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# A study of the relationship between foot size and combat boot size in the Canadian Forces

*W. Dyck*

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**Defence and Civil Institute of Environmental Medicine**

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## Abstract

Foot and boot size data were collected on 825 individuals (70 females and 755 males) predominantly Canadian Forces (CF) Land Force (LF) infantry. The differences between foot-plus-sock dimensions and boot dimensions were determined and the results indicate that 227 personnel were wearing the predicted length of boot, 217 were wearing the predicted width of boot, and only 58 were wearing the predicted length and width of boot. The data suggests that priority is given to finding the best fit in the width of a boot and then accepting the best length available in that width. A large number of individuals, however, cannot find a boot that fits properly or do not know what constitutes a good fit and thus must compromise on at least one dimension, usually resulting in wearing a boot that is too long. A new sizing system for boots, which is better correlated to the foot dimensions of the CF LF population, is required. The numerous occurrences of very large differences between boot fit dimensions and foot-plus-sock measurements indicate that many personnel have not been fitted properly. Since these large differences exist for all lengths and widths, a much better fit was theoretically available for many. Soldiers admit there is not enough effort expended to achieve a good fit, a deficiency that can be overcome with minimal training and patience.



## Résumé

On a recueilli des données sur la pointure des bottes de 825 personnes, soit 70 femmes et 755 hommes, principalement de l'infanterie de la force terrestre des Forces canadiennes (FC). La différence entre les dimensions du pied avec chaussette et celles de la botte a été déterminée et les résultats montrent que 227 membres du personnel portaient une botte de la longueur calculée, 217 portaient une botte de la largeur calculée et seulement 58 portaient une botte de la longueur et de la largeur calculées. Les données indiquent qu'on devrait chercher en premier à trouver la largeur de botte qui convient le mieux et accepter ensuite la botte de cette largeur qui présente la meilleure longueur qui soit. Toutefois, un grand nombre de personnes ne peuvent pas trouver une botte qui chausse bien et ne savent pas ce qui constitue un parfait ajustement, aussi doivent-ils s'accommoder d'au moins une dimension, se retrouvant généralement à porter des bottes trop longues. On a besoin d'établir un nouveau système de pointures qui soit mieux en rapport avec les dimensions des pieds des membres de la force terrestre des FC. Le grand nombre de cas où la pointure des bottes et les dimensions des pieds avec chaussettes diffèrent énormément montre que la plupart des membres du personnel n'étaient pas bien chaussés. Étant donné que ces grosses différences se retrouvaient dans toutes les longueurs et toutes les largeurs, cela veut dire qu'il était théoriquement possible de trouver une bonne pointure pour beaucoup. Les soldats admettent qu'on ne consacre pas assez de temps à la recherche de bottes qui chaussent bien, une déficience qu'un minimum de formation et de patience pourraient combler.

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# Executive summary

In discussions with soldiers, the process of fitting the combat boot MKIII was described by phrases such as insufficient sizes, no foot measurements taken, no feedback from wearer, no confirmation of fit by someone experienced in fitting boots, and did not know how a boot should fit. The underlying theme of these descriptions was that there was a general dissatisfaction with the fit of the boot. A poor fit can result in injuries such as blisters, chafing, bunions, sprains and strains, to name just a few. An investigation to determine the reasons accompanying the poor fit of the combat boot might lead to recommendations to mitigate this problem.

The right foot was measured and boot sizes recorded on 825 members of the CF LF (70 females and 755 males). The personnel measured represented many bases and trades, but were predominantly infantry. A separate study determined the amount added to the length and width of a bare foot by a CF standard issue gray wool sock. The differences between foot-plus-sock dimensions and boot dimensions (Mondopoint sizes) were calculated for all personnel. The results indicated that 227 personnel were wearing the predicted length of boot, 217 were wearing the predicted width of boot, and only 58 were wearing the predicted length and width of boot.

The data suggests that priority is given to finding a boot that fits best in the width and then accepting the best length available in that width. A large number of individuals, however, cannot find a boot that fits properly (length and width) and must compromise on at least one dimension. Because they are placing a higher priority on the width, the compromise usually results in wearing a boot that is too long. Observing the frequency of use of the various sizes of combat boots by the test population, and comparing the current sizing system for the combat boot with the sizes of the feet (wearing a gray wool sock) in the CF LF population, indicates that the narrowest sizes are not being used and a large number of personnel cannot find a wide enough boot in their size. A new sizing system for boots is required which is better correlated to the CF LF population.

The very large positive and negative differences between boot fit dimensions and foot-plus-sock measurements indicate that many personnel have not been properly fitted. Since large differences exist for all lengths and widths, a much better fit was theoretically available for most of the population in this study. Those being fitted and those in the supply system admit that there is not enough effort expended to achieve a good fit because neither the wearer nor the supplier felt qualified to assess a good fit. This is a deficiency that can be easily overcome with minimal training and patience.

Dyck, W. 2000. A study of the relationship between foot size and combat boot size in the Canadian Forces. DCIEM TR 2000-137. Defence and Civil Institute of Environmental Medicine.

# Sommaire

Lors de discussions avec les soldats, ces derniers illustraient la description du processus d'ajustement de la botte de combat MKIII par des expressions comme « il manque de pointures, les pieds ne sont pas mesurés, le porteur de la botte n'exprime pas ce qu'il pense, l'ajustement de la botte n'est pas confirmé par une personne qualifiée en la matière, je ne savais pas ce qui constituait une botte bien à ma pointure ». Tout cela sous-entendait un mécontentement général à propos de l'ajustement de la botte. Une botte qui chausse mal peut provoquer des blessures telles que des boursouflures, des irritations, des oignons, des entorses et des déformations, pour ne mentionner que quelques-unes. Un examen visant à déterminer les raisons pour lesquelles la botte de combat chausse mal pourrait aboutir à des recommandations qui serviraient à atténuer le problème.

On a mesuré le pied droit et enregistré les dimensions des bottes de 825 membres de la force terrestre des FC, soit 70 femmes et 755 hommes. Ces membres étaient représentatifs de beaucoup de bases et de professions, mais ils appartenaient principalement à l'infanterie. On a par ailleurs mené une étude séparée pour déterminer la longueur et la largeur qu'une chaussette grise de laine réglementaire des FC ajoutait au pied nu. Les différences entre les dimensions du pied avec chaussette et celles de la botte (pointure Mondopoint) étaient calculées pour tout le personnel. Les résultats ont montré que 227 membres du personnel portaient une botte de la longueur calculée, 217 portaient une botte de la largeur calculée et seulement 58 portaient une botte de la longueur et de la largeur calculées.

Les données laissent entendre qu'il faudrait chercher en premier lieu une botte de la largeur qui convient le mieux et accepter ensuite la botte de cette largeur qui présente la meilleure longueur qui soit. Toutefois, un grand nombre de personnes ne peuvent pas trouver une botte qui leur aille bien (en longueur et en largeur) et doivent s'accommoder d'au moins une dimension. Et puisqu'ils se soucient beaucoup plus de la largeur, ils finissent par porter une botte trop longue. En observant la fréquence avec laquelle les différentes dimensions de bottes de combat sont utilisées par l'ensemble des personnes qui font l'objet de cette étude et en comparant le système de pointures courant pour les bottes de combat avec les dimensions des pieds (portant une chaussette de laine grise) des membres de la force terrestre des FC, on est amené à conclure que les pointures les plus étroites ne sont pas utilisées et qu'une grande partie du personnel ne peut pas trouver des bottes assez larges pour ses pieds. Il est nécessaire d'avoir un nouveau système de pointures de botte qui soit mieux en rapport avec l'ensemble des membres de la force terrestre des FC.

Les très grands écarts négatifs et positifs entre les dimensions d'ajustement de la botte et des dimensions du pied avec chaussette indiquent que beaucoup de membres du personnel n'ont pas été bien chaussés. Puisque les gros écarts se retrouvaient dans toutes les longueurs et toutes les largeurs, il était théoriquement possible d'avoir des bottes qui chaussent mieux pour la plupart des gens qui faisaient l'objet de cette étude. Les personnes qui sont chaussées et celles qui se trouvent dans la chaîne d'approvisionnement admettent qu'on ne fournit pas assez d'effort pour trouver une botte qui s'ajuste bien, cela étant que ni le porteur ni le fournisseur ne se sent pas qualifié pour évaluer un bon ajustement. C'est là une déficience qu'on peut combler aisément avec un minimum de formation et de patience.

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# Acknowledgements

The author wishes to thank the staff of the Clothe the Soldier project for the opportunity to gather the data used in this report during the execution of some of their field trials with boots, and to Mr. P. Meunier for gathering the extra data on boot sizes from some of the volunteers taking part in the anthropometric survey.

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# Introduction

During the last three years, DCIEM (Defence and Civil Institute of Environmental Medicine) has participated in several military field studies in support of the Canadian Forces (CF) Land Force (LF) Anthropometric Survey [1] and the Clothe the Soldier program [2, 3, 4] during which foot dimensions and boot sizes were acquired. Many complaints were heard regarding the comfort of the combat boot MKIII, mostly dealing with poor cushioning and fit. In discussions regarding fit, the five shortcomings most often stated were the same as the deficiencies found previously by Bailey [5] in a study done in 1989. The deficiencies were:

1. There were insufficient sizes at the supply section.

2. No foot measurements were taken and thus no comparisons were made between foot size and boot size.

3. No feedback was solicited from the wearer as to the 'goodness' of the fit.

4. No confirmation of 'proper' fit was made by a specialist.

5. There was insufficient knowledge by many wearers as to what actually constitutes a good fit.

The first shortcoming would suggest a sizing system problem while the middle three suggest a problem with using a proper fitting procedure. The last problem deals with a personal concept or paradigm related to fit which was brought into question by some individuals. If the individuals thought they had achieved a good fit and then experienced problems when wearing their boots, then maybe they need training to learn the definition of correct fit.

Much research has been done on footwear comfort factors [6] and design and function [7] but fit is always mentioned as a necessary prerequisite. Haber [8] has studied the problem related to how many sizes should make up a sizing system considering equipment and cost, but still suggests the overriding requirement is enough sizes to fit a population in a way that they are protected from injuries resulting from poor fit (blistering, chafing, black toes, bunions etc.). The fit issue is discussed with respect to mismatch tolerance i.e. how much mismatch between foot length and shoe length the wearer will tolerate. For shoes, the estimated mismatch tolerance is 10 mm for length and 3 mm for width. For example, a foot with a measurement of 270 mm in length will achieve an acceptable fit by a shoe 270-280 mm in length. A shoe shorter than 270 mm or longer than 280 mm will not fit.

It is argued [8] that four dimensions of the foot affect the fit of shoes:

1. the length of the foot from heel to widest point between the metatarsal and ball of foot;

2. the circumference of the foot around the widest part;

3. the additional length added by the toes; and

4. the curvature of the arch.

Because this takes time, additional measuring tools and training to use them, these measurements are not considered practical, and simply length and width are measured, neither of which coincide with any of the above mentioned measurements. Length and width of the foot are the most often measured variables of the foot and the most often used in correlating the foot size with the shoe sizes.

Goonetilke [9] suggests there is still much that is not known in evaluating the quality of fit. Quantification of fit will allow for prediction of discomfort and pain. Since most pain is associated with a fit that is too tight, a 'loose' shoe is generally not as uncomfortable as when it is tight, even though function may be equally impaired. Perceived fit also depends on many factors such as time of day, activity being performed, health status etc. Although methods are described for determining several forms of static mismatch between the foot and the shoe, "variations in the level of discomfort with varying pressure are still not quantified completely".

As far as the actual fitting process is concerned the American Foot and Ankle Society, National Shoe Retailers Association and Pedorthic Footwear Association have produced a video entitled "The Basics of Professional Shoe Fitting" to explain the process, and outdoor magazines [10, 11] have made much of this information available to the general public. The actual fitting process takes time and is thus not popular with footwear retail outlets. Since it is vital to the mobility of an organisation such as the army to issue good boots and provide a good fit thereof, more time should be spent fitting the recruit properly so as to lessen foot injuries which may stay with them for the rest of their lives. "The improvements in customer satisfaction that can be achieved with even 15 minutes' effort by a fitter who's had a couple of days of training are enormous."

Since there are currently fewer opportunities of measuring more feet, a study was done with the data acquired on the relationship between the CF LF foot and the combat boot MKIII in order to learn more about the basis of the perceived 'poor fit'.

## Methodology

During the conduct of the studies mentioned above [1-4], the length and width of a large number of right bare feet were measured using a metal footbox, using the method employed by Les Consultants Genicom Inc. during the anthropometric survey [1].

The sizing system used for the CF combat boot is the Mondopoint sizing system. Mondopoint is defined as " an intended international method of designating shoe sizes. It provides that the marking should consist of two numbers: (1) a number corresponding to the length in millimeters (measured weight-on and wearing hose) of the average foot fitted; and (2) a number corresponding to the joint width in millimeters (measured weight-on and wearing hose) of the average foot fitted. Mondopoint has been adopted by the British Standards Institution and the International Standards Organization, which have specified that the size interval should be 5 mm or 7 mm, depending on the type of footwear. For example, 5 mm would be appropriate for women's court shoes and 7mm for footwear for which fitting tolerance is not so critical, such as moulded footwear." (taken from http://www.cityintl.com/footwear/glossaryM-R.htm). An example of a Mondopoint size for a boot is 270/104. If one assumes a 5 mm size interval for length and a 4 mm size interval for width, then this size would accommodate a foot with hose whose length is between 265 and 270 mm in length and between 100 and 104 mm in width. It is important to understand that this does not mean that the inside boot dimensions are 270 mm in length and 104 mm in width. For this reason, 270 mm in this example will be referred to as the length fit dimension of the boot and the 104 mm will be referred to as the width fit dimension of the boot. Whenever possible, while an individual's foot was being measured, that person's boot size was read directly off the sole of the boot and recorded as a Mondopoint.

In total, foot and boot size data were collected on 825 individuals, 70 females and 755 males. The personnel measured represented many bases and trades, predominantly infantry.

As seen by the above definition of Mondopoint, the bare foot size cannot be directly compared to the Mondopoint boot size. To allow for a more direct comparison, a small study was done at DCIEM, in which 24 feet were measured with and without the CF issue gray wool sock using the same metal footbox mentioned above. The mean changes in length and width were derived and added to the bare foot dimensions of the 825 personnel. The results were compared to the fit dimensions of the boots they were wearing.

## Results/Discussion

The fit study population was composed of 825 individuals, 70 females and 755 males. The bivariate plot of foot length versus foot width is shown in Figure 1. The bivariate plot of foot length versus foot width as determined by the anthropometric survey is shown in Figure 2 for comparison. The anthropometric survey gathered data on 709 individuals, 250 females and 459 males. Both plots show the measured population separated by gender surrounded by 95% confidence ellipses. The male population distribution in both studies is very similar and would seem to represent the same population. The anthropometric survey includes data from a much larger female population than the fit study, and captured a greater number of smaller and larger sized feet compared to the fit study as evidenced by the longer confidence ellipse. It would appear, however, that the smaller number of females in the fit study make up a subset of the female population of the anthropometric study.

The study of how much a standard issue gray wool sock adds to the length and width of a foot, resulted in an increase of $2.9 \pm 2.6$ mm to the length and $3.0 \pm 2.8$ mm to the width (mean $\pm$ std dev). These sock dimensions were added to the measured bare foot lengths and widths and compared to the boot Mondopoint. Since the CF combat boot is graded in 6 mm length increments and 4 mm width increments, the foot-plus-sock dimensions were compared to these ranges. For example, if a boot was a Mondopoint 276/104, then a foot-plus-sock dimension falling in the range $270 \leq$ foot-plus-sock length $< 276$ mm and $100 \leq$ foot-plus-sock width $< 104$ mm would fit by definition. Results indicate that of the 825 right feet, 227 were wearing the predicted length of boot, 217 were wearing the predicted width of boot, and only 58 were wearing the predicted length and width of boot. This is how the industry defines the target range of fit. If this definition is relaxed slightly by including the upper limit of the range and repeats this comparison, then 239 were wearing the predicted length of boot, 242 were wearing the predicted width of boot, and only 71 were wearing the predicted length and width of boot.

Figure 1: Fit Study Barefoot Length versus Width
Separated by Gender

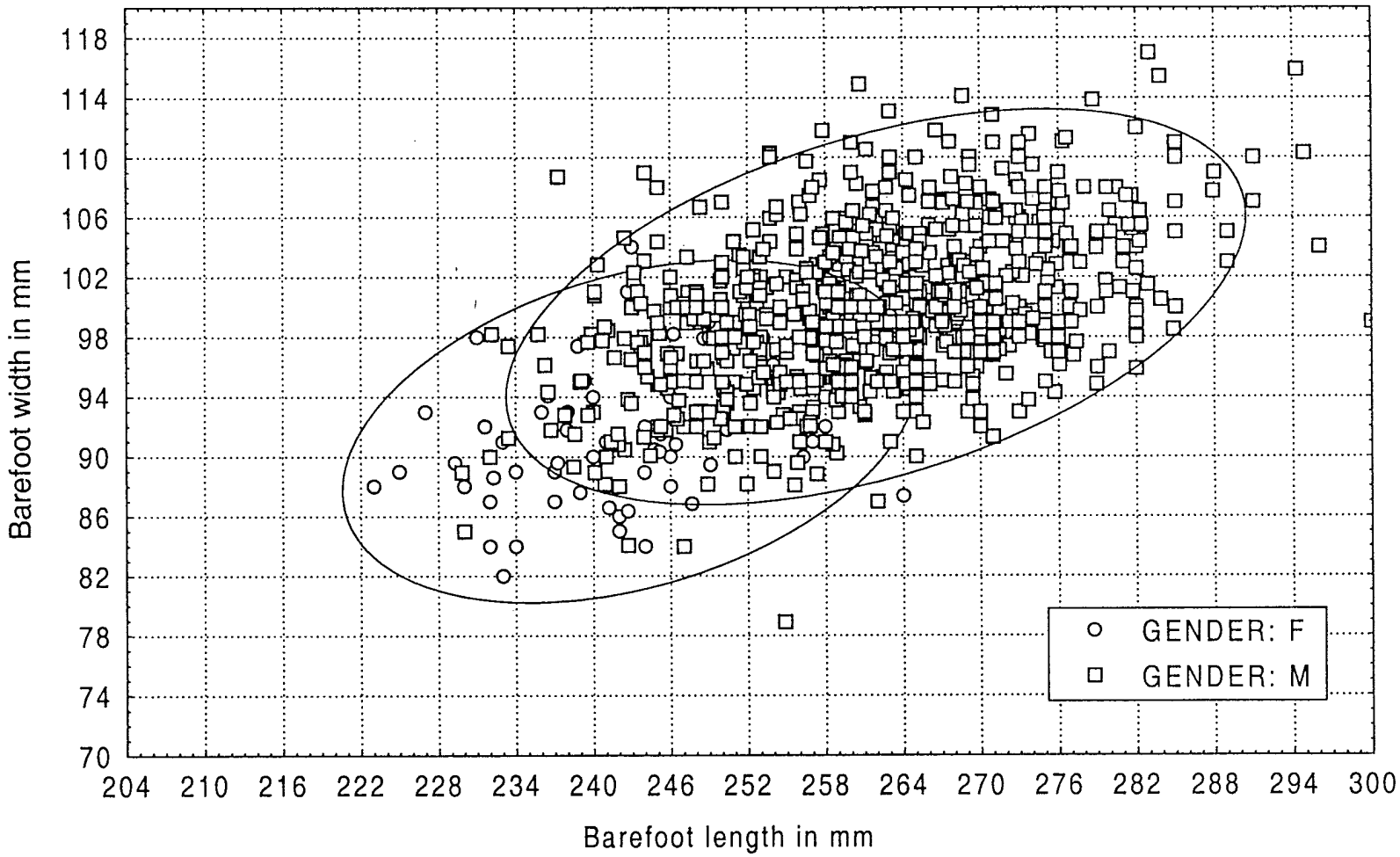
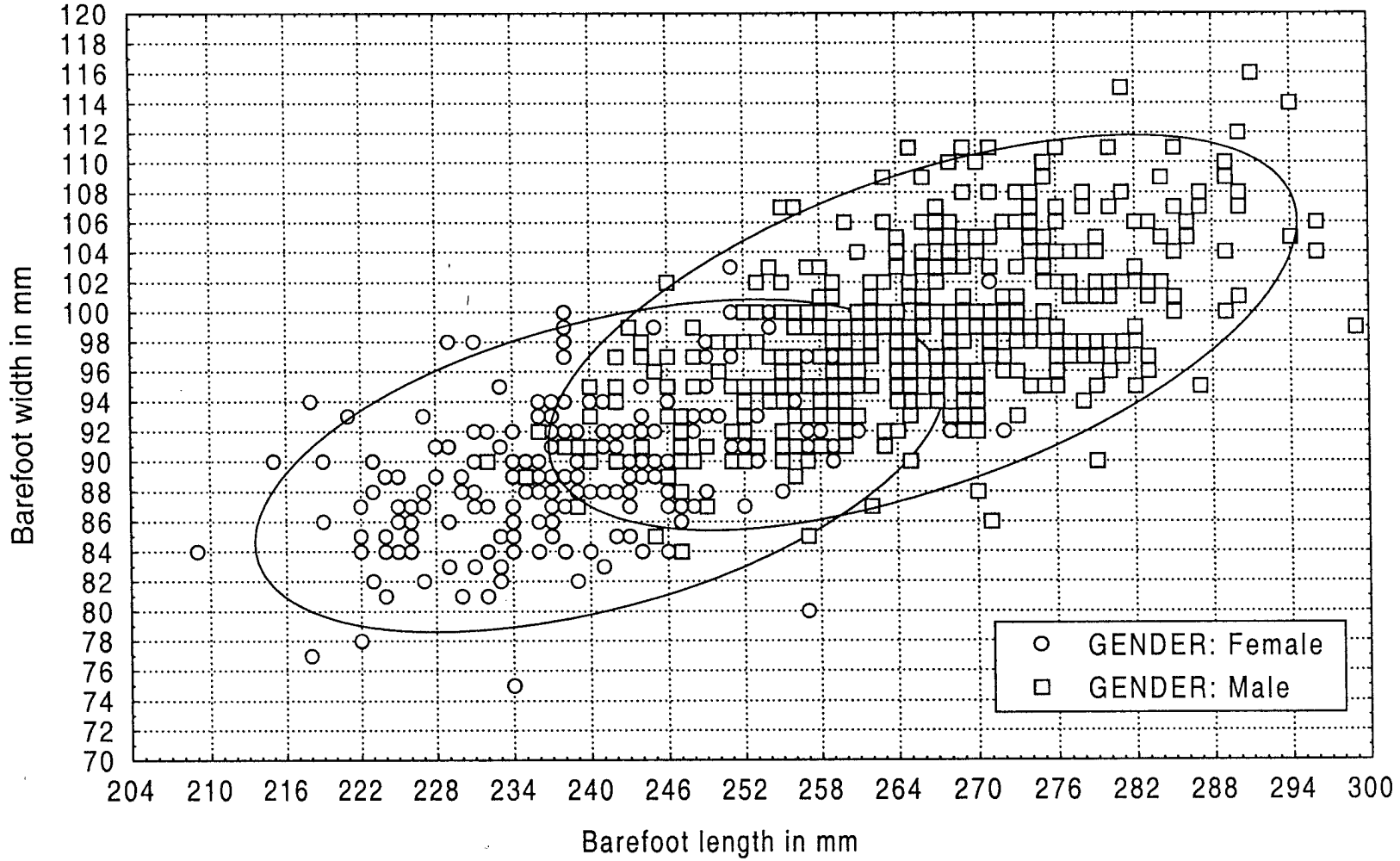


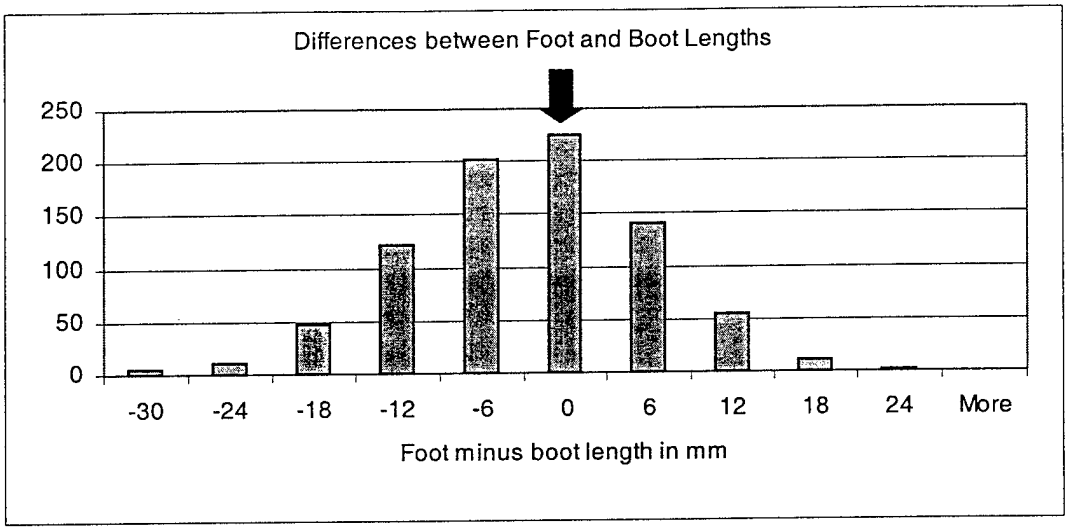
Figure 2: Anthropometric Survey Barefoot Length versus Width
Separated by Gender

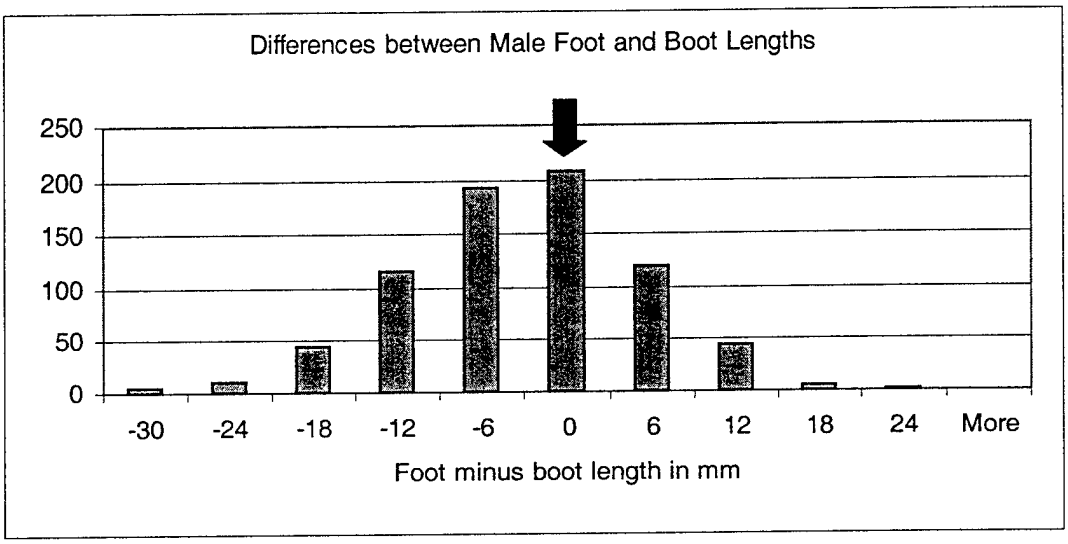


The actual differences in dimensions were calculated for all personnel and frequency plots were generated of the population as a whole, broken down by gender. These differences were calculated by subtracting the boot fit dimension from the foot-plus-sock dimension such that a positive difference would indicate the foot was larger than the boot fit dimension. Table 1 contains the results of the descriptive statistical analysis done on the differences, and Figures 3 and 4 show the distributions. The boundaries of the groups along the x-axis of the frequency distribution plots coincide with the length and width increments of the boot sizes. The arrows indicate where the predicted "best fit" would occur according to the size markings on the boots.

***Table 1:*** *Results of descriptive statistical analysis on the differences between foot dimensions and boot fit dimensions.*

| | LENGTH DIFFERENCE (MM) | WIDTH DIFFERENCE (MM) |
|---|---|---|
| Overall Maximum | 21.9 | 17.0 |
| Overall Minimum | -48.3 | -16.1 |
| Overall Mean | -5.5 | 0.6 |
| Overall Standard Deviation | 8.7 | 4.9 |
| | | |
| Male Maximum | 21.9 | 17.0 |
| Male Minimum | -48.3 | -16.1 |
| Male Mean | -6.1 | 0.5 |
| Male Standard Deviation | 8.6 | 4.9 |
| Male Median | -5.8 | 0.5 |
| Male Skewness | -0.304 | -0.028 |
| Male Std Error of Skewness | 0.089 | 0.089 |
| Male Kurtosis | 0.945 | 0.037 |
| Male Std Error of Kurtosis | 0.178 | 0.178 |
| | | |
| Female Maximum | 17.0 | 17.0 |
| Female Minimum | -19.7 | -10.2 |
| Female Mean | 0.3 | 1.2 |
| Female Standard Deviation | 8.6 | 4.8 |
| Female Median | 1.0 | 1.0 |
| Female Skewness | -0.148 | 0.422 |
| Female Std Error of Skewness` | 0.287 | 0.287 |
| Female Kurtosis | -0.52 | 1.23 |
| Female Std Error of Kurtosis | -1.04 | 0.566 |
| | | |



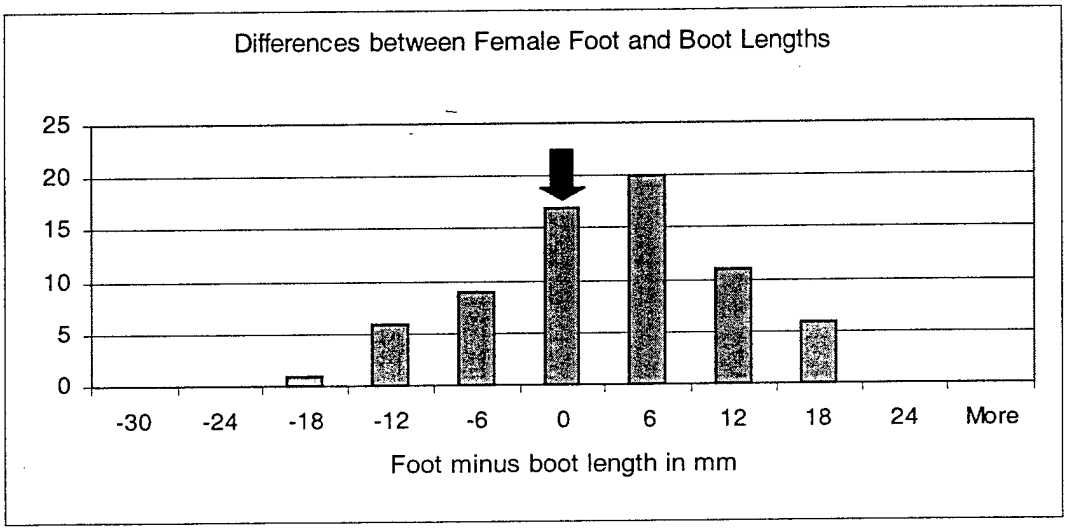




***Figure 3**: Frequency distribution plots of foot and boot length differences. The arrow points to the predicted 'best fit' group.*

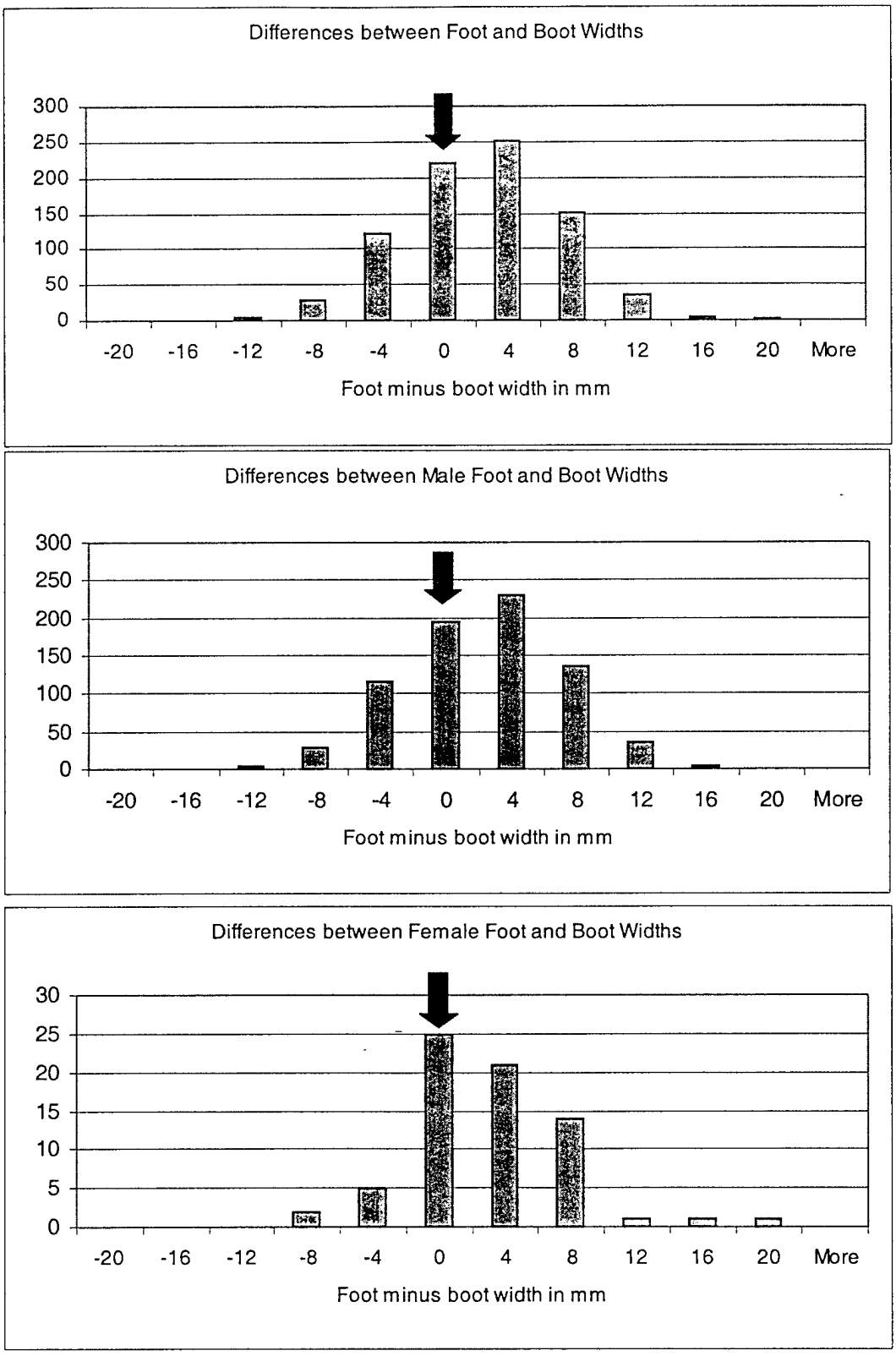



***Figure 4:*** *Frequency distribution plots of foot and boot width differences. The arrow points to the predicted 'best fit' group.*

Since males make up the majority of the total distribution, it is not surprising that the total population and the male population frequency plots and descriptive statistics are similar. Thus, only the genders are compared in this discussion.

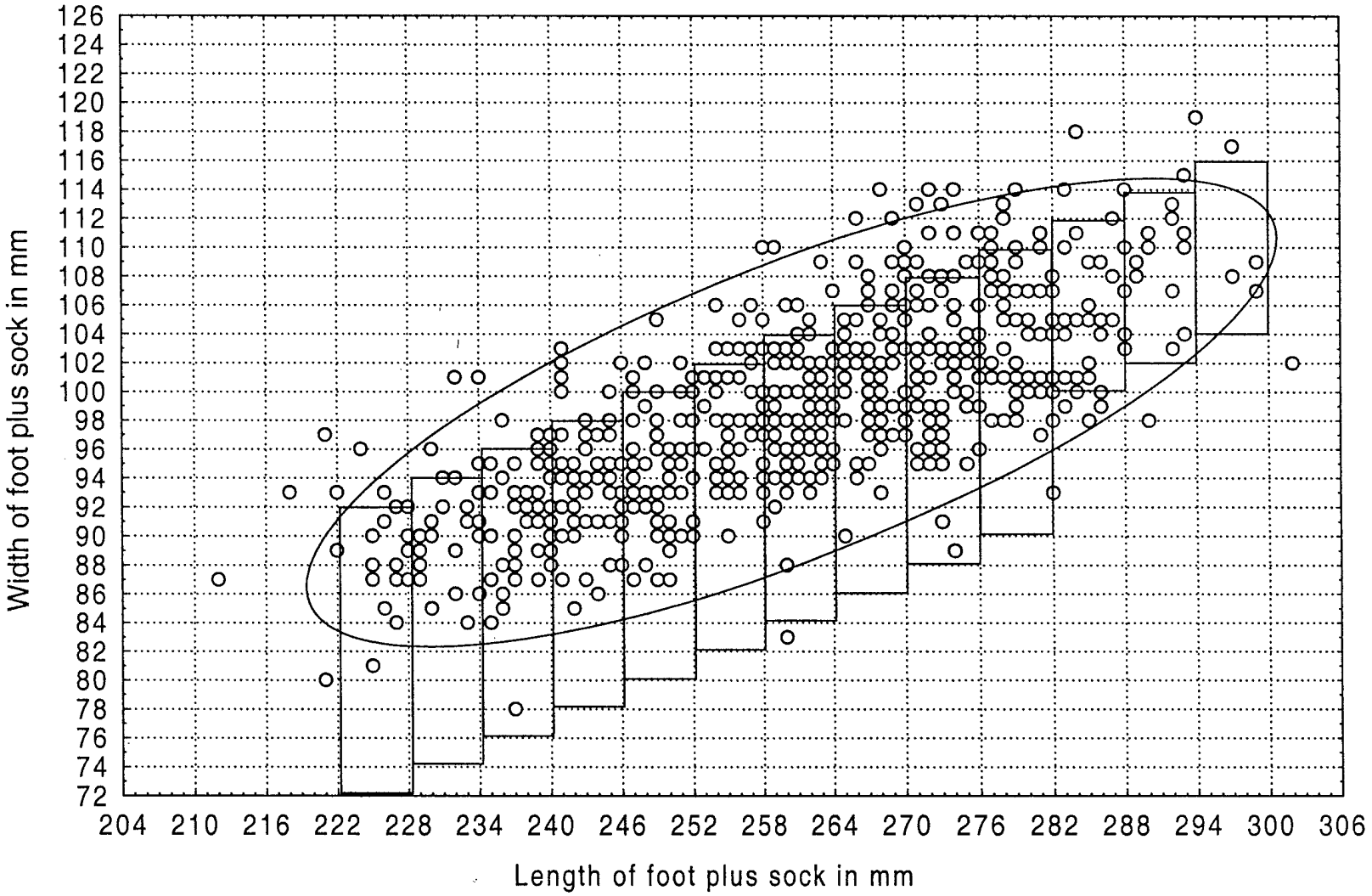
Two tests of a frequency distribution shape are the skew (symmetry) and kurtosis (a measure of how flat or peaked a distribution is). Dividing the skew (or kurtosis) value by its standard error yields a value which can be interpreted like a Z score [12] i.e. if it is greater than 1.96 or less than –1.96 the data is significantly skewed (kurtotic). The skewness scores (-0.31 for males and 1.47 for females) indicate that for both genders, the differences between foot-plus-sock width and boot fit width are distributed symmetrically. The kurtosis scores (0.21 for males and 2.17 for females) would suggest that the width distribution for males was normal and that of the females leptokurtic or peaked. The footwear industry teaches that the fit in the width should be snug i.e. not too tight (which would cause pressure injuries) and not too loose (side-to-side motion would cause instability). If personnel were employing this principle, then width difference kurtosis is expected, and realised in the female data. The mean width differences indicate that for both genders, the foot widths slightly exceeded the boot fit dimension (0.52 mm for males and 1.25 mm for females). One explanation for this would be that there are many personnel that couldn't find the correct width (either unavailable or non-existent) and accepted something too snug. The result could also indicate a preference for a slightly tighter fit in the width, females preferring a slightly tighter fit than males. Another possible reason for this result might be that the boot manufacturer was in error in developing the correlation between boot width and the target range of foot widths. One must remember, however, that foot fit is a three dimensional problem, and that there might very well be some "give" in width if there is some excess in circumference. Although this might explain someone wearing a boot that is one size too narrow (very snug fit), and possibly two sizes too narrow (very tight fit), the author is at a loss to explain how some personnel (42/755 males and 3/70 females) could be wearing a boot 3-5 sizes too narrow in width. Some of those wearing boots wider than predicted, however, indicated a preference to wearing 2 pairs of socks at various times on duty.

The scores for skew (-0.52) and kurtosis (-1.04) for female length differences would indicate that this distribution is normal. The male scores for skew (-3.42) and kurtosis (5.31) indicate that the male length difference distribution was both skewed (larger tail pointing to where the boot is longer than the foot) and leptokurtic (peaked). The larger standard deviation in the male mean also suggests there is more incidence of wearing longer and shorter sizes. The negative skew would suggest, however, that wearing a larger boot is more prevalent than wearing a boot smaller than the foot-plus-sock length. The female mean length difference (0.28 mm), as with width, indicates the foot-plus-sock is slightly longer than the boot fit dimension in length. The reasons could be the same as discussed for width. The male mean length difference (-6.08 mm) suggests that, for some reason, a larger number of males are wearing boots at least one size larger than predicted. Only 7/755 males and 6/70 females are wearing boots more than 2 sizes too small, whereas 63/755 males and 1/70 females are wearing boots more than 2 sizes too large. The only way to explain the 13 people being able to wear a boot more than 1 size too small is either the boots are actually accommodating larger foot-plus-sock ranges, or the worst-case personnel were curling their toes in the boots. A general complaint heard from those wearing larger than predicted boots was that the boots were not bending near their ball of foot area, and thus "tough to break in". This would indicate an obvious improper fit in length.

Because of the smaller variability (smaller standard deviation) of the differences in width compared to length, and the relatively larger spread of boot lengths, it would appear that priority is given to fitting the width and then accepting the best length available in that width. It has also been suggested that the boot size "target range" of foot-plus-sock range of measurements might

be off by several millimetres. In an attempt to visualise the relationship between the foot-plus-sock measurements and the boot sizes, the subjects in this study were plotted again with the boot Mondopoint size ranges superimposed (Figure 5). The sizes are shown as vertical rectangles. The various widths available in each size would divide the vertical bar into 4 mm segments starting from the narrowest at the bottom to the widest at the top. The noticeable offset between boot and foot sizes suggests very little use is made of the narrowest sizes and many personnel would be unable to find a proper width in a particular size. The latter population would have to select a larger sized boot in order to accommodate the greater widths.

Figure 5: CFLF Foot + CF Sock Compared to Cbt Boot MkIII Sizes



There are 64 sizes of combat boot in the Canadian LF supply inventory, ranging from 222/78 to 306/118. The distribution of sizes being worn by the test population is shown in Table 2.

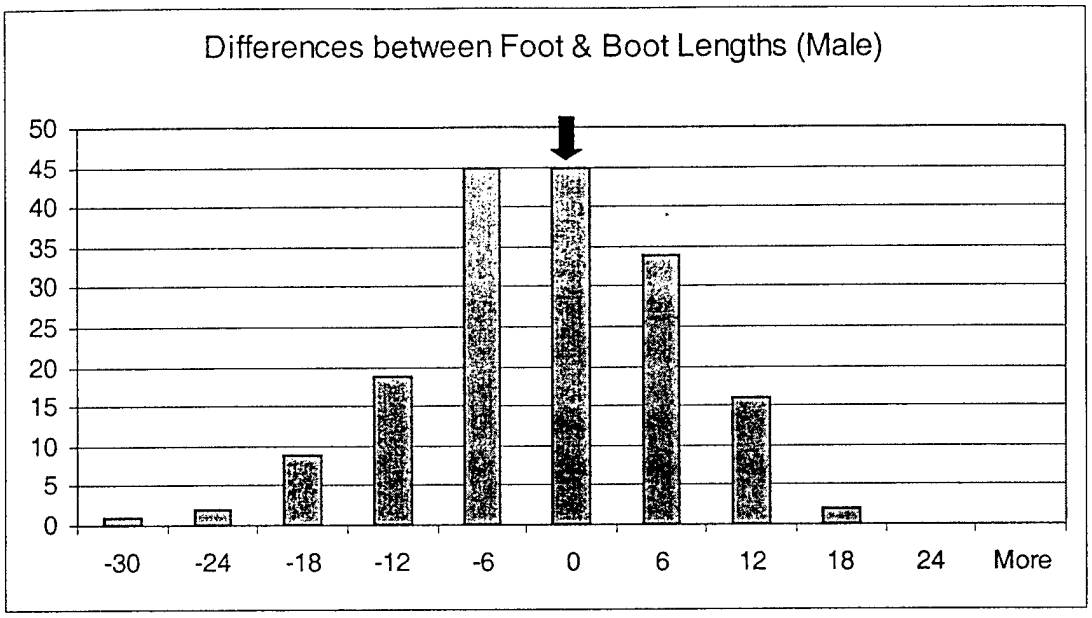
*Table 2: Size distribution of the fit test population.*

| | BOOT MONDOPOINT SIZE | | |
|---|---|---|---|
| NSN | LENGTH | WIDTH | NO. OF PERSONNEL |
| 8430-21-904-6618 | 222 | 78 (C) | |
| 8430-21-904-6619 | 222 | 90 (F) | |
| 8430-21-888-7061 | 228 | 76 (B) | |
| 8430-21-888-7062 | 228 | 80 (C) | |
| 8430-21-888-7063 | 228 | 84 (D) | |
| 8430-21-888-7064 | 228 | 88 (E) | 2 |
| 8430-21-888-7065 | 228 | 92 (F) | 1 |
| 8430-21-888-7066 | 234 | 78 (B) | |
| 8430-21-888-7067 | 234 | 82 (C) | |
| 8430-21-888-7068 | 234 | 86 (D) | 2 |
| 8430-21-888-7069 | 234 | 90 (E) | 3 |
| 8430-21-888-7070 | 234 | 94 (F) | 5 |
| 8430-21-888-7071 | 240 | 80 (B) | |
| 8430-21-888-7072 | 240 | 84 (C) | 1 |
| 8430-21-872-4292 | 240 | 88 (D) | 4 |
| 8430-21-872-4293 | 240 | 92 (E) | 8 |
| 8430-21-872-4294 | 240 | 96 (F) | 2 |
| 8430-21-888-7073 | 246 | 82 (B) | |
| 8430-21-888-7074 | 246 | 86 (C) | |
| 8430-21-872-4295 | 246 | 90 (D) | 8 |
| 8430-21-872-4296 | 246 | 94 (E) | 20 |
| 8430-21-872-4297 | 246 | 98 (F) | 8 |
| 8430-21-888-7075 | 252 | 84 (B) | |
| 8430-21-888-7076 | 252 | 88 (C) | |
| 8430-21-872-4298 | 252 | 92 (D) | 4 |
| 8430-21-872-4299 | 252 | 96 (E) | 25 |
| 8430-21-872-4300 | 252 | 100 (F) | 17 |
| 8430-21-888-7077 | 258 | 86 (B) | |
| 8430-21-888-7078 | 258 | 90 (C) | |
| 8430-21-872-4301 | 258 | 94 (D) | 14 |
| 8430-21-872-4302 | 258 | 98 (E) | 47 |
| 8430-21-872-4303 | 258 | 102 (F) | 18 |
| 8430-21-888-7079 | 264 | 88 (B) | |
| 8430-21-888-7080 | 264 | 92 (C) | |
| 8430-21-872-4304 | 264 | 96 (D) | 17 |
| 8430-21-872-4305 | 264 | 100 (E) | 93 |
| 8430-21-872-4306 | 264 | 104 (F) | 35 |
| 8430-21-888-7081 | 270 | 90 (B) | |
| 8430-21-888-7082 | 270 | 94 (C) | |
| 8430-21-872-4307 | 270 | 98 (D) | 33 |
| 8430-21-872-4308 | 270 | 102 (E) | 77 |
| 8430-21-872-4309 | 270 | 106 (F) | 39 |

| | | | |
|---|---|---|---|
| 8430-21-888-7083 | 276 | 92 (B) | |
| 8430-21-888-7084 | 276 | 96 (C) | 2 |
| 8430-21-872-4310 | 276 | 100 (D) | 41 |
| 8430-21-872-4311 | 276 | 104 (E) | 104 |
| 8430-21-872-4312 | 276 | 108 (F) | 31 |
| 8430-21-888-7085 | 282 | 94 (B) | |
| 8430-21-888-7086 | 282 | 98 (C) | |
| 8430-21-872-4313 | 282 | 102 (D) | 20 |
| 8430-21-872-4314 | 282 | 106 (E) | 75 |
| 8430-21-872-4315 | 282 | 110 (F) | 19 |
| 8430-21-872-4316 | 288 | 104 (D) | 5 |
| 8430-21-872-4317 | 288 | 108 (E) | 18 |
| 8430-21-872-4318 | 288 | 112 (F) | 7 |
| 8430-21-872-4319 | 294 | 106 (D) | 5 |
| 8430-21-872-4320 | 294 | 110 (E) | 10 |
| 8430-21-872-4321 | 294 | 114 (F) | 3 |
| 8430-21-872-4322 | 300 | 108 (D) | |
| 8430-21-872-4323 | 300 | 112 (E) | |
| 8430-21-872-4324 | 300 | 116 (F) | 1 |
| 8430-21-872-4325 | 306 | 110 (D) | |
| 8430-21-872-4326 | 306 | 114 (E) | 1 |
| 8430-21-872-4327 | 306 | 118 (F) | |
| | | | |

The first 10 sizes come in 5 widths, and for convenience, they will be referred to as B for the narrowest width to F for the greatest width. The largest 3 sizes come in only the 3 greatest widths (D-F). Of the 825 individuals making up the fit trial population, 0 were wearing the B width, 3 the C width, 153 the D width, 483 the E width and 186 the F width. As discussed previously, a comparison of the fit trial population to the anthropometric survey showed the male foot size distribution to be quite similar between the two groups while some of the smallest female sizes (length and width) were not present in the fit study. The difference between the female distributions of the 2 surveys, with respect to foot width, is less than one boot width increment. Clearly, the narrowest two widths are not being used.

If personnel were indeed unable to find a width in their size, then one alternative would be to wear a boot one size larger in an F width, or even 2 sizes larger in an E or F width in order to accommodate their foot-plus-sock width. All those wearing the F width boot were separated from the overall population and re-analysed. Of the 186 personnel in this study, 13 were female and 173 were male. It was decided that the female population was too small for a meaningful analysis so only the males are discussed. The new frequency graphs are shown in Figure 6. The plots indicate that the widths are indeed normally distributed about the predicted fit dimension for width, but the plot for length shows a high number of individuals wearing boots that are too long.



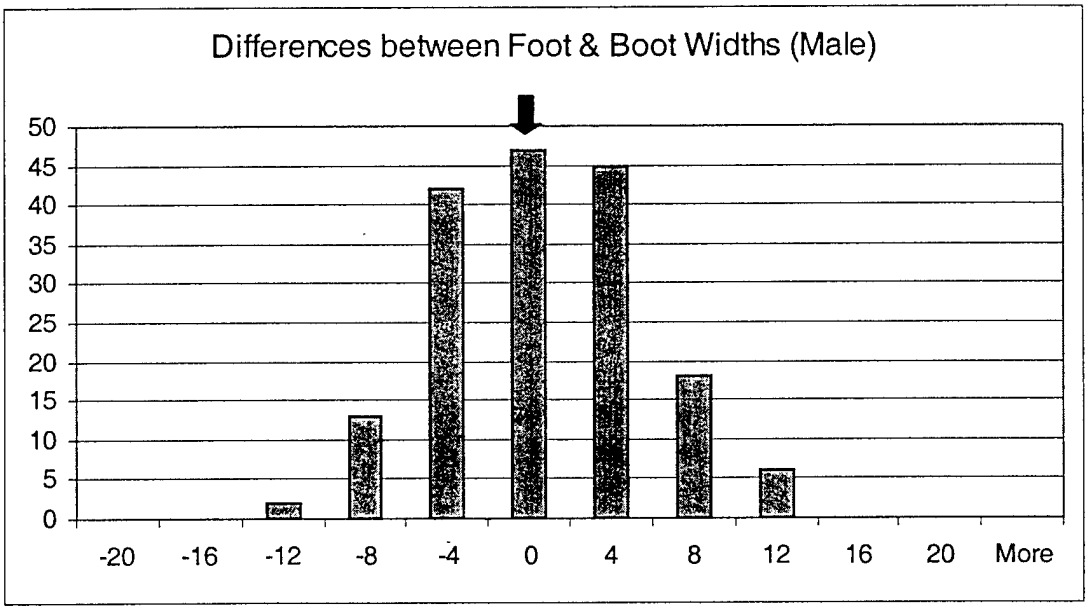
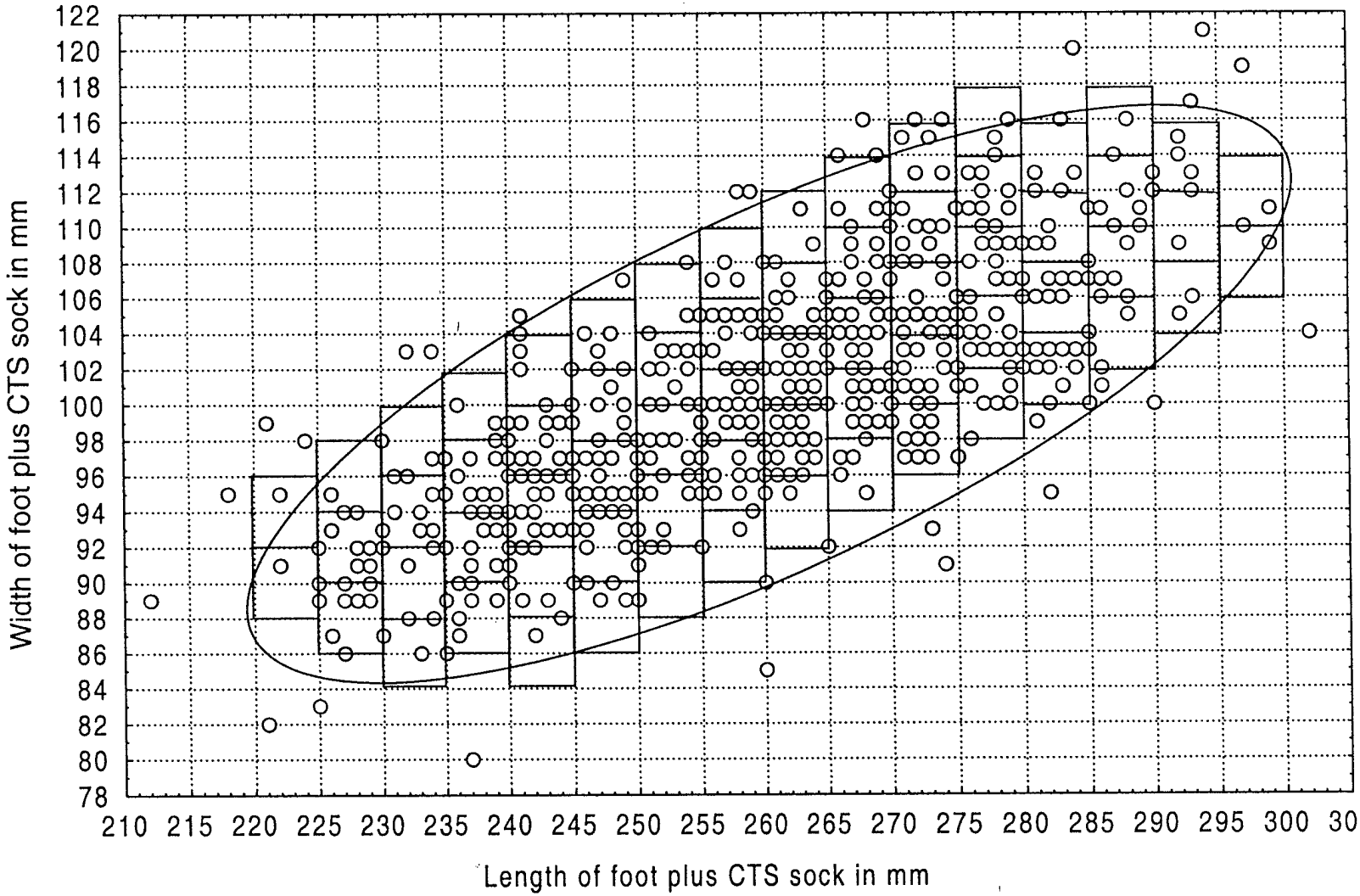




***Figure 6:*** *Frequency distribution plots of foot and boot, length and width differences, for males currently wearing the widest width (F width). The arrow points to the predicted 'best fit'*

The latter two results along with Figure 5 combine to support the hypothesis that the Canadian combat boot Mk III sizing system is not well correlated to the current CF LF population. Developing a new sizing system using methodologies such as those described by McConville [13] are outside the scope of this project. Changing the gradings and distribution of sizes would go a long way to solving many of the current boot fitting deficiencies. With the assistance of the technical authority on the CF LF combat boot, a new sizing system has been developed and is shown in Figure 7. This sizing system is estimated to accommodate approximately 96% of the CF LF population. This new system will be evaluated soon with the introduction of a new Wet Weather Boot scheduled to be issued some time in the year 2001.

Figure 7: CFLF Foot + CTS Sock Compared to Proposed Mondopoint Sizing System



# Conclusion

825 members of the CF LF had their right bare foot measured and the size of their current Canadian combat boot Mk III recorded. A separate sock study determined, on average, how much a sock increased an individual's foot length and width. The participants had their bare foot measurements corrected and compared to their boot size. An alarmingly small number of subjects were wearing boots that fit in both length and width.

Fit is a subjective personal issue. The frequency distributions of fit indicate that a boot that is predicted to be too big or too small for a large number of people, is apparently acceptable to many of them. Unfortunately, a large number of individuals simply cannot find a boot that fits properly and must compromise on at least one dimension, usually resulting in wearing a boot that is too long. A new sizing system for boots is required which is better correlated to the CF LF population.

One can also conclude from the very large maxima and minima of the differences of boot fit dimensions and foot-plus-sock measurements that many personnel have not been fit properly. Large differences exist for all lengths and widths which means a much better fit was theoretically available for many. Not enough effort was expended to achieve a good fit, and this is a deficiency which can be overcome with some simple training and patience.

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14. ABSTRACT

(U) Foot and boot size data were collected on 825 individuals (70 females and 755 males) predominantly Canadian Forces (CF) Land Force (LF) infantry. The differences between foot-plus-sock dimensions and boot dimensions were determined and the results indicate that 227 personnel were wearing the predicted length of boot, 217 were wearing the predicted width of boot, and only 58 were wearing the predicted length and width of boot. The data suggests that priority is given to finding the best fit in the width of a boot and then accepting the best length available in that width. A large number of individuals, however, cannot find a boot that fits properly or do not know what constitutes a good fit and thus must compromise on at least one dimension, usually resulting in wearing a boot that is too long. A new sizing system for boots, which is better correlated to the foot dimensions of the CF LF population, is required. The numerous occurrences of very large differences between boot fit dimensions and foot-plus-sock measurements indicate that many personnel have not been fitted properly. Since these large differences exist for all lengths and widths, a much better fit was theoretically available for many. Soldiers admit there is not enough effort expended to achieve a good fit, a deficiency that can be overcome with minimal training and patience.

On a recueilli des données sur la pointure des bottes de 825 personnes, soit 70 femmes et 755 hommes, principalement de l'infanterie de la force terrestre des Forces canadiennes (FC). La différence entre les dimensions du pied avec chaussette et celles de la botte a été déterminée et les résultats montrent que 227 membres du personnel portaient une botte de la longueur calculée, 217 portaient une botte de la largeur calculée et seulement 58 portaient une botte de la longueur et de la largeur calculées. Les données indiquent qu'on devrait chercher en premier à trouver la largeur de botte qui convient le mieux et accepter ensuite la botte de cette largeur qui présente la meilleure longueur qui soit. Toutefois, un grand nombre de personnes ne peuvent pas trouver une botte qui chausse bien et ne savent pas ce qui constitue un parfait ajustement, aussi doivent-ils s'accommoder d'au moins une dimension, se retrouvant généralement à porter des bottes trop longues. On a besoin d'établir un nouveau système de pointures qui soit mieux en rapport avec les dimensions des pieds des membres de la force terrestre des FC. Le grand nombre de cas où la pointure des bottes et les dimensions des pieds avec chaussettes diffèrent énormément montre que la plupart des membres du personnel n'étaient pas bien chaussés. Étant donné que ces grosses différences se retrouvaient dans toutes les longueurs et toutes les largeurs, cela veut dire qu'il était théoriquement possible de trouver une bonne pointure pour beaucoup. Les soldats admettent qu'on ne consacre pas assez de temps à la recherche de bottes qui chaussent bien, une déficience qu'un minimum de formation et de patience pourraient combler.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) Foot; boot; footwear; sock; fit; sizing system; Mondopoint