at right angles to its shaft (this being studied in the supero-inferior x-ray projection). In order that all would agree on the cases determined to be short 1st metatarsal as compared with the 2nd, trifling degrees of shortness were not recorded as such. Such

trifling shortness up to about 1 mm. was recorded as of equal length of 1st compared with 2nd. On this basis, it is found that 35.4% had shortness of the 1st metatarsal. A clinical judgment was also made at the same time by flexing the toes sharply at the metatarso-phalangeal joint and observing the apparent relative length of the 1st and 2nd metatarsals. Cases were not recorded as short (by clinical judgment) unless it was felt virtually certain that this was so. The clinical judgment listed 7.4% as being short, but in spite of the effort not to give this classification unless sure, it may be noted that 23% of those which were clinically judged to be short turned out to be not short as measured on x-rays. It was felt necessary to do more than simply record the presence or absence of shortness of the 1st metatarsal, therefore, measurements in mm. were made. We noted, because of variation in the degree of varus and valgus of the fore part of the foot, compared with the rear part of the foot (occurring particularly in the metatarsals) that it seemed better to measure the length of the 1st metatarsal compared with the 2nd as a difference in distance from the middle of the back of the calcaneus; accordingly all our cases have been measured in this manner. However, we undertook the measurement in mm. of half of the cases by Morton's method as well.

Results in Graphic Form - The relationship of shortness of the 1st metatarsal to increased weight borne by 2nd and 3rd metatarsals is best shown by means of graphs (graphs 20 to 33 inclusive, Appendix "F"). These show that at any degree of shortness of the 1st metatarsal more cases are without excess weight than with excess weight on the 2nd and 2nd and 3rd. Conversely, excess weight on the 2nd or 2nd and 3rd occurs in a proportion of instances where the 1st is distinctly longer than the 2nd. The graphs show that with shortness of the 1st, frequency of excess weight on the 2nd or 2nd and 3rd metatarsal heads is increased.

Decrease in Mobility of 1st not Considered to Offset the Effects of Shortness - From the atavistic theory of shortness of the 1st there would presumably occur an increased incidence of excessive mobility of the 1st in

cases with shortness of the 2nd. At least there seems to be no reason to suppose that excessive mobility is more frequent in cases of full length of the 1st than in cases of shortness of the 1st metatarsal. We were unable to arrive at any method of demonstrating variations of mobility in the 1st metatarsal segment and, therefore, are unable to prove or disprove what has just been stated.

Excess Weight on 2nd or 2nd & 3rd Not Common in Cases with Short 1st - On the presumption that the incidence of hypermobility is approximately equal in the cases with shortness as against the cases without shortness, then if shortness is a great influence in giving rise to excess weight bearing on the head of the 2nd or 2nd and 3rd metatarsal, there should be a high incidence of excess weight on these heads where the shortness is more marked. However, excess weight is a comparatively infrequent occurrence even in the cases where shortness of the 1st metatarsal is greatest.

Metatarsals Other Than 2nd or 2nd & 3rd May be Involved In cases which have excess weight on the metatarsal heads, there is variation, from case to case, as to which head or heads are involved. See Fig. 36. Such excess weight affects any of the other metatarsals in addition to the 2nd. Any combination of metatarsals carrying excess weight may occur. This is readily seen in an examination of the sole.

Clinical Picture - The heads of metatarsals carrying excess weight feel as if they are depressed plantarwards in relation to the other metatarsal heads. The skin of this area of the sole appears to respond to excess weight fairly uniformly by keratinization (callus). This means that where excessive keratinization is present, there is more weight bearing per unit area being carried. If this were a matter of "dropping" of the metatarsal arch, it seems unreasonable that the intermediate heads of the arch would drop so much that they carried more weight, this situation implies that they are not "dropping" but are being pushed against the floor or held against the floor.

Question of Hypermobility of the 1st - If the foot of cases with excess weight on 2nd or 2nd & 3rd metatarsal heads, but without shortness of the 1st metatarsal, is studied respecting the mobility of the 1st metatarsal segment, it is our impression that the segment often definitely is not excessively mobile but is bound in the foot in a dorsal position. If the head of the 1st metatarsal is pushed down to be in the same plane as the other metatarsals it frequently can be seen to spring back into its previous position. Such an observation appears also to have been recently reported in England.

Conclusion - Our conception then of this matter is that where excess weight occurs on the 2nd or 2nd & 3rd or any other metatarsal, the greatest causative factor is that the metatarsal bones are held in an irregular alignment (respecting the plane of the floor) by the ligaments of the foot and the contour of the bones. We agree that shortness of the 1st has an influence in originating excess weight particularly on the 2nd or 2nd & 3rd heads, but that this is a minor influence rather than a major one.

Symptoms from Excess Weight - Our studies indicate that the symptoms produced by excess weight on the 2nd or 2nd & 3rd or other metatarsals is one of excess pressure giving rise to troublesome hyperkeratosis (callus). We have seen no evidence that there are symptoms deep in the arch region in any greater frequency on this account than would be expected if the excess weight were not present. This has not been statistically established as yet but is our firm impression.

Short 1st and Planus - It has been suggested that shortness of the 1st metatarsal may allow pronation and hence a real or apparent depression of the longitudinal arch. This does not appear to have been stated by Morton but to have been implied by others. To study this we made separate frequency curves for various heights of arch. Reference to Graph 21, Appendix "F", and the table thereon show the arithmetic means of the length of the 1st metatarsal relative to the 2nd (Survey method) are as follows:

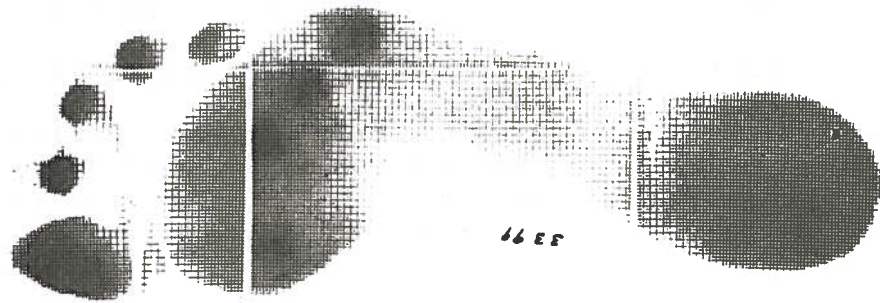
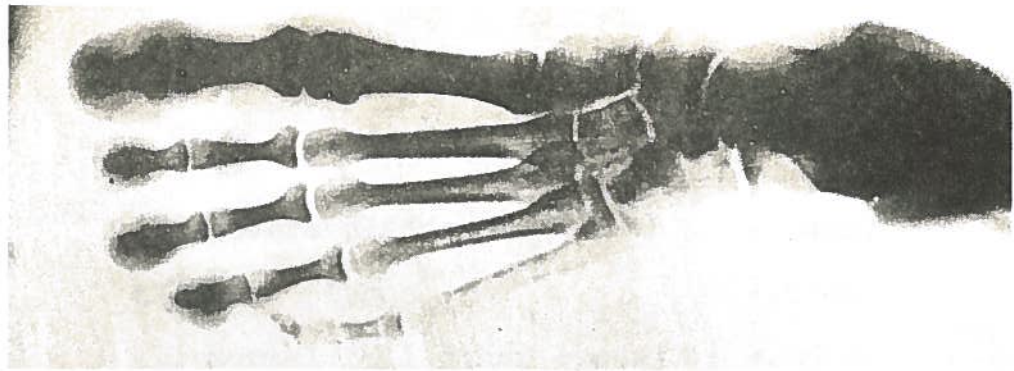


Fig. 36 - Excess weight 3rd, 4th and 5th metatarsals left; 3rd and 5th metatarsals right; to illustrate the occurrence of asymetry.

All severe planus	+ .04mm.
All mild planus	+ .03mm.
All normal (all other cases)	+ .05mm.
All mild cavus	+ .21mm.
All severe cavus feet	+ .30mm.

The "T" values of the difference between the means taken together with the small differences between the means would show that there is no practical association between the height of the arch and the length of the 1st metatarsal.

The question, however, is not quite completely decided by this set of curves. It will be recalled that weak or firm support of the head of the talus also gave rise to variation in the arch. In order to limit the variables, all the cases with weak or firm support of the head of the talus were eliminated and the frequency curves and tables made up from the remaining. See Graph 23 - Appendix "F". When this is done we get the following arithmetic means for the length of the 1st metatarsal (Survey method):

All severe planus	- .12mm.
All mild planus	- .31mm.
Normal (all other cases)	+ .10mm.
Mild cavus	+ .53mm.
Severe cavus	+ 1.46mm.

We see that here (with the exception of the severe planus) the 1st metatarsal gets shorter with the depression of the arch. The "T" values for the differences between the means show significance to these differences.

In the final conclusion on this point we may argue from all of this that depression of the arch has

associated with it a slight shortening of the 1st metatarsal.

Excess Weight and Hypertrophy of 2nd Metatarsal - It will be recalled that Morton suggested that the thickness of the 2nd metatarsal (or perhaps more properly the strength of its shaft) is proportional to the weight carried upon it. We were unable to devise means for practical use, of measuring the hypertrophy of the shaft of the 2nd metatarsal. The most pronounced weight bearing on the 2nd metatarsal occurs where there is callus under this metatarsal head alone. In our series there were 7238 feet seen, 25 of which had enough excess weight on the 2nd metatarsal to cause callus. Division of each of these groups into those with and those without thickening of the 2nd metatarsal is shown in the following small table:

	Thickened 2nd (no. of feet)	Without Thickened 2nd (no. of feet)	TOTAL (no. of feet)
Cases with excess weight on 2nd with callus to correspond	12	13	25
All cases whether or not with excess weight or callus	1136	6102	7238

The thickness of the 2nd metatarsal was not recorded unless it was felt that it would be agreed in by other observers using Morton's criteria. The cases with thickness and without thickness were divided into those with excess weight and those without and this in tabular form as follows:

Classification	No		TOTAL
	Thickening	Thickening	
Excess weight 2 alone	7.3%	53.6%	100%
Excess weight 2 & 3 together	4.6	57.7	100

Classification	Thickening		No Thickening		TOTAL
	(Cont'd. from page 116)				
Excess wt. 2 & 4, 2 & 5, 2 & 1	0.1	6.7	0.2	93.3	100%
Excess wt. 1, 3, 4, or 5 in any combination	6.6	20.7	4.7	79.3	100
Excess weight not specified	7.3	24.9	4.1	75.1	100
No excess weight	74.1	13.5	88.2	86.5	100
TOTAL	100		100		

NOTE: Percentages on the left in each column are of the total with thickening of the 2nd metatarsal and without thickening of the 2nd metatarsal as applicable. Percentages on the right in each column are of total for each classification of excess weight regardless of thickening or absence of thickening.

It is seen from the table that of those with thickening of the 2nd metatarsal 74.1% have no excess weight at all, whereas, 11.9% have excess weight on the 2nd alone or 2nd & 3rd alone. Where no thickening is present 88.2% have no excess weight, whereas 2.8% have excess weight on 2nd & 3rd together only. It is, therefore, concluded that thickening of the 2nd metatarsal is only slightly associated with excess weight. Lacking other explanation it is not unreasonable to consider it slightly dependent on excess weight. This, however, is by no means proved. It is possible to speculate as to what other factors might be operative to cause increased thickness of the 2nd but we prefer for the present, to regard them as fortuitous.

THE MANAGEMENT AND TREATMENT OF FOOT
DISABILITIES IN THE ARMY

On the basis of the experience gained in the Foot Survey, it is now possible to discuss the management and treatment of such disabilities in the Army and to formulate improvements.

Project - Army Meds. - No. 22

The problem divides itself into two phases.

1. the recognition of structural foot disabilities and the proper assessment of them in respect to function.
2. the treatment of such foot disabilities as develop during military training and service.

Recognition of foot disabilities and
proper assessment of their functional capacity

This phase is of greatest importance at the Reception Centre since it is there that functionally unfit feet should be eliminated. But throughout the whole period of a soldier's service the problem may recur. Consequently, it is THE MANAGEMENT AND TREATMENT of every Medical Officer be familiar with the problem and skilled in its management.

OF

FOOT DISABILITIES

IN THE ARMY

In dealing with these cases at the Reception Centre it is expedient to reject only those cases which it is reasonably certain will not stand the strain of training. If there is real doubt as to their functional capacity it is wise to enlist them and submit them to the test of training. Often the functional capacity is greater than might be anticipated from the degree of structural abnormality. There has been a tendency on the part of the Reception Centre to "play safe". This leads to the rejection of men about whose functional capacity there is doubt. Often this causes needless loss of army personnel. Insofar as physical fitness is concerned, the sound procedure is to reject those who certainly will break down in training; enlist those who obviously are fit and also enlist those about whom there may be reasonable doubt. The test of training will determine their functional capacity better than anything else.

The following structural lesions can be regarded

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On the basis of the experience gained in the Foot Survey, it is now possible to discuss the management and treatment of foot disabilities in the Army and to formulate improvements.

The problem divides itself into two phases.

1. the recognition of structural foot disabilities and the proper assessment of them in respect to function.
2. the treatment of such foot disabilities as develop during military training and service.

Recognition of foot disabilities and
proper assessment of their functional capacity

This phase is of greatest importance at the Reception Centre since it is there that functionally unfit feet should be eliminated. But throughout the whole period of a soldier's service, the problem may recur. Consequently, it is of fundamental importance that every Medical Officer be familiar with the problem and skilled in its management.

In dealing with this problem at the Reception Centre it is expedient to reject only those cases which it is reasonably certain will not stand the strain of training. If there is real doubt as to their functional capacity it is wise to enlist them and submit them to the test of training. Often the functional capacity is greater than might be anticipated from the degree of structural abnormality. There has been a tendency on the part of the Reception Centre to "play safe". This leads to the rejection of men about whose functional capacity there is doubt. Often this causes needless loss of army personnel. Insofar as physical fitness is concerned, the sound procedure is to reject those who certainly will break down in training; enlist those who obviously are fit and also enlist those about whom there may be reasonable doubt. The test of training will determine their functional capacity better than anything else.

The following structural lesions can be regarded

as sufficiently disabling to justify rejection.

Severe hypermobile flat foot with short tendo achillis. These cases all develop difficulties in training and are not functionally able to undertake the training of a soldier. A severe degree of this lesion may be described as one which has marked flattening of the longitudinal arch on standing (though the deformity may disappear when weight is off the foot) marked limitation of dorsi-flexion at the ankle joint and marked hypermobility of movement at the subastragalar and mid-tarsal joint. These signs are accompanied by symptoms of weak arch, pain on standing or walking.

The milder degrees of this structural foot lesion should be enlisted. Generally speaking their functional capacity is greater than might be anticipated from the degree of deformity. They probably will require a lowered L grading. This may be assigned on the basis of the Reception Centre examination or it may be postponed until the test of training permits more accurate assessment of functional capacity.

Peroneal spastic flat foot. Generally speaking all but the mildest cases of this lesion are unfit for military service and should be rejected. The mild cases may be enlisted with a lowered L grading.

Severe hallux valgus - should not be enlisted. Severe cases would be those who will have difficulty with boot fitting and diminished capacity to march. They will have a large exostosis - marked widening of the forefoot - the great toe deviated so far that it no longer takes part in the thrust of the stride and disturbances of weight bearing in the forefoot with calluses beneath the heads of the metatarsals.

The milder cases of hallux valgus may be enlisted. They stand the stress of training surprisingly well provided

their boots are fitted properly. They must be free from pressure on the exostosis.

Severe and moderately severe hallux rigidus of the intra articular type. This is a seriously disabling lesion which completely prevents military service. Even the milder degrees interfere so much with marching that they require a lowered L grading.

Severe hallux rigidus would be one which extends less than 25° beyond the straight line, which has a dorsal exostosis on the head of the metatarsal and has pain on the extremes of movement.

Severe pes cavus. This might be described as one in which the long axis of the hindfoot meets the long axis of the forefoot (in the lateral projection) at about a right angle at the mid-tarsal joint. Weight is borne on the tip of the heel and on the heads of the metatarsals. The arch is high. The middle of the foot does not touch the ground. The prominence of the heel is lost. The toes are clawed. There are calluses beneath the metatarsal heads.

Milder cases do better in training than might be anticipated provided they are properly fitted with shoes. They may be enlisted and their L grading adjusted to conform with their functional capacity.

Calluses. The presence of severe calluses on the sole of the foot beneath the heads of the metatarsals no matter what the cause is a serious handicap to military training. The more severe cases would be better not enlisted. Their calluses are due to structural abnormality and interfere greatly with strenuous use of the foot.

The remaining common foot lesions have proven not to handicap greatly military training: flat foot other than HFF-STA; accessory tarsal scaphoid; hammer toe; exostosis.

Standardized plan of examination of the feet of soldiers.
 It is valuable to have a standardized plan for the examination of the feet of soldiers. The circumstances under which such examinations are conducted almost always necessitate their being done rapidly. Some orderly plan ensures speed and the certainty that nothing will be overlooked.

Watch the man as he walks into the examining room. Look for limp or deformity of the feet. Have him stand and examine him front and back for deformity, especially flat foot and valgus of the heel. Note the presence of hallux valgus, hammer toe or exostosis. Then have him sit down and with his knee fully extended and his heel on the examiner's knee, determine the range of dorsi-flexion at the ankle, the range of dorsi-flexion of the great toe, the degree of mobility of the subastragalar and mid-tarsal joints, the characteristic features of HFF-STA and of peroneal spastic foot. Examine the sole of the foot to determine the area which makes contact with the ground and look especially for the presence of calluses. Too little stress is laid upon the significance of callus.

A considerable experience including that derived from this Survey leads us to the conclusion that the whole examination of a soldier's feet can best be carried out by simple clinical methods. Elaborate technical procedures such as radiographs and foot prints are unnecessary for standard routine examination, though they have great merit in a programme of research.

Certain foot problems are commonly overlooked or underestimated at the Reception Centre. Moderate degrees of HFF-STA are prone to be underestimated probably because they conform to the description of flexible flat foot which certain authorities state is of little functional significance (wrongly in the case of HFF-STA). Claw foot is frequently missed unless the deformity is severe. Often disregarded are the calluses beneath the heads of the metatarsals, probably because their significance in relation to function is not well appreciated for the calluses are easily enough seen when the sole of the foot is examined.

Need of uniform training of Medical Officers in the problem of foot disabilities. It is obvious that there must be some uniformity in the management of foot problems in soldiers. This can only be accomplished on the basis of established facts. The Foot Survey will go far to provide these facts which heretofore have not been available. It remains to instruct Medical Officers in the recognition of foot lesions, the assessment of their functional capacity and their management in the Army. This can best be accomplished as part of the training of Medical Officers on enlistment. Foot problems are so much more important in military medicine than in civil life that adequate and uniform instruction will only be accomplished in the Army. Instruction in boot fitting should be included.

Treatment of foot disabilities which develop during military service

Prophylaxis. Much foot disability can be prevented by good foot care. It should be the responsibility of the Medical Officer to determine that adequate foot hygiene is the rule in his unit. If he think it needs to be improved he should so advise the Commanding Officer.

The elements of good foot care are simple: clean feet; clean, dry socks, well fitting boots in good condition. The soldier must be persuaded to assume the responsibility of caring for his own feet and not wait until he is ordered to do so.

The Medical Officer will be greatly aided by a chiroprapist or a foot orderly. At least one man on the strength of the Medical Inspection Room should have sufficient skill and interest and training in foot problems to justify his carrying out whatever treatment the Medical Officer may think necessary. It is not necessary that he be a fully trained and qualified chiroprapist though if he is not he must be a man of intelligence and skill who will quickly learn to carry out efficiently the procedures which are necessary. Whatever his skill he must function only under the instruction of the Medical Officer.

Ingrown toe nails. If severely septic the man should be admitted to hospital and the whole nail removed by simple avulsion from its bed. This permits the infection to subside and as the new nail grows out care can be taken to prevent it again growing into the soft tissues.

In most other cases all that is necessary is to elevate the corner of the nail out of the ulcerated pocket it has made for itself and maintain it so until it grows out beyond the soft tissue bed. A pledget of cotton packed under the corner of the nail will provide the necessary lift. It should be renewed daily or every second day. The man himself under instruction can quickly learn to do this.

The nail should be cut transversely and once it has grown out beyond the soft tissues, care must be taken in trimming that the corner never again is cut so short as to permit the soft tissues to fold over it.

Blisters. These may be the result of poorly fitting shoes or of friction between the skin and its coverings. It is especially prone to occur in feet sodden from excessive sweat.

If blisters have occurred the man must be excused duty and the wearing of boots until such time as they are healed. Care must be taken to prevent infection.

Much can be done to prevent blisters. The important precautionary measures are properly fitting of boots, good socks which are clean and free from rough darns. If there are irregularities in the shape of the foot e.g. exostosis, hallux valgus, special precautions must be taken to make the boot fit the foot without pressure on the bony prominence. Excessive sweating can be overcome by dilute formalin foot baths. Too little attention is paid to excessive sweating and its control. Dilute formalin baths are effective in most cases but they must be stopped if skin irritation develops.

Callus. The disabling type of callus is that beneath the heads of the metatarsals. In army

circumstances it is not possible to treat this very effectively or satisfactorily. The measures which give much relief in civil life (metatarsal pads etc.) are impractical in the army and in many cases the demands upon a soldier's feet are such that even metatarsal supports will not protect him. If callus beneath the heads of the metatarsals is severe and producing symptoms, it is best to dispose of the problem by lowering the man's L grading sufficiently so that the demands placed upon him will not exceed his capacity.

Tendinitis. The cure of this is rest. The boot must be refitted to prevent further pressure upon the tendon. This will necessitate the ironing out of wrinkles. Often it is best to provide him with a new boot.

Hallux Valgus. Unless of severe degree, bunions give little trouble if the boot does not press on the exostosis. The important measure therefore is to provide a boot of adequate width in front. If necessary it should be stretched over the bunion.

Operation has little place in the management of bunions in the Army. Occasionally the simple removal of a large exostosis without operation upon the joint will result in improvement sufficiently great to justify its performance. Operation upon the joint, even when it satisfactorily corrects the deformity, leaves such a degree of functional incapacity as precludes service as a soldier.

If the hallux valgus is causing disablement which cannot be improved by shoe fitting or stretching, the soldier should be down-graded.

Problems related to boot fitting

There are two kinds of problems related to boot fitting: first, the normal foot, wearing boots of improper size or width; second, the abnormal foot which requires something out of the ordinary in boot fitting.

It is important that the Medical Officer be sufficiently familiar with shoe fitting to be able to determine himself whether or not any given pair of shoes are of the proper size. His chiropodist or foot orderly should also be able to determine this. For this purpose the Medical Inspection Room should have the equipment necessary to determine foot size and in addition, equipment for certain simple changes in boots. A foot-measuring stick and a clamp to stretch the boot at any selected point will cover most problems.

If the Medical Officer feels that a soldier's foot complaint is due to ill-fitting boots, it is important that he demonstrate this by actual measurement of the foot and the boot. Otherwise his request for the issue of a new pair of boots may lead to misunderstanding between himself and the quartermaster.

Abnormal feet constitute a separate problem. They may be grossly outside - large or small. More frequently they have some local abnormality such as bunion or claw toes. These require special fitting to ensure that boots of adequate width and height in the toe are provided.

No. 1 Boot Rebuilding Depot - Montreal

The establishment of this plant by Army Salvage and Disposal did much to solve problems related to shoe fitting. Its primary object was to remake boots, using whatever of value that could be salvaged from condemned boots, adding such new material as was needed. It proved a valuable experiment in salvage.

Because of difficulties in the supply of outsize boots, their manufacture was taken on by No. 1 Boot Rebuilding Depot. This activity came to provide a solution for most of the serious boot fitting problems of soldiers. A fitting chart upon which was recorded the outline of the foot and various measurements when sent to the Depot gave sufficient information to permit the making of outsize boots from lasts of standard design. Minor adjustments in shape to accommodate exostoses could be indicated by tracing and measurements and

by a simple procedure translated to the last and a boot built to accommodate the minor abnormality. These boots of modified construction solved the problem of foot wear for many cases.

The possibilities of the Depot for the supply of footwear for abnormal feet had not been fully exploited by the time the war ended. Even on a limited scale the value of the service it was able to render was sufficiently great to justify the statement that such a Depot should always be part of the Army organization and that the possibility of using it for the alleviation of other foot problems - especially callus beneath the heads of the metatarsals - should be fully explored.

Flat Foot. Pes planus giving rise to symptoms cannot be very satisfactorily managed in the Army in such a manner as to retain the soldier in an Ll grading. Most such cases are examples of hypermobile flat foot with short tendo achillis or of peroneal spastic flat foot. The measures which are of value in civil life (foot supports or boot modifications) are impractical in the Army. To supply foot supports on any extensive scale would necessitate an elaborate orthopaedic supply organization, and to maintain the supply to the individual soldier from training center to front line would be so difficult as to be impractical.

In several training centres, boot modifying units were set up which were equipped and staffed to make corrective alterations in boots on the prescription of a Medical Officer. These were of the nature of metatarsal bar, metatarsal lifts inside the sole, wedges in the sole and heel, moulded leather supports for the longitudinal arch. Such units often served a useful local purpose. They but fell far short of solving the general problem of what to do for the soldier with painful feet. There were many reasons for their imperfect success. First, the method of treating painful feet by modifications to

the boot is not the most efficient except perhaps in lesions of the metatarsal arch. Second, the boot modification, if at first efficient, quickly loses its shape and the support it gives to the foot. Third, to accomplish any measure of success the modification to the boot must suit the individual foot, i.e. the modification cannot be standardized. Fourth, no sooner was the soldier provided with a modified boot which gave him some relief than he moved on to another military training centre or went overseas. It was impossible to provide him continuously with individualized modifications of his boot. Fifth, it was impractical (indeed impossible) to equip these boot modifying units with machinery. Work had to be done by hand. This limited their output and lowered its quality since soles were nailed instead of sewn.

The attempt to support painful feet in the Army by methods which are valuable in civil life, has not been successful. In addition to the defects in the method which have been enumerated above, there is the overriding fact that the proof of success in treatment will be the ability to undertake the strenuous effort of an infantry soldier - probably as great a stress upon the feet as they are ever called upon to bear. It is unreasonable to expect that modifying the boots will so improve structurally weak feet that they will bear great stresses. Their structure is such that the load they can bear in terms both of weight and stress is limited. Little can be done to improve this. The fact that the feet are weak must be appreciated and accepted.

In general the best management of disabling flat foot in the Army is by regrading. When it is clear that the functional capacity of the man's feet is such that he cannot accomplish the effort required of an L1 soldier, he should be regraded to a level compatible with his disablement.

Conditioning Centres. These units were established originally to accomplish rapid restoration of sufficient physical fitness to permit resumption of training in men whose training had been interrupted by illness or injury. They proved so useful that their activities were expanded in many directions. Amongst

other things they were used in an attempt to improve weak feet by a specific programme of exercise. The experiment was not entirely successful but this does not quite condemn the principle.

If weak feet are to be treated by a programme of physical training obviously only those capable of improvement by increased muscle strength will be benefitted. No others should be sent for such training. Those in which there is a significant element of muscle weakness and capable of improvement by increased muscle power are few in number. They are nearly all cases of hypermobile flat foot with short tendo achillis. The first requisite for success in any programme of training, therefore, is proper selection of cases. This implies a knowledge and skill on the part of Medical Officers which seldom exists. In actual experience, the knowledge that facilities existed in Conditioning Centres for the treatment of painful feet led most Commanding Officers and some Medical Officers to utilize the Conditioning Centre as a dumping ground for all foot problems. Nine out of ten cases were unsuitable for improvement by any programme of physical training, (hallux valgus - callus under metatarsal heads, etc.). This resulted largely from imperfect appreciation of the nature of various foot problems and the benefit which could be obtained by increased muscle power.

The possibility of improving certain types of foot disability by exercise has not yet been exhausted. There is good reason to believe that muscle power can be selectively developed in specific muscle groups, and that this can be applied to the problem of weak and painful feet. Even though the basic fault be one of structure it may be possible to compensate for it and diminish the disability by the development of powerful muscle action. The work of DeLorme (16) on the development of muscle power by heavy resistance exercises and particularly his spectacular success in stabilizing disorganized knees by the development of muscle power invites the application of the same principle to the problem of weak feet.

16. DeLorme, Capt. Thos. L. J. Bone & Joint Surg. Vol. 28. No. 2, Mar. 1946.

Any programme for the management of foot problems should, therefore, explore the possibility of salvaging selected foot cases by physical retraining. This could be carried out in a unit such as a Conditioning Centre. It would necessitate careful selection of cases, and careful supervision of training. To accomplish this, Medical Officers with adequate knowledge of foot problems should be trained and placed in the Conditioning Centre in charge of this specific problem. A useful purpose could be served by such a programme even though the field is limited.

Military Training. What has been said in this section concerning the management and treatment of foot problems in the Army is predicated upon the conception that the training of a soldier will involve great effort and that his life will always be strenuous. It is conceivable that there may be profound changes in military training and that future armies may not demand so much on soldiers' feet. In that case the problem would be simplified. Most of the weak and painful feet would function usefully since less would be demanded of them in the way of effort. But for the immediate future, there seems little prospect of a change in the basic principles of training. We think that soldiers will still require to be physically fit and that much will be demanded of their feet.

The possibility of improving certain types of foot disability by exercise has not yet been explored. There is good reason to believe that muscle power can be selectively developed in specific muscle groups and that this can be applied to the problem of weak and painful feet. Even though the basic fact is one of structure, it may be possible to compensate for it and diminish the disability by the development of powerful muscle action. The work of DeLorme (10) on the development of muscle power by heavy resistance exercises and particularly his spectacular success in stabilizing disorganized knees by the development of muscle power, raises the question of sufficient physical fitness for the solution of the problem of weak feet. It is interesting to note that DeLorme used had similar success in his training of weak feet. (10) DeLorme, Capt. Mos. L. J. Bone & John S. Vol. 28. No. 2. Mar. 1946.

CONCLUSIONS

From our extended study it is possible to have certain details of the foot problems of soldiers which are as follows:

Project - Army Meds. - No.22

1. Incidence of foot disabilities in the young male population of Canada. For the first time a comprehensive study has been made of a reasonably large group of individuals for the purpose of determining the foot defects which exist amongst them and in what orders. This provides a background of much needed information, especially when we try to assess the foot problems of soldiers. Figures of their occurrence are given elsewhere. In general the findings indicate that the incidence of serious foot lesions is low. Even when present, they do not always result in incapacity or the incapacity is less than might be anticipated. Such foot lesions, as do exist are of two types, congenital - those which result from some variation of structure, and acquired, those which result from injury or disease. The congenital lesions occur in every grade of severity and are dependent upon the degree of deviation from the normal and the efficiency of compensatory mechanisms.

PRINCIPAL CONCLUSIONS

AND

RECOMMENDATIONS

2. Function of various foot lesions as determined by their effect on the soldier's performance. The examination by the Survey of enlisted men during their period of training gives an accurate picture of the performance which may be expected from various foot lesions and indicates those which are most prone to cause disability. From the experience so obtained it is possible to state that certain foot lesions are so disabling to a soldier as to incapacitate him from service, others are less incapacitating and some are not incapacitating at all. The sum of this knowledge is valuable for the assessment and management of foot problems in soldiers.

3. New information gained by the Survey. New details have been gained to add to our knowledge of certain foot lesions.

Hypermobile Flat Foot with Short Tendon Achilles
We have defined and described a particularly

CONCLUSIONS

From our extended study it is possible to make certain observations and to draw certain conclusions, which are summarized below.

1. Incidence of foot disabilities in the young male population of Canada. For the first time a comprehensive study has been made of a reasonably large group of individuals for the purpose of determining the foot defects which exist amongst them and in what numbers. This provides a background of much needed information against which we may assess the foot problems of soldiers. Figures of their occurrence are given elsewhere. In general the findings indicate that the incidence of serious foot lesions is low. Even when present, they do not always result in incapacity or the incapacity is less than might be anticipated. Such foot lesions as do exist are of two types. Congenital - those which result from some variation of structure, and acquired, those which result from injury or disease. The congenital lesions occur in every gradation of severity dependant upon the degree of deviation from standard structure and the efficiency of compensatory mechanisms.

2. Functional capacity of various foot-lesions as determined by their performance during military training. The examination by the Survey of enlisted men during their period of training gives an accurate picture of the performance which may be expected from various foot lesions and indicates those which are most prone to cause disablement. From the experience so obtained it is possible to state that certain foot lesions are so disabling to a soldier as to incapacitate him from service, others are less incapacitating and some are not incapacitating at all. The sum of this knowledge is valuable for the assessment and management of foot problems in soldiers.

3. New information gained by the Survey. New details have been gained to add to our knowledge of certain foot lesions.

Hypermobile Flat Foot with Short Tendo Achillis
We have defined and described a particularly

disabling type of flat foot which we have designated hypermobile flat foot with short tendo achillis HFF-STA. It forms a clear cut clinical entity. In the main it is due to inadequate support of the head of the talus by the calcaneus. The various elements in the syndrome may not all be present and any or all of them may be present in any degree of severity. The clinical picture therefore varies in their wide limits but in all cases there is great diminution in the load capacity of the foot.

Atavistic First Metatarsal. The thorough study of Dudley Morton's thesis conducted by the Survey leads us to the conclusion that there is but little association between foot disability and short first metatarsal or other forms of atavism. Excess pressure upon one or other metatarsal heads, with callus formation, is not consistently or even frequently due to short first metatarsal. We have demonstrated that atavism of the first metatarsal has little or nothing to do with depression of the longitudinal arch or pronation. We have been unable to observe that deep symptoms in the region of the base of the metatarsal are caused by atavism.

Calluses beneath metatarsal heads. It has been possible to demonstrate that these are greatly disabling. Their cause is obscure; perhaps there are several causes. Suggestions for continued investigation have been indicated.

Peroneal Spastic Flat Foot. The findings of Survey emphasize the importance of this rather rare foot lesion since it causes much incapacity. It has been shown also that rigid valgus feet must be divided into two groups; one characterized by peroneal spasm; the other by fixation in valgus because of intra-articular changes.

Hallux Ridigus. The Survey findings indicate some additional features of the limitation of dorsiflexion of the metatarso-phalangeal joint of the great toe which constitutes hallux

rigidus. The common and disabling type is due to intra-articular changes. There are other less disabling types caused by the periarticular soft tissues and particularly by the hold of the plantar fascia upon the hallux.

4. Grading of Soldiers. The Survey demonstrated a great lack of uniformity in the grading of soldiers by Medical Officers. Throughout Canada each Medical Officer had his own views as to the factors which guided him in predicting disability. This resulted in wide variations in the practice of grading. Such difference of opinion springs from imperfect knowledge of foot disabilities and lack of information regarding the functional capacity of foot lesions. The findings of this Foot Survey should do much to supply this information.

5. Prognosis of Disability. The findings of the Survey indicate that full understanding of foot structure and foot defects will explain the vast majority of symptoms which occur during military training. Also no important symptoms occur which cannot be understood on this basis. On the other hand not all soldiers with defects had symptoms or if they had symptoms they often were not as severe as might be anticipated. In part this results from compensatory mechanisms in the use of the foot and is an expression of the fact that human beings solve specific problems of effort in individualistic ways. Just as a good game of golf may be played by a man who has a shoulder with limited movement; so a foot which is not of the normal pattern of structure may yet accomplish results by modification in the manner of its use.

6. Effect of Training on Feet. We were unable to detect any evidence that the training programme brought a permanently defective change either in a normal or abnormal foot; only one case was observed in which flat feet were detected during training which had not been recognized at the Reception Centre. It is possible that they may have been missed. This was the only instance suspicious of flat feet developing during training. Soldiers, of course, do report that their feet have become flat during Army training. We saw a number of such cases but could show

that this was present on enlistment in every case, save the one mentioned above. Presumably, when symptoms develop the soldier's attention is attracted to his feet for the first time and hence his misconception. From the point of view of pensions, we feel that flat feet should not be regarded as caused by Army training, though they may deteriorate more rapidly in Army service than otherwise would be the case.

7. Boots and Boot Fitting. An appreciable amount of foot disablement is due to poor fittings of boots and a smaller amount is due to the necessity of improvement in the design and manufacture of boots. While Medical Officers are ill-equipped to pass judgment upon the manufacturing of boots they could render valuable service by recognizing those foot disabilities which are due to poor boot fitting and for this purpose they should acquire sufficient knowledge of boot fitting to enable them to recognize ill fitting of boots.

There is also a place for the Medical Service in the designing of new types of Army boots. In collaboration with the Master General of Ordnance, Medical Officers with accurate knowledge of foot problems could ensure that new boot designs conform to the anatomical structure and the physiological function of the foot.

RECOMMENDATIONS

The experience gained in the Foot Survey suggests certain changes in Army policy and practice, the adoption of which would do much to diminish the foot problems of soldiers and place their management on a sounder basis. These changes are summarized below:

1. Education in the soldiers' foot problems
The Survey has shown that comprehensive and accurate knowledge of foot lesions facilitates their recognition and permits reasonably precise estimate of their behaviour under stress. It is of fundamental importance, therefore, to provide better information regarding the basic problems of the foot lesions of soldiers in all who have to deal with them. To do so would also ensure greater uniformity in the management of foot problems. These

ends could be accomplished by the following measures.

Instructions to Medical Officers during their Corps training at A22 Camp Borden. It is not to be expected that the young Medical Officer who has recently graduated from Medical School will have a very profound or accurate knowledge of foot problems. There is little time in his crowded undergraduate years for instruction in this field. Moreover, foot problems actually are complex and there is still much that is obscure about them. Much important knowledge can only be acquired by painstaking investigation such as that which has been conducted by the Foot Survey. Detailed, precise and accurate knowledge does not lend itself easily to condensation and is not found in sufficient detail in standard surgical text books. Moreover, the military approach to foot problems necessarily is entirely different than is the approach to civil life. Soldiers' foot problems therefore are part of military medicine and should be carefully taught to Medical Officers when they first join the Army. Even the most junior Medical Officer is expected to pass judgement upon foot problems and his decisions will have a profound effect upon manpower and wastage of personnel.

Provision should be made in the syllabus of A22 for instruction of Medical Officers in soldiers' foot problems; their nature, recognition and treatment. This training should include sufficient instruction in the rudiments of boot fitting as will enable Medical Officers to determine whether foot disablement is due to poorly fitted boots.

Publication of a brochure on the soldier's foot.

There are remarkably few people in the country with a full and complete knowledge of foot problems in relation to Army service. Even amongst orthopaedic surgeons, there often is no very profound knowledge of the problem and the most extra-

ordinary lack of any uniformity of thought and practice in its management. It would be well therefore to publish in the form of a small brochure or monograph all the available information which bears on foot lesions in soldiers including the information obtained in this Foot Survey. This would permit ready instruction in the problem and would provide reference work which Medical Officers could use in their work.

2. Revision of physical standards and instructions for Canada. Those sections of this guide which refer to feet should be revised to incorporate new knowledge and to give more precise instruction regarding foot problems in relation to Army service. Suggestions for such revision will be found in Appendix "I". This would do much to secure greater uniformity of assessment of function.

3. Chiropodists and Foot Orderlies. There is a field of usefulness for O.R. medical personnel trained in simple fundamental procedures for the care of the feet and the treatment of foot problems. They need not be completely trained chiropodists; indeed in most instances it would be better were they not. There should be one on the staff of every Medical Inspection Room and Regimental Aid Post. He should carry out such details of the management of soldiers' foot problems as are delegated to him by the Medical Officer.

4. School of Chiropody. To provide the number of Foot Orderlies it will be necessary to train them within the Army. For this purpose there should be a School of Chiropody maintained at the RCAMC Training Centre, Camp Borden.

5. Grading. An earnest attempt should be made to secure uniformity of practice in the grading of soldiers as far as foot problems are concerned. Important steps towards the accomplishment of this end have already been indicated in the sections on "Education in the soldiers' foot problems" and "Revision of physical standards and instruction in Canada".

It should be appreciated and accepted as a fact that the degree of functional capacity of an individual cannot always be determined from a single examination; also insofar as foot problems are concerned, the

functional capacity of the feet may be much greater than might be expected from the degree of structural change which is present. In any case, for a great group of borderline problems, the test of military training is the only means by which functional capacity can be ascertained with reasonable accuracy. The principle of periodic revision of functional fitness, therefore, should be accepted. The grading given at the Reception Centre should be regarded as tentative. The final grading will only be determined after observation and revision of the man's physical standard during training. To do otherwise involves too much wastage of manpower. Any attempt to make the assessment of the Reception Centre final and permanent can only succeed if the standard for enlistment is set very high. This involves the needless rejection of far too many men. Under such standards the Medical Officer must reject every man about whose fitness he has any doubt. The proper policy is to reject only those men whose foot problems will certainly prevent them serving as soldiers. The remainder who are enlisted should be submitted to the test of training. It should be accepted as normal procedure that they will be reviewed from time to time and regraded when necessary.

6. Conditioning Centres. Though little was accomplished in manpower salvage by treatment of foot problems in Conditioning Centres, we believe they have a useful purpose to serve. Their failure to salvage more cases by a programme of physical training was due to a variety of causes; the chief being improper selection of cases. This in turn stems from imperfect knowledge of foot problems on the part of Medical Officers. Hallux valgus; claw foot; claw toes and painful calluses beneath the heads of the metatarsals cannot be cured by any form of exercise; on the other hand, it is probable that hypermobile flat foot with short tendo achillis (HFF-STA) can be benefitted by a properly planned and skillfully supervised routine of exercise. The merit of DeLorme's (16) heavy resistance exercises in the management of foot pro-

blems has not been adequately investigated and there is reason to think this principle might be of material value. The use of compensating mechanisms in standing and walking should be investigated. Those of value could be taught to selected cases with hope of improvement.

Conditioning Centres have the facilities, equipment and trained personnel to utilize a programme of physical training for the improvement of selected foot problems. There is good reason to believe that an appreciable number of cases could be salvaged by such means.

7. Foot Centres. Few Medical Officers have any great knowledge of the nature of foot problems or skill in their management. It will be long before education changes this. There is need for an authority to whom Medical Officers can turn for advice regarding the diagnosis and treatment of foot problems. They constitute such a special problem and are so numerous as to be best handled in special centres wherever this is feasible. Suitable Medical Officers could be trained in a few months to be competent to direct such centres and to do so better than it is likely to be done by the Surgical Specialist whose interest is in other fields than orthopaedic surgery.

Such centres might well be established in Conditioning Centres and in Camp Hospitals. They should be in charge of a Medical Officer with special training in this problem. It would be his responsibility to revise the diagnosis of foot problems; advise the Medical Officer regarding their disposal; select those cases suitable for conditioning by physical training; plan and supervise programmes of physical training; conduct such investigation on foot problems as may be necessary. The Medical Officer in charge of such a foot centre would require the assistance of a chiropodist or good foot orderly and a cobbler.

The establishment of such Foot Centres in Conditioning Centres and Camp Hospitals would permit them to function as advisory and treatment centres for wide areas. The Medical Officer in charge could be made responsible for instruction in foot problems and if necessary could be sent to Training Centres from time to time to advise

the Regimental Medical Officers on their foot problems.

8. Orthopaedic Appliances. Special Boots and the use of No. 1 Boot Rebuilding Plant - Montreal. The supply to Army personnel of orthopaedic appliances and modifications to boots through the Department of Veteran's Affairs is unsatisfactory and cannot ever be otherwise. The DVA has its own responsibilities which must come first. When the Army in training is most in need of DVA assistance the responsibilities of the latter are mounting rapidly so that they have little time or manpower or equipment to spare for Army problems. Such appliances or modifications to footwear or special boots as the Army may need for the management of the soldiers' foot problems they must provide themselves.

Generally speaking the attempt on the part of the Army to solve foot problems by boot modifications and appliances has not been practical or satisfactory. Only the simplest measures of this type have any field of usefulness: e.g. stretching a boot to accommodate a bunion. Measures which are useful in civil practice, especially foot supports, are impractical in the Army because the enormous problem in supply they introduce far outweighs any benefit which is obtained. It is more practical to accept the man's disability and regrade him according to his functional capacity than to undertake to provide him with appliances in an attempt to raise his grading.

For certain foot problems such may not always be the case. There is need for investigation of the possibility of compensating for certain foot lesions by special measures. Such example is the problem of calluses. These may well be alleviated by special types of insole. Investigation into such new forms of treatment could well be carried out at the Foot Centres advocated above.

The valuable service rendered by No. 1 Boot Rebuilding Plant in Montreal should be continued and expanded. Originally set up to salvage from condemned boots such material as might still have value and reprocess it into new boots, it took on also the manufacture of out-size boots, either very large or very small. These were ordered on a special form which recorded measurements and

outline of the foot. From this it was an easy step to supply boots for feet whose proportions were abnormal. This solved very satisfactorily the supply of boots for claw feet and feet with hallux valgus. It seems likely that it could be expanded to provide satisfactory boots for other foot disabilities, notably the foot with cal-luses.

9. Peacetime Operation of No. 1 Boot Rebuilding Plant. The Survey has demonstrated that an important part of the population have foot difficulties which could be materially decreased by boots of sizes and shape not obtainable on the market to-day, but which could be rather easily supplied by the manufacturer from casts especially made for the individual. Custom building of shoes and boots is rapidly becoming an art of the past. No manufacturer would have enough business to warrant catering to this trade at prices which could be paid by any large part of the population. It is here suggested that the No. 1 Boot Rebuilding Plant be kept in operation during peacetime at least as a pilot plant; that it produce boots for the standing Army; that it experiment with methods of production for the overall benefit of the trade; that it cooperate with D.V.A. where possible in the making of boots and shoes; that it be used for the production of experimental footwear for all the services; that it offer to produce boots and shoes of a minor orthopaedic nature in cooperation with bona fide orthopaedic practitioners and for the benefit of the public, especially the indigent public.

The benefits expected by such operation of this plant would be: the maintenance of the plant in operation which is, in itself, a defence measure; the benefit of the public who would obtain footwear unobtainable otherwise; there would be a continual opportunity to improve the footwear of the forces; there would be a continual stimulus to enlarge the field of manufacture of custom footwear by production line methods.

It is appreciated that objection may be raised that in this the Government would be in competition with the private boot and shoe trade. However, this is not strictly so as no shoe industry has undertaken this kind

of service nor could it profitably do so. We already have a precedent in that for many years artificial limbs have been made by a Government agency with great credit to itself and great benefit to amputees. This was done to fill a need that the private industry was unable to supply.

10. Cooperation between Medical Services and Directorate of Ordnance Stores. An intimate relationship exists between the design of army boots, the fitting of army boots and certain kinds of foot disablement. Because of this it is desirable that there be a close collaboration between the D.G.M.S. and the D.G.O. in design, manufacture and fitting of army boots.

The fitting of army boots is a problem of very great importance. The prime responsibility for it rests upon the Director of Ordnance Stores. His programme for training quartermasters and quartermasters staff in boot fitting should be expanded to include instruction to Medical Officers in this problem. Such instruction could well be conducted at the R.C.A.M.C. Training Centre A22 at Camp Borden.

The design of the Canadian Army boot is good. Nevertheless it is capable of improvement. The Medical Service can contribute something towards improved design by reason of their knowledge of the anatomy and physiology of the foot. Therefore, any action in relation to new designs for army boots should only be taken in collaboration with the Medical Services. If this principle is accepted it would be incumbent upon the D.G.M.S. to delegate his responsibility to a Medical Officer with special knowledge and interest in this field.

11. Special Consultant for the foot problems. The multiplicities and the importance of the foot problems appear to us to be great enough to warrant the full time employment of a Medical Officer at the D.G.M.S.'s office even during peacetime. Such an Officer would not necessarily need to be an important orthopedist and in fact, it would probably be preferable not to have an orthopedist for this work as he would undoubtedly be otherwise preoccupied and not be of a mind to undertake the

large amount of study required to master the administrative problems involved in the maximum correction of this problem. The complete control of the foot problem in the Army requires a thorough knowledge of the boot and shoe industry as well as the more clearly medical aspects. Such an Officer should have a rank such that a capable person could be attracted to the task and so that his views could command respect. It is visualized that he would take a really active part in advising on the design of footwear, on training and other matters that may have a bearing on feet. He would, or should, be simultaneously an advisor to the other two armed services as well as to the Department of Veterans Affairs. The work would be of such magnitude, if of this scope, that he would probably require an assistant. He would be expected, of course, to take the lead in future studies in this field and to be responsible for the training of medical personnel in expertness in management of foot problems. He should be the official advisor to the Directorate of Military Training on applicable matters. In peacetime it might be possible to offer his services impartially to the boot and shoe trade in order that he himself might be kept acquainted with their problems and that he might help the industry to avoid mistakes due to lack of full understanding of feet. The better the shoes and boots the industry can make the greater their sales and the greater the industry which is in itself a defence industry and therefore worthy of development especially if this can be done without subsidy. A consultant in foot problems could conceivably take an active part in this.

12. Need for future research. The problem of foot ailments in the Army has been shown to be of sufficient magnitude to warrant its continual study by repeated or multiple research projects. Such projects would be of value whether or not they were productive of useful information in themselves. The other value would lie in the constant training of those engaged in the research and also the very activity of those conducting the research is a constant stimulus to those in a wider circle.

Such research should take in not only the question of the feet themselves, but also should comprise the problem of boots and socks. Some unsolved problems that come to mind are (a) whether the clump soles have any unfavourable

physiological effects, (b) can the upper of boots be made of anything but leather and we refer in this thought to the experience of the U.S. Marine Corps which found heavy nylon uppers highly satisfactory, (c) are hob nails in boots any value other than preventing wear in the boots and is this offset by any detriment, (d) would the metal on the heel and toe be better left off, (e) is the design of the boot last the best possible, (f) is the sterilizing of rebuilt and reconditioned boots effective and if not, does any consequence result, (g) is a water-proofing as done with dubbin the most suitable and (h) can the socks be improved?

Project - Army Meds. - No. 22

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ARMY FOOT SURVEY

VOLUME II - APPENDICES

CONTENTS

Volume II - Appendices

Appendix "A"	- Data for record card and descriptive key	A1-40
Appendix "B"	- Method of foot printing	B1- 3
Appendix "C"	- Technique to obtain standardized radio- graphs	C1- 4
Appendix "D"	- Method of studying x-rays	D1- 8
Appendix "E"	- Titles of tables which appeared in the first edition	E1- 3
Appendix "F"	- Graphs (only the notes on graphs have been reproduced in this edition)	F1- 3

APPENDIX "A"

The following appendices have been omitted
from this edition:-

Appendix "G"	- Canadian Army Routine Orders	G1-16
Appendix "H"	- Miscellaneous observations and illustrated case histories	H1-34
Appendix "I"	- Suggested revisions of "Physical Standards and Instructions" for Canada	I1-12
Appendix "J"	- Lasts	J1-68

DATA FOR RECORD CARD

and

DESCRIPTIVE KEY

APPENDIX "A"

Project - Army Meds. - No. 22

All information obtained by the Survey was recorded on Keystone "Kwiksort" Statistical Cards, one card for each individual surveyed. This plan of recording proved admirable for our purpose. It can be recommended highly for surveys of this type upon groups of individuals not exceeding 5,000 in number. Some explanation of the card and its use is necessary for clear understanding of the Survey. This Appendix therefore is devoted to a description of the Card and the manner of its use. It should be studied in conjunction with Fig. 11 which is an illustration of the card as engraved.

APPENDIX "A"

The face of the Card is divided by ruled lines into rectangles in which to record the items of information determined by examination. Written within each rectangle is the designation of the item for which it is specifically reserved. For reasons of space these descriptive words must often be abbreviated, but the Key which follows in this Appendix describes fully the item for which each rectangle is reserved and the manner in which information is to be recorded within the rectangles.

The individual rectangles are grouped together in Sections which are bordered by heavier lines. Within each section are all the rectangles which are reserved for the related items of information concerned with a specific case of the problem. A descriptive title indicates the particular phase of the problem with which the section is concerned and a serial number is printed at the head of each Section.

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The individual rectangles within each section are identified further by numbers or by letters which run consecutively or alphabetically respectively. The numbered rectangles are for data which is to be transferred to the marginal perforations for statistical

analysis in the manner to be described later. The lettered rectangles are for information which will not be sorted either because it does not lend itself to such sorting (e.g. address) or because it is not necessary to sort (e.g. date of examination).

Each item of information obtained from examination has reserved for it therefore a specific rectangle in which it will be recorded and this rectangle is identified by a descriptive title printed within it and a number (or letter). The rectangle will be grouped together with other rectangles reserved for related items of information within a Section which also has a descriptive title and a number. For example:- the finding of peroneal spastic flat foot on examination would be recorded by entering a plus (+) sign within the rectangle titled "peroneal spastic ft" and numbered 5 within Section 4 which is headed "Pes Planus - (4)".

By an ingenious correlation of letters with numbers it is possible to sort the cards alphabetically and thus find the card of a particular individual whose name only is known.

About the margin of the card are perforations which are used in the statistical sorting of the information obtained. With the exception of the fifteen perforations reserved for the alphabetical sort, each of the perforations corresponds to one of the small numbered rectangles on the face of the card and carries the same identifying number. The perforated margin of the card is divided by radiating lines into groups of perforations, each of which corresponds to a Section on the face of the card and is similarly titled and numbered. Each perforation therefore represents a particular item of information.

The Card is used as follows:- In the Section "Basic Data - (1)" is entered the man's name, address, occupation and age. As the examination of the man proceeds, entries are made on the face of the card which indicate, in the appropriate rectangle, the existence of the condition for which that rectangle is reserved. At a later date the information so indicated is transferred to the marginal perforations. This is accomplished by

transforming the appropriate perforation into a notch by cutting out the thin edge with a punch somewhat like that used by the conductor to punch railroad tickets. Positive items of information therefore are ultimately represented by a series of notches about the margin of the card.

Statistical sorting is simple. As large a number of cards as can be handled conveniently are set on edge. Into the perforation representing the particular item of information it is desired to study, is inserted a long stiff wire on the end of a handle. With this the cards are lifted and shaken. Those on which this particular perforation has been transformed into a notch to indicate the existence of that particular item fall off the pin. The positive cases are thus separated from the negative cases and can be studied further in a variety of ways.

KEY TO USE OF RECORD CARD

Information entered at the Reception Centre in blue ink; at Basic Training Centre, in pencil; at Advanced Training Centre, in green ink.

Alphabetical Sort - It is possible to sort the cards alphabetically according to the man's name. This is important when the card of a specific individual must be found. Alphabetical sorting is accomplished as follows:

The alphabet is divided into two equal groups of letters "a" to "m" and "n" to "z" and each of these is numbered consecutively from 1 to 13 as follows:

A	1	N	The four numbers 7, 4, 2, 1 when used singly or in combination permit us to obtain any number from 1 to 14. Thus 1 = 1; 2 = 2; 3 = 2 + 1; 4 = 4; 5 = 4 + 1; 6 = 4 + 2 etc. By using these number combinations the letter number of any letter in the first or the last half of the alphabet can be punched out. Punching the hole N:Z thus indicates that the letter is in the last half of the alphabet and
B	2	O	
C	3	P	
D	4	Q	
E	5	R	
F	6	S	
G	7	T	
H	8	U	
I	9	V	
J	10	W	

K 11 X leaving it unpunched indicates that the
 L 12 Y letter is in the first half of the al-
 M 13 Z phabet. A set of five perforations NZ
 7.4.2.1 will therefore permit any letter
 of the alphabet to be indicated by
 appropriate punching. Three such sets
 permit sorting by the first three letters
 of the surname. Further sorting is done
 by hand which is not unduly troublesome
 when the number of individuals is not
 excessive.

DATA FOR ENTRIES ON CARD.

Number (or letter) of
 rectangle and the des-
 ignation printed in it.

Description of the informa-
 tion to be entered in
 the rectangles.

SECTION I. BASIC DATA.

- | | |
|---|--|
| (a) Name | (a) Name. Surname first. 1st and 2nd given names in the order in which he uses them. Third or more names if any are omitted. |
| (b) Address | (b) Civilian address (community only). |
| (c) Occupation | (c) Occupation - state the occupation and in the space provided enter the approximate number of hours he is on his feet per day. A clerk will do this. The simple number only will be entered. |
| (d) Regimental number or rank. | (d) Regimental number or rank if commissioned. This will be entered when obtainable. |
| (e) Date of examination at Army Reception Centre. | (e) Enter date by numbers in army fashion, e.g. 9/4/44 - 9th April, 1944. |

- | | | |
|---|------------|---|
| <p>(1) Up to and inclusive 24 years</p> | <p>(1)</p> | <p>Enter Y.O.B. (year of birth) in correct applicable space. For this purpose he will be considered to have been born on the 1st January in the year of his birth. Those born in the year 1920 or</p> |
| <p>A
(2) G 25-34 inclusive</p> | <p>(2)</p> | <p>A after are below 25, those G born between 1910 and E 1919 are 25-34 inclusive.</p> |
| <p>E
(3) 35-44 inclusive</p> | <p>(3)</p> | <p>Those born 1900-1909 inclusive are 35-44 inclusive. Those born before year 1900 are 45 or over.</p> |
| <p>(f) Year of Birth of those born before 1900.</p> | <p>(f)</p> | <p>This square is to record Year of Birth of those born before year 1900.</p> |

SECTION 2 - HISTORY

1. Old disease or injury. (1) An elongated square to specify history of old disease or injury to the foot itself or to the lower extremity such that structural weakness of the foot itself may occur or excessive strain may be thrown upon the foot. Example old polio, injury to the foot, fractures of the leg with defective weight bearing, etc. This hole is confined to history. Do not mark unless the examiner feels that some real significance may be present.
2. Complains on standing (2) Complaining of feet on standing rather than on walking.

3. Complains on walking (3) Complaining of feet on walking rather than on standing. (1)
4. Symptoms at heel. (4) This will cover either plantar aspect of heel or back of heel.
5. Symptoms mid-tarsal. (5) Complaints are located to arch region either on plantar or dorsal aspect.
6. Symptoms at head of metatarsals. (6) Complaints are located in the region of the metatarsal heads. (3)
7. Symptoms located at other places. (7) This hole will be used when there is complaint at other points than those covered by 4, 5 and 6. Example: aching or soreness in the calves or front of the leg, localized pain in tendons, symptoms at ankle etc. This is to be used only when it is felt that the symptoms if above the ankle have good likelihood of being secondary to a problem which is primarily in the foot. The space and hole will also be used when the symptoms are in the ankle even if pathology is in the ankle. Specify symptoms in writing in space. (1)
8. Recruit estimates up to and including 4 miles per day. (8) These holes will be punched in their respective positions in answer to the question "How many miles do you think you can walk in a whole day?" In the space corresponding to the hole will be entered the number of miles he states. (1)
9. Recruit estimates 5 to 9 miles per day, inclusive. (9) If he asks questions as to the circumstances, time will be taken to find how much he thinks he can march at the time of enlistment. (1)

10. Recruit estimates 10-19 miles per day, inclusive.

(a) Record 20 miles or more.

11. Rheumatism reported in feet.

10. In the event that his answer is - "I don't know -- I never have any trouble with my feet" or some such answer -- it will be interpreted as over 20 miles.

(a) In this square record the number of miles estimated by the recruit when it is 20 miles or more.

11. This is marked when recruit is complaining of "rheumatism" in the feet with or without "rheumatism" elsewhere, (defined as pain in joints or muscles in cold or damp weather or similar complaints which recur). This is history only - the actual presence or absence of arthritis will be brought out in the examination but for the most part no real arthritis will be present.

CLINICAL EXAMINATION

SECTION 3 - FACTORS IN FOOT STRAIN

(a) Height and weight

(a) Height and weight to be entered in elongated and partially divided square. This is to be done at Army Reception Centre if information available and at Training Centre if not at Army Reception Centre.

1. Obesity or deformity

1. This space large enough to specify condition present. It will be used where obesity or deformity (especially of lower extremities) is present which would reasonably be a factor in development of food symptoms, e.g. genu valgum or varum. This includes deformity from old injury which causes strain on foot but does not include injury to the foot itself.

2. Long slender foot.

2. Presence of long slender foot. Use the space and hole when applicable.

SECTION 4 - PES PLANUS

1. Mild low longitudinal arch.

1. With the recruit standing the examiner decides whether there is depression of the longitudinal arch and if present uses the mild or severe space and hole depending on how marked this feature is if present.

2. Severe low longitudinal arch.

2. Severe space and hole depending on how marked this feature is if present.

3. Mild pronation present

3. This is pronation (not valgus of fore part of the foot). It is judged on the basis of whether the weight bearing line falls too far medially, plus the general appearance of pronation which may be determined by or substantiated by the alignment of tendo achillis.

4. Severe pronation present.

4. by the alignment of tendo achillis.

5. **Peroneal spastic foot.** 5. The foot in this case is in fixed pronation and passive supination is not possible. To attempt to separate those in which the fixation at the time of examination is actually due to the peroneal muscles from those in which it is due to some other factor (e.g. - ligamentous change in subastragalar joint) mark + (plus) for those in which the tension of peronei seems actually to account for the limitation and - (minus) for those in which it does not. The space and hole will be used as positive where there is definitely abnormal limitation of passive supination even though the contour of the arch (in standing) appears normal and even though the "peroneal spastic flat foot" in the full sense is not present. The separation of cases of flat foot due to limited supination from those with limited supination not causing flat foot will be done by use or non-use of holes 1 - 4 in Sec. 4.
6. **Questionable hypermobile flat foot with short tendo-achillis** 6. Suggestive features of hypermobile flat foot with short tendo-achillis present but of dubious significance. Perhaps only a feature which is present in a foot with other defects. The characteristics of hypermobile flat foot with short tendo-achillis

6. Questionable hypermobile flat foot with short tendo-achillis

6. for this study are: excess laxity of the mid-tarsal and subastragalar joints; limited dorsi-flexion of the ankle when tested with the fore foot in a sufficiently neutral or slightly inverted position that the front of the calcaneus feels to the examiner to be bearing under the head of the talus; some flattening of arch; increased apparent dorsi-flexion when eversion is allowed compared to the dorsi-flexion when eversion is prevented; and distinctly less arch when the foot is pushed into dorsi-flexion plus eversion than into dorsi-flexion plus inversion. A requirement of a definite hypermobile flat foot with short tendo-achillis is that dorsi-flexion with the foot in this position shall be less than 90°. Some cases, however, have many features of the hypermobile flat foot with short tendo-achillis (as defined) without all and such cases will be classed as "questionable". The most common of these is where dorsi-flexion above 90° is present, but where there is much more dorsi-flexion when pronation and eversion of the foot are allowed. Simple limitation of dorsi-flexion does not make a hypermobile flat foot with short tendo-achillis, but a distinct limitation of dorsi-flexion plus mild mid-tarsal and subastragalar looseness might be classed questionable hypermobile flat foot with short tendo-achillis.

7. Mild hypermobile flat foot with short tendo achillis.
7. Marked positive if hypermobile flat foot with short tendo achillis is definite but slight. It should be the probable basic defect in the foot.
8. Severe hypermobile flat foot with short tendo achillis.
8. Very definite hypermobile flat foot with short tendo achillis is evident and is the basic defect.
9. Prominence at tuberosity of scaphoid.
9. This space and hole will be used if there is prominence at the inner end of the scaphoid (indicating accessory tarsal scaphoid or enlarged tuberosity of scaphoid), of such degree that function of the posterior tibial tendon may be interfered with. It is to be emphasized that the item is to be considered positive and the hole and space used only if the prominence is made evident by reason of enlargement of the tuberosity or by reason of the presence of accessory scaphoid. Such prominence (due to enlarged tuberosity or accessory scaphoid) is usually rather sharply localized. Prominence of the region of the tuberosity due to the presence of other deformity of the foot (pronation of the foot or depression of the longitudinal arch) does not make this item positive. This latter prominence if present is usually in the form of a diffuse bulge.

10. Poor elevation on toes. 10. Considered positive when there is poor ability to stand on toes and/or poor reformation of longitudinal arch when tried.

SECTION 5 - PES CAVUS

1. Mild high longitudinal arch. 1. Space and hole to be used when mildly abnormal elevation of longitudinal arch is present. This is based on anatomical not symptomatic grounds. Based on previous experience at least equalling the minimum elevation which was used to explain the symptoms in a clinical case justifies classification mild cavus.
2. Severe high longitudinal arch. 2. Severe elevation of longitudinal arch.
3. Clawing of toes. 3. This space and hole used for clawing of the toes with or without cavus. Occasional cases with otherwise normal feet have a degree of clawing of the toes. This hole and space will be used when this is so. (The cavus feet with clawing will be separated by hole 1 and 2 not being used where no cavus is present) Mark † for mild and †† for features of severe clawing.

SECTION 6 - INDEPENDENT METATARSAL DEFORMITY OR DISABILITY

1. Excess weight on metatarsal heads. 1. This space and hole will be used when there is callus under, or sufficient prominence of the heads of

1. **Excess weight on metatarsal heads.**
 1. **Individual metatarsals, to represent an abnormal weight load on them. It will be recorded positive whether or not there is associated other lesions of the foot (cavus or short first metatarsal). The condition should be a real one and definitely abnormal. The foot print will be considered in deciding the point. The condition may be present with or without callus severe enough to warrant use of hole 12 - 1. It will not be used in cavus feet where the excess weight is evenly distributed over the 5 heads and represents merely the increased load caused by the cavus shape. The identity of the head or heads giving rise to pressure will be recorded. The use of the space and hole to specify the metatarsal began 17/7/44. (Case 724).**
2. **Morton's metatarsalgia.**
 2. **This space and hole to be used when genuine Morton's metatarsalgia is present whatever other associated deformity of the foot is present (if any). It means digital nerve irritation.**
3. **Other disturbance at heads of metatarsals**
 3. **Space and hole to be used if other disturbance associated with heads of metatarsals are present. Specify such disturbance in elongated space or on back.**

SECTION 7 - ATAVISTIC 1st METATARSAL SEGMENT

1. Short 1st metatarsal. 1. Use hole and space when short 1st metatarsal is present (judged clinically). To be considered positive on anatomical grounds alone, without consideration of symptoms or probable disability. Not to be used if real doubt as to its presence exists and this would exclude its use where a trifling degree of 1st metatarsal shorter than 2nd is judged. It is desired to use this hole only where anatomical abnormality is considered to be present.
2. Metatarsus primus varus. 2. Use the space and hole where the anatomical varus of the 1st metatarsal is considered to exist.
3. Hypermobile. 3. Unused. Ability to judge hypermobility clinically proved impossible and this hole therefore was not used for this purpose as originally intended.
4. Excess wt. heads 2 - 3. 4. This space was intended originally to record evidences of excess pressure under heads of 2nd and 3rd metatarsals resulting from hypermobile first metatarsal segment (Morton's thesis). As it proved impossible to determine clinically the existence of hypermobility of the first metatarsal segment, this space and hole had no use. It was redesignated as the space and hole in which to record the

- | | |
|--|--|
| 4. Excess wt. heads
2 - 3. | 4. results of certain attempts to demonstrate hypermobility of the first metatarsal segment by radiological methods. Evidences of excess weight under heads of metatarsals 2 - 3 is recorded in 6-1. |
| 5. Atavistic 1st metatarsal is severe grade. | 5. Use when the features of stavism are of severe grade on anatomical grounds. Disability not factor in this judgment. |

SECTION 8 - HALLUX VALGUS, HAMMER TOES AND
HALLUX RIGIDUS

- | | |
|----------------------------|---|
| 1. Hallux valgus (mild). | 1. Mark space and use hole if mild hallux valgus deformity is present irrespective of the disability which is reported or seems to be present. |
| 2. Hallux valgus (severe). | 2. Mark space and use hole if severe hallux valgus deformity present. |
| 3. Hammer toes. | 3. Mark space and use hole if hammer toes present and causing disability. Note the requirement of disability. |
| 4. Hallux rigidus. | 4. Hallux rigidus is defined as anything less than 45 degrees dorsi-flexion. This is a record of anatomical finding and the presence of disability is not to be a factor in the consideration of its presence though with this degree of limitation disability is likely to be present. |

SECTION 9 - METATARSO-CUNEIFORM EXOSTOSIS

**Metatarso-cuneiform
exostosis.**

This space and hole to be used for recording the presence of metatarso-cuneiform exostosis but only if there is disability associated with it.

**Discharge cases
Stiff Feet**

This hole will also be used to record cases seen who are being discharged from the Army. This numbers only about 6. When used for this purpose, the space will also be marked "Dis". For m-c exostosis it will be simply checked. Mark "Stiff" where a generally stiff foot to what seems like a pathological degree is present.

SECTION 10 - AFFECTION OF HEEL

Affection of heel.

Space is to be used for painful and/or tender plantar aspect of heel or prominent heel (exostosis at tendo-achilles) with disability. Specify in space "p" for plantar "B" for back of heel.

SECTION 11 - INJURIES.

Old injury.

This space will be used where there is disability from old injury. An elongated space is provided and if this is not enough to be specific the back of the card to be used. This would include post-traumatic stiffness in foot (not ankle) and Sudek's atrophy.

Old injury. Use only where abnormal state is present in the foot itself (c.f. Factors in foot strain Section 1.).

SECTION 12 - SKIN

- | | |
|--|--|
| 1. Callosities and corns. | 1. Callosities and corns.
This space to be used for the presence of callus and/or corns that are a problem for treatment on their own account, i.e., a chiropodist may be necessary in addition to or instead of treatment of abnormalities of feet or boot fitting. (Slightly elongated space to specify condition). There must be some disability from this alone if untreated. |
| 2. Onychogryphosis and ingrown toe nail. | 2. Use this space if onychogryphosis or ingrown toe nail are present such that at least some disability exists if not cared for. (Elongated space to specify). |
| 3. Fungus infection and hyperhidrosis. | 3. Use space when at least some problem requiring medical attention is present if not cared for. Elongated space to specify which it seems to be. |
| 4. Plantar warts. | 4. Presence of plantar warts. |
| 5. Severe skin condition. | 5. This hole will be used where the above conditions give rise to more than minor disability and/or there is more likelihood of (a) requiring extensive treatment or |

5. Severe skin condition. 5. (b) lowering of grade or (c) failure to relieve by treatment. In short this hole is to be used for the generally difficult skin problem. Most plantar warts may be of this group.

SECTION 13 - VASCULAR, ARTHRITIS AND OTHER

1. Vascular disease. 1. This space used for the presence of vascular disease (Raynaud's, Buerger's, late effects of frost-bite and other more obscure such as vaso-motor instability affecting the feet). Specify in elongated space.
2. Arthritis. 2. Used for arthritis affecting the feet.
3. Other conditions of feet. 3. This space and hole for other conditions of feet not included elsewhere. If no disability they should be of exceptional interest, otherwise disability should be present. This space will be used if the condition is discovered clinically or by x-ray. Conditions which come to mind are Frieberg's 2nd metatarsal, march fracture, club feet, tendosynovitis, overlapping toes, etc.

SECTION 14 - SYMMETRY

- Right. If feet are not symmetrical (judged on clinical grounds) use the appropriate hole for the foot having the predominant variance from normal.
- Left.

X-RAY EXAMINATION

(See also Appendix "D" - Method of Studying X-rays)

SECTION 15 - ATAVISTIC 1st METATARSAL SEGMENT

- | | |
|--|--|
| <p>1. Mild atavistic 1st metatarsal.</p> | <p>1. It is recognized that some shortness of 1st metatarsal or some thickness of 2nd metatarsal may be present without a real atavistic state being considered to be present. & These holes will be used if shortness of first or thickness of second or both (with or without other features of atavism) are considered to be severe enough to represent true atavism. They will also be used if other features of true atavism are considered to be present - the most obvious of which would be varus of the 1st metatarsal.</p> |
| <p>2. Severe atavistic 1st metatarsal.</p> | <p>2. Use when 1st metatarsal is shorter than 2nd by Morton's method of measurement. Up to 1 mm. shortness for this square not considered short. If one side only is short it will be considered positive. Where the feature is unilateral, R or L are used to indicate the side.</p> |
| <p>3. 1st metatarsal shorter than 2nd.</p> | <p>3. Use when increased strength of 2nd metatarsal is definite even though slight. Marked positive if present on either side. It does not need to be bilateral. Where unilateral, R or L used to indicate the side.</p> |
| <p>4. Thickened 2nd metatarsal.</p> | <p>4. Use when increased strength of 2nd metatarsal is definite even though slight. Marked positive if present on either side. It does not need to be bilateral. Where unilateral, R or L used to indicate the side.</p> |

- (a) Comparative length 1st and 2nd metatarsal (mm). (a) Enter mm. head of 1st metatarsal is longer or shorter than 2nd. "+" to represent longer, "-" shorter. In the supero-inferior view from the mid-point of the posterior aspect of the calcaneus as the centre, the measurement is the difference in radii of concentric circles through the respective joint lines. (See Appendix "D" - Method of Studying X-rays).
- (b) Length of foot. (b) Enter mm. length of foot from head of 1st metatarsal to back of calcaneus taken from the lateral view.
5. First shorter than normal mm. Unused. 5. This space and hole was to have been used if 1st metatarsal is shorter than the outside limit of normal range. The amount by which this occurred was to have been entered. As it was impossible to develop a normal, this space was not used.
6. Too oblique metatarso-cuneiform joint. Unused. 6. This was to have been used to record greater than normal obliquity of metatarso-cuneiform joint. The normal however, could not be established so the space and hole were not used.
- (c) Obliquity metatarso-cuneiform joint. (c) Obliquity of metatarso-cuneiform joint. With the base line from the mid-point of the posterior shadow of the calcaneus to the centre of the head of the 2nd metatarsal, the angle that is subtended by a line that is

- (c) Obliquity metatarso-cuneiform joint. a tangent to the proximal articular surface of the metatarsal so that equal portions of bone are on the proximal side of this line. The proximal angle is recorded.
- (d) Angle 1st metatarsal with 2nd. (d) Angle of 1st metatarsal with 2nd. The angle subtended by the lines through the central long axis of the 1st and 2nd metatarsals.
7. Metat. primus varus Unused. 7. This was to have been used to record increase in angle of 1st with 2nd beyond the limit of previously determined normal. As a normal could not be established the space and hole were not used.
8. Other atavistic feature. Unused. 8. This space and hole was to be used to record and specify any other predetermined feature of atavistic 1st segment which can be decided upon by x-ray, e.g., we may decide to use this hole for recording x-ray evidence of hypermobile segment if we can decide what may be used for this, such as increased space between 1st and 2nd cuneiforms. The space and hole were not used.

SECTION 16 - SUPPORT OF HEAD OF TALUS

1. Firm support of talus. 1. These spaces and holes (1 & 2) are used to record the support of the head of the talus, as determined by x-ray, the appropriate space and hole being used. Where weak support is present neither is used. The support of the head

Firm support of talus.

of the talus is judged in supero-inferior, lateral and oblique view taking into consideration (1) medial and lateral position of head, (2) depression or elevation (3) length of spring ligament, (4) position, size and other features of sustentaculum, (5) presence of articulation on front of os calcis, etc. The judgment is to be made on the general appearance of these points but is not dependent on the detailed measurements below.

2. Moderate support of talus.

2.

(a) Overlap in S-I View.

(a) Overlap (in mm.) of head of talus over calcaneus as seen in supero-inferior view of x-ray. Measured as the distance between two parallel lines each parallel to the long axis of the calcaneus. One of these lines passes through the point where the lateral border of the head or neck of the talus crosses the calcaneocuboid joint line. The other passes through the junction of the sustentaculum and body of the calcaneus (often marked by a line of condensation at the medial margin of the body of the calcaneus).

(b) Diameter of talus in S-I view.

(b) Diameter (in mm.) of head of talus seen in supero-inferior view. Measure the widest point of the articular surface of the head of the talus, at right angles to the long central axis of the talus.

3. Head medial. Unused. 3. This was to have been used to record less than normal overlap in the supero-inferior view. As a normal could not be established, this was not used.
4. Head lateral. Unused. 4. This was to have been used to record greater than normal overlap in the supero-inferior view. As a normal could not be established, this was not used.
- (c) Overlap of talus lateral view. (c) Used to record overlap head of talus with front end of calcaneus in mm. seen in lateral view of x-ray. From the anterior-superior prominence of the calcaneus seen as the highest point on the x-ray to the most inferior point of the articular surface of the head of the talus in a perpendicular line.
- (d) Width of talus lateral view. (d) Diameter (mm.) of head of talus seen in lateral x-ray. The widest point of the articular surface of the head of the talus in the lateral view.
5. Elevated head talus. Unused. 5. Was to have been used to show less than normal overlap, in the lateral view. A normal could not be established so the space and hole were not used.
6. Depressed head talus. Unused. 6. Was to have been used to show greater than normal overlap, in the lateral view. A normal could not be established so the space and hole were not used.
- (e) Length of spring ligament. (e) Records the length of the spring ligament (mm.). Measured from the mid-point of the

anterior border of the sustentaculum in a line parallel to the axis of the foot to the most posterior margin of the inferior border of the scapoid.

7. Short spring ligament. Unused
7. Was to have been used to show less than normal length of spring ligament. A normal could not be established so the space and hole were not used.
8. Long Spring ligament. Unused
8. Was to have been used to show greater than normal length of spring ligament. A normal could not be established so the space and hole were not used.
- (f) Position of sustentaculum.
- (f) Distance of front of sustentaculum behind front of os calcis. Measured on superoinferior x-ray from the midpoint of the anterior border of the sustentaculum to the most anterior upper border of the calcaneus at the calcaneocuboid joint line.
9. Sustentaculum posterior. Unused
9. Was to have been used to show greater than normal distance of sustentaculum behind front of os calcis. As a normal could not be established this was not used.
10. Sustentaculum anterior. Unused.
10. Was to have been used to show less than normal distance of sustentaculum behind front of os calcis. As a normal could not be established this was not used.
11. Tendency to obliterate sustentacular notch.
11. Sustentaculum in superoinferior view tending to join the front end of calcaneus and obliterate the notch

- between anterior margin of the sustentaculum and the side of the body of the calcaneus.
12. Articular facet for talus on front of calcaneus. 12. The articular facet for head of talus probably is present on front end of calcaneus as judged by x-ray.
- (g) Forward projection of head of talus. (g) Records the distance of the head of the talus in front of the calcaneus (taken from S-I view of x-ray). Measured from the most anterior upper border of the calcaneus at the calcaneo-cuboid joint line to the most forward projection of the head of the talus in a line parallel to the line of the foot.
13. Decreased forward projection of head - Unused. 13. Was to have shown less than normal distance of head of talus in front of anterior border of calcaneus. As no normal could be established this was unused.
14. Increased forward projection of head - Unused. 14. Was to have shown greater than normal distance of head of talus in front of anterior border of calcaneus. As no normal could be established this was unused.
- (h) Divergence of axis of talus from axis of calcaneus (h) Records the divergence of axis of talus from axis of calcaneus measured as the angle subtended by lines through the central long axis of the central long axis of the talus.

15. Decreased angle - Unused. 15. Was to have shown less than normal angle as measured in 16 (H). As no normal could be established this was unused.
16. Increased angle - Unused 16. Was to have shown greater than normal angle as measured in 16 (H). As no normal could be established this was unused.
- (1) Slope of sustentacular facet. (1) Records the angle of inclination of articular surface of sustentaculum (in sagittal plane --- seen in lateral x-ray) (Angle with the floor).
17. Decreased slope of sustentaculum - Unused. 17. Was to have shown less than normal angle of sustentaculum with the floor. As no normal could be established this was unused.
18. Increased slope of sustentaculum - Unused. 18. Was to have shown greater than normal angle of sustentaculum with the floor. As no normal could be established this was unused.

SECTION 17 - SESAMOIDS

- (a) Position of sesamoids (measured). (a) Distance of sesamoids behind head of 1st metatarsal (mm.) measured from the mid-point of the sesamoids, i.e., from the middle point between the distal border of the medial sesamoid and the proximal border of the lateral sesamoid, to the most distal point on the head of the first metatarsal.

Dorsi-flexion of ankle.

- (a) Dorsi-flexion of the ankle quickly came to be recognized as an important function of the foot and that some record of it was needed in this Survey.
- As no space had been allotted for it in the original designing of the card, the right hand half of the above space 17-A was used for this purpose. It is recognized that marked variation in dorsi-flexion may occur. Some cavus feet cannot be dorsi-flexed to 90 degrees while others dorsi-flex very well. Some otherwise normal feet (not hypermobile flat foot with short tendo-achillis) dorsi-flex poorly. Also there is variation in the dorsi-flexion of hypermobile flat foot with short tendo-achillis. In order to record this, dorsi-flexion will be considered to mean the amount of dorsi-flexion that can be obtained with the knee straight and the shape of the foot such that the examiner gets the feel of the front of the calcaneus being locked under the head of the talus, so that no movement takes place at subastragalar and mid-tarsal joints and all dorsi-flexion is limited to movement at the ankle joint. This shape usually required slight supination of the heel and varus of the fore part of the foot (but not necessarily so). The angle will be that made by the outer side of the foot

with the long axis of the leg. As we have no measuring device the examiner's estimate of the angle will be used. It will be marked as degrees that dorsi-flexion brings the foot past a right angle, and degrees that it fails to come up to a right angle. It will be entered on the card in the right hand side of the space (17)-A. It will have a "-" sign if dorsi-flexion is less than 90 degrees. The recording of amount of dorsi-flexion was begun on 20/7/44 with case No. 966.

- | | |
|---|--|
| 1. Forward position - unused. | 1. Was to have shown less than normal distance of sesamoids behind head of 1st metatarsal. As no normal could be established this was unused. |
| 2. Posterior position - unused. | 2. Was to have shown greater than normal distance of sesamoids behind head of 1st metatarsal. As no normal could be established this was unused. |
| 3. Presence of unusual features of sesamoids. | 3. Used to record unusual features of sesamoids, specifying in this elongated space or on back of card. |

SECTION 18 - SPURS, EXOSTOSES, ETC.

Spurs, exostosis or unusual x-ray findings.

Use this hole when there is present (a) plantar calcaneal spur or (b) exostosis at back of calcaneus detectable by x-ray (into tendo-achillis) or (c) metatarsal-cuneiform exostosis, demonstrable by x-ray, (d) exostosis of hallux rigidus or (e) other exostosis or (f) other unusual

x-ray findings not recorded elsewhere. Elongated space to specify.

SECTION 19 - ACCESSORY TARSAI SCAPHOID.

This space and hole to be used when x-ray reveals presence of accessory tarsal scaphoid. No consideration as to size or likelihood of causing disability need be given as this question is sorted out on clinical grounds (Section (4)-9). The absolute fact of its anatomical presence requires the checking of this hole as positive.

SECTION 20 - MISCELLANEOUS ITEMS MEASUREABLE BY X-RAY

- | | |
|--|--|
| <p>(a) Width (cm.) -
Unused</p> | <p>(a) Was to have been used to record the measured width of the foot from medial side of head of 1st metatarsal to lateral side head of 5th (cm.). This measurement subsequently was not considered to be of sufficient importance, so was dropped.</p> |
| <p>1. Narrow - Unused.</p> | <p>1. Was to show feet which are narrower than normal. The space and hole however were unused.</p> |
| <p>2. Wide - Unused</p> | <p>2. Was to show feet which are wider than normal. The space and hole however were unused.</p> |
| <p>(b) Height of arch
Entered in (24)-2.</p> | <p>(b) Was to have been used to record distance from lowermost part of head of talus to the base line (mm.) This measurement has been entered in 24(2) by mistake so was</p> |

just left there.

3. Low - Unused.

3. Was to show less than normal distance of head of talus to the base line, in proportion to the length of the foot. As no normal could be established this was unused.

4. High - Unused.

4. Was to show greater than normal distance of head of talus to the base line, in proportion to length of foot. As no normal could be established this was unused.

(c) Angle at mid-tarsus. S-I view

(c) This records the angle between 2 lines (a) posterior line joining mid-posterior point of calcaneus and a point half way between the lateral border of the calcaneus and the medial border of the head of the talus (b) anterior line is the central long axis of 2nd metatarsal. Where anterior line is varus to posterior line the angle is marked "+". This measurement was not recorded on the cards, but is to be found entered on large sheets of tabulated measurements at the right hand side. This space however is reserved for the purpose.

5. Mid-tarsal valgus. Unused.

5. This was to have been used if fore part of foot in valgus in comparison to normal. (Entering in space the number of degrees departure from the normal range). As a normal could not be established this was not used.

6. Mid-tarsal varus. 6. This was to have been used
 Unused. if fore part of foot in varus
 in comparison to normal.
 (Entering in space the number
 of degrees departure from the
 normal range). As a normal
 could not be established this
 was not used.

SECTION 21 - X-RAY FEATURES OF CALCANEUS WHICH
 MAY BE OF INTEREST

- (a) Angle of posterior (a) Records the angle of axis of
 with base line. calcaneus (in lateral view)
 with the base line. This is
 the angle of the central
 long axis of the calcaneus with
 the base line.
1. Greater than normal 1. Was to have shown greater than
 angle at summit of normal angle between anterior
 arch - Unused. and posterior pillars of the
 arch. As a normal could not
 be established this was not
 used.
2. Less than normal 2. Was to have shown less than
 angle at summit of normal angle between anterior
 arch - Unused. and posterior pillars of the
 arch. As a normal could not
 be established this was not
 used.
- (b) Length of calcaneus (b) Records the length of os
 calcis (mm.), lateral view.
- (c) Part in front (c) Proportion in front) These
 articular facet of posterior articular) three
 (not done). facet.) measure-
) ments
 (d) Part which is arti-(d) Proportion occupied) were not
 cular facet (not by post articular) done,
 done). facet.) partly
) for lack
 (e) Part behind arti-(e) Proportion behind) of time
 cular facet (not post articular facet.) and
 done).

) partly because of the
) difficulty of determining
) uniform points to measure,
) and partly because it was
) felt they might not be so
) very useful.

SECTION 22 - SYMMETRY (X-RAY).

Right.

Use their holes and spaces for side which has the preponderant deviation from normal if asymmetric. Don't use either hole if approximately symmetrical.

MISCELLANEOUS RECORDS

SECTION 23 - MEDICAL SUMMARY.

- | | |
|---|--|
| <p>1. Survey grading on feet L-1</p> | <p>1. Use of this space means that the Foot Survey Team considered that grading of L-1 should be given as respects the feet. It should be noted that there are five grades which may be given, that L-1 means no practical lack of function and L-5 means enough lack of function that the soldier should not be in the army. Intermediate degrees are indicated by the other numbers.</p> |
| <p>2. Survey grade L-2 or 3.</p> | <p>2. Used if survey grading L-2 or 3. Which of these is shown in the space.</p> |
| <p>3. Grade L-1 given by Army Reception Centre.</p> | <p>3. This hole and space used if grading L-1 was given by Army Reception Centre Staff.</p> |

- | | |
|--|--|
| 4. Grade L-2 or 3 given by Army Reception Centre | 4. This hole and space used if grading L-2 or 3 was given by Army Reception Centre Staff (Specify which grading). |
| 5. Lowered L grading of Army Reception Centre for reasons other than feet. | 5. Used if the lowered L grading given by the Army Reception Centre would not have been so low had this grading been based on feet alone, i.e., even if the feet were a factor the grading would not have been so low except for presence of other defects of lower extremity. |
| 6. Reject because of feet. | 6. This space and hole used if rejected from army because of feet. |
| 7. Rejected - other medical reasons. | 7. This space and hole used if rejected from army for medical reasons other than feet. |
| 8. Rejected - administrative reasons. | 8. This space and hole for cases examined but not taken into army for other reasons, e.g. O.M.E. cases. (O.M.E. cases are "Order for Medical Examination". They are examinations ordered on industrial workers to determine the number who could make soldiers if the need arose. They are not inducted at this time). |

SECTION 24 - DISPOSAL AND TWO MEASUREMENTS

- | | |
|------------------------------------|--|
| (a) Name of Basic Training Centre. | (a) Enter the name of the Basic Training Centre to which he goes from Army Reception Centre. |
|------------------------------------|--|

- | | |
|---|---|
| <p>1. Slope of anterior pillar of arch.</p> <p>2. Elevation of head of talus.</p> <p>3. Unused.</p> | <p>1. Records the angle between two lines 1. a line joining the lowermost point on head of talus where it crosses calcaneo-cuboid joint line with the under surface of sesamoids, and 2, the line of the floor, i.e. the base line on the x-ray.</p> <p>2. Height of head of talus above base line from the most inferior point of the head of the talus in a perpendicular line to the base line. (mm.).</p> <p>3. Unused.</p> |
|---|---|

SECTION 25 - MEDICAL EXAMINATION AT TRAINING CENTRE

- | | |
|---|--|
| <p>1. Test prevented.</p> <p>2. Tolerance tested.</p> <p>3. Missed defects.</p> | <p>1. When other physical defects than in foot are present which prevent training and prevent pushing the man to the limit of his foot ability or if he has not been given training for administration reasons.</p> <p>2. Use this space and hole to indicate that the man has been pushed to the limit of his foot ability so that his capability can be stated.</p> <p>3. When foot defects are found which should have been found at Army Reception Centre but were missed, use this hole and specify the condition in elongated space.</p> |
|---|--|

Miles marched.

In order to record the number of miles marched by the man as a maximum at one time, this will be put into right hand side of this square (25) - 3.

- | | | | |
|----|--------------------------------------|----|---|
| 4. | New trouble | 4. | Use this hole and space (elongated to permit statement as to its nature) for new foot trouble which has developed in the army which has been severe enough to interrupt training or which has some probability of doing so during the remainder of basic or advanced training. Examples: blisters; fungus infection; acute foot strain; tendosynovitis; bursitis of bursa of tendo achillis; gonococcal arthritis; etc. |
| 5. | Proven ability less than five miles. | 5. | This space is used if it has been shown that the individual's ability to march is less than 5 miles in a day. If used mark in the space -- the miles per day of marching ability. |
| 6. | Proven ability 5 - 9 miles. | 6. | This space and hole used similarly to the previous one. Mark miles per day of ability. |
| 7. | Proven ability 10 - 19 miles. | 7. | This space and hole used similarly to the previous two. Mark miles per day of ability. |
| 8. | Five days or less of training lost. | 8. | Use this space and hole if 5 or less training days were lost on account of foot trouble. (State the |

number of days). Some days must have been lost for this item to be used.

9. More than 5 days lost. 9. Use this space and hole if more than 5 days were lost from training on account of the feet. (State the number of days in the space).
10. Foot disability prevented completion of Basic. 10. This hole is to be used if the soldier is known not to have completed basic training on account of foot disability within 6 weeks more than the syllabus called for.
11. Upward re-grade. 11. Upward re-grading seems indicated or has been done (and if done I agree that it was correctly done).
12. Down re-grade. 12. Re-grading downward seems indicated or has been done (and if done I agree that it was correctly done).
13. Controllable disability not controlled. 13. This space and hole will be used when there has been failure to bring under control at the time of examination during training, apparently controllable problems, e.g., callosities and corns, ingrown toe nails, mild fungus infection, etc. Elongated space to specify.
14. Stabilized L grading given. 14. This space used if the final correct grading on feet has been given, based on sufficient training to warrant considering it as final.
15. Stabilized grade L-1. 15. Used if (25) - 14 has been used and if the stabilized grading is L-1.

16. Stabilized grade L-2 or 3. 16. Used if (25) - 14 has been used and if the stabilized grading is L-2 or 3. The grading given is marked into the space.
- (a) M & S grading at A.R.C. (a) Mark M and S grading given at Army Reception Centre ("M" refers to a score on a mental test. "S" refers to a score given on the question of stability).
- (b) M & S grading on review. (b) Mark M and S grading given at review of the case from this aspect if there was any.
17. Lacks motivation. 17. If known enter here the opinion that psychiatric state is one to give rise to lack of stamina, or will to use feet (motivation). The marital status, army status as to N.R.M.A. or Active M.O.'s report, psychiatric opinion, army examiner's opinion and training officer's opinion will be used to come to this conclusion but each duly weighed --- the psychiatrist probably having more weight than all others combined if his up-to-date opinion is available.

SECTION 26 - SHOE FITTING

1. Unsatisfactory at District Depot. 1. Shoe fit at District Depot not satisfactory. Elongated space to specify why. The District Depot gives the first pair of boots to the new recruit. In this study it was No. 2 District Depot in Toronto.

2. Three fittings or more necessary. 2. Three fittings or more necessary. This implies that the individual required more than two attempts before being properly fitted.
3. Final fit unsatisfactory. 3. This was planned to record cases in which the final fitting was not satisfactory. However in those with poor fit, the final fitting often was not achieved when last seen. The use of this space therefore would be misleading. It was therefore seldom used.

SECTION 27 - MAINTENANCE OF SHOES, SOCKS & SKIN

1. Shoes not well maintained. 1. Use this space and hole if shoes are not being maintained in good condition. In the elongated space specify the problem.
2. Socks not well maintained. 2. Use this elongated space if socks are not being maintained in good condition and specify the problem.
3. Skin not well maintained. 3. Use this elongated space if skin is not being well cared for and specify the problem.
4. Lack of knowledge. 4. Use this space if soldier seems not to know how to care for feet, socks or shoes and specify the problem.

SECTION 28 - TIME AND PLACE OF EXAMINATIONS

- (a) No. of weeks in training at 1st visit. (a) Enter the number of weeks in training at time of 1st visit.

- | | |
|--|---|
| (b) No. of weeks in training at last visit. | (b) Enter the number of weeks in training at time of last visit. |
| (c) Date of last visit. | (c) Enter the date of last visit. |
| 1. Was examined at basic training. | 1. Use this space and hole if he was seen at Basic Training Centre. |
| 2. Examined at advanced training centre. | 2. Use this space and hole if he was seen at advanced training centre. |
| 3. Advanced training was infantry. | 3. Use this space and hole if his advanced training was infantry corps. |
| 4. Advanced training was medical or engineers. | 4. Use this space and hole if his advanced training was medical corps (R.C.A.M.C.) or engineers (R.C.E.). Enter "M" if medical or "E" if engineers. |
| (d) Other corps. | (d) Enter the name of the corps if advanced training was other than infantry, medical or engineers. |

SECTION 29 - EXTRA HOLES

- | | |
|-------------------------------------|---|
| 1. Unused. | 1. Unused. |
| 2. Unused. | 2. These holes were provided for unforeseen needs. They were not used. |
| 3. Unused. | 3. Unused. |
| 4. Mild disabilities or complaints. | 4. Use this space and hole to indicate the development of mild symptoms during training which are not recorded in (25) - 3 or 4. Details are put on the back of the card. |

5. Unused.

5. This hole was provided for unforeseen needs. It was not used.

1. Was examined at basic training. If he was seen at basic training center.

2. Examined at advanced training center. If he was seen at advanced training center.

3. Advanced training was in his advanced training center. If he was seen at advanced training center.

4. Use this space and hole if his advanced training was in his advanced training center. If he was seen at advanced training center.

5. Other categories: (d) Enter the name of the center. If he was seen at advanced training center.

SECTION 29 - EXTRA HOLES

1. Unused.

2. Unused. These holes were provided for unforeseen needs. They were not used.

3. Unused.

4. With disabilities or other conditions. Indicate the development of any symptoms during training which are not recorded in (2) - 3 or 4 Details are put on the back of the card.

Project - Army Meds. - No. 22

APPENDIX "B"

METHOD OF FOOT PRINTING

APPENDIX "B"

METHOD OF FOOT PRINTING

Aim

It was desired to demonstrate the outline of that part of the foot which contacts the floor on weight bearing and at the same time to demonstrate pressure distribution on the sole. Sporadic attempts have been made to do this before in different ways. We desired a simple and effective method and succeeded in obtaining this after a number of trials.

Method

The successful principle was to make the foot print from a rubber mat the surface of which is covered with fine ridges at different levels regularly alternating with one another. Light pressure then prints only the highest ridges - heavy pressure prints all the ridges and hence gives a decidedly darker imprint. The first successful model was made with two sets of ridges and with this model the whole of the foot prints of the Survey at the Reception Centre were made. Later on an improved model with three sets of ridges was made. This is now the standard type.

The original model with which the Survey was made consisted of a set of rubber mats 4 1/2" square and about 1/12" thick. The effective upper surface was covered with two sets of fine ridges each of which consists of ridges crossing one another at right angles - one set of ridges is higher than the other set by .003". These alternate with one another; one high ridge alternating with one low one. The ridges are .023 and .020" respectively in height. The faces of the ridges make an angle (in width) of 25° with the vertical. The flat top of the ridge is .004". The rubber base of the mat is about .040" thick (or the overall thickness of the mat is about .060"). Rubber of a durometer reading about 50 is satisfactory for the above dimensions though a softer rubber may be used. The die mold for the mat was made

Fig. 11 - Photograph of wooden model made to scale 100 times natural size showing the texture of the surface of the rubber foot printing mat used during the Survey. The flat tops of the ridges are 0.004 inches wide. The ridges alternate between 0.023 and 0.020 inches in height.

made by machining grooves in a magnesium plate. In the early stages a mold larger than 4 1/2" x 4 1/2" was not obtainable because of the shortage of magnesium. It was therefore necessary to mount nine mats of the 4 1/2" x 4 1/2" size on a wooden base to give a total area of 13 1/2" x 13 1/2" (Fig.37).

The pattern of the surface of the rubber mat is illustrated by Fig. 38 which is a photograph of a wooden model made to a scale one hundred times normal.

The mold and the rubber were made by Bernard Cairns Ltd., 134 Richmond St., West, Toronto.

A satisfactory paper for the prints is a 13 lb No.7 Sulphite Bond, cut in size 17" x 12". That used in this work was 13 lb Revenue Bond, obtained from Buntin-Reid, 117 Peter St., Toronto.

The ink used is black printer's ink which is quite viscid. The viscosity and drying qualities were adjusted to be suitable to the rubber pad and absorbent qualities of the paper. The ink was combined by and is obtainable from Ault and Wiburg Co., of Canada Ltd., 82 Peter St., Toronto. The formula is on their record under the heading "Foot Imprint - Black".

To make a foot print, a thin layer of ink is spread evenly on a glass plate with a printer's roller. Printer's rollers are readily obtainable. Ault and Wiburg Co., of Canada Ltd., 82 Peter St., Toronto, is one supplier. It can be made in any width and circumference and in variable degrees of softness. A very soft roller 13 inches in circumference and 8 inches wide is satisfactory. The ink on the glass then acts as the immediate reservoir for use. Rolling the printer's roller through the ink on the glass once or twice then inks the roller. The foot printing mat is inked by passing the roller over it. (Fig.39). A sheet of paper is then gently placed over the inked printing mat and the subject steps on and off the paper. (Fig.40) The print may be made with the subject walking or simply standing, or the foot may be placed in position and a long stride taken off as shown in Fig.40.

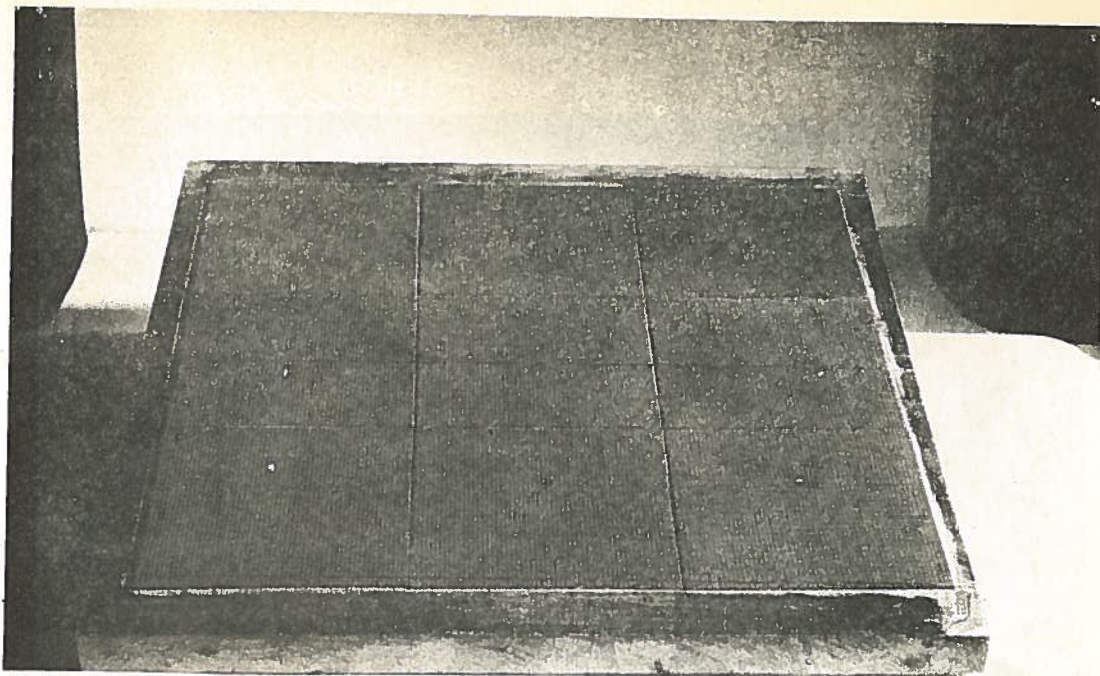


Fig. 37 - The rubber foot printing mat used during the Survey mounted on wood. Note wires to give slight support to the paper.

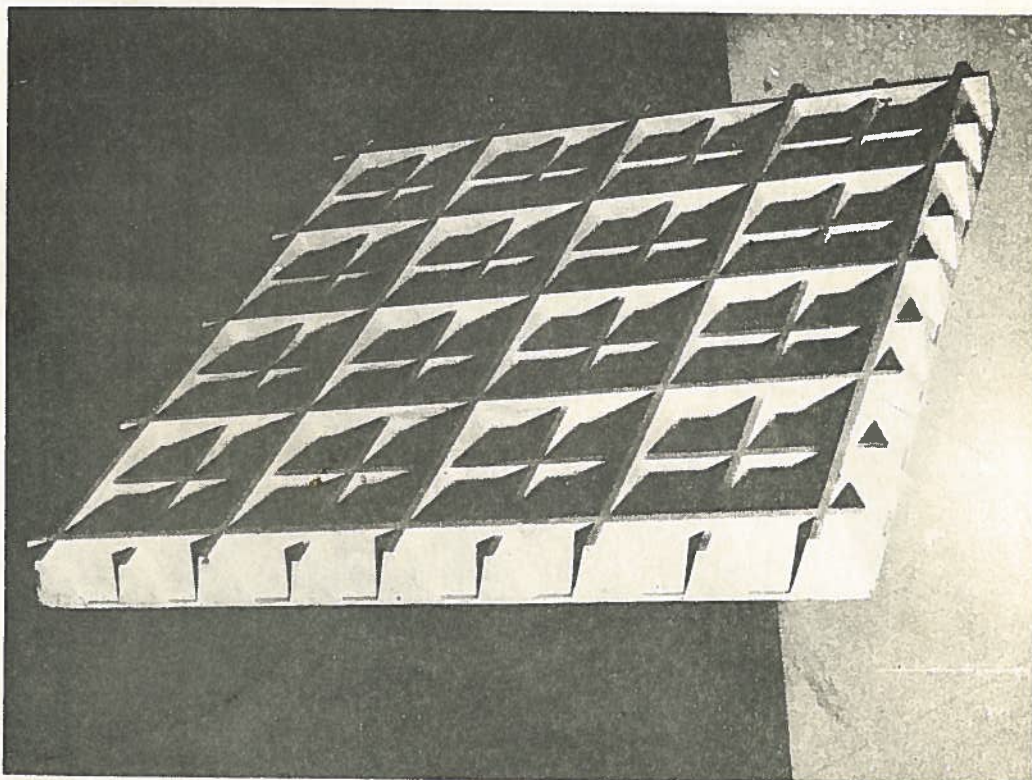


Fig. 38 - Photograph of wooden model made to scale 100 times natural size showing the texture of the surface of the rubber foot printing mat used during the Survey. The flat tops of the ridges are 0.004 inches wide. The ridges alternate between 0.023 and 0.020 inches in height.



Fig.39 - Inking the rubber mat.



Fig.40 - Taking the impression of the left foot.



Beard Standing

Fig.41 - Prints with three different mats. Ridges in the rubber in one direction and at one level - left. Ridges in two directions but at one level - middle. Ridges in the rubber in two directions and at two levels - right. This last is the pad used in the Survey. These three prints were made with the same individual who has a callus under the 5th metatarsal only.

Varsol or carbon tetrachloride are good solvents for the ink but are hard on the rubber, particularly carbon tetrachloride. Ethyl acetate is a satisfactory cleaner.

It might be noted that the ink solvents and possibly the temperature tends to alter the surface of the foot printing mat.

Some device to support the weight of the paper off the mat is desirable to prevent marking of the paper in the area not pressed upon by the foot. An aid in this has been three wires of about 20 gauge, stretched over the rubber mat in the long axis of the foot; one at each edge of the mat and one in the middle.

The value of different levels of ridges on the foot print mat is illustrated by Fig.41. Each foot print is the same foot in the same individual. The print on the left is made by using a mat with ridges of a single level running in one direction only. The middle print is made by using a mat with ridges of a single level, running in two directions. The right print is made using a mat with two levels or ridges as described above.

When the merit was demonstrated of the foot printing pad with two sets of ridges at different levels, a new model was designed and ultimately constructed. It has five sets of ridges at different levels varying by gradations of .0025 inches and is full size. The tops of the ridges are rounded. The texture of the surface is shown in Fig.42. The foot print shown in Fig.43 made on this mat is from the same individual as that shown in Fig.41. The engraving of the die mold for this was a very lengthy task so that it was not available for the greater part of the Survey. To have waited for it would have set us back several months. The pad which was used, however, was adequate to demonstrate what was desired to show.

A portable foot printing box was made and is depicted in Fig.44.

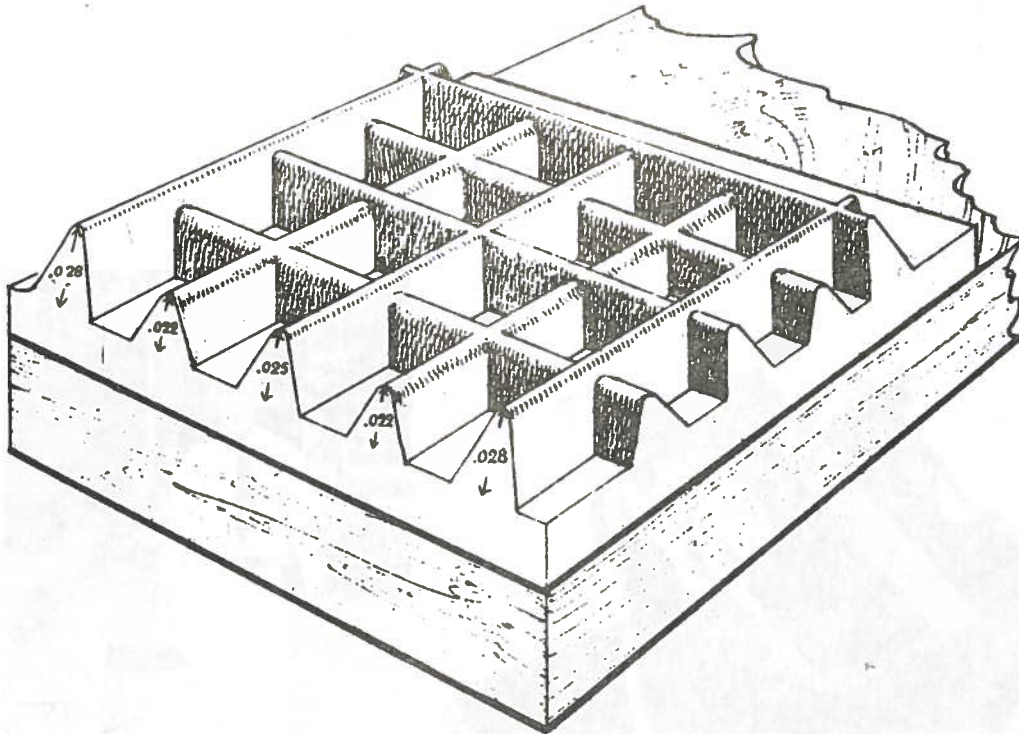


Fig.42 - Drawing to show the texture of the new pattern rubber mat made in the later stages of the Survey. There are three levels of ridges in the rubber respectively 0.022, 0.025 and 0.028 inches in height. The top of the ridges are rounded to a radius of 0.0025 inches.

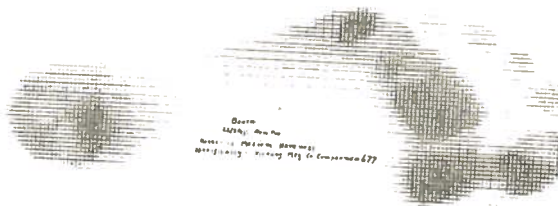


Fig.43 - Print of the same foot as used in Fig.41 made with the new pad, the texture of which is depicted in Fig.42.

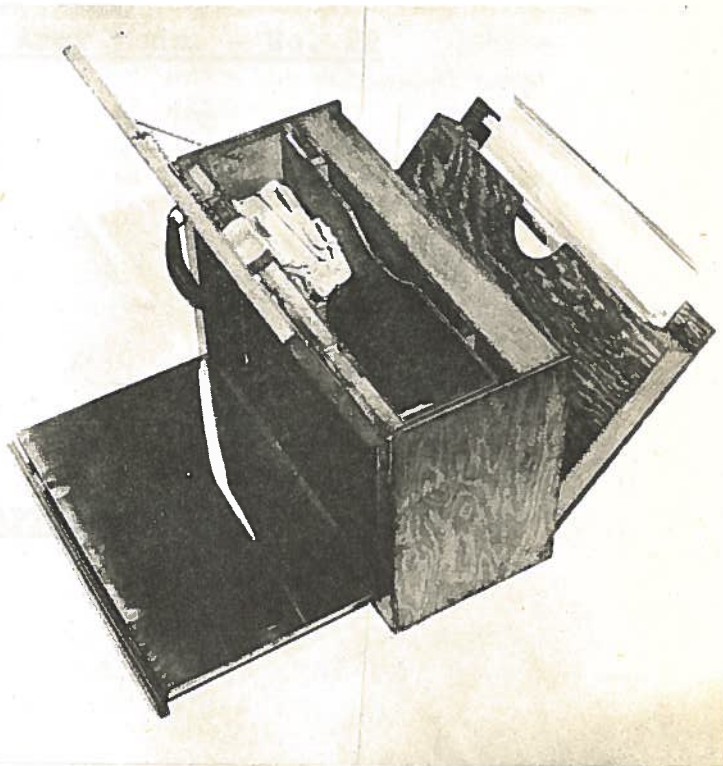


Fig.44 - A portable foot printing unit complete in itself.

Project - Army Meds. - No. 22

APPENDIX "C"

TECHNIQUE TO OBTAIN

STANDARDIZED RADIOGRAPHS

FOR MED. USE

A Picker Weigh Model B X-ray Unit was the only machine available. It had the following features: 25

APPENDIX "C"

TECHNIQUE TO OBTAIN STANDARDIZED RADIOGRAPHS

Requirements of the Technique

Supero-inferior View - For the purpose of this study it was necessary to visualize the calcaneus and talus in the supero-inferior (dorsi-plantar) view. This was required in order to study both the general and detailed variations of the talus and calcaneus. At the same time it was necessary to visualize the rest of the tarsals and metatarsals and if possible the phalanges also. What was required therefore, was a single supero-inferior view which would visualize, with equal clarity, all of the bones of the foot from post end of os calcis to the tip of all of the toes.

Oblique View - It was desired to determine (if possible) variations in the joint between the front end of the calcaneus and the head of the talus.

Lateral View - In this view we desired to study the contour of the arch as shown by the bones. We required a means of measuring the height of the arch and therefore had to have a base line to measure from.

Standardization - In all views we wished to have a technique which would be constant from case to case; which would obtain maximum speed so that it could be applied to a survey; which would be taken with weight bearing in at least two views; which might be acceptable to others, so that our measured results could be compared with the results of measurements on x-rays which might be done elsewhere. After considerable thought three views were decided upon, viz: 1. A supero-inferior view. 2. An oblique view. 3. A lateral view. The supero-inferior and lateral views were taken with the individual standing equally on both feet i.e., about half the body weight on each foot. This was found to be sufficient weight to stabilize the bones. The oblique view was with only a small amount of weight upon the feet.

The Machine

A Picker-Waite Mobile X-ray Unit was the only machine available. It had the following features: 15

milliamperes, 79 kilovolt, operated from a 110 volt, 15 ampere, 25 cycle electrical service. The unit is totally shock proof. The tube is the single focus type, with a 2.3 mm. focal spot. Both tube and transformer are contained within one shock proof head. This machine has a range of from 30 to 79 kilovolts with 1 kv. steps. It is provided with an inductance type filament regulation.

Supero-inferior View - The following technique was evolved from the suggestion of many friends, particularly Lt. Col. R.M. Boyd, R.C.A.M.C., Dr. H.M. Worth and Mr. W.W. Whitehouse of Toronto General Hospital.

Avoiding the Leg Bone Obstruction - The tibia and fibula interfere with visualization of the back of the foot in the dorsi-plantar projection. To overcome this difficulty the foot was plantar-flexed 15° at the ankle and the axial beam of the x-ray was passed down through the mid-tarsal region of the foot at an angle of 15° to the foot backwards. The x-rays then pass through the leg bones at an angle of 30° to their long axis. (Fig.45) This decreases the obstruction of the leg bones sufficiently that with careful adjustment of other factors, visualization of the outline of talus and calcaneus can be obtained and their mutual relationship demonstrated.

Arrangement of Equipment - Fig.46 shows the equipment used. On the floor is a Bucky diaphragm tipped at 15° upon which the subject stands. The tube head is tipped 30° with the floor. The target distance is 30 inches. A plumb is fastened to the tube head to indicate by its relationship to a mark on the floor that it is in the proper position. A wooden bar down the middle of the Bucky and a painted outline of a foot on the surface of the Bucky aid in rapid positioning of the subject. A wooden frame in the film tray raises the cardboard film holder a little closer to the foot. A railing of pipe fastened to the wall is an aid to the subject in steadying himself and keeps him from pushing the x-ray tube out of position.

Prevention of Burning Out the Toes - The penetration necessary to visualize the talus and calcaneus gives marked over-exposure of the fore part of the foot. This is prevented by making a suitable wedge filter of opaque

METHOD FOR SUPERO-INFERIOR EXPOSURE

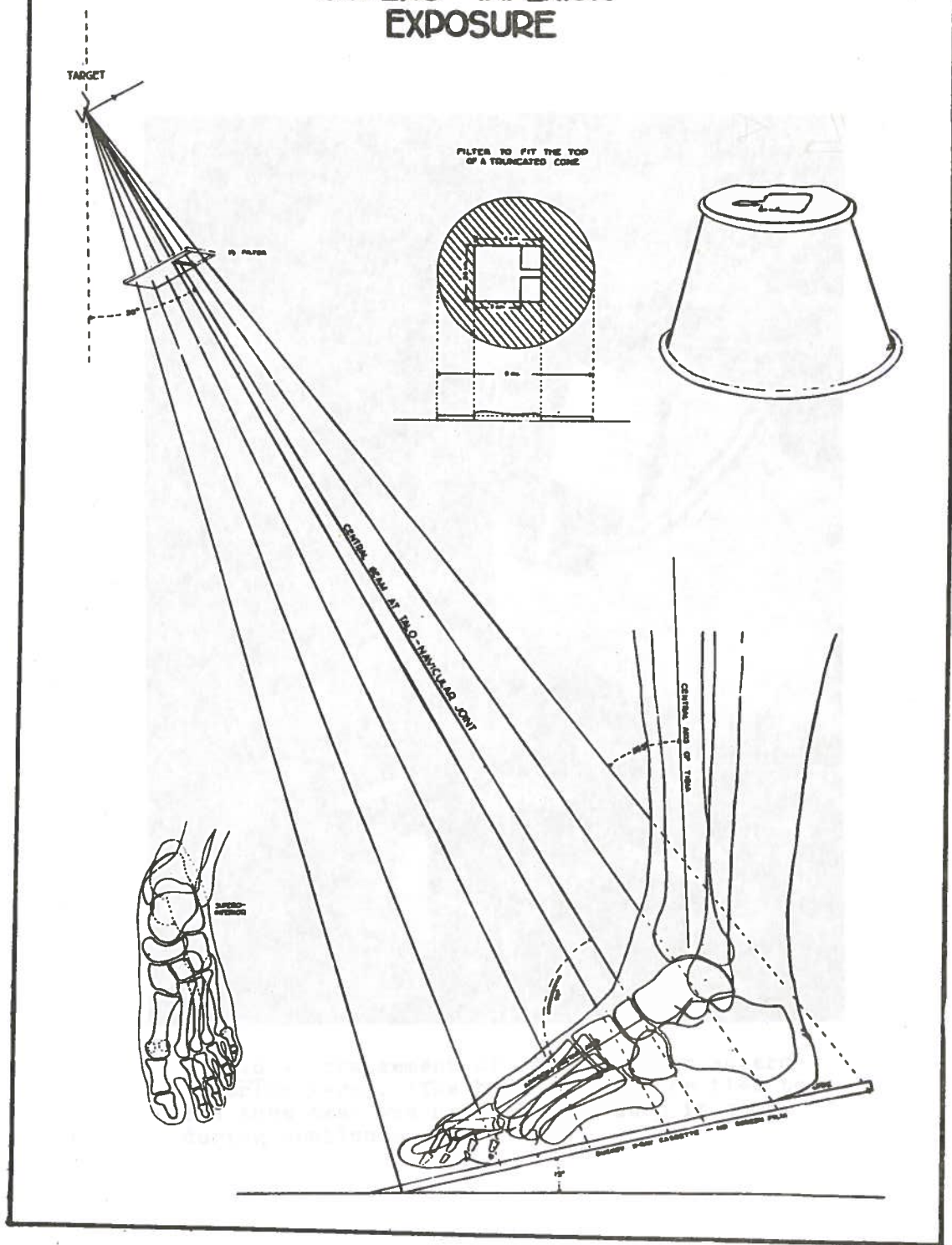


Fig.45 - Method for supero-inferior x-ray.

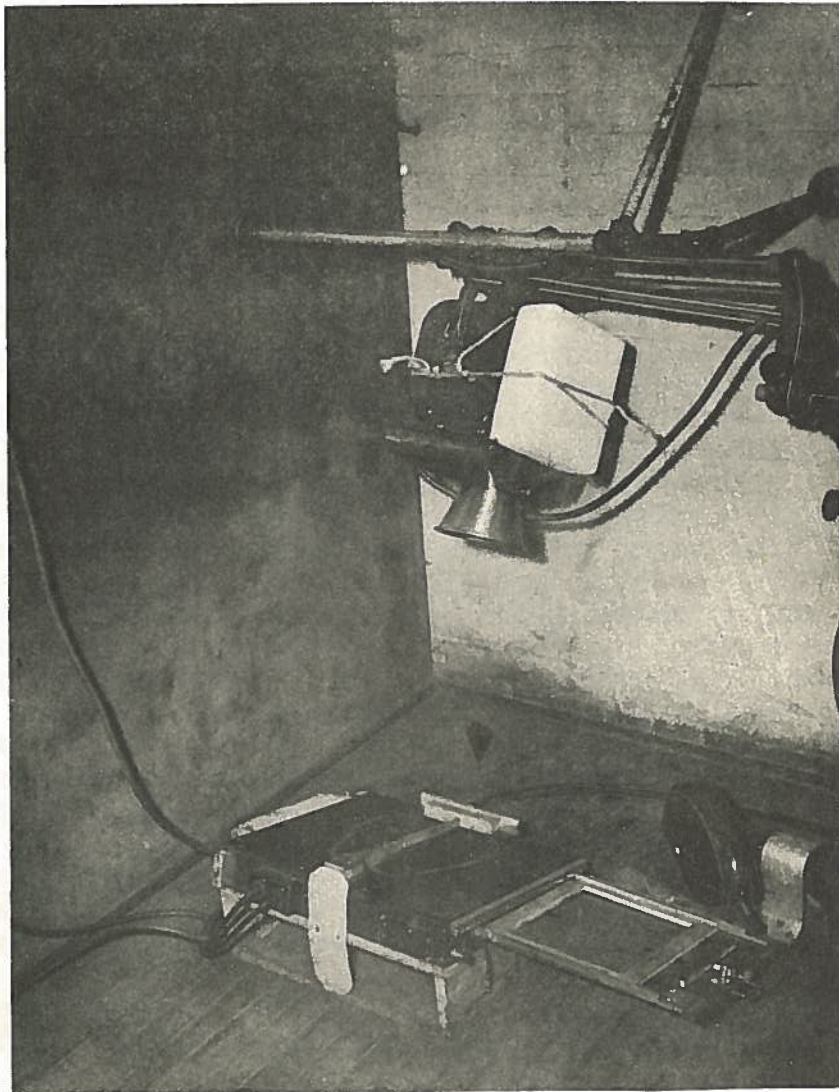


Fig.46 - Arrangement of equipment for supero-inferior x-ray. (The block of dry ice tied to the tube head was necessary to keep it cool during continuous use.)

plastic material and attaching it to the inner side of the cone of the tube, (see Fig.47). A sheet of lead is fitted inside the cone with an opening of size and shape to limit the beam of x-rays to no more than enough to cover the film. This is to reduce blurring caused by secondary x-rays.

Exposure and Film - Exposure was for 9 seconds, at 79 kv. 15 milliamperes with load on. 10" x 12" no-screen film was used in a cardboard holder. Film processing was that used for no-screen film.

Lateral View

Arrangement of Equipment - The apparatus for taking the lateral view is illustrated in Fig.48 and 49. It consists of a turntable upon which the subject stands. The turntable turns through 180° and locks into position. There is a slot in the surface which takes a 10" x 12" film in a cardboard holder, the bottom half of the film being protected during exposure of the upper half. A wire has been placed in the bakelite surface under the longitudinal axis of each foot. This marks on the film the level surface of the platform and so forms a base line for measurements. The pictures show the platform sloping downward and forward 15°. It was so made hoping to use the turntable for making the supere-inferior exposure. The slope is not necessary but is no real defect in the apparatus.

Position of Tube - The tube was set so that the axial beam passed horizontally $\frac{3}{8}$ " above the surface of the platform and $1\frac{3}{4}$ " behind the centre of the platform.

Exposure - Exposure was $2\frac{3}{4}$ seconds at 60 kv. No-screen film technique was used with cardboard film holders.

Doing the Opposite Foot - Fig.49 portrays the exposure of the right foot. When this has been done the film is turned over so that the exposed side goes down in the slot for protection while the unexposed side is up. The turntable is then turned 180° and the position becomes correct for the left foot.

Oblique View

Visualization by This View - This is primarily to visualize better the relationship of the front of the sustentaculum and front of body of calcaneus to the head of the talus. The size and shape of the articular facet for the talus on the upper surface of the front of the body of the calcaneus is to be judged in this view.

The Method - In this view the x-rays are passed from lateral to medial side of the foot at an angle of 30° downward. The exposure is made in a manner very similar to that used in the lateral x-ray. The subject sits on a small stool and puts his feet on a pair of balsa wood blocks. The balsa wood blocks are shaped and tip the foot approximately 30° . The knees fall apart and are steadied by a light frame (Fig.50). The tube is left in the same position as for the lateral exposure. The right and left foot are exposed alternately after turning the turntable just as is done in the case of the lateral views. Exposure technique is the same as for the lateral view.

Controlling the Tube Temperature - By technique described, it was possible to make the five exposures on three films for as many as 35 subjects per hour. The heat generation of the tube head, however, limited the number to about 50 - 60 subjects per day. To overcome this limitation a block of carbon dioxide ice was fastened against the metal of the tube head. This effectively cooled the tube and apparently did no harm. With the ice in place it was impossible to overheat the tube by operating at a rate up to 35 per hour or 200 in 6 to 7 hours. The dry ice was used on both tubes.

Illustrations - Fig.51 is a tracing of a fairly average left foot x-rayed by the technique described. Fig.52, 53 and 54 are copies of a set of three (supero-inferior, oblique and lateral) views in another case of about normal structure except for the presence of some shortness of the 1st metatarsal. A great deal is lost in copying these x-rays to print but the arrangement can be seen.

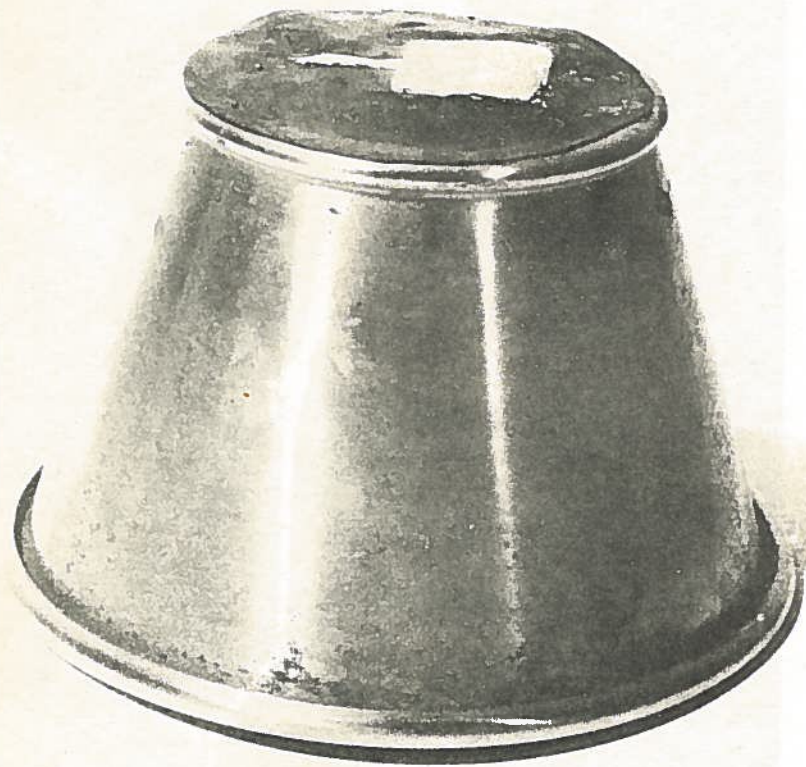


Fig.47 - Plastic filter attached to cone. Used to equalize penetration of x-rays throughout whole foot. The backward prolongation of the filter is to decrease exposure of tuberosity of scaphoid.

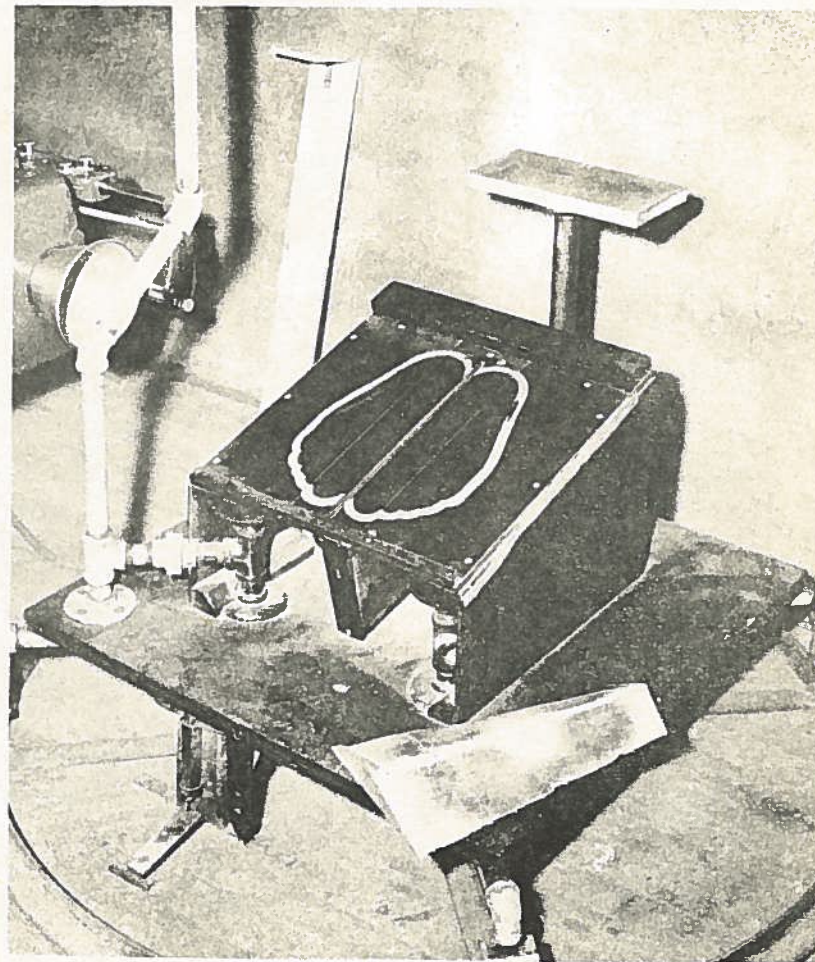


Fig.48 - The turntable and its arrangement for taking lateral and oblique films.



Fig.49 - A method for taking right lateral film.

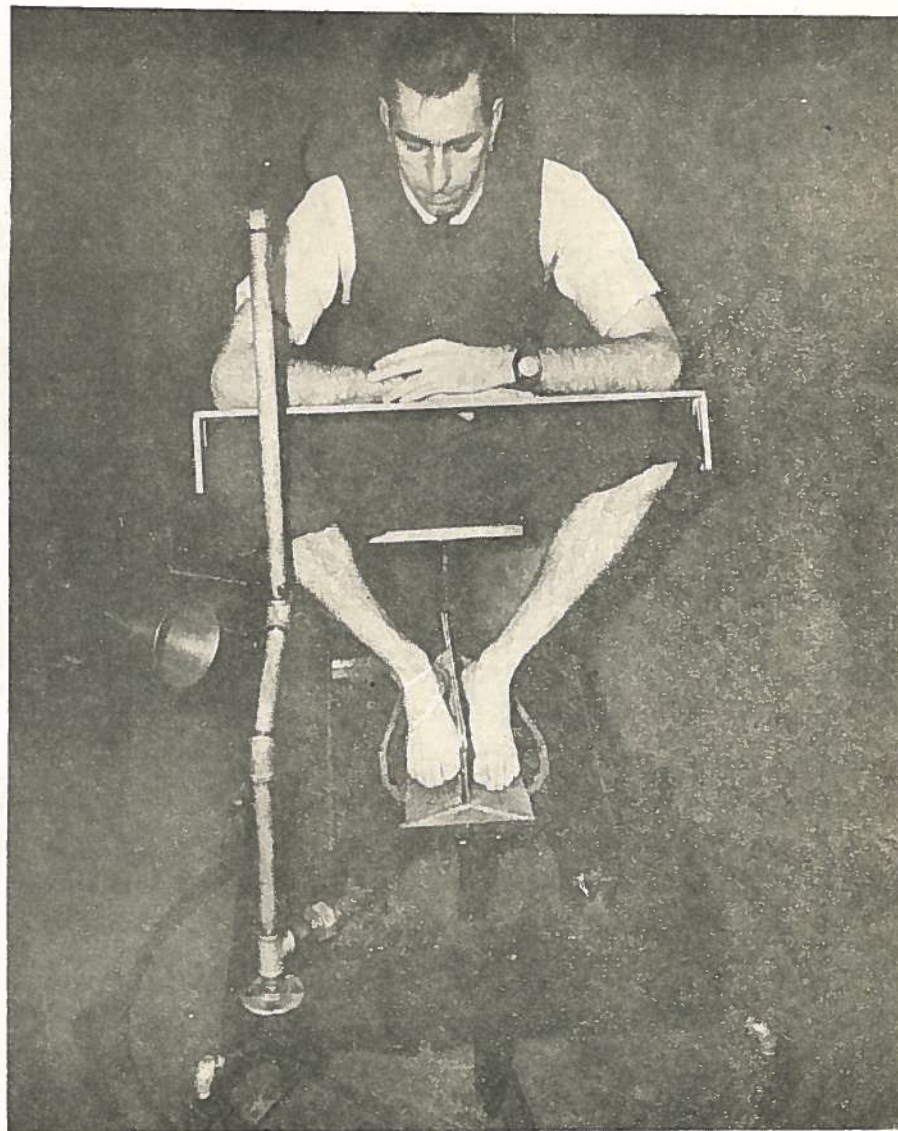


Fig.50 - Method for taking right oblique film.
The turntable has been moved about 20° from
the position actually used during the exposure.

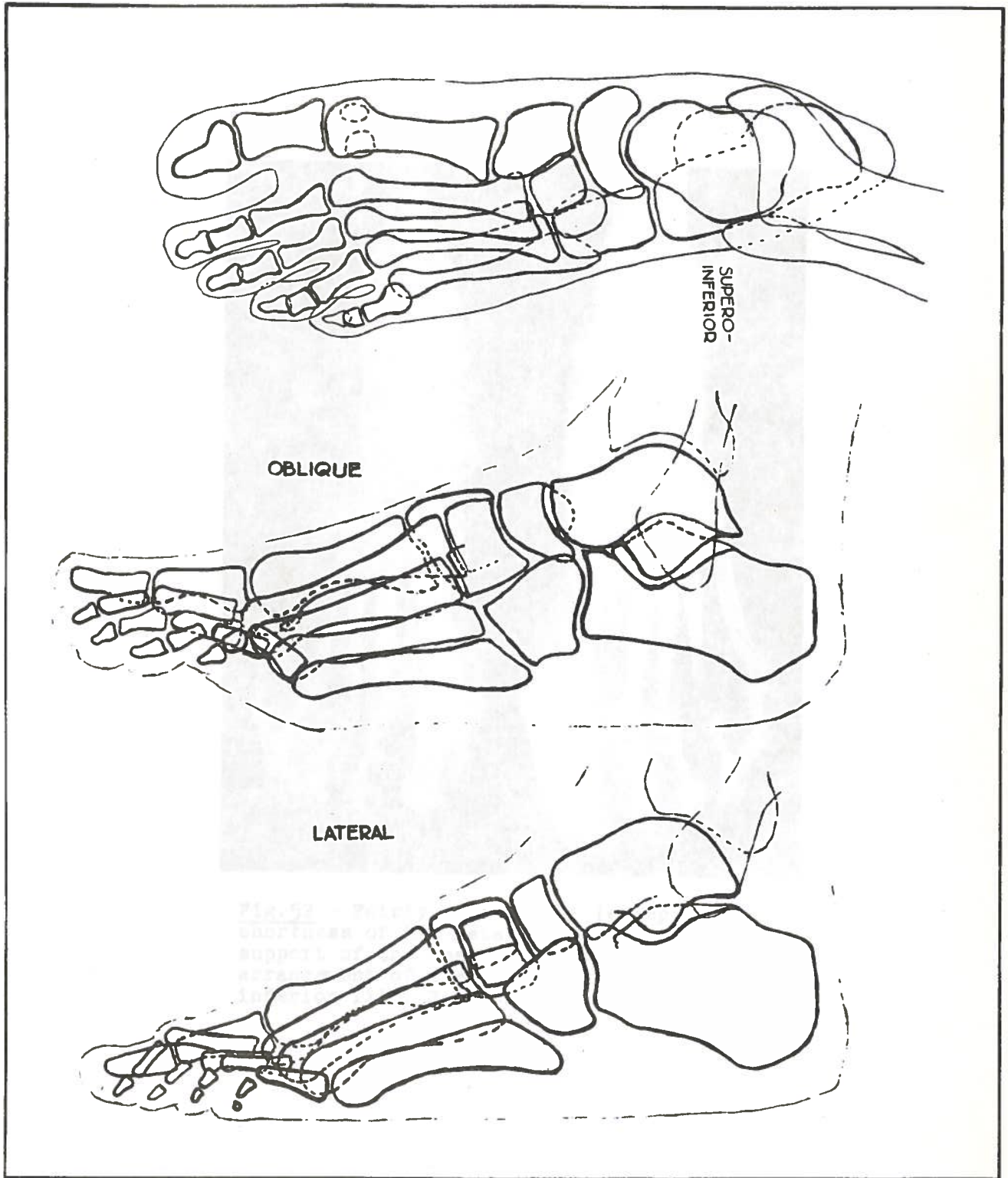


Fig.51 - Tracings of radiographs illustrating what is visualized by the x-rays.

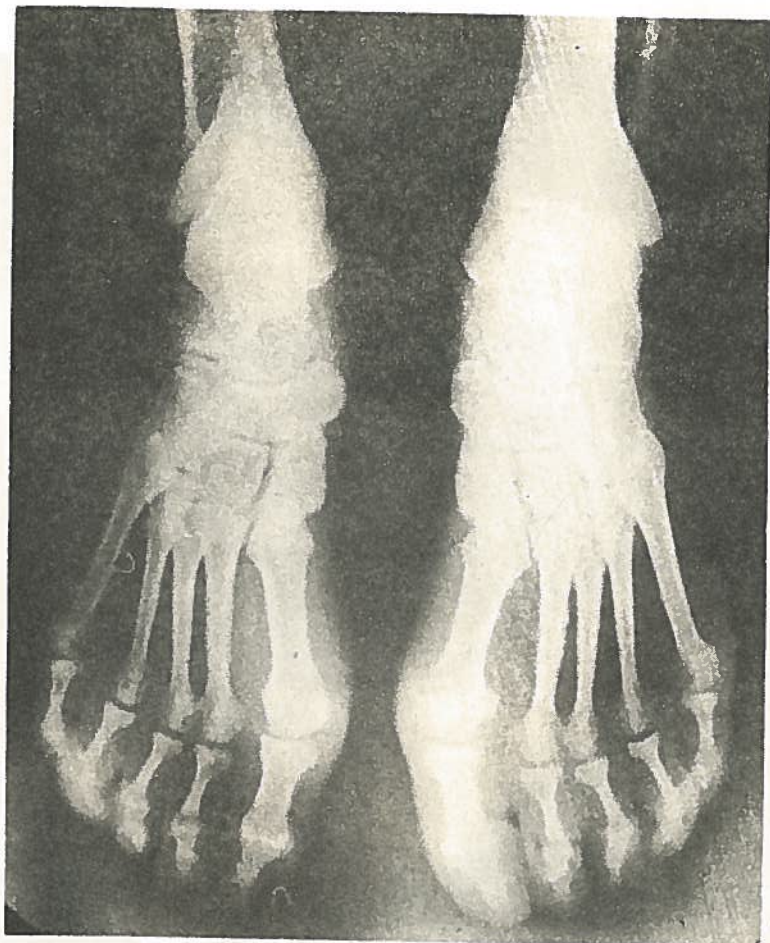


Fig.52 - Fairly normal feet (except some shortness of 1st metatarsal). Moderate support of the head of the talus. This shows arrangement of the x-rays on the superoinferior film. Same case as Figs.53 and 54.

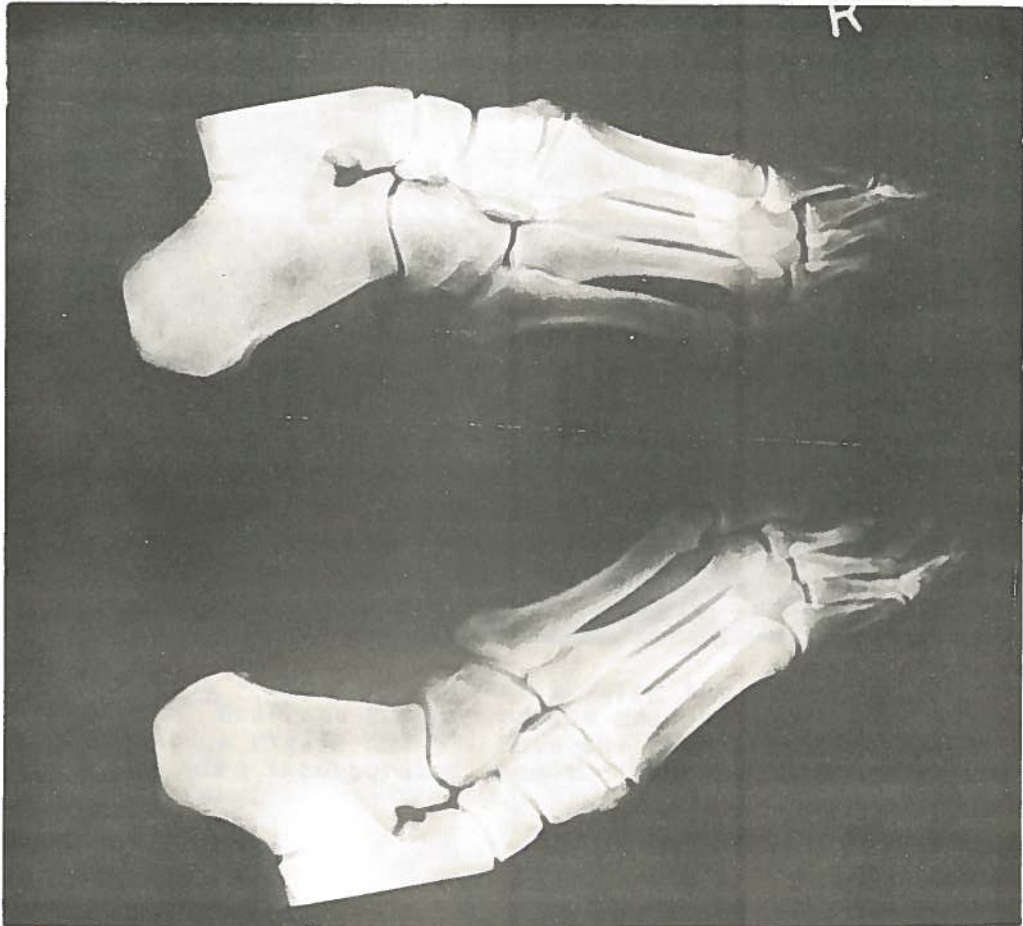


Fig.53 - Oblique view showing clearly the articulation between the head of the talus and front of the calcaneus. Moderate support of the head of the talus. Same case as Fig.52 and 54. This is the arrangement of the oblique exposure.

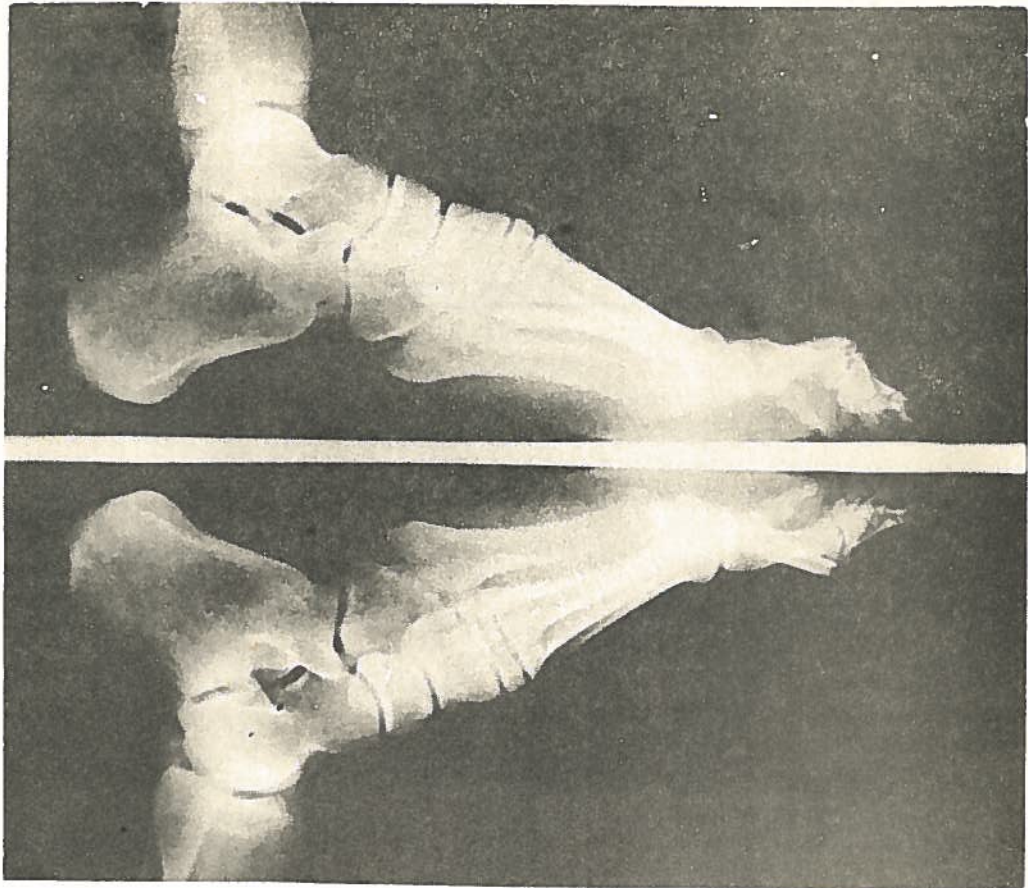


Fig.54 - Lateral exposure showing the arrangement on the film. Moderate support of the head of the talus. Same case as Fig.52 and 53. Note the fine visualization of the wire incorporated into the surface of the bakelite platform.

APPENDIX "D"

METHOD OF STUDYING X-RAYS

General - An attempt was made in the first few cases to have the x-rays present and try at the time of the clinical examination of the individual. However, this was found to be more necessary to go on with the clinical examination and at the end of the day make a study of the x-rays. This means that the clinical examination was separated from the x-rays and results in lack of influence of x-rays on the clinical judgment. At this stage the support of the head of the tarsus was studied, the presence or absence of shortness of the 1st metatarsal as compared with the 2nd was studied, the question of thickness of the 2nd and other features shown on the x-rays, as they are ordinarily examined, were noted. These points were recorded on the record card. Later certain measurements were taken from the x-rays. The measurements which are noted above in Appendix "A" "Data for Cards", in addition to those measurements noted in Appendix "C" "Cards" about half of the x-rays were measured by the method of the 1st metatarsal by Morton's method. The method of getting these measurements follows:

APPENDIX "D"

Measurements on X-rays

Purpose of Measurements - It was thought advisable to supplement the visual and gross interpretation of the x-ray films with measurements of those features of the foot that are variable and have been found, or are thought to be characteristic of the weak or painful foot. This was with a view to establishing a statistical normal and determining if the variations in a measurement, or a group of measurements, would lead to a classification of feet that can be expected to have foot trouble. It was also hoped that this knowledge, foot trouble developing under the stress of army training could be more accurately predicted and steps taken to prevent such disability.

METHOD OF STUDYING X-RAYS

Degree of Accuracy - It must be stressed that the measurements are not true measurements of the foot but are of the shadow of the foot on an x-ray film. To ensure accuracy, therefore, the system of exposure must be as nearly stan-

APPENDIX "D"

METHOD OF STUDYING X-RAYS

General - An attempt was made in the first few cases to have the x-rays present and dry at the time of the clinical examination of the individual. However, this was found to be impossible and it was therefore necessary to go on with the clinical examination and at the end of the day make a study of the x-rays. This means that the clinical examination was separated from the x-rays and results in lack of influence of x-rays on the clinical judgment. At this stage the support of the head of the talus was studied, the presence or absence of shortness of the 1st metatarsal as compared with the 2nd was studied, the question of thickness of the 2nd and other features shown on the x-rays, as they are ordinarily examined, were noted. These points were recorded on the record card. Later certain measurements were taken from the x-rays. The measurements made are noted above in Appendix "A", "Data for Cards". In addition to those measurements noted in the "Data for Cards" about half of the x-rays were measured for shortness of the 1st metatarsal by Morton's method. The method of getting these measurements follows.

Measurements on X-rays

Purpose of Measurements - It was thought advisable to supplement the visual and gross interpretation of the x-ray films with measurements of those features of the foot that are variable and have been found, or are thought to be characteristic of the weak or painful foot. This was with a view to establishing a statistical normal and determining if the variations in a measurement, or a group of measurements, would lead to a classification of feet that can be correlated to clinical foot trouble. It was also hoped that from the resulting knowledge, foot trouble developing under the stress of army training could be more accurately predicted and steps taken to prevent such disability.

Degree of Accuracy - It must be stressed that the measurements are not true measurements of the foot but are of the shadow of the foot on an x-ray film. To ensure accuracy, therefore, the system of exposure must be as nearly stan-

standard as possible and such a system was worked out as described. As the measurements were made by men without previous experience in medical or x-ray work, standards had to be laid down and instruments devised to make the work simple yet as accurate as possible.

General Method - A long work bench was constructed, containing five view boxes, each provided with suitable desk space (Fig.55). Charts of the various measurements were drawn and placed on the wall for convenient reference. Early in the work it was found that a greater degree of accuracy could be obtained if the lines and points mentioned below were drawn in ink on the film. As a result one man was trained, and made responsible for the marking of the supero-inferior view and another for the lateral. The work was then conducted as in a production line.

Instruments

For Linear Measurements - To make all the linear measurements, with the exception of the length of the foot, a ten centimeter by ten centimeter square of transparent plastic was ruled (Fig.56) each line the equivalent of two millimeters with every fifth line heavy, numbered and extended to the edge.

Length of 1st Metatarsal Compared with 2nd - Morton postulated foot disability to be a result of a short 1st metatarsal segment. His measurement was plus or minus the distance of the periphery of the head of the 1st metatarsal from a line drawn at right angles to the long axis of the 2nd metatarsal and tangential to the most distal portion of the head of the 2nd metatarsal. As the degree of varus or valgus of the metatarsal profoundly alters this measurement, it is of limited value. A truer measure would be the relative distance of the head of the 1st metatarsal and the head of the 2nd metatarsal from the posterior end of the os calcis since these measurements are constant and also since they represent points of support of the foot. For this measurement an instrument was made of plastic (Fig.57). From a point A - a series of concentric arcs were scratched on the plastic at 2 millimeter intervals starting at a radius of 16 millimeters and extending to a radius.....



Fig.55 - Shows part of the team of soldiers making measurements on the x-rays.

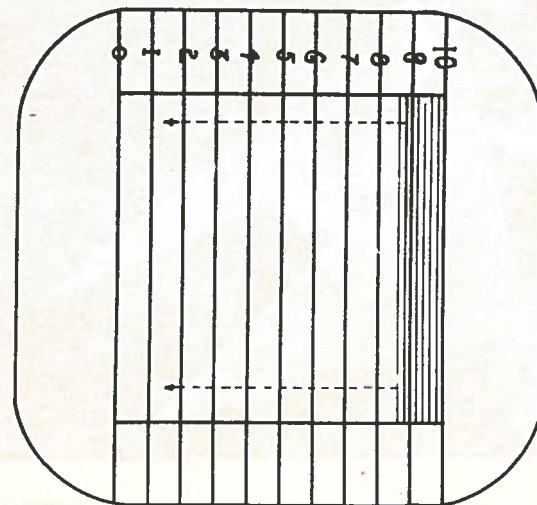
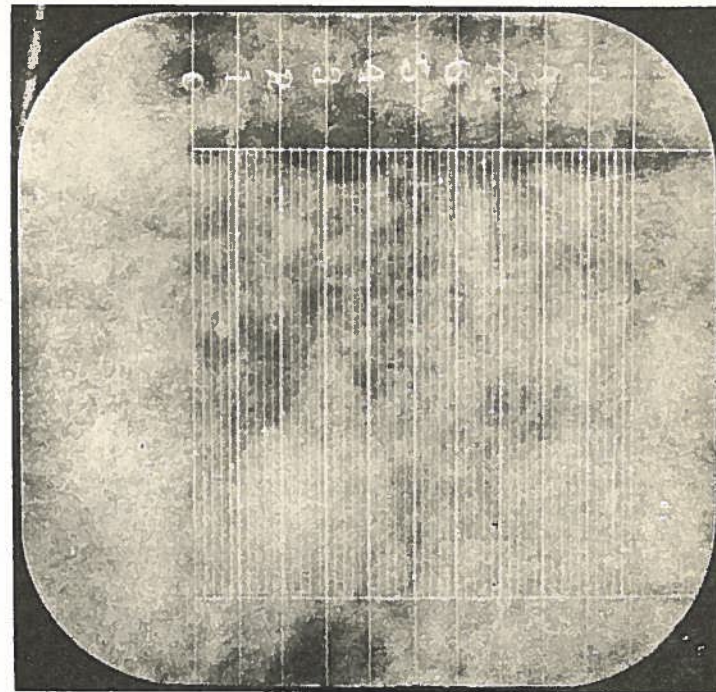


Fig.56 - Instrument for making linear measurements.

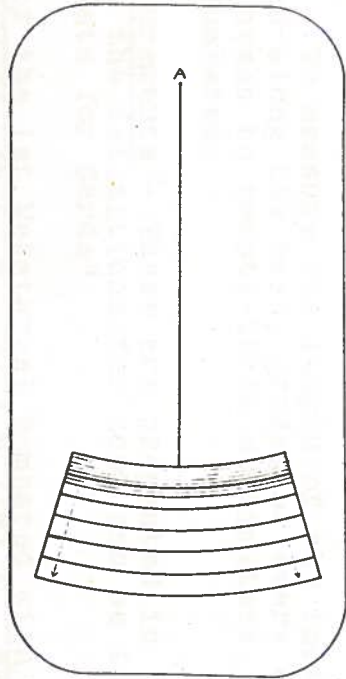
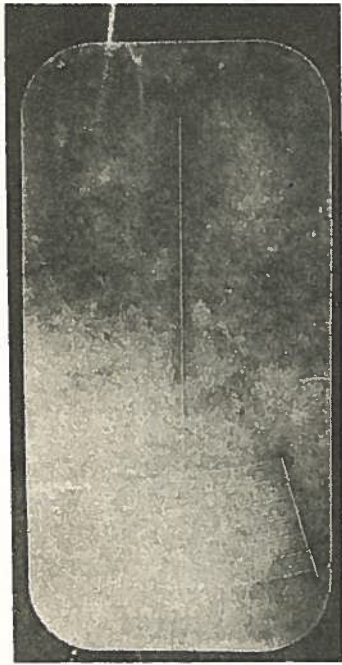


Fig.57 - Instrument for measuring the forward projection of the 1st metatarsal compared with the 2nd by the Survey method.

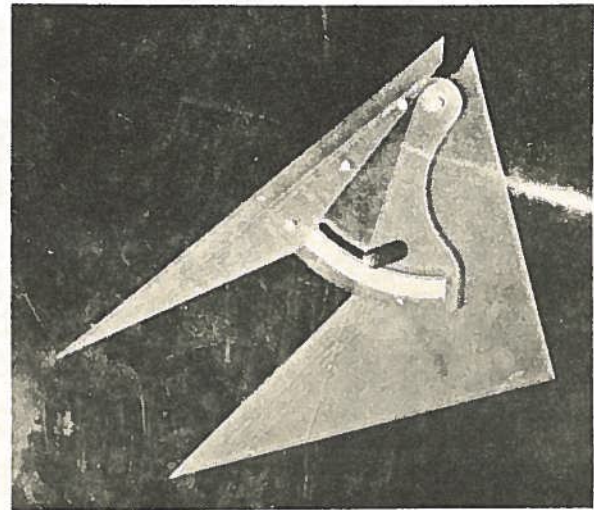
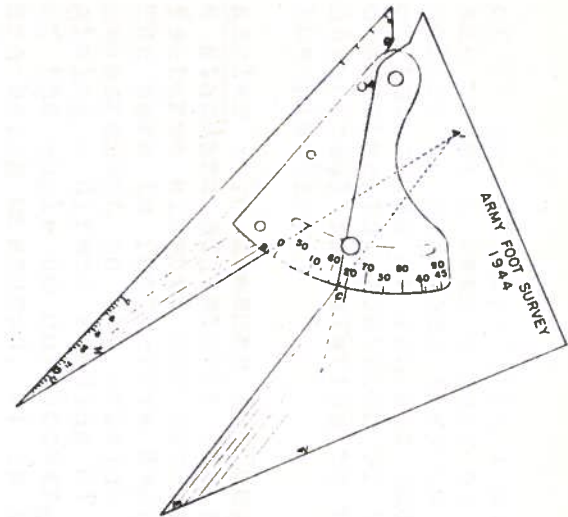


Fig.58 - Instrument for making angular measurements.

of 24 mm. Every fifth line was made heavy. By placing the point A over a mark at the posterior end of the os calcis it was then easy to determine the relative distance of the heads of 1st and 2nd metatarsal from this point by observing the position of the periphery of the head of the metatarsal in relation to the A measured arcs scratched on the plastic.

Angles - To measure the angles and the length of the foot a standard adjustable set square was purchased and various features altered and several new lines added (Fig.58). The zero to forty-five degree scale which is an outside measurement on the original instrument, was reversed, giving a direct reading of the angle CAB, or if the lines of the angle do not converge at the point at which they are being measured, it is the same reading for EAD. In addition, supplementary lines were drawn parallel to BD and CE so that without sliding the square up or down four points could be accurately measured. The line AC was extended to the edge F to increase the scope of the angle CAB. Another line (GH) was drawn parallel to the base to facilitate the use of the forty-five to ninety degree scale in measuring the obliquity of the 1st metatarso-cuneiform joint.

To measure the length of the foot, a scale was inscribed along the base, graduated every two millimeters from eighteen to twenty-three centimeters, with the centimeters numbered.

The Measurements - These are presented in the same order in which the definitions for them can be found in Appendix "A" - "Data for Cards".

Length of the 1st Metatarsal Compared with 2nd - For definition see "Data for Cards" (15)-A. For illustration see Fig.59. Morton's method of making this measurement is contrasted to ours in Fig.60. We recognized that a considerable degree of variation in varus and valgus of the forefoot occurs and that this variation would introduce an unwanted variable if Morton's method were used, as illustrated by Fig.61. For this reason the present method was used. However, a large number of feet (3923) were measured by Morton's method as well.

Length of the Foot This is not really a measure of the length of the foot since it is taken only to the head of the 1st metatarsal. For definition see "Data for Cards" (15)-B. See Fig.62 (bottom). The measurement was taken as a guide to the size of the foot and was felt, on account of variation in toe length, to be more reliable than a measurement taken to the tip of the distal phalanx would be.

Obliquity of Metatarso-cuneiform Joint - Defined in "Data for Cards" (15)-C. Illustrated in Fig.63. This angle was measured to determine whether it might vary in relation to hallux valgus or metatarsus primus varus.

Angle of 1st Metatarsal with the 2nd. - Defined in "Data for Cards" (15)-D. Illustrated in Fig.63. Much has been said about widening of this angle as being an atavistic feature. A wide angle has also been considered to be correlated to hallux valgus. Therefore we measured it.

Overlap of the Talus and Calcaneus in the Supero-inferior View - Defined in "Data for Cards" (16)-A. Illustrated in Fig.64. We thought lack of this overlap to be associated with weak support of the head of the talus and a weak defective foot. Therefore we measured it.

Diameter of the Head of the Talus in the Supero-inferior View - Defined in "Data for Cards" (16)-B. Illustrated in Fig.59. This was measured because we felt that the amount of overlap of the talus and calcaneus would have more meaning if expressed as a ratio of the diameter of the head of the talus.

Overlap of Talus and Calcaneus in the Lateral View - Defined in "Data for Cards" (16)-C. Illustrated in Fig.62 (bottom). Depression of the head of the talus down the side of the calcaneus was thought to be representative of weak support of the head of the talus and therefore to be associated with a defective foot. Hence our interest to make this measurement.

Diameter of the Head of the Talus in the Lateral View. Defined in "Data for Cards" (16)-D. Illustrated in Fig. 62 (top) and 67. This was measured in order that the

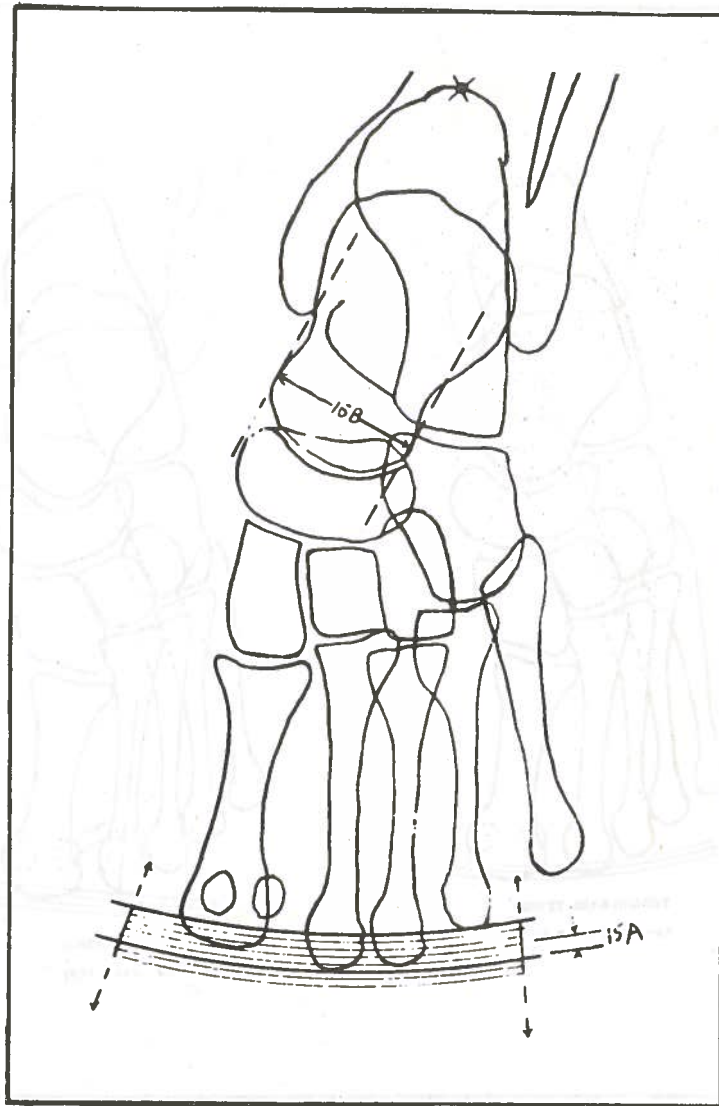


Fig. 59
of measurement
method

Fig. 59 - Shows the method of making the survey measurement for the comparative forward projection of the 1st and 2nd metatarsals. Shows the method of measuring the diameter of the head of the talus.

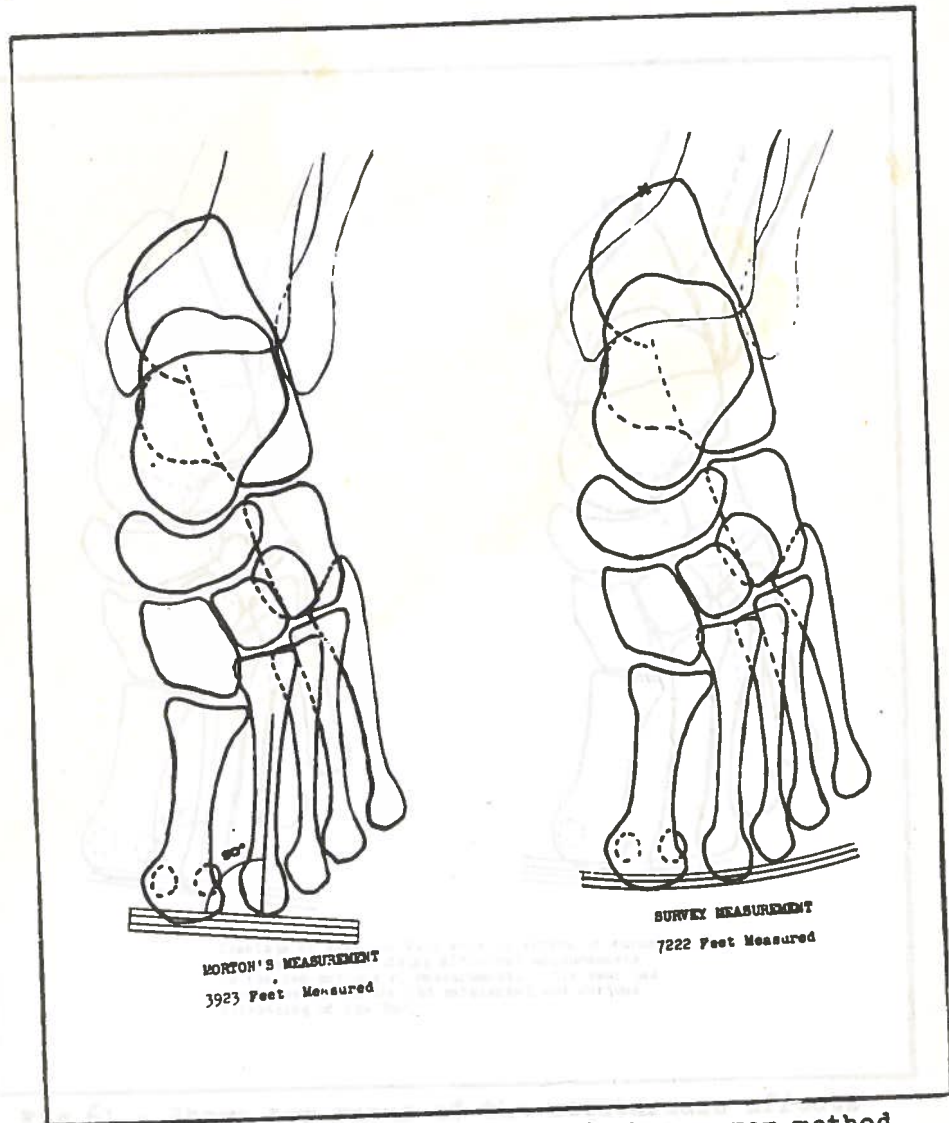


Fig.60 - Shows a comparison of the survey method of measuring the 1st metatarsal with Morton's method. See text page 71.

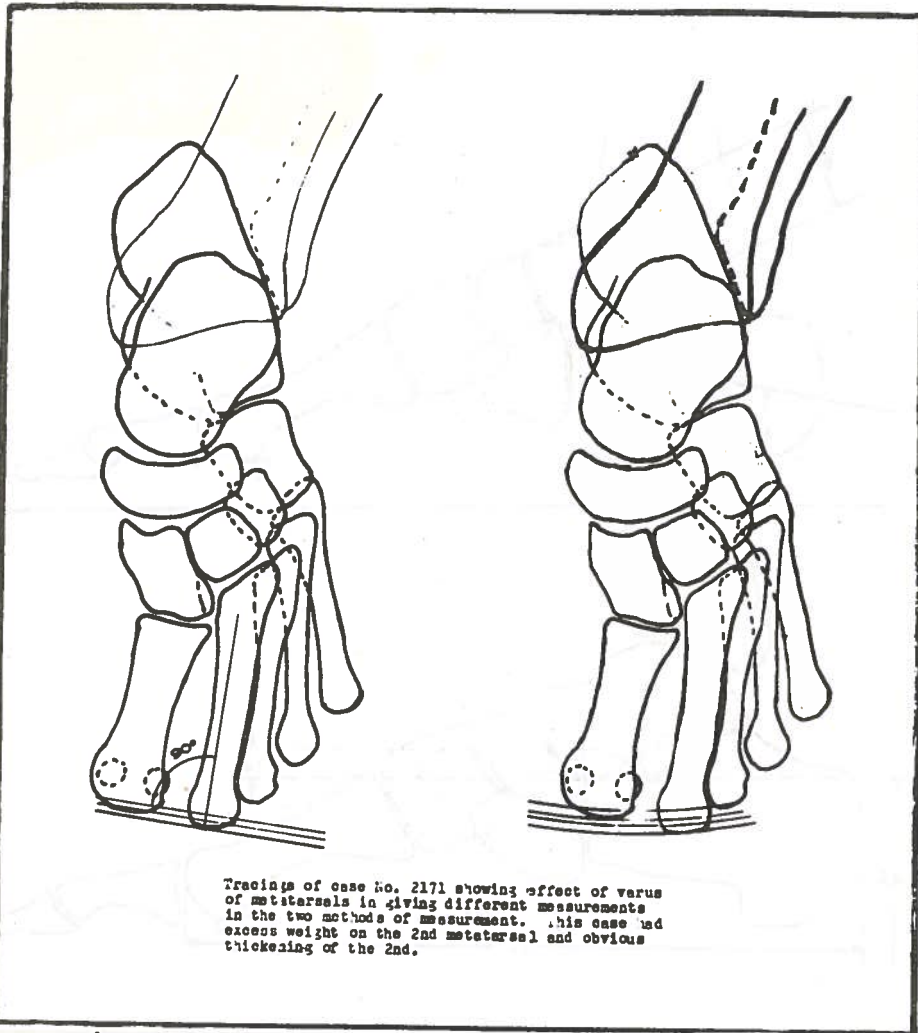


Fig. 61 - Shows how varus of the metatarsals affects Morton's method of measuring length of the 1st metatarsal. Left - though the first metatarsal looks short by Morton's measurement there is less than one millimetre of shortness. Right - the true measurement (Survey) shows the actual shortness of the first metatarsal. Same tracing in each case.

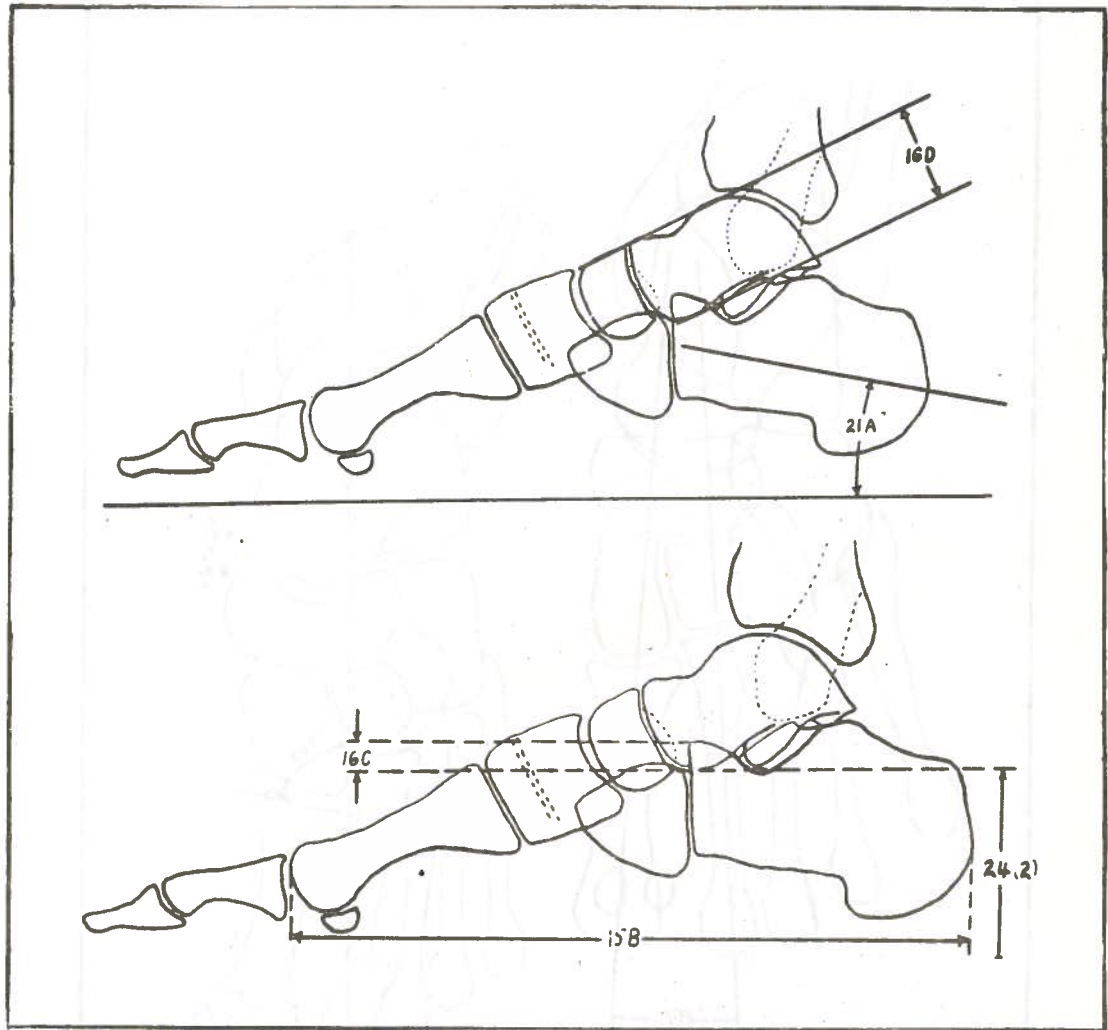


Fig.62 - Shows: measurement for diameter of head of talus (lateral view); angle of axis of calcaneus with the floor (angle of posterior pillar of arch with the floor); overlap of talus and calcaneus (lateral view); height of head of talus from floor; length of foot.

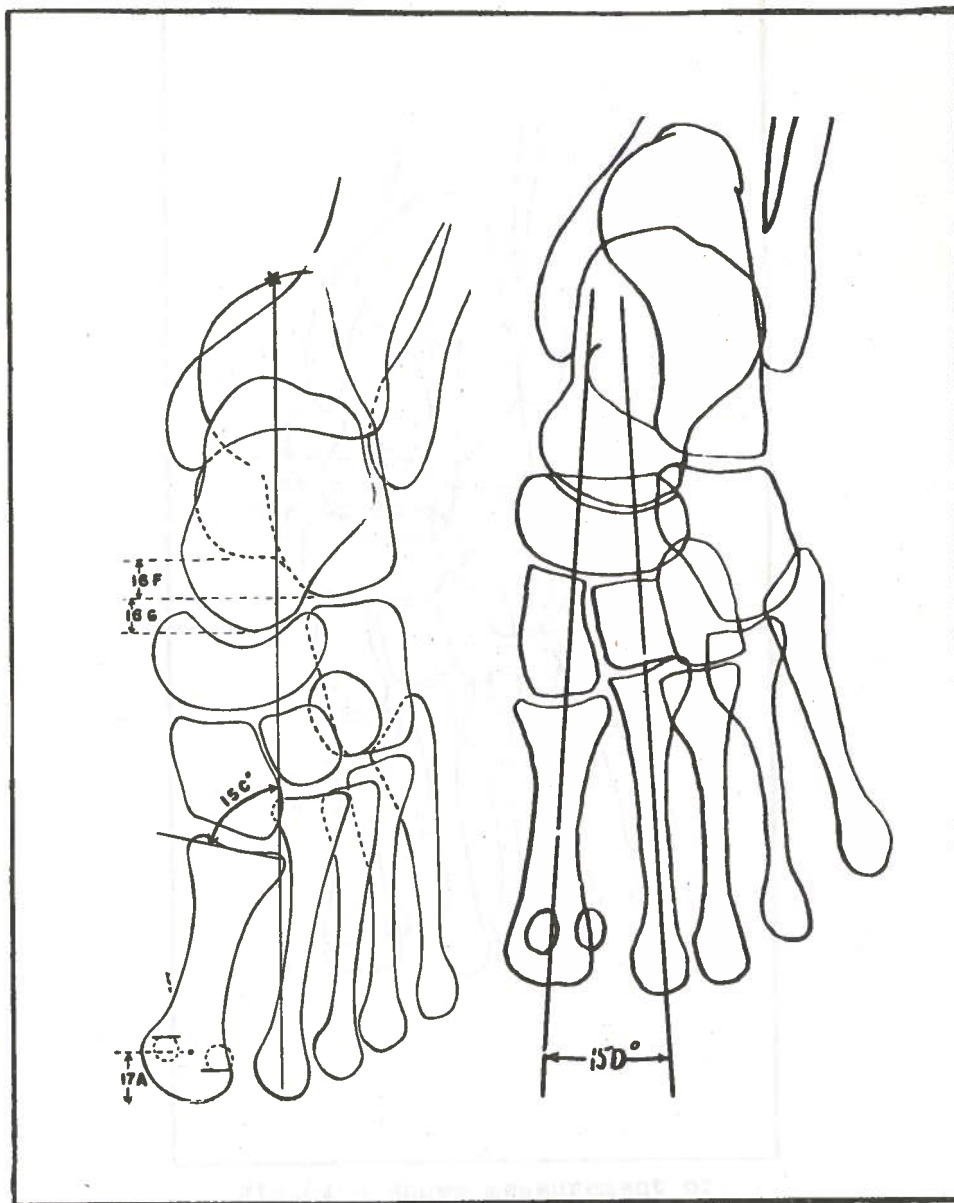
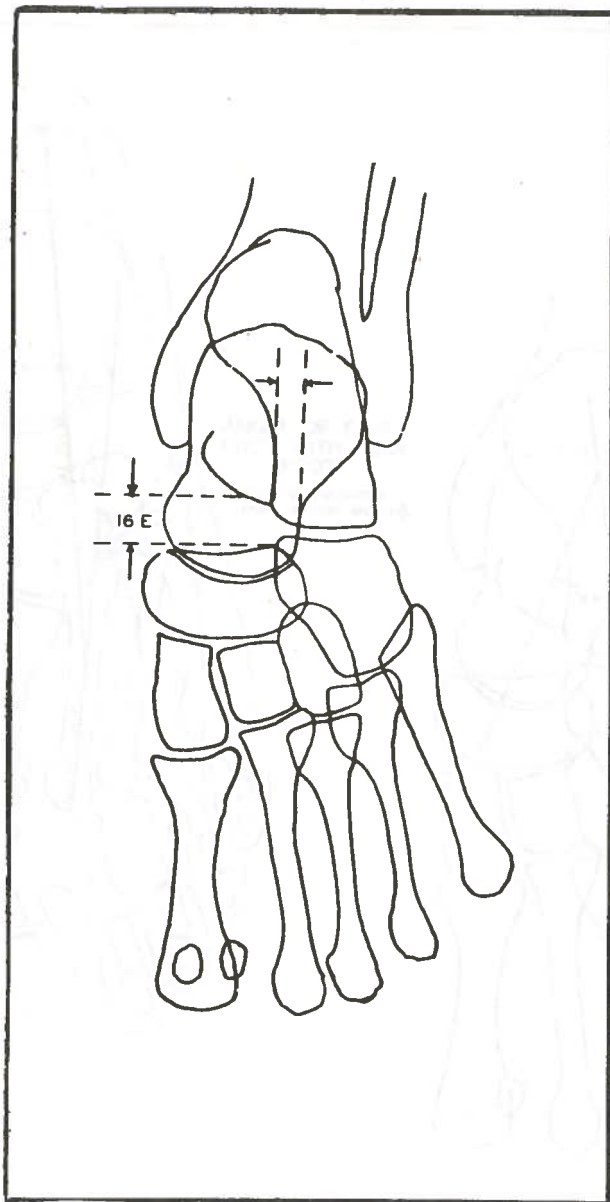


Fig.63 - Shows measurement of: distance of sustentaculum behind front of calcaneus 16F; forward projection of head of talus in front of calcaneus 16G; obliquity of 1st metatarso-cuneiform joint 15C; distance of sesamoids behind head of 1st metatarsal 17A; angle of 1st with 2nd metatarsal 15D.



**Fig.64 - Shows measurement of:
overlap of talus and calcaneus
S-I view; length of spring
ligament 16E.**

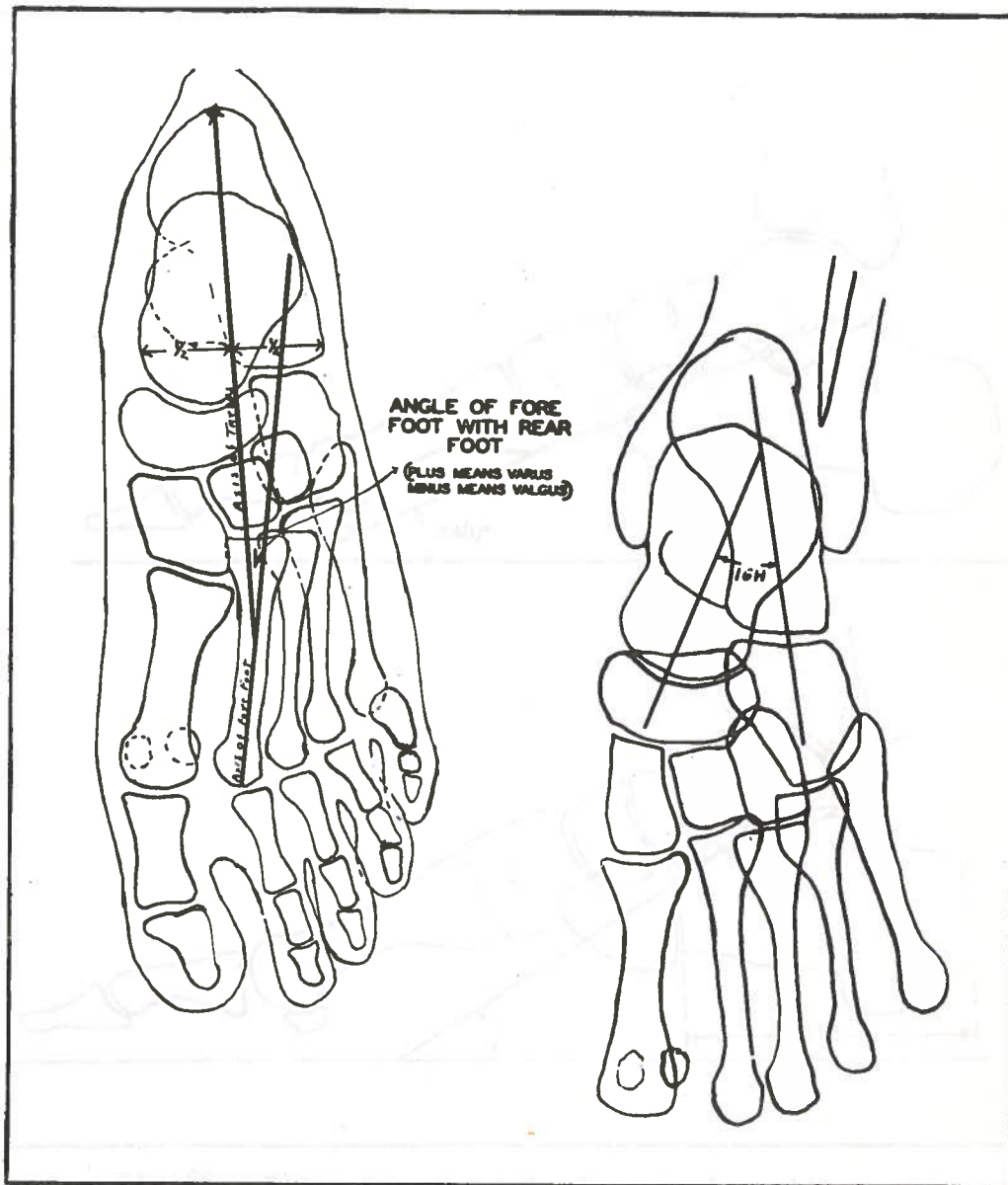


Fig.65 - Shows measurement of: angle of the forefoot with the rear foot; angle of axis of calcaneus and axis of talus S-I view 16H.

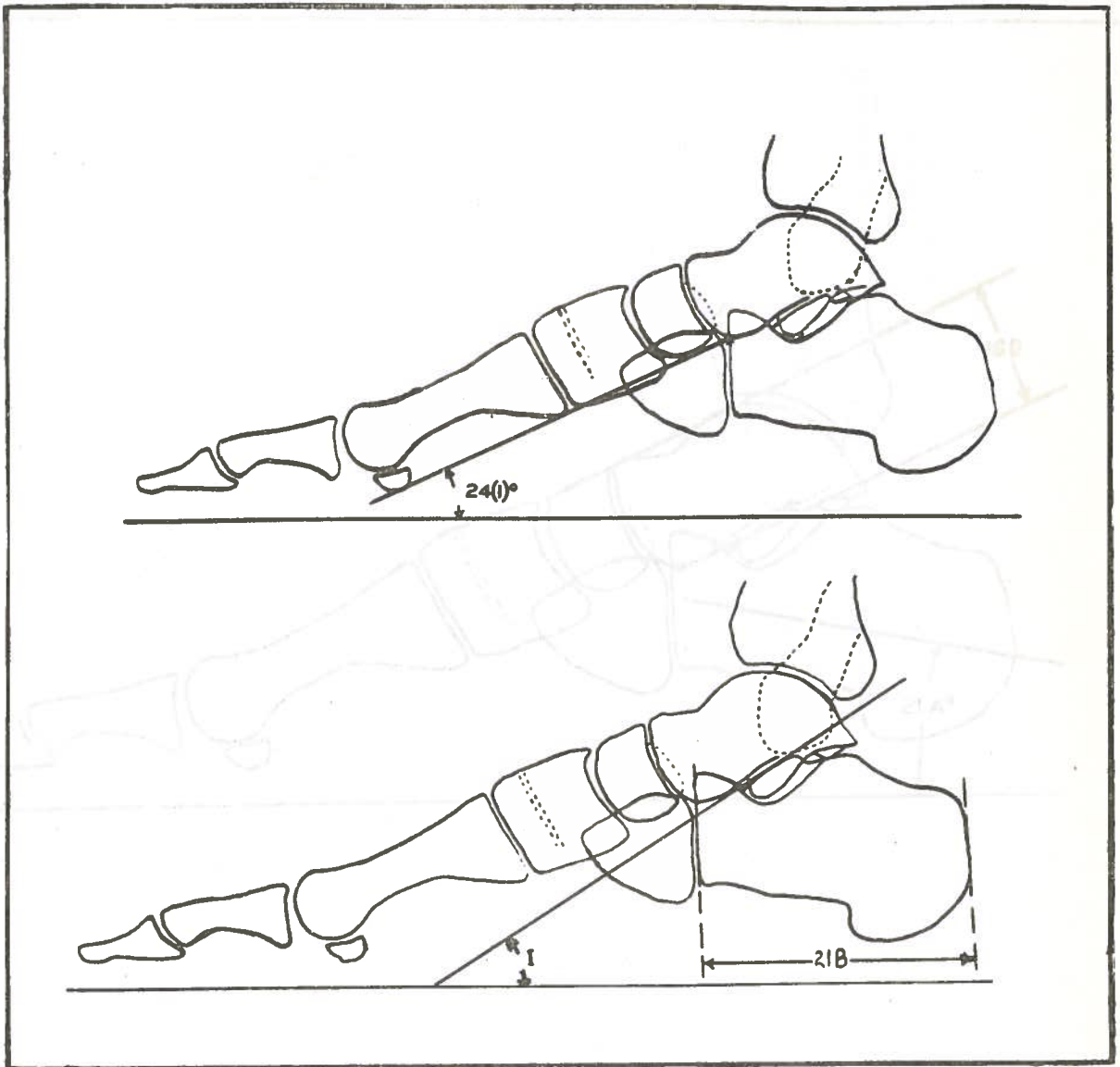


Fig. 66 - Shows measurement of: anterior pillar of the arch with floor; slope of sustentaculum; length of calcaneus.

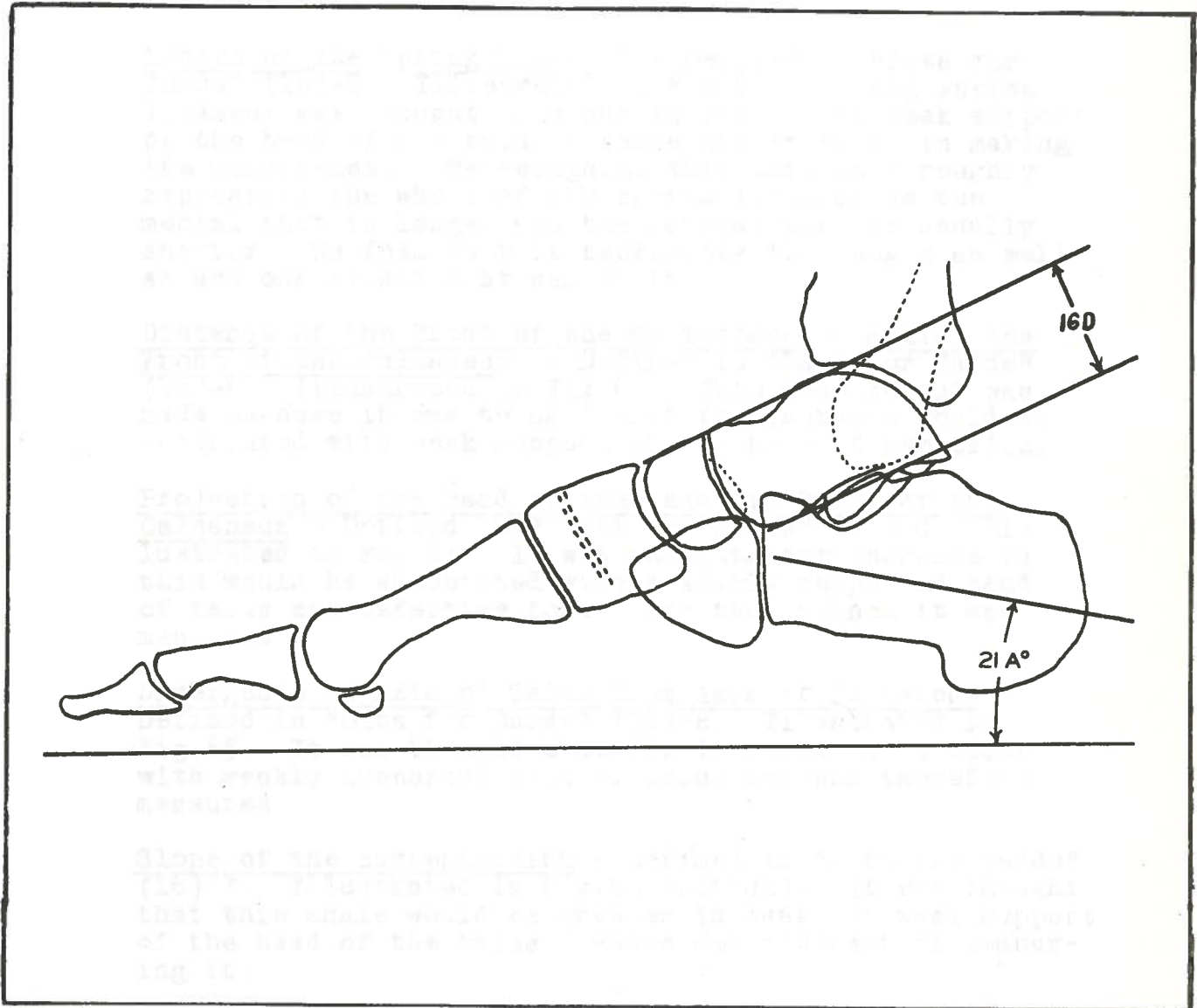


Fig.67 - Shows measurement of: diameter of head of talus (lateral view); angle of axis of calcaneus with floor (lateral view) i.e. slope of posterior pillar of arch with floor.

overlap of talus and calcaneus in the lateral view could be expressed as a ratio of the diameter of the head in the same view.

Length of the Spring Ligament - Defined in "Data for Cards" (16)-E. Illustrated in Fig.64. A long spring ligament was thought to occur in cases with weak support of the head of the talus - hence our interest in making the measurement. We recognize that this only roughly represents the whole of the spring ligament as the medial part is longer and the lateral part is usually shorter. We feel that it represents the length as well as any one measurement can do it.

Distance of the Front of the Sustentaculum Behind the Front of the Calcaneus. - Defined in "Data for Cards" (16)-F. Illustrated in Fig.63. This measurement was made because it was thought that its increase would be associated with weak support of the head of the talus.

Projection of the Head of the Talus in Front of the Calcaneus - Defined in "Data for Cards" (16)-G. Illustrated in Fig.63. It was thought that increase in this would be associated with a weakly supported head of talus and defective foot. For that reason it was measured.

Divergence of Axis of Talus from Axis of Calcaneus - Defined in "Data for Cards" (16)-H. Illustrated in Fig.65. It was thought that its increase would occur with weakly supported head of talus and was therefore measured.

Slope of the Sustentaculum - Defined in "Data for Cards" (16)-I. Illustrated in Fig.66 (bottom). It was thought that this angle would be greater in cases of weak support of the head of the talus. Hence our interest in measuring it.

Distance of Sesamoids Behind Head of 1st Metatarsal - Defined in "Data for Cards" (17)-A. Illustrated in Fig. 63. Morton has said that undue backward displacement of the sesamoids gives rise to excessive weight on the head of the 2nd metatarsal. In this last our interest in making the measurement.

Angle Between the Axis of the Rear Part of the Foot and the Axis of the Forefoot - Defined in "Data for Cards" (20)-C. Illustrated in Fig.65. It has been said that when this angle indicates valgus it is representative of a weak foot. This was our interest in making the measurement.

Angle of the Axis of the Calcaneus (lateral view) with the Floor - Defined in "Data for Cards" (21)-A. Illustrated in Fig.67. We regard this angle as the angle of the posterior pillar of the arch. If added to the angle for the anterior pillar of the arch and total subtracted from 180° , it would give an expression of the angle of the apex of the arch. This was our interest in measuring this angle.

Length of the Calcaneus - Defined in "Data for Cards" (21)-B. Illustrated in Fig.66 (bottom). A long calcaneus was thought to be associated with a weak support of the head of the talus. For this reason we were interested in making this measurement.

Angle of the Anterior Pillar of the Arch with the Floor - Defined in "Data for Cards" (24)-1. Illustrated in Fig.66 (top). Measured in order that, used with the angle of the posterior pillar with the floor, the angle of the apex of the arch could be derived.

Height of the Head of the Talus from the Floor - Defined in "Data for Cards" (24)-2. Illustrated in Fig.62 (bottom). We considered this perhaps the best single measurement representing height of the arch. The interest in this measurement is obvious.

Method of Processing Measurements Statistically

Grouping of Measurements - The measurements made on the talus and calcaneus were designed to show the relationship between the obtained measurements and foot defects of the arch. These measurements for each of the different types of feet were grouped together and the arithmetic mean worked out. For instance, all the measurements of the slope of the sustentaculum which were taken on flat feet were put together to contrast the mean with those for a

cavus group. An even more detailed breakdown was undertaken which will subsequently become evident. Similarly, for other measurements, the pertinent groupings were made. From these groupings the arithmetic mean, standard deviation, standard error and test of significant (T value) was calculated.* A further simplification was made by grouping two or three measurements together; for instance, where the angle between the 1st and 2nd metatarsals was measured in single degrees, it was advantageous in handling the data, to group the cases together with three contiguous measurements. If the measurements were 3, 4 and 5 degrees they are grouped together around the mid point, which is 4. If eleven cases are shown as measuring 4 degrees, this then means that there are eleven cases which actually measure between 2.5 degrees and 5.5 degrees. Since no half degrees were measured and recorded the 2.5 + ~ 5.5 really includes the actual measurements of 3, 4 and 5 degrees. As this appears to be a standard statistical method, no further explanation is offered.

Test of Significance - Where the arithmetic means between two groups of measurements shows only a small difference, it becomes a problem to decide what this difference means. It is possible to apply a test of significance which will mathematically demonstrate the importance of such a difference. For instance, it is possible to say that the same difference would occur in a very high or low percentage of cases in which the whole experiment was repeated. If, for instance, the chance of recurrence of the difference is one thousand to one, we would regard this difference as significant. However, if the chance of recurrence of the difference is only in the range of three or four to one, the difference between the means loses its significance.

*

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(Q)^2}{N} + \frac{(Q)^2}{N}}}$$

*"P" values were obtained from Fisher's Table.

The difference between the means.

(See F.C. Mills Statistical Methods.)

Graphs - (see Appendix "F") - It was decided to present the measurements in the form of graphs of the percentile type. Two types of these graphs were chosen, one of which is easily translatable into the other. One might be termed a "cumulative type of percentile curve", the other a "non-cumulative percentile curve". The non-cumulative percentile curve shows for each measurement, the percentage of the total cases for the graph, which fall in the individual measurement. The cumulative type of graph shows the percentage of all of the cases falling below any specified measurement. In addition to these two graphs, a third graphical presentation was worked out which shows for each measurement the percentage of cases falling into certain types of feet. For example: if a certain measurement for the slope of the sustentaculum is chosen, the graph divides all the cases seen which have that measurement into cavus feet, hypermobile flat feet, other arch cases and cases normal with respect to the arch. In these graphs the data are presented as bars.

Tables with the Graphs - It should be noted that since all of these curves show only percentages, a false impression of the importance of these may be had without a knowledge of the number of cases from which the percentages were drawn. For this reason a table is placed on the graph showing the number of cases from which the graph was made up. Of course at the extremes of the measurements, the number is very small. As regards the arch problem, it was found to be too complicated a graph if six groupings of cases were plotted. These groups would be severe cavus, mild cavus, severe hypermobile flat foot, mild hypermobile flat foot, all other arch cases and cases exclusive of the other defects. For this reason the mild and severe cavus and mild and severe hypermobile flat foot were grouped together for the graphical presentation, but are shown separated on the tables. By combining the mild with the severe, the emphasis of the variation of the measurements without abnormality is, to some extent, lost and to bring this out fully, one should study the table or draw a graph from the table.

Sketch on the Graphs - On the graphs a small sketch is incorporated attempting to depict the measurements involved.

PRESENTATION OF DATA

Tables

Selection of Tables

In this appendix is presented a series of tables which have been selected and arranged to give the information for which the Foot Survey was planned.

Reading of Tables

Most of the tables are divided into enlisted and non-enlisted groups and totals are shown. In addition each column shows a percentage to the right of each figure of the number of cases. There are footnotes indicating what total these percentages are of. The letter associated with the percentage number and which indicates the applicable footnote should be considered to be repeated for each number below until the footnote indicating letter changes. In other words, where there is a vertical column with a letter associated with the percentage number, that letter should be considered to repeat for each percentage number beneath in the vertical column unless it is changed by another letter which also should be considered to repeat until changed. It should be pointed out that with totals going in each direction, as most of these tables show, it is possible to take percentages in each direction. The percentage chosen was one which it was thought might be of most interest.

TITLES OF TABLES WHICH APPEARED IN APPENDIX "E"
 IN THE FIRST EDITION

Table No.

- 1 Incidence of Selected Defects Commonly Discussed
- 2 Tables of Selected Foot Defects
- 3 Incidence of Variation of Height of Longitudinal Arch
- 4 Incidence of Variation of Height of Longitudinal Arch
 (Complete Breakdown)
- 5 Incidence of Peroneal Spastic Foot
- 6 Incidence of Peroneal Spastic Feature
- 7 Table of Hypermobile Flat Foot with Short Tendo
 Achillis to Show Incidence and Associated
 Occurrence of Flat Foot
- 8 Table Showing Variation of Support of Head of Talus
 in Different Types of Feet
- 9 Table of Accessory Tarsal Scaphoid and Prominence of
 Tuberosity of Scaphoid
- 10 Table of Accessory Tarsal Scaphoid to Show Relationship
 to Height of Longitudinal Arch
- 11 Table of Cavus Feet to Show Incidence and Associated
 Occurrence of Clawing
- 12 Table to Show Relationship of Types of Feet to Dorsiflexion
 and to Show Number of Cases Examined in Relationship to
 Recording Various Types of Feet
- 13 Table of Severe Hypermobile Flat Foot with Short Tendo
 Achillis to Show Incidence of Symptoms and Grading
 Given
- 14 Table of Mild Hypermobile Flat Foot with Short Tendo
 Achillis to Show Incidence of Symptoms and Grading
 Given
- 15 Table of Questionable Hypermobile Flat Foot with Short
 Tendo Achillis to Show Incidence of Symptoms and
 Grading Given

Table No.

- 16 Table of Planus Foot to Show Incidence of Symptoms and Grading Given
- 17 Table of Severe Cavus Foot to Show Incidence of Symptoms and Grading Given
- 18 Table of Mild Cavus Foot to Show Incidence of Symptoms and Grading Given
- 19 Table of Weak Support of Head of Talus to Show Incidence of Symptoms and Grading Given
- 20 Table of Moderate Support of Head of Talus to Show Incidence of Symptoms and Grading Given
- 21 Table of Firm Support of Head of Talus to Show Incidence of Symptoms and Grading Given
- 22 Table Relating Varying Support of Head of Talus to Reasonably Associable Symptoms
- 23 Table of Accessory Tarsal Scaphoid and Prominence of Tuberosity of Scaphoid to Show Incidence and Consequent Symptoms
- 24 Table of Defects Other Than Arch Cases to Show Incidence of Symptoms and Grading Given
- 25 Table to Show Incidence of Atavism
- 26 Table of Shortness of 1st Metatarsal Judged Clinically Compared with that Shown by Morton's Method of Measurement
- 27 Table Relating Excess Weight on Metatarsal Heads and Shortness of 1st Metatarsal
- 28 Incidence and Distribution of Excess Weight on the Heads of Metatarsals
- 29 Incidence of Hallux Valgus, Hammer Toe, Hallux Rigidus
- 30 Table of Hallux Rigidus to Show Incidence and Symptoms
- 31 Incidence of Injuries
- 32 Table of Skin Lesions to Show Incidence at Time of Enlistment
- 33 Table of Exostosis to Show Incidence of Symptoms

Table No.

- | | |
|----|--|
| 34 | Table of Defective Feet to Show Overall Incidence and Symptoms Produced |
| 35 | Table of Cases Without Defects to Show Incidence of Symptoms and Grading Given |
| 36 | Table to Show Incidence of Symptoms Brought About During Training |
| 37 | Table to Show Incidence of Symptoms Brought About During Training |
| 38 | Tables to Compare Survey Gradings with Army Reception Centre Gradings |
| 39 | Table of Grading Based on Feet To Show Incidence of Rejection |
| 40 | Table Relating Expectancy of Symptoms with Occurrence of Symptoms |
| 41 | Table of Unsatisfactory Boot Fitting |
| 42 | Table to Show Incidence of Recognition of the Cause of Symptoms |

Project - Army Meds. - No. 22.

The purpose of this report is to present the results of the study of the effect of the measurements of the various factors in this section of this report. The results of the study are presented in the following tables, standard deviations, and the differences between means. The results of the study are presented in the following tables, standard deviations, and the differences between means. The results of the study are presented in the following tables, standard deviations, and the differences between means.

APPENDIX "F"

GRAPHS

APPENDIX "F"

Graphs

The general form of the presentation in graphs was described in Appendix "D", Method of Studying X-rays. The graphs were drawn and based upon the measurements made. They are given together in this section of this report. Arithmetic means, standard deviation, standard error and the "T" values for differences between means were calculated (the equation for "T" was given above in a footnote). By means of the calculated "T" value the significance of the difference between means can be estimated by the use of Fisher's tables by which the "P" (probability) value corresponding to the "T" may be obtained. For the meaning of "P" reference may be made to the discussion on Table 10. Such a table copied from Mills and extracted from Fisher follows:

<u>Appendix Table II¹</u>			
<u>Table of t</u>			
n	P = .05	.02	.01
1	12.706	31.821	63.657
2	4.303	6.965	9.925
3	3.182	4.541	5.841
4	2.776	3.747	4.604
5	2.571	3.365	4.032
6	2.447	3.143	3.707
7	2.365	2.998	3.499
8	2.306	2.896	3.355
9	2.262	2.821	3.250
10	2.228	2.764	3.169
11	2.201	2.718	3.106
12	2.179	2.681	3.055
13	2.160	2.650	3.012
14	2.145	2.624	2.977
15	2.131	2.602	2.947
16	2.120	2.583	2.921
17	2.110	2.567	2.898
18	2.101	2.552	2.878
19	2.093	2.539	2.861
20	2.086	2.528	2.845
21	2.080	2.518	2.831
22	2.074	2.508	2.819
23	2.069	2.500	2.807
24	2.064	2.492	2.797
25	2.060	2.485	2.787
26	2.056	2.479	2.779
27	2.052	2.473	2.771
28	2.048	2.467	2.763
29	2.045	2.462	2.756
30	2.042	2.457	2.750
	1.95996	2.32634	2.57582

¹Excerpts from Table IV, R.A. Fisher, Statistical Methods for Research Workers. These excerpts are printed here through the courtesy of Dr. Fisher and his publishers, Oliver and Boyd, of Edinburgh.

In general we are regarding a "T" value of less than 2.0 to indicate that the significance of the difference between means is almost nil. A "T" value of 2.5 and greater as indicating that the difference is definitely significant. Between these values, the significance may be considered problematical.

The "T" value is shown on the table which is on each graph. It is the figure lying between two adjoining arithmetic means.

The classification for the graphs is shown in the following table:

Definition for Graph Sets: 1,2,3,4,5,7,8,11,19,17 showing section of the cards in which the measurement is recorded.

Severe Hypermobile Flat Foot Alone---from all cases extract those marked in Section (4)-8 on the card.
 Mild Hypermobile Flat Foot Alone---from the remaining extract those marked in Section (4)-7 on the card.
 Severe Planus----from the remaining extract those marked in Section (4)-2 on the card.
 Mild Planus----from the remaining extract those marked in Section (4)-1 on the card.
 Severe Cavus----from the remaining extract those marked in Section (5)-2 on the card.
 Mild Cavus----from the remaining extract those marked in Section (5)-1 on the card.
 All Other Cases-----the remaining cases, this would include some (4)-3,4,5,9,10 and (5)-3.

Definition for Graph Sets: 9,10,13,15,16,20,21,22,23, showing section of the cards in which the measurement is recorded.

Severe Planus-----from all cases extract those marked in Section (4)-2 on the card.
 Mild Planus-----from the remaining extract those marked in Section (4)-1 on the card.
 Severe Cavus----from the remaining extract those marked in Section (5)-2 on the card.
 Mild Cavus----from the remaining extract those marked in Section (5)-1 on the card.
 All Cases Not Included in the Four Items Above----- the remaining cases.

18
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