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2012 Canadian Forces Anthropometric Survey - Lessons Learned

(January - April 2012)

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Abstract

In preparation for the 2012 Canadian Forces Anthropometric Survey (CFAS), a two pilot trials were held at DRDC Toronto Research Centre and the Canadian Army Training Centre Meaford. As the CFAS was to be a yearlong venture, visiting 14 bases and wings across the country, it was import to conduct pilot trials to provide the survey team with an opportunity to practice logistics and verify team performance so that any issues could be identified and remedied before the launch of the main phase of the survey. This document details the procedures and logistics followed during the pilot trials. These trials proved beneficial in confirming aspects of the project plan as well as identifying logistical and measuring practises that required further attention. This information is captured as a list of lessons learned and recommended actions that were then implemented throughout the survey.

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1 Introduction

The project plan (Mangan and Angel, 2012) for the Canadian Forces Anthropometric Survey (CFAS) 2012 included a pilot study. Pilot tests are at the heart of any good experiment and while the goals of pilot studies may vary, they all serve to improve the main study. According to the National Centre for the Replacement, Refinement and Reduction of Animals in Research (2006) pg. 1:

> *"A pilot, or feasibility study, is a small experiment designed to test logistics and gather information prior to a larger study, in order to improve the latter's quality and efficiency. A pilot study can reveal deficiencies in the design of a proposed experiment or procedure and these can then be addressed before time and resources are expended on large scale studies… A good research strategy requires careful planning and a pilot study will often be a part of this strategy.*

Two pilot sessions were under taken in support of the CFAS 2012, one at DRDC Toronto (DRDC-T) and the other at the Central Area Training Centre (CATC) Meaford. The principal objective of the pilot testing was to determine the efficacy of the anthropometric survey data collection plan method and the state of training of the data collection observers. The goals of the pilot tests were as follows:

- Evaluating the data collection protocols, optimizing data collection procedures
- Evaluating observer error, observer training
- Evaluating resource requirements
- Evaluating timings, throughput

Data collection on the CFAS began after the pilot sessions and lasted until 331 March 2012 (Phase II) and 30 April (Phase III).

2 Aim

The primary aim of this technical memorandum is to highlight lessons learned on the pilot studies of the CFAS. The secondary aim of this technical memorandum is to highlight some of the lessons learned on the CFAS Phase II survey.

Note: Lessons learned is an on-going effort and new information has been added to this technical report since its original draft.

3 Method

3.1 General

Two pilot tests were conducted, one at DRDC-T and the other at CATC Meaford. The DRDC pilot session was conducted during the period of 24 – 27 Jan 2012 and involved a total of 10 personnel, the majority

of whom attended parts of both days. The DRDC-T pilot trial involved the set-up, calibration, data collection and tear down of the measurement stations. The CATC Meaford pilot session was conducted during the period of 5 to 8 February 2012 and involved the participation of 39 personnel. The CATC Meaford pilot session involved the off-loading, disassembly and reassembly of the scanner, site set-up, calibration, data collection, measurement extraction, site disassembly and repacking.

3.2 Sample

- At DRDC-T - 6 males and 2 female volunteers were measured
- At CATC Meaford – 36 males and 4 female volunteers were measured

3.3 DRDC-T Pilot: General Approach

The DRDC-T pilot session utilized empty office space at DRDC-T for measurement stations. The Vitus XXL scanner was set up in the area of the Experimental Dive Unit Chamber and the measurement stations were set up a short distance away on the second floor of the northwest corner of the facility. The stations included the following:

- Intake
- Change rooms
- Station 1: Anthropometer
- Station2: Calipers
- Station 3: Tape
- Station 4: BoSS XXI
- Station 5: Vitus XXL

Participants were required to complete both a morning and an afternoon measurement session. Due to work hours, afternoon data collection was limited to 1500hrs. Pilot data collection was captured over the course of two days. Participants were requested to return again on the Thursday for a second replicate.

Participants were directed to the intake station where they were provided with a briefing on the survey. After completion of the consent forms, the participants were given a subject number, set of compression underwear, robe, slippers, lock & key, as well as a thumb drive. The participants were then sent to the change rooms to change into their garments, the participants then proceeded to the measurement stations. Due to subject availability not all participants were measured twice. Additionally, different subjects participated over the course of the two days.

The focus of the DRDC-T pilot tests was to optimize the data collection protocol, i.e. determining which measures should be taken where and when. Ambiguous data collection procedures were also identified and formalized.

Dedicated subjects are needed in pilot sessions. Recruiting adequate numbers of subjects at DRDC-T for the two sessions was challenging. Some personnel were only available for one day while the pilot plan identified the need for all participants to return.

Issues during intake processing were observed. The duties and responsibilities of the intake personnel were not adequately briefed by the data collection team.

The facilities at DRDC-T did not permit adequate setup of the measuring site. Office spaces were used vice the portable wall/rooms that were to be used during the survey.

3.4 CATC Meaford Pilot: General Approach

The CATC Meaford pilot session was a complete pilot of the whole anthropometric data collection process. A total of six vehicle bays in the Operations and Training Building at CATC Meaford were used to house the survey stations. Separate stations were set up using portable posts, fabric walls and guy wires. Extension cords were used to power the data collection stations. Participants were able to use male and female change lockers next to the vehicle bays as change rooms. The stations included the following:

- Intake
- Change rooms (utilizing existing facilities)
- Station 1: Anthropometer
- Station2: Calipers
- Station 3: Tape
- Station 4: BoSS XXI
- Station 5: Vitus XXL

Participants were required to complete one measurement session. Due to work hours, afternoon data collection was limited to approximately 1530hrs. Pilot data collection was captured over the course of two days.

The focus of the CATC Meaford pilot tests was on assessing observer expertise and intra-observer error. Timings were captured for all aspects of the study, including:

- Vehicle off-loading
- Total site set-up
- Calibration
- Subject throughput
- Site tear down
- Vehicle loading

The final focus of the CATC Meaford pilot trial was on capturing additional resource requirements.

3.5 Landmarking

At the landmarking station, landmarks were identified by observation, palpation and joint movement. Once a landmark was identified a cross, line or dot was drawn on the participant using a water soluble black eye-liner pencil or indicated using a black-and-white roundel sticker of 1cm diameter. Scye marking aid, landmark transfer rod and wooden step stool were used to help locate/transfer certain landmarks.

3.6 Traditional measuring stations

At the traditional anthropometry measuring stations teams of measurers and recorders captured the dimensions of a variety of measures. Measurers of the same gender as the participant were utilized for obtaining intimate measures (e.g. chest circumference and crotch height). Two measurements were taken for each measure per participant. Third measurement was taken if the difference between the initial 2 measurements was outside of the allowable error. The pair of measures within the allowable measures were recorded and their mean value calculated. The data recorder entered each measurement value directly into an electronic data form. Between participants, the anthropometric instruments were sanitized with alcohol wipes. The following dimensions were captured in each measuring station:

3.6.1 Station 1: Anthropometer

- Stature
- Eye Height, Standing
- Acromial Height
- Crotch Height
- Sitting Height
- Eye Height, Sitting
- Acromial Height, Sitting
- Elbow Rest Height, Sitting
- Thigh Clearance
- Knee Height, Sitting
- Popliteal Height
- Buttock-Knee Length
- Buttock-Popliteal Length

3.6.2 Station 2: Calipers

- Chest Breadth
- Hip Breadth
- Foot Length
- Biacromial Breadth
- Bideltoid Breadth
- Hip Breadth, Sitting

- Hand Length
- Hand Breadth
- Index Finger Length
- Menton-Sellion Height
- Bizygomatic Breadth
- Head Breadth
- Head Length
- Foot Breadth
- Interpupillary Breadth
- Weight

3.6.3 Station 3: Tape

- Vertical Trunk Circumference (ASCC)
- Arm Length
- Cervicale-Wrist length
- Scye Circumference
- Elbow Girth
- Chest Circumference
- Waist Circumference (Omphalion)
- Buttock Circumference
- Outer Leg Length
- Sagittal Arc
- Bitragion Coronal Arc
- Hand Circumference
- Acromial Wall Depth
- Span
- Thumb tip Reach
- Thumb tip Reach, extended
- Wrist-Wall Length

3.7 Data input tool

Measurement values were directly entered at each station into a Microsoft Excel database. This database allowed the recorder to input information about the subject (subject number, sex), the measurer and the recorder prior to inputting measurement values for each participant. For each measure, automatic validity check was running in the background of the database. If the input measurement value was outside of the allowable measurement error, the input cell turned orange; if the input measurement value was outside of ±3 standard deviations of the equivalent measure in the 1997 LF Anthropometry Survey (Chamberland, et. al, 1998), the input cell turned pink. This automated

validity check allowed for rapid identification and correction of any errors that might have arose during measurement.

4 Lessons Learned

4.1 General

- An all-female measurement day worked well. Some females did not want the chance of co-workers seeing them in robes, let alone compression shorts and sports bras.
- Some females requested all female measuring and recoding teams. Future surveys should have the capability to have dedicated female teams.
- Some bases brought in coffee and snacks for the participants. The refreshments were well received.
- Some bases provided box lunches for personnel finishing up over the lunch hour. Having a number of box lunches available soothed some angst over working into lunch.

4.2 Participant Recruitment

- Formal Command and Base Commander support is necessary to recruit volunteer participants. Without proper support sufficient participation was difficult to achieve.
- Base OPIs need to be provided with participant sampling goals. These goals should be forwarded to individual units to identify who we would like to measure.
- OPI's who developed an individual booking appointment calendar were more successful than those who simply asked units to send personnel in the morning or afternoon.
- Depending on the time of the appointment, the time taken to complete the survey could be as much as 2.5 hours.
- If individual bookings are being made a "joining instruction" email should be sent to remind participants to bring a robe and slippers.
- Some personnel were ordered to go to the survey and since participation was discretionary a number of personnel did not volunteer after hearing the briefing. Protocols on what to do with these non-participants needs to be refined. Some personnel simply sat in the waiting area for 2 hours, others went off for personal administration and still some went back to work. Ethically non-participants should not be penalized for non-participation.

4.3 Setup

- Facilities should permit the use of the hand truck when off-loading and positioning supplies. The presence of stairs significantly increases workload and the time to set up the site.
- The use of aluminum posts with weighted bases was problematic. The weight of the sheets caused walls to sag. In order for the wall-concept to work ropes were tied off on existing anchors where ever possible. Some sites did not have enough tie-down points. Approximately 500 kg of bagged

salt was used to weigh down the bases. The movement of the salt was challenging. The use of portable/rapid shelters is recommended.

- Concerns were raised with the female change facility at one site. A second floor (hangar) balcony over looked the site and it may have been possible to see areas of the change room. Dedicated change tents are recommended.
- Not enough tables and chairs were provided by the bases. Two of the tables and one of the chairs were broken. Lighter weight tables and chairs should be secured for future measurement sessions.
- The table cart borrowed from DRDC-T was useful. Future sessions should make use of a similar cart.
- A chair cart with appropriate sized chairs would facilitate set-up and tear down.
- One of the power bars provided by DRDC-T was damaged – it sparked when used for the first time. All equipment should be inspected for serviceability.
- The team should acquire a roll of 8-strand parachute cord (MIL-C-5040 Type III 550#). A partial roll was donated by CATC Meaford and it proved invaluable for the remainder of the Phase II survey.

4.4 Intake

- A display banner should be used to visually present the measurement process. The banner should be augmented by a PowerPoint presentation describing the process in detail.
- Time should be taken to orally brief participants on the purpose of the CFAS and the content of the informed consent form to ensure participants understand why certain measures are taken, and they feel comfortable participating in the survey.
- It should be emphasized that all measurement scans that can identify an individual are confidential, and participants' demographic information is Protected.
- Participant should be aware of the option to opt out of participation at any one of the scanner or traditional anthropometry measuring stations.
- If participant wishes to opt out from certain measuring station – the intake personnel should cross out that particular station on the participant's sheet with a visible marker.
- Master sheets should include a space to record rank. Some individuals were upset when young measurers used the term "sir" as a measure of respect. Adding rank to the master sheet will eliminate this problem.
- Disposable paper slippers did not work very well. The universal size was often too small for male participants. Furthermore, the slippers often tore already at the first station (landmarking), resulting in some participants walking bare foot from station to station.
    - Examine purchasing :

      Scuffs disposable slippers
      http://www.bhmedwear.com/products.asp?product_id=10136&dept_ID=1145

BH-1650 slippers
http://www.bhmedwear.com/products.asp?product_id=10135&dept_id=1145&parent_id=1128

- Patient robes worked well for participants who did not bring their own gowns.
- Each participant should be advised to wear the issued white compression shorts over their own underwear.
- Sizes XL and XXL female compression shorts need to be purchased to accommodate heavier female participants. Female participants that did not fit into the L size felt uncomfortable wearing male XL shorts.
- Sizes XL female bras need to be purchased to accommodate heavier female participants.
- More chairs are required.
- Compression shorts and sports bras need to be numbered and accounted for by the intake and out take personnel. The compression shorts were highly sought after by some personnel.
- Some participants did not receive warnings as to what to bring to the survey, i.e. their own robe as well as running shoes or slippers.

4.5 Landmarking

- Systematically organized landmarking order (top down order, landmarks grouped by tool, and landmarks grouped by posture) allowed landmarkers to work faster and more efficiently.
- Landmark lists (both a list and a visual image) are kept nearby to serve as a checklist.
- If two landmarkers work simultaneously in two separate stations, the most effective way to cooperate is:
    - Landmarking station 1 - prepares participants for traditional measurement stations (Anthropometer, Calipers, Tape) and marks participants with drawn landmarks only.
    - Landmarking station 2 - prepares participants for scanner stations (Vitus, BOSS) and marks participants with drawn landmarks and scanner stickers over top of the drawn landmarks.
    - The above strategy allows participants to gradually disperse to all stations.
- All drawn landmarks are represented with a cross, except omphalion (horizontal line) and infraorbitale landmarks (dot).
- Various eyeliner pencil brands, types and colors were tested. Black wooden eyeliner pencil worked the best. Cheaper eyeliners (e.g. Annabelle) worked very well for landmarking purposes.
- A QUO pencil sharpener was used to keep the tips of the pencils sharp and to sanitize the tip after each participant. Multiple sharpened pencils were kept within reach at all times.
- Coloured labels did not work well with the Vitus XXL scanner, except for jet-black stickers (site-modified) the stickers did not show up well in the Vitus XXL grey scale images. Black and white roundel-style circular stickers (black on white and white on black) proved to be the best landmark label for the 3D scanners. Printed circular Avery-style labels were not accurate, i.e

when the label was peeled away from the sheet the circle was off-center. Die-cut labels were ordered.

- Some participants preferred to engage in very little conversation with the landmarkers, others preferred to be told what landmark is going to be marked next. Either strategy has shown to be effective, as long as the landmarker does not get distracted by the conversation.
- Tape marking on the floor of the station guide participant to stand clear of the table (or any other obstacles).
- Issues with reliably locating the deltoid landmark at stand #2 necessitated the inclusion of this landmark.
- Feedback during Phase II identified the need to better locate the ectocanthus for eye height measurements. Eye height is currently measured by placing the anthropometer probe arm close to the side of the eye. Adding a line parallel to the ectocanthus allowed measurement away from the corner of the eye.

4.6 BoSS XXl

- *For DRDC*
- The BoSS requires the use of fluorescent lighting. Halogen lighting in aircraft hangers is incompatible with the system. This limitation was overcome by placing the system near windows and augmenting illumination with portable light stands.
- If future measurement is under taken in hangers, then the efficacy of conducting BoSS measures under an overhead cover (portable tent fly) should be evaluated.
- BoSS required the use of green shorts.

4.7 Vitus XXL Scanner

- *For DRDC*
- Care must be taken to insure the scanner heads are returned to the base position prior to dismantling the system for transport. If the scanning heads are not in the proper position the traveling safety locks will not work.

4.8 Vitus aHead Scanner

- *For DRDC*
- The aHead scanner requires an adjustable stool with a backrest. Although a stool was used in the station it did not have a backrest and some participants fell off the stool as they assumed the anthropometric seated position.
- Care must be taken to insure the scanner heads are returned to the base position prior to dismantling the system for transport. If the scanning heads are not in the proper position the traveling safety locks will not work.

4.9 Pedus Foot Scanner

- *For DRDC*

- The Pedus required the use of a cloth drape to reduce light emissions. The efficacy of conducting Pedus measures under an overhead cover (portable tent fly) should be evaluated.
- A hand rail is required with the Pedus
- The scanner should be raised to facilitate hand scanning. This may require a series of steps to facilitate foot scanning
- A stylion landmark is required on the scanner to facilitate hand placement.

4.10 Anthropometer Station

- Rearranging the order in which measures are taken such that error is inherently decreased. It was very challenging to replicate seated buttock knee and buttock-popliteal measures if the participant stands up between measures. Participants were not proficient at sitting the same way against the back rest.
- Differences in seated height and seated eye height were often attributed to changes in subject posture. Subjects would relax and slump slightly. When conducting repeated measures subjects must be prompted to adopt the proper seated sitting position.
- Measures should be grouped by tool.
- Measure all standing postures twice before the participant moves to a different posture (seated).
- Utilize a step stool to reduce parallax errors in tall standing subjects.
- The protocol for measuring crotch height was modified from the ANSUR approach. Rather than the measurer exerting pressure until the blade of the anthropometer was in firm contact with the crotch, the protocol was amended to have the subject raise the blade until firm contact was made.
- Ensuring that measuring is a team task whereby the recorder observes the measurers technique and critiques as necessary.
- Maintaining a consistent 'script' between participants that is clear, direct, and without any extraneous instruction.
- Having physical markers on the ground that orients the participant such that measurement is unobstructed and easy.
- Clamps were purchased to secure the planks to the back of the seated table back rest. When not secured the spacers had a tendency to angle in (towards the buttocks) at the bottom.
- Frequent movement of the anthropometer out of its base and frequent separation of the anthropometer sections is required. As a result the joints between anthropometry sections loosened off considerably and the anthropometer attachment point separated from the base.
- A number of participants commented on the "garage-like" appearance of the measuring table. If funds permit a more professional bench should be built.

4.11 Caliper station

- Spending more time positioning the participants (to reflect the proper measurement position) than actually measuring them increases measurement effectiveness. Correct positioning of participants will ensure that any subsequent measurements are valid.
- Providing instructions on the next measurement as the previous measurement is taking place saves overall time per participant.
- Provide concrete examples on how participants should place their arms as well as physical focal-points for where participants should be looking or standing.
- Use teamwork between recorder and measurer to allow the measurer to have a break from talking. Assign certain posture explanations to the recorder. Also, the recorder can clean tools while measurer measures with different tools.
- Always place measuring tools and materials to their specific designated locations. Keep the overall station layout consistent amongst various CFB locations. Ideally, the station layout should look exactly the same at each location, except for size of the station itself.
- Cut out descriptions of measurements that you are going to do; participants generally do not care about the details.
- Originally bi-deltoid breadth landmarks were identified visually by the measurer in stand #2 and this approach led to inter-measurer variability. Deltoid landmarks were marked in the landmarking stand to eliminate variability.
- Originally chest breadth was measured by placing the blades of the beam caliper on the sides of the chest and having the subject squeeze their arms together. This approach led to considerable variability. Instead the ANSUR approach was utilized where the arms were held away (abducted) enough to allow the blades to be positioned at the lateral edges of the chest. Even with this approach care was required to not include the Pectoris Major and Latissimus Dorsi muscles.

4.12 Tape station

- Rearranging the order in which measures are taken (more anatomically oriented order categorized by posture) such that error is inherently decreased.
- Arranging the measurements by posture, and repeating each measurement twice before proceeding to the next posture, decreases the amount of time each participant spends at this station.
- By rotating between measurer and recorder in a sequence of 5-10 participants, both, the recorder and the measurer are able to stay alert throughout the day.
- Recorder should help measurer with specific measurements to ensure correct procedures are followed.
- Measuring twice or three times if one of the measurements is outside of the allowable error ensures greater accuracy.

4.13 Out processing

- *For DRDC*
- Positive control is required to ensure that all equipment and clothing loaned to the survey participants is returned.

5 Timings

- The results of the CATC Pilot study indicate that 36 to approximately 45 subjects could be measured every day if the participants are properly scheduled. Conducting a full repeat of all traditional measures is possible as the Vitus XXL appears to be the rate limiting station.
- The average length of time to complete a traditional measurement station is between 10 and 12 minutes.
- The plan of conducting three readings for each measure was not practical if a throughput of 40 subjects a day is desired. The use of two readings and the error checking algorithm allowed the team to achieve its measurement goals.
- The intake stand requires support at the beginning of each morning and afternoon session.
- Vehicle off load and site set up takes approximately 4 hours with a full crew.
- Site tear down and vehicle load takes approximately 2 hours with a full crew.

6 Resources

- Extra tables and chairs are required. The current plan identified the need for 7 six foot tables, 12 folding chairs and 10 benches. Some of the chairs and all of the benches requested were not provided. Extra chairs had to be borrowed from CATC and other base support personnel.
- The folding chairs were metal-backed and thus uncomfortable for the participants wearing gowns. Soft-backed chairs will be better.
- The folding chairs were transported in tri-wall boxes. Purpose-built chair racks will make transport and set-up easier and faster.
- The tables provided were in poor repair and one was unusable. The intake station requires three tables and a total of 10 tables are required. A table rack was borrowed from DRDC-T, this rack was invaluable.
- The four heavy duty power cables were used in CATC Meaford. If longer distances are required then additional cabling may be necessary.
- The temperature in the CATC building was cool if not cold. Personnel in the hospital gowns were cold. Additional blankets, warmer robes may be necessary if this survey is done during the winter.
- The paper slippers were not effective. The slippers tore and were not functional for many. The participants were informed ahead of time to bring their own sandals and running shoes but

many did not read the message or were informed of this requirement. The message provided to units should highlight the desire for the participants to bring proper foot gear.

- A number of individual use razors were purchased for use in the landmarking stand. None of the pilot personnel required the use of the razors.
- The compression shorts were highly sought after items and several participants were reminded to return the garments upon completion. The out processing station needs to include return of garments in its process protocol.

7 Personnel

- The pilot study identified the need for two personnel at each measuring stand (traditional and Vitus XXL). While one staff conducts the measurement the other acts as a data recorder.
- The traditional data collection stand observers and recorders need to spell each other off. While some switched at every noon, others identified the need to spell each other off more often.
- Some observers from DRDC-T were not comfortable with the level of training received. Future training should include a minimum number of personnel measured (i.e. 20/30) that a measurer should assess.
- Future training should include a formal test of measurer and landmarker competence.
- Two personnel are required for landmarking. The landmarkers must include a male and a female. The female landmarker also assisted other measurement stands if a female requested an all-female measuring crew.
- The BoSS station appeared to require one measurer.
- The Intake station appeared to require one person but there were occasions when more than one person appeared necessary.
- One supervisor is also required to oversee the overall anthropometric data collection process. Supervisors are currently embedded in data collection stations and thus are not able to observe the other stands, deal with problems, etc. Currently there is no back-up in case of illness.
- A total of 14 personnel are required to effectively and efficiently conduct the survey:
    - Intake x 1
    - Vitus XXL x 2
    - Vitus aHead, Pedus and BoSSx 2
    - Landmarking x 2
    - Traditional measurement x 6
    - Supervisor x 1

8 Intra-observer Error

During the development of the anthropometric data collection plan the quality assurance approach utilized in the ANSUR program (Gordon et al., 1989) was reviewed for its efficacy. The ANSUR approach involved the re-measuring of two subjects every day. This approach would have meant the provision of 10 subjects per week for the assessment of daily observer error. The approach utilized in the CFAS 2012 was the complete re-measuring of every dimension for every subject. Although the original plan identified a total of two replicates (or three measures per dimension) time only allowed two measures per dimension.

During the initial DRDC-T pilot trial the input spreadsheet was still in its development stage and as a result, data was hand recorded. Error limits were noted on the data collection sheet to identify when observations were outside the error limits.

Captured measures were entered into the input template. The input table included an algorithm to determine if the value entered was within the limits of the 1997 CLFS. If the value entered was outside the limit the cell was flagged in red while measures within the limit were flagged green. This approach captured transcription and data entry errors. It should be noted that some captured dimensions were outside the limits of the 1997 CLFS (min and max). In this case, careful review of the measure and participant was conducted to determine the validity of the dimension. All dimensions were measured twice and if the two recorded measures were outside the allowable error limits the second dimension was flagged in orange. Allowable observer error was based on the limits developed for ANSUR and are detailed in Annex A. The recorder then notified the observer to repeat the measure for a third time. If the third measure was within the allowable error of the second measure the error flag disappeared (turned green). A software limitation meant that the first number entered was always the standard by which the others were compared to and as a result it sometimes became necessary to replace the first number with the second (e.g. the second and third numbers were within allowable limits). The replacement of the first number entered thus affected the capture of measurement errors. On the inputted spreadsheet the replacement of the first number made it appear as if all measures were within limits.

The intra-observer errors noted during the DRDC-T Pilot Trial and the CATC Meaford Pilot Study for anthropometry stands 2 and 3 are detailed in Table 1 and 2. The DRDC-T pilot was conducted immediately after initial anthropometric training while the CATC pilot was conducted after a week of additional training.

Over the course of one week the number of measures outside of limits at stand #2 for measurer B dropped from approximately 18% to 6% - see **Table 1**. The number of measurers outside of limits for measurer C did not change significantly while at CATC Meaford (7.1% vs. 8.1%). Chest breadth, bideltoid breadth and hip breadth sitting were problematic measurements. Changes to measurement protocols with chest breadth and bideltoid breadth significantly reduced error. Issues with measurer B and hip

breadth sitting were resolved with a review of measurement sites, initially this measure was not including the most lateral aspects of the thighs.

Table 1: *Observer Error DRDC-T & CATC Meaford Station #2*

Observer	B		B		C		C	
Location	DRDC-T		Meaford		Meaford		Meaford	
Date	24-Jan		7-Feb		6-Feb		7-Feb	
Total number of subjects measured	8		10		3		7	
	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits
Chest Breadth	5.6	5	0.4	1	0.2	0	0.5	2
Hip Breadth	2.1	1	3.8	1	0.4	1	0.4	0
Foot Length	0.6	0	0.1	0	0.1	0	0.1	1
Biacromial Breadth	1.5	0	0.4	1	0.5	0	0.3	1
Bideltoid Breadth	3.0	3	0.7	1	0.3	0	0.2	0
Hip Breadth, Sitting	2.4	3	0.6	3	0.3	0	0.2	1
Hand Length	0.9	0	0.2	0	0.3	1	0.1	0
Hand Breadth	0.7	1	0.1	0	0.0	0	0.1	0
Index Finger Length	0.4	0	0.0	0	0.1	1	0.1	1
Menton-Sellion Height	1.3	2	0.1	1	0.1	0	0.2	1
Bizygomatic Breadth	0.4	1	0.1	0	0.0	0	0.0	0
Head Breadth	0.4	1	0.1	0	0.0	0	0.0	0
Head Length	0.8	2	0.1	1	0.0	0	0.0	0
Foot Breadth	-	-	0.1	0	0.1	0	0.1	1
Weight	-	-	-	-	-	-	-	-
Total number of measures outside of limits vs total number measured		**19**/104		**9**/140		**3**/42		**8**/98

Differences in inter-measurer error were noted at the beginning of the survey. After approximately 30-50 measurements on different subjects, inter-observer error reduced to similar levels for two different measurers. Although measurer B had more initial experience than measurer C, this measurer was involved in refining measurement protocols (chest breadth and hip breadth sitting). Measurer C benefitted from the lessons learned and refinements.

Over the course of one week the number of measures outside of limits at stand #3 for measurer D dropped from approximately 25% to 0 – see **Table 2**. The number of measurers outside of limits for measurer E dropped from approximately 26% to 3%. Issues with measurement error dropped with more experience.

Table 2: *Observer Error DRDC-T & CATC Meaford Station #3*

Observer	D		D		E		E	
Location	DRDC-T		Meaford		DRDC-T		Meaford	
Date	24-Jan		7-Feb		24-Jan		7-Feb	
Total number of subjects measured	4		8		6		10	
	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits	Average error (cm)	Number outside limits
Vertical Truck Circumference (ASCC)	0.8	1	0.8	0	1.5	2	0.9	1
Arm Length	0.2	0	0.3	0	0.2	0	0.5	0
Cervicale-Wrist Length	0.3	1	0.5	0	0.9	2	0.4	0
Scye Circumference	0.2	0	0.5	0	0.6	2	0.5	0
Elbow Girth	-	-	0.3	0	-	-	0.3	0
Axillary Arm Circumference	-	-	0.4	0	-	-	0.4	0
Chest Circumference	1.2	2	0.6	0	0.9	2	0.9	2
Waist Circumference (o)	1.3	1	0.6	0	0.4	1	0.4	0
Buttock Circumference	0.4	0	0.5	0	0.3	0	0.5	0
Outside Leg Length	-	-	0.2	0	-	-	0.3	0
Sagital Arc	0.9	1	0.5	0	0.3	0	0.2	0
Bitragion Coronal Arc	0.4	1	0.2	0	0.3	2	0.3	0
Hand Circumference	0.2	1	0.1	0	0.1	1	0.1	0
Span	0.6	2	1.1	0	0.6	3	0.5	0
Thumbtip Reach	1.8	2	1.5	0	1.1	2	1.3	1
Thumbtip Reach, extended	0.7	1	1.6	0	1.0	2	1.1	1
Wrist-Wall Length	1.1	2	0.7	0	1.2	3	1.3	1
Acromion-Wall Depth	0.1	0	0.1	0	0.1	0	0.1	0
Interpupillary Breadth	0.1	1	-	-	0.2	3	-	-
Total number of measures outside of limits vs total number measured		**16**/64		**0**/144		**25**/96		**6**/180

As seen in tables 1 and 2 measurer error dropped with more experience. The CATC pilot provided the survey team with access to 39 participants. Observer error dropped with Over the course of Phase II of the CFAS the number of measures outside of limits at stand #1 for measurer A dropped from approximately 40% to 0. The number of measurers outside of limits for measurer E as well dropped from approximately 26% to 3%. Issues with measurement error dropped with more experience as well as with changes to the measurement protocols.

The parallax errors associated with standing eye height and stature were resolved by making a step stool available to the measurers. Measurement errors in buttock- knee or buttock- popliteal lengths were resolved by performing measurement replicates at one sitting.

It was observed that measurers were reluctant to move the blade of the anthropometer close to the corner of the eye when measuring eye height (standing and seated). An additional landmark was added –line parallel and in line with the ectocanthus (towards the posterior) which allowed the measurer to place the blade in a less dangerous position.

Errors were frequently observed when participants relaxed from the proper anatomical position. Although body slump was imperceptible to the observer and measurer, it was notable when measured. Stand instructions were revised to instruct the subject to sit or stand properly when conducting the second measure.

Table 3: *Observer Error DRDC-T & CFB Trenton Station #1*

Observer	**A**		**A**	
Location	**DRDC-T**		**Trenton**	
Date	**24-Jan**		**19-Apr**	
Total number of subjects measured	14		19	
	Average error (cm)	**Number outside limits**	**Average error (cm)**	**Number outside limits**
Stature	0.3	2	0.1	0
Eye Height, Standing	0.5	6	0.2	4
Acromial Height	0.9	5	0.1	1
Crotch Height	0.6	6	0.2	0
Sitting Height	0.4	6	0.1	1
Eye Height, Sitting	0.6	6	0.2	1
Acromial Height, Sitting	0.4	5	0.1	2
Elbow Rest Height, Sitting	0.5	6	0.1	1
Thigh Clearance	0.5	7	0.1	1
Knee Height, Sitting	0.2	9	0.1	2
Popliteal Height	0.3	3	0.1	0
Buttock-Knee Length	0.4	7	0.1	2
Buttock-Popliteal Length	0.4	5	0.1	0
Total number of measures outside of limits vs total number of measures		**73**/182		**15**/247

In the DRDC-T pilot session the rate of measurements outside of limits varied between 18% and approximately 40%; in the CATC Meaford pilot survey the rate varied between 0% and approximately 8%. The rate of measurement error dropped as data collection proceeded (133 re-measures on 24 January (DRDC-T) vs. 24 re-measures on 7 Feb). While this trend would suggest that measurement error could approach 0 it was not be possible for all measurements. Refinements in measurement protocol and experience (by 19 April approximately 700 subjects had been measured) reduced "observer error" to approximately 5% across all measurers. These results support the ISO approach of conducting replicates for each measure. Even with highly trained observers, participant breathing and relaxation changed heights etc.

Differences between two measures were called observer error but in many cases it was not observer error per se but rather the participants had changed their posture. Standing and sitting erecting in the anatomical standing and sitting position was a novelty for a number of subjects. The postures utilized seldom used muscles on some subjects causing fatigue; between measures the subjects would unconsciously relax their spine and slump down changing heights. As well some subjects unconsciously adjusted the angle of their shoulders and head.

9 References

Chamberland, A., Carrier, R., Forest, F., Hachez, G. (1998). 1997 Anthropometric Survey of the Land Forces, DCIEM Report 98-CR-15. Defence and Civil Institute of Environmental Medicine.

Mangan, B. and Angel, H. (2012) Human Factors Plan: 2012 CF Anthropometric Survey. In process DRDC Toronto.

NC3RS Experimental Design Working Group (2006). Why do a pilot study? Retrieved on 31 march 2012 from http://www.nc3rs.org.uk/downloaddoc.asp?id=400

Annex A: Allowable Observer Error

The table below outlines the allowable observer error limits, which were used as a quality control measure to evaluate measurer reliability. Measures were deemed reliable if the absolute difference between two consecutive measures was within the limits indicated below.

A.1 : Maximum allowable observer error

Dimension	Allowable Error (mm)
Abdominal Extension Depth, Sitting	10
Acromial Height	7
Acromial Height, Sitting	9
Acromion-Radiale Length	4
Ankle Circumference	4
Axilla Height	10
Axillary Arm Circumference	8
Ball of Foot Circumference	4
Ball of Foot Length	6
Biacromial Breadth	8
Biceps Circumference, Flexed	6
Bideltoid Breadth	8
Bimalleolar Breadth	2
Bispinous Breadth	3
Bitragion Chin Arc	8
Bitragion Coronal Arc	7
Bitragion Crinion Arc	5
Bitragion Frontal Arc	5
Bitragion Submandibular Arc	6
Bitragion Subnasale Arc	6
Bizygomatic Breadth	2
Bustpoint/Thelion-Bustpoint/Thelion Breadth	10
Buttock Circumference	12
Buttock Depth	8
Buttock Height	7
Buttock-Knee Length	6
Buttock-Popliteal Length	7
Calf Circumference	5

Dimension	Allowable Error (mm)
Calf Height	3
Cervicale Height	7
Cervicale Height, Sitting	10
Chest Breadth	8
Chest Circumference	15
Chest Circumference at Scye	15
Chest Circumference below Breast	16
Chest Depth	4
Chest Height	11
Crotch Height	10
Crotch Length (Natural Indentation)	16
Crotch Length (Omphalion)	18
Crotch Length, Posterior (Natural Indentation)	11
Crotch Length, Posterior (Omphalion)	11
Ear Breadth	3
Ear Length	2
Ear Length above Tragion	2
Ear Protrusion	3
Elbow Circumference	4
Elbow Rest Height	10
Eye Height, Sitting	8
Foot Breadth, Horizontal	2
Foot Length	3
Forearm Circumference, Flexed	5
Forearm-Forearm Breadth	17
Forearm-Hand Length	4
Functional Leg Length	17
Gluteal Furrow Height	6
Hand Breadth	2
Hand Circumference	4
Hand Length	3
Head Breadth	2
Head Circumference	5
Head Length	2
Heel Ankle Circumference	6
Heel Breadth	2
Hip Breadth	7

Dimension	Allowable Error (mm)
Hip Breadth, Sitting	6
Iliocristale Height	5
Interpupillary Breadth	2
Interscye I	10
Interscye II	13
Knee Circumference	4
Knee Height, Midpatella	6
Knee Height, Sitting	2
Lateral Femoral Epicondyle Height	3
Lateral Malleolus Height	3
Lower Thigh Circumference	4
Menton-Sellion Length	3
Midshoulder Height, Sitting	9
Neck-Bustpoint/Thelion Length	8
Neck Circumference	6
Neck Circumference, Base	11
Neck Height, Lateral	7
Overhead Fingertip Reach	20
Overhead Fingertip Reach, Extended	20
Overhead Fingertip Reach, Sitting	20
Popliteal Height	7
Radiale-Stylion Length	6
Scye Circumference	13
Scye Depth	4
Shoulder Circumference	22
Shoulder-Elbow Length	6
Shoulder Length	3
Sitting Height	6
Sleeve Length: Spine-Elbow	10
Sleeve Length: Spine-Scye	11
Sleeve Length: Spine-Wrist	9
Sleeve Outseam	6
Span	10
Stature	10
Strap Length	12
Suprasternale Height	5
Tenth Rib Height	5

Dimension	Allowable Error (mm)
Thigh Circumference	6
Thigh Clearance	3
Thumb Breadth	2
Thumbtip Reach	20
Trochanteric Height	7
Vertical Trunk Circumference (ASCC)	22
Vertical Trunk Circumference (USA)	24
Waist Back Length (Natural Indentation)	5
Waist Back Length (Omphalion)	5
Waist Breadth	6
Waist Circumference (Natural Indentation)	11
Waist Circumference (Omphalion)	12
Waist Depth	8
Waist Front Length (Natural Indentation)	5
Waist Front Length (Omphalion)	5
Waist Height (Natural Indentation)	4
Waist Height (Omphalion)	7
Waist Height, Sitting (Natural Indentation)	6
Waist Height, Sitting (Omphalion)	8
Waist-Hip Length	6
Waist (Natural Indentation) -Waist (Omphalion)	3
Weight	.3kg
Wrist-Center of Grip Length	4
Wrist Circumference	5
Wrist Height	11
Wrist Height, Sitting	10
Wrist-Index Finger Length	4
Wrist-Thumbtip Length	3
Wrist-Wall Length	20
Wrist-Wall Length, Extended	20

List of Acronyms/Abbreviations

ANSUR	Canadian Army
CATC	Canadian Army Training Centre
CFAS	Canadian Forces Anthropometric Survey
DRDC-T	Defence Research and Development Canada – Toronto Research Centre
OPI	Office of Primary Interest

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