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A PROJECTION OF THE SECULAR TREND OF CANADIAN FORCES AIRCREW ANTHROPOMETRY

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ABSTRACT

~~It is acknowledged that~~ as a population, adults on average are larger and taller than in the past. Projection of this trend into the future provides valuable information to the engineer working to design equipment or systems for future populations. In this report, recently collected anthropometric data on Canadian Forces (CF) aircrew are compared to past data to examine this trend. Mean stature is used as an indicator of population trends of change in body size. It is concluded that the "young adult" CF aircrew population is increasing in average stature at a rate of approximately 0.55 cm per decade. However, due to a number of non-biological factors, the mean of the CF aircrew population may not increase as quickly.

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1. INTRODUCTION

It is a widely held belief that as a population, adults are larger and taller than in the past. It is not known however, exactly how much change has occurred or how fast it is currently progressing. Churchill and McConville (Ref 1) comment that "Men, both individually and collectively, change in body size and shape with the passage of time.... Unfortunately, these trends are not easily measured and it has, in fact, been argued that trends as such do not exist." Roebuck (Ref 2) on the other hand, indicates that the United States (U.S.) male population is increasing in stature by approximately one centimeter per decade. These arguments are not necessarily contradictory. In the very long term, there has been a gradual increase in stature, however, over relatively short terms, (10-30 year periods) data have shown this process to be erratic.

It is not clear if these erratic changes are entirely biological, due to sampling, or other unknown causes. It is also not clear whether this increase will continue to progress at the same rate in the future, although it is improbable that it will continue indefinitely.

Identification of secular trends, in body size have important implications for designers and engineers working to produce efficient workspaces and equipment systems for future CF aircrew populations. Lead times of 7-10 years are not uncommon for the development of a complete system; from inception of the idea, to a prototype system, and then to an actual production model being utilized in the field. If this system or equipment is effective, it will remain in use for several years following its introduction. Despite the uncertainties of projection, the design of equipment today, for the use of aircrew in the future, requires that estimates of future population physical characteristics be made available.

One objective of a recent anthropometric survey of Canadian Forces (CF) pilots and navigators (Ref 3) was to provide the necessary information for estimating future aircrew body sizes. These data, in conjuction with past surveys, were used to project aircrew stature over the next 20 year period. Stature was chosen for direct comparison as it is an important design dimension for which data are easily found and therefore compared, and because it is probably the body dimension most indicative of change.

2. REVIEW OF EXISTING ANTHROPOMETRIC DATA

The sources of CF aircrew anthropometric data available for comparison are described briefly. These surveys comprise all the known sources of CF aircrew anthropometric data collected over approximately the last 30 years:

a) AGARD Body Measurements of 1578 RCAF Aircrew Trainees Smiley, 1958, (Ref 4):

The purpose of this Institute of Aviation Medicine (IAM) report was to make available basic anthropometric data of recent Royal Canadian Air Force (RCAF) aircrew trainees. Nude measures were taken on 1578 personnel (ie. 998 pilot trainees, 580 observer trainees) using a Morant board. Also, data were provided on the effect of aircrew clothing upon these body measures. Unfortunately, definitions of landmarks used for these measures were not included in this report, making it difficult to confidently compare any data other than stature and mass to other data of different time periods.

b) RCAF Anthropometrical Survey: Based on Probability Sample of 314 Pilots and 290 Navigators Stratified by Trade and Command, Smiley, 1962, (Ref 5):

This study, conducted by IAM, involved sixty-eight body dimensions. Both American and British techniques were used to allow for the comparison of the two. Generally, there was high agreement between the two methods of body measurement. Definitions of landmarks used for these measures were not included in this report.

c) 1974 Anthropometric Survey of Canadian Forces Personnel, McCann et al, 1975, (Ref 6):

This report summarizes the data collected as a result of a survey of Canadian Forces (CF) personnel across all major trades. A sample population of 565 personnel was selected, 31 of which were CF aircrew (13 pilots and 18 navigators). The survey was designed to provide data for CF clothing designers and human engineers. Definitions of landmarks, along with percentile distribution and descriptive statistics were included for each measurement taken.

d) 1985 Anthropometric Survey of Canadian Forces Aircrew, Stewart, 1985, (Ref 3):

> This recent multi-purpose survey involved anthropometric data collection on a sample of 519 CF aircrew stratified by Offficer Classification (ie. pilot or navigator) and type of aircraft flown. Direct measures of 72 nude body measures were acquired, along with basic background information (eg. education, racial heritage, age, etc). Complete statistical information as well as definitions of landmark and measuring technique are reported.

Secular trends discussed in this report are based on the foregoing collection of reports. It must be noted, however, that the McCann et al study (Ref 6) contains too few aircrew to be statistically valid to suit this purpose.

3. RESULTS and DISCUSSION

There are a number of procedures which are used by engineers to achieve estimates of trends in body size. For projection purposes, mean stature is generally used. The mean, as a descripter, is a relatively stable statistic, and stature is used as the most representative dimension of the average population and its change. Three common methods were used to estimate secular trends in CF aircrew stature. They are presented here.

A) Projection A

The first method employed a linear projection based on the history of the CF aircrew population mean. In this instance the estimated mean for combined pilot and navigator data from the 1962 survey (Ref 5) and the mean for combined data from the 1985 survey (Ref 3) were used. The data and results are summarized in Table 1.

Table 1. Projection A. A prediction of future CF aircrew stature using 1962 data and 1985 data as indicators of growth rate.

		1962	1985	Projected to 2005
Pilots	1%	164.2	162.8	
	Mean (cm)	177.4	176.8	176.2
	99%	191.5	193.2	
Navigators	1%	161.8	160.2	
	Mean (cm)	176.7	176.5	176.3
	99%	190.3	193.0	
Combined	1%		162.8	
	Mean (cm)	177.1	176.8	176.5
	99%		193.2	

The mean stature in 1985 is suprisingly lower than the mean stature in 1962. This marginal difference may be partially or entirely due to non-biological causes which will be discussed later.

B) Projection B

The second method used, sought to find the trend for young adult CF aircrew stature based on the premise that if the young adult population on average is becoming taller, then eventually the general population mean will follow. This method may be more sensitive to detecting change than using the entire population. To complete the analysis, 1958 data for pilot and observer trainees (Ref 4) were compared to the young adult CF aircrew of the 1985 survey. The age group of 20-25 years was chosen, based on three working assumptions: 1) males as a group have achieved their adult stature by this age; 2) generally personnel begin service within this age span (based on average ages and years of service of the aircrew population) and; 3) trainees in 1958 were of approximately the same age. The data and results are summarized in Table 2.

Table 2. Projection B- A prediction of future CF aircrew (aged 20-25 years) stature using 1958 trainee data and a subset of the young adults from the 1985 survey as indicators of growth.

		1958	1985	Projected to 2005
Pilot and Observer Trainees	Mean (cm)	176.4	177.9	179.0
	S.D.		(6.29)	

This projection indicates that the young adult population has increased in stature at a rate of approximately 0.55 cm per decade. Roebuck (Ref 2) reported that the U.S. male recruits are increasing in stature at a rate of 0.418 inches (1.06cm) per decade, however, he also referred to a recent unpublished document which revised the rate to 0.32 inches (0.81cm) per decade for the last two decades. According to these reports, it would appear that the projection of young adult height presented here is reasonable.

C) Projection C

The third method, adapted from Churchill (Ref 1) is based on the assumption that the 20-25 year age group will, in 10 years, be the average age of the population, and therefore will represent the average size as well. Using the average stature of the entire 1985 CF aircrew sample, and the average stature of the subset of aircrew between 20-25 years of age as the average in 10 years, a projection was made for mean stature in 20 years.

Table 3. Projection C- A prediction of future CF aircrew stature using the 1985 population and a subset of young adult CF aircrew as indicators of growth.

		1985	1995	Projected to 2005
CF aircrew	Mean (cm)	176.8	177.9	179.0
	(S.D.)	(6.8)	(6.29)	
Young Adult	Mean (cm)	177.9		
	(S.D.)	(6.29)		

This method predicts that the CF aircrew will increase in stature at the rate of 1.1 cm per decade; a much higher rate than results from using either of the previous two methods of projection.

The results of these three projection methods are presented diagrammatically in Figure 1. From the figure, the two projections involving young adults (ie. Projection B and Projection C) agree on mean stature in the year 2005. However, they certainly do not agree in their estimates of mean stature in the years before 2005.

Different methods each have qualities and faults. Hence, a closer look at the methods is needed to determine possible sources of error.

For Projection A, the 1962 data presented were acquired using the British method of measuring stature with a Morant board. Smiley (Ref 4) suggested that using the Morant board technique may increase measured stature slightly due to the postural support of the back wall. Unfortunately, data obtained in the 1962 (Ref 5) survey, acquired using the American method of measuring stature (ie. using a free standing anthropometer), were not available.

Also the 1962 combined data mean is estimated from data converted from the British system to the metric system and may be subject to rounding off error. A metric scaled anthropometer and the American method were used in data collection for the 1985 survey.

For Projection B, a number of assumptions were made, due to a lack of information regarding the age of trainees in 1958. These assumptions may not have been accurate. For example, if the trainees in question were several years younger than estimated, then it is possible that they, as a group had not achieved their full adult stature. Projections of mean stature based on such data would exaggerate growth rates.

The third Projection, adapted from Churchill (Ref 1), assumes that the personnel of average age will in the future, also be of average body size. A corallary to this is that people presently of average age should represent the present average body size. Knowing that the 1985 CF aircrew mean age was approximately 32 years, a quick review of 1985 raw data was done. Analysis showed that the personnel 30-35 years of age had a mean stature of 178.9cm (S.D. 7.76),

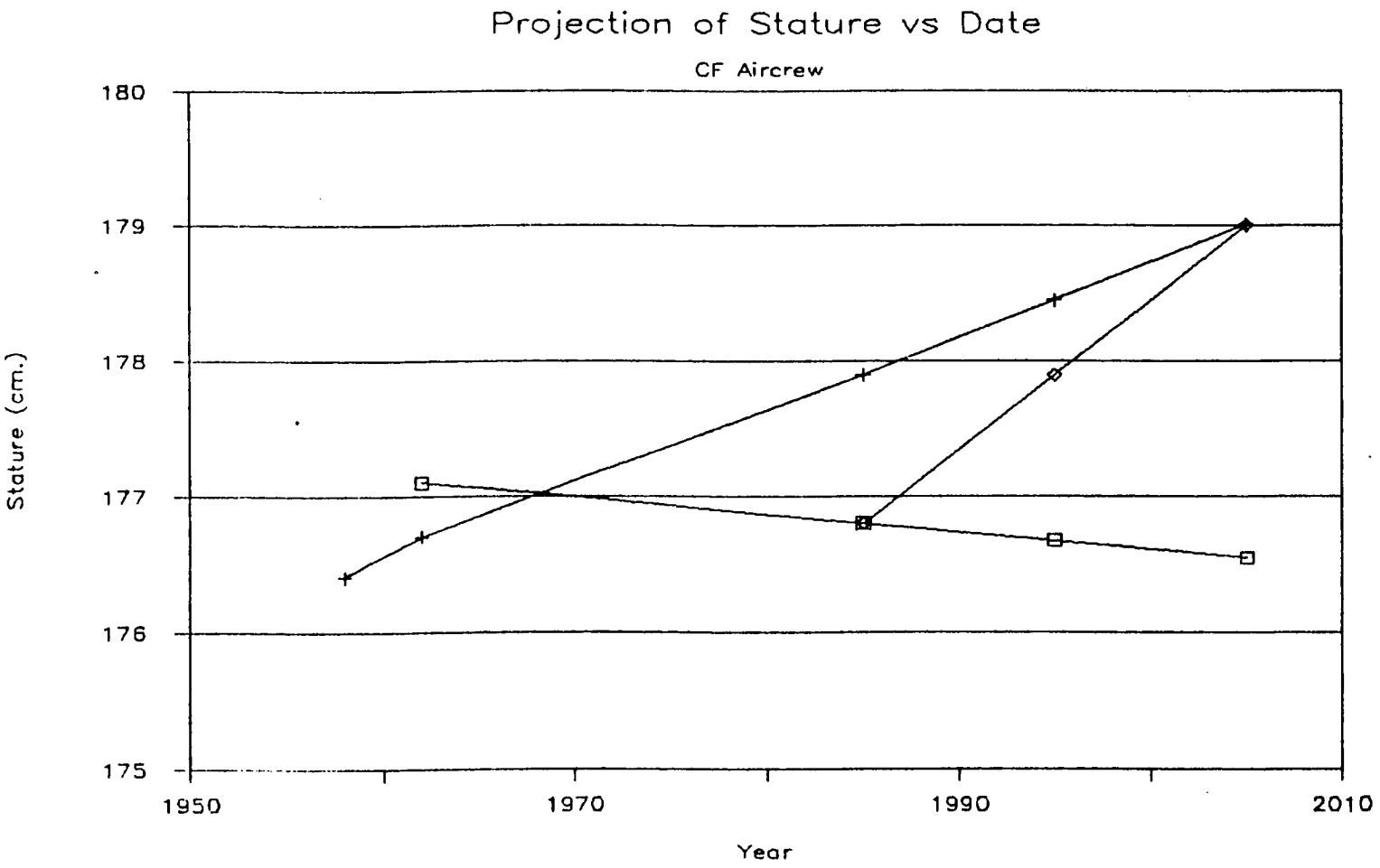
Projection of Stature vs Date
CF Aircrew
180
179
178
177
176
175
Stature (cm.)
1950
1970
1990
2010
Year
Projection A
Projection B
Projection C

Figure 1

well above the sample mean of 176.8cm (S.D. 6.8). It is evident that the use of Projection method C is of questionable value for a large population.

Several other points must be considered in relation to projections in general. Simple linear extrapolations, as used in all of the above methods, imply that the rate of change of stature in the past is primarily of biological origin and will continue at the present rate indefinitely (at least 20 years). In the absense of other information, this assumption is perhaps the quickest and easiest to apply to the general population. However, this assumption may not be entirely appropriate for the CF aircrew as there are several confounding factors in effect which are not present in a normal population.

The normal growth pattern of a population is influenced biologically by a number of factors, including genetic make-up, medical services and improved food. In the CF, aircrew also have non-biological restrictions imposed upon them - those of physical selection criteria based on the size of cockpits. Obviously, until the day comes when aircrew workspace can be made to accommodate everyone, this will be a necessary and appropriate procedure. However, it will also have the effect of stabilizing the mean scores of the selected population (aircrew). For example, the exclusion of taller persons, due to selection , will contribute to the stabilizing effect of already statistically stable mean. In this way, the CF aircrew mean stature will increase much more slowly than the candidate aircrew population.

Another element to consider is the introduction of females into this traditionally male occupation. It is not unreasonable to assume that females will become more common to aircrew populations in the future. On average, female stature and limb dimensions are approximately 92% of those of males. The introduction of this shorter population will have the effect of drawing downward the means of stature and other body dimensions.

Finally, assuming the increase of stature of young adult CF aircrew males will continue, and that this increase applies to both sexes, the use of the current CF aircrew anthropometric selection criteria will become increasingly more restrictive for males, but less restrictive to females. In turn, this will contribute further still to the introduction of the females to the aircrew population and the lowering of CF aircrew mean stature.

4. CONCLUSIONS

The projection of stature based on data representing a short time period, is presently not an exact science. The erratic nature of the data make it difficult to separate biological variation and sampling-induced error from true secular data.

It is apparent that the mean stature of the young adult CF aircrew population is increasing. Although the rate of increase can be argued, a reasonable estimate is approximately 0.55 cm per decade. This rate is in general agreement with the projected rate of increase in stature of U.S. aviator recruits, which was recently established to be approximately 0.81 cm per decade (Ref 2).

CF aircrew mean stature, however, is quite likely to increase only a marginal amount, if at all, over the next twenty years. It seems paradoxical that the male trainees introduced as aircrew are on average becoming taller, but the entire aircrew mean does not rise with them. The unchanging aircrew mean stature however, is based on the assumptions that: the mean is ordinarily a stable statistic; it will be yet more stable because of the imposition of anthropometric selection criteria; and females will become more common in the CF aircrew population.

Due to current body size selection limitations, the 5th and 95th percentile aircraft design criteria cannot be expected to change substantially in the near future. It must be noted, however, that these percentiles are subject to the varying distribution of body sizes within the CF aircrew population and may vary slightly from time to time.

Although the method used to estimate future body size in Projection C is not appropriate for use with a large population, it may have a very useful application for a select group of personnel targeted for specific projects. It has been proposed that body stature and size remain stable across a pilot's flying career (Ref 4). Therefore, it may not be necessary to estimate future personnel body size, but proceed to gather dimensional measures directly from the required people, years before they use the equipment designed for them. It is probably this latter purpose for which this technique was originally intended.

5. RECOMMENDATIONS

a) Periodic surveys are required to establish more closely the variations of body size within the population. However, there is no need in the immediate future to gather extensive data per subject.

b) Future surveys should include at least some subjects that were involved in the 1985 survey. It has been proposed that body stature and size remain stable across a pilot's flying career (Ref 4). Therefore, for small selected groups targeted for special projects in the future, it is possible to measure the personnel directly 7-8 years beforehand, to avoid the errors involved with population projections. Longitudinal data of body changes with respect to age, would confirm or reject this potentially accurate and simple procedure.

c) If longitudinal data confirms that aircrew anthropometric dimensions are relatively stable throughout the normal flying career, utilize this direct measure approach to determine estimates of future population anthropometric characteristics in place of the present projection and estimation methods.

d) Reports containing data acquired from future surveys, should include thorough descriptions of measurement techniques used to gather the dimensional data. This will make direct comparisons of limb dimensions between studies easier. Thus, indications of body proportional changes may be found which will aid the engineers and designers in their efforts to accommodate future populations.

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