AIS

AUSTRALIAN HIGH PERFORMANCE SPORT SYSTEM

DUAL-ENERGY X-RAY ABSORPTIOMETRY

Technician Best Practice Protocols for DXA Assessment of Body Composition - GE Lunar

CONTRIBUTORS

These Best Practice Protocols are an initiative of the Australian High Performance (HP) Sport System. The Australian Institute of Sport (AIS) acknowledges the support of members of the National Institute Network (NIN) and National Sporting Organisations (NSO) and their staff.

ACKNOWLEDGEMENTS

These Best Practice Protocols received contributions from Gary Slater (AIS), Nicole Townsend (AIS), Aimee Morabito (AIS & ACU), Louise Burke (ACU), Chris Schultz (ANZBMS), Denise Brookes (ANZBMS), Ava Farley (UniSC), Jarrod Meerkin (MeasureUp), and Kagan Ducker (Curtin University). The AIS acknowledges the contribution Australian Catholic University (ACU) have made to advancing best practice protocols for assessment of body composition, through the sponsorship of several PhDs focusing on DXA precision. Thanks goes to the ASC Media and Communications, and Production and Design teams for their important roles in the delivery of these resources.

OBJECTIVE

These Best Practice Protocols aim to support optimal assessment of body composition via dual-energy x-ray absorptiometry (DXA) of athletes in the Australian HP Sports System, particularly athletes associated with the NIN and NSOs. They are targeted to the DXA Technician ("Technician") and provide information on acquisition and analysis of total body composition scans. This summary is specific to GE Lunar DXA machines, including the iDXA and Prodigy. These protocols also contain important considerations for the Technician that are not manufacturer specific. These address relevant issues including radiation safety, precision error, hygiene practices, athlete engagement, informed consent, plus athlete preparation and presentation.

This document does not contain details of site specific DXA scans used to assess bone mineral density (BMD). A detailed document specific to referring Practitioners is available in the **Best Practice Guidelines for DXA Assessment of Body Composition**, which provides higher level information to aid discussions relating to body composition assessment.

It is important that the information within this document is interpreted within the confines of state-based radiation health guidelines which provide specific recommendations on accepted referral sources and scan frequency.

SUMMARY

These Best Practice Protocols focus on the capture and analysis of total body composition data for the quantification of body composition, including bone mineral content (BMC), fat mass (FM), lean mass (LM), and relevant derivatives of these, at the total body and regional levels. When undertaking DXA scans for the assessment of body composition, it is important to adhere to Best Practice Protocols relating to acquisition and analysis of DXA data. This may assist in the identification of small but potentially important changes in body composition often observed among athletic population. Best practice also takes into consideration, and prioritises, the physical and emotional well-being of the athlete throughout the process, including appropriate informed consent prior to assessment, data capture and analysis, plus reporting, interpretation, and feedback to the athlete. Failure to comply with Best Practice Protocols for scan capture and subsequent analysis may result in data which are erroneous, leading to inappropriate clinical judgement and management protocols, and undue psychological stress for the athlete.

CONTENTS

ABBREVIATIONS

AIS – Australian Institute of Sport

AMS – Athlete Management System

ANZBMS – Australian and New Zealand Bone and Mineral Society

BMC – Bone Mineral Content

BMD – Bone Mineral Density

DE – Disordered Eating

DXA – Dual-energy X-ray Absorptiometry

ED – Eating Disorder

FM – Fat Mass

HP – High Performance

ISCD – International Society for Clinical Densitometry

ISAK – International Society for the Advancement of Kinanthropometry

LSC – Least Significant Change

LM – Lean Mass

NHANES – National Health and Nutrition Examination Survey

NIN – National Institute Network

NSO – National Sporting Organisations

PST – Performance Support Team

QA – Quality Assurance

QC – Quality Control

ROI – Regions of Interest

TBLH – Total Body Less Head

BACKGROUND

Dual-energy X-ray Absorptiometry (DXA) has been utilised historically as the reference technique to quantify bone mineral density (BMD) at specific sites of the body and to diagnose associated bone health disorders, including low bone mineral density and osteoporosis. This technology also has the capability to measure soft tissue, providing a means of quantifying body composition, including whole-body bone mineral content (BMC), fat mass (FM) and lean mass (LM), as well as information on regional composition (i.e., individual arms, legs, trunk). This makes DXA unique among body composition assessment techniques, and thus appealing to Performance Support Practitioners when assessing body composition of athletes.

Standardised subject preparation and scanning technique are critical for accurate and reliable measurements and as such, it is important that DXA Technicians are appropriately trained. Equally, athletes must be well informed on the importance of standardised preparation prior to a scan, given the potential impact on scan results. This document provides a thorough overview of Best Practice Protocols DXA Technicians must follow to support the capture of high-quality data amongst athletic populations.

Technical solutions are provided to accommodate the unique physique trait characteristics of some athletes. Tall, broad and/or particularly muscular individuals can be more challenging to assess for a variety of reasons, yet present commonly amongst athletic populations, especially in some sports. Furthermore, the significant training loads undertaken by athletes result in high fluxes in body water and muscle solute content, both of which impact estimates of body composition. Compliance with Best Practice Protocols will assist in mitigating the impact of these nuances implicit amongst athletic populations.

When undertaking a DXA scan, the physical and emotional well-being of the athlete must be considered and should remain a priority. As such, every reasonable effort must be made to avoid directly critiquing or commenting on the physical form, shape, size or weight of an athlete, regardless of whether it is believed to be true or helpful. Where appropriate, consideration should be given to gender compatibility between the Technician and athlete, with privacy in data collection and reporting always assured. Unless explicitly specified otherwise, DXA Technicians are to provide reports directly to the referring Practitioner, and not the athlete. Sensitivity should be shown to cultural beliefs and tradition. Procedures should be explained to those unfamiliar, with information provided in advance on what testing is to be undertaken and the rationale for it, plus specific requirements of the athlete in advance. While this is often facilitated by the referring Practitioner, it should be confirmed by the Technician.

DXA machines from different manufacturers have individual nuances such as the size of scanning areas, as well as differences in hardware and software, and reference database. Research confirms even different machines of the same manufacturer and model may provide different results. As such, the same DXA machine (and software) should be used for all longitudinal monitoring of athletes. When a machine is replaced (or hardware upgraded), cross-calibration procedures in line with recommendations of The International Society for Clinical Densitometry (ISCD) should be undertaken to facilitate consistency of data. Therefore, centres completing longitudinal scans of athletes must ensure their radiation license allows for a minimum of two DXA machines on site at one time. Likewise, if software is upgraded, it is important all scans on an individual athlete are reanalysed using the new software. Where possible, the same DXA Technician should undertake scans for all longitudinal monitoring of athletes.

DXA CONTRAINDICATIONS

Although the referring Practitioner should assess the appropriateness of a total body composition DXA scan prior to scheduling the athlete, it is critical that the Technician performing the total body composition DXA scan confirms any possible contraindications.

A DXA scan should NOT be undertaken under the following circumstances:

- **The athlete is < 18 years of age**, except when parental/carer informed written consent is provided, and a case for clear justification for data collection is supported.
- **Failure to identify a valid reason for the assessment of body composition** with the support of the Performance Support Team (PST).
  - The data gained from the assessment should be used to assess or inform training and/or nutrition interventions. The data gained from this assessment is integrated into a management plan for the athlete with input from the athlete's PST.
- **Past or current history of disordered eating (DE) or eating disorder (ED)** – The appropriateness of testing an individual athlete should be discussed with the athlete and relevant members of their PST.
- **Body image concerns** – An evaluation should be made of the risk that the assessment may exacerbate body image concerns, with consideration of processes and support that are in place to safeguard the athlete.
  - Where there is concern regarding potential negative implications to athlete wellbeing from an assessment of physique traits, athlete safety should always be prioritised. In making such decisions amongst the PST, validated screening tools relating to athlete eating behaviour and body image are available.
- **Failure to obtain athlete informed consent,** including failure to provide a thorough explanation of the protocol to the athlete, and where appropriate (i.e., <18 years.), their guardian, including rationale to why the scan has been requested, the requirements and risks of the scan, and subsequent informed consent.
- **Inability to provide athlete with guidelines on appropriate scan preparation** and/or athlete fails to comply with best practice guidelines for data capture.
- **Inability to schedule feedback to individual athletes** following scans on the interpretation of DXA results with an appropriate member of the athlete's PST. Typically, this would be the referring Practitioner.
- **Where a scan(s) will result in radiation exposure exceeding annual limits,** considering all other sources of radiation.
- **Athlete has been exposed to nuclear medicine examinations or radiographic agents in the previous 48 hours (IV agents) to two weeks (oral agents).**
- **Athlete weighs more than the machine's weight capacity.**
- **Athlete is, or suspects they may be pregnant, or is breastfeeding.**
- **Where all data related to body composition assessment (assessment, feedback, storage of data) cannot be treated as confidential health information with appropriate data security.**
- **Absence of appropriately trained and credentialed Technicians** to acquire and analyse the scan.
- **Lack of availability of appropriate equipment.** Equipment used in the assessment of body composition should be calibrated and maintained as per manufacturer's specifications and according to industry quality assurance standards. For longitudinal assessment, the same DXA scanner should be used each time.
- **Where precision error data (generated via between day repeat scans) specific to the Technician and DXA scanner are not available,** making interpretation of change impossible.
- **Para athletes – According to the type of impairment, some modification of the assessment protocol and interpretation of results may be needed.** If these cannot be accommodated, then the assessment should not proceed. For an athlete with an intellectual disability, considerations around the level of understanding of the entire process needs to be considered.

PRECISION ASSESSMENT

Knowledge of measurement precision is required for interpreting what constitutes a true and meaningful change. To perform a precision analysis, the ISCD recommend measuring 15 athletes three times, or 30 athletes twice, repositioning the athlete after each scan. In practice, longitudinal measures are taken weeks or months apart, and despite following recommended best practice protocols, some level of day-to-day biological variation will be present in variables such as hydration status and muscle solute content, both of which impact results. As such, precision error determined from consecutive day, following best practice protocols are advocated, given this considers both technical error and biological variation, and both contribute to precision when interpreting longitudinal change. The ISCD have a basic and an advanced **precision calculating tool** to assist with precision assessment data collection.

Once the precision error of a device is established, the least significant change (LSC) value can be calculated:

$$LSC = 2.77 \times \text{Precision Error}$$

The ISCD recommends the application of LSC for interpreting longitudinal body composition measurements. Thus, technician specific precision error for each DXA machine should be quantified. The ISCD recommend the minimum acceptable within-day precision for an individual technologist is 3% and 2% for FM and LM, respectively. However for interpreting longitudinal change, LSC for FM and LM should be quantified in grams.

QUALITY ASSURANCE AND QUALITY CONTROL PROTOCOLS FOR THE DXA MACHINE

Quality assurance (QA) and quality control (QC) protocols must be undertaken on any day scans are acquired, prior to the first scan. When the DXA machine is not in use, these protocols should be completed three times weekly.

Quality Assurance (QA)

Quality assurance requires use of a calibration block issued with the DXA machine as guided by the machine software **(Figure 1**). All other checks will run automatically once the process has started.

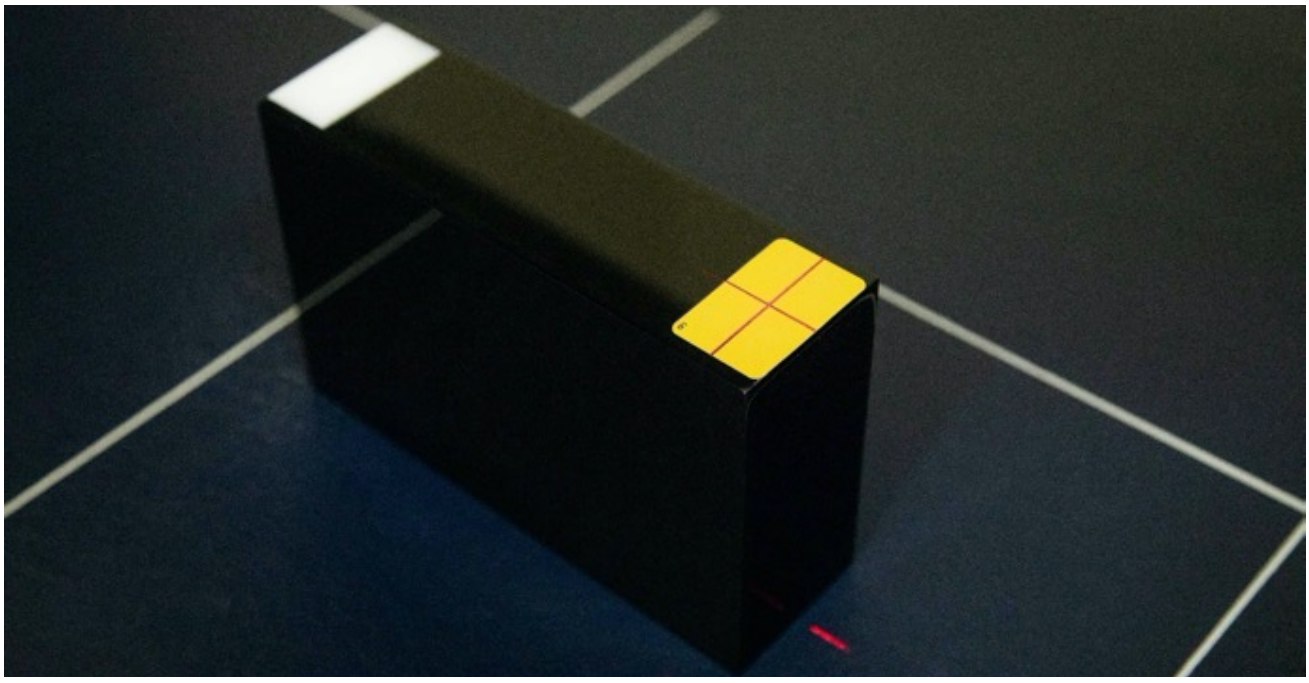


Figure 1. *Correct placement of routine quality assurance calibration block.*

1. In the enCORE software interface, click on *Quality Assurance*.
   Note: The screen may indicate that the daily QA has passed – this will refer to the previous day check and a new QA check should be undertaken.
2. Click on *Start* from the top menu bar. When prompted, place the calibration block in line with the laser as indicated by the diagram on the screen **(Figure 1)**.
3. Click *OK*. The DXA machine will run through a series of checks, which should take approximately 7-minutes.
   - If the screen indicates that QA has passed, save the QA report, and click Close from the top menu bar.
   - If the screen indicates that QA has NOT passed, reposition the calibration block and run the procedure again.
   - If the QA check does not pass a second time, do not proceed further. Notify your DXA Lead Technician who will liaise with their service contact or customer support at Getz Healthcare – 1800 886 385. **Do not conduct any further scans until the issue is resolved and QA passes.**

Quality Control (QC)

Quality control should be undertaken immediately after the QA measure. This requires the use of an encapsulated aluminium spine phantom of known BMD issued with the DXA machine **(Figure 2)**.

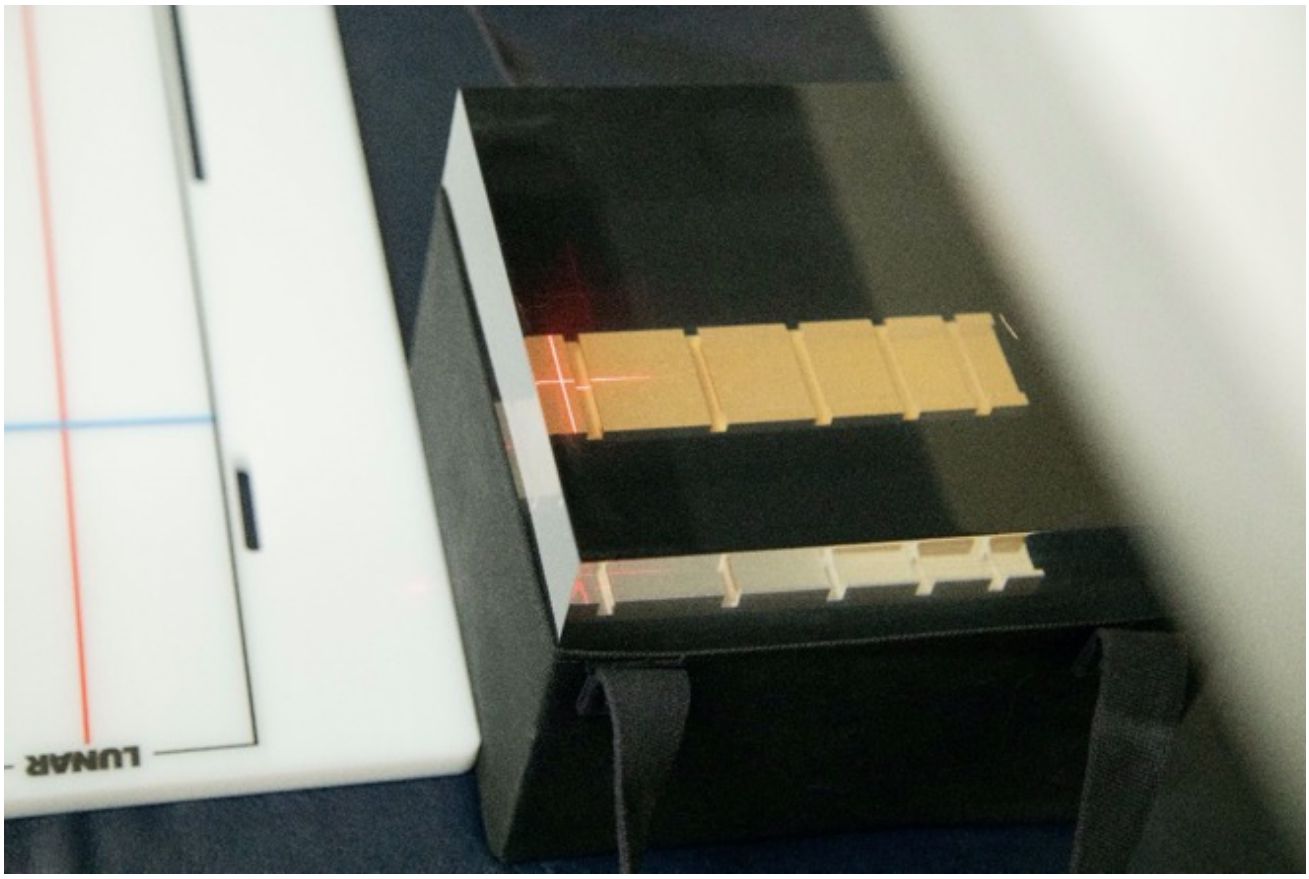


Figure 2. *Correct placement of quality control phantom spine block.*

1. Return to the enCORE directory and select the Phantom Spine from the appropriate database.
2. Select *AP Spine* from the skeleton **(Figure 3)**, and then *Position* from the top menu bar.

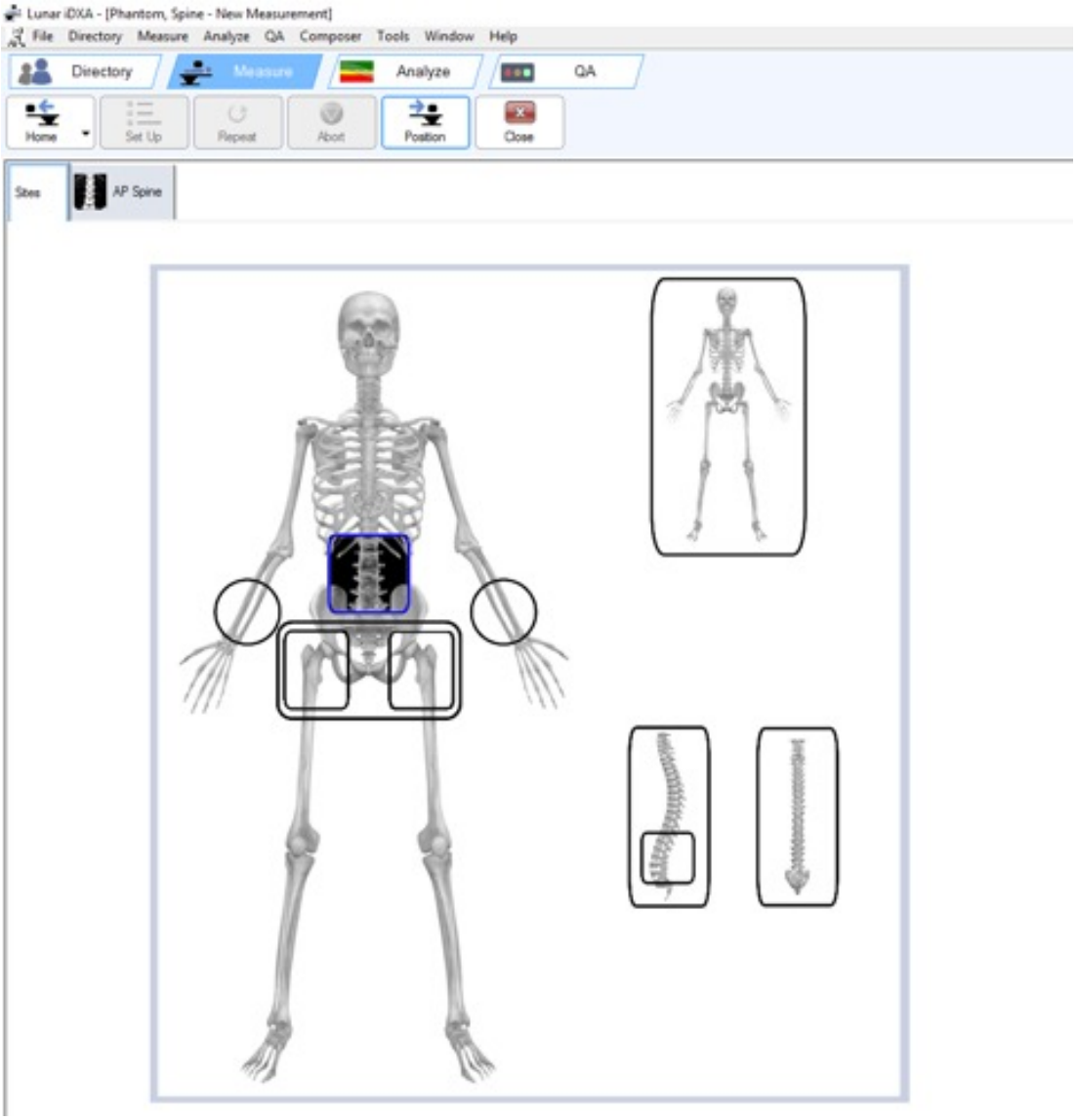
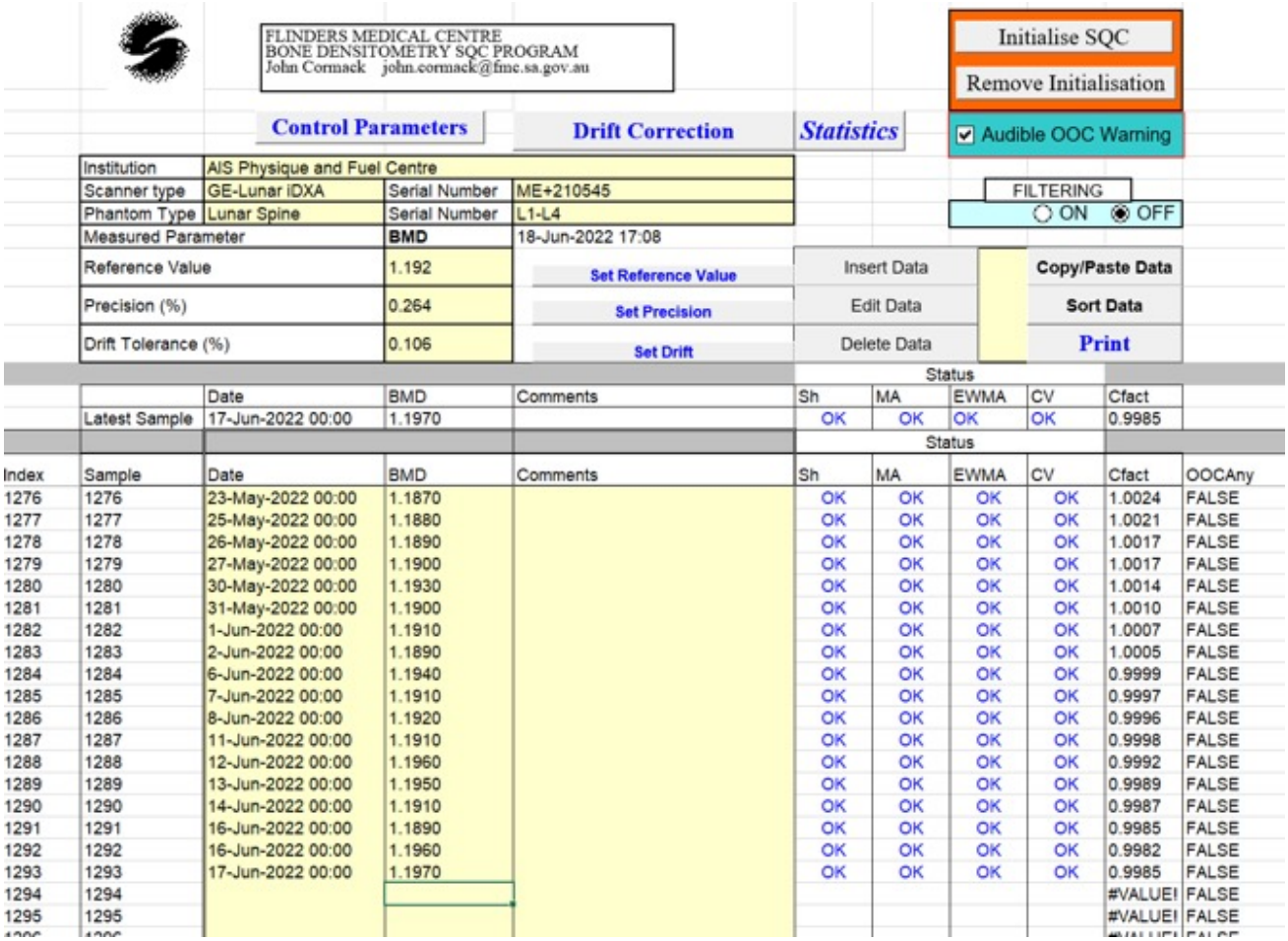


Figure 3. *Spine scan selection in the enCORE Measure interface.*

1. When prompted, place the spine phantom on the scan bed, aligning the laser over the ID and serial number on the phantom (**Figure 2)** and click *Start*.
   Tip: Use the forearm board to ensure the calibration block is square against the side of the DXA machine.
2. Once the spine scan is complete and in the analysis interface, click *Copy* and select the baseline QC spine scan to copy over regions of interest (ROIs) to the current scan.
   Note: To ensure each QC scan aligns with the baseline scan, ROIs should only be copied and not adjusted.
3. Click on *Densitometry* and record the BMD g/cm2 value for L1-4 in an appropriate spreadsheet **(Figure 4)** that is set up to detect drifts in the measurement of the spine phantom (e.g. John Cormack's Flinders Medical Centre DXA Statistical Control Spreadsheet).
   - If the spreadsheet indicates 'OK' across Sh, MA, EWMA and CV columns, continue with usual use of the DXA machine.
   - If the spreadsheet reports 'OOC' across any columns, repeat the QC procedure 5x.
   - If the spreadsheet continues to report 'OOC', do not proceed further. Notify your DXA Lead Technician who will liaise with their service contact or customer support at Getz Healthcare – 1800 886 385. **Do not conduct any further scans until the issue is resolved and QA passes.**
4. Once complete, click *Archive* to archive the database.



FLINDERS MEDICAL CENTRE
BONE DENSITOMETRY SQC PROGRAM
John Cormack john.cormack@fmc.sa.gov.au

Initialise SQC | Remove Initialisation | Audible OOC Warning

Control Parameters | Drift Correction | Statistics

Institution	AIS Physique and Fuel Centre		
Scanner type	GE-Lunar IDXA	Serial Number	ME+210545
Phantom Type	Lunar Spine	Serial Number	L1-L4
Measured Parameter		BMD	18-Jun-2022 17:08
Reference Value		1.192	Set Reference Value
Precision (%)		0.264	Set Precision
Drift Tolerance (%)		0.106	Set Drift

FILTERING: ON / OFF

Insert Data | Copy/Paste Data | Edit Data | Sort Data | Delete Data | Print

	Date	BMD	Comments	Status Sh	MA	EWMA	CV	Cfact
Latest Sample	17-Jun-2022 00:00	1.1970		OK	OK	OK	OK	0.9985

Index	Sample	Date	BMD	Comments	Status Sh	MA	EWMA	CV	Cfact	OOCAny
1276	1276	23-May-2022 00:00	1.1870		OK	OK	OK	OK	1.0024	FALSE
1277	1277	25-May-2022 00:00	1.1880		OK	OK	OK	OK	1.0021	FALSE
1278	1278	26-May-2022 00:00	1.1890		OK	OK	OK	OK	1.0017	FALSE
1279	1279	27-May-2022 00:00	1.1900		OK	OK	OK	OK	1.0017	FALSE
1280	1280	30-May-2022 00:00	1.1930		OK	OK	OK	OK	1.0014	FALSE
1281	1281	31-May-2022 00:00	1.1900		OK	OK	OK	OK	1.0010	FALSE
1282	1282	1-Jun-2022 00:00	1.1910		OK	OK	OK	OK	1.0007	FALSE
1283	1283	2-Jun-2022 00:00	1.1890		OK	OK	OK	OK	1.0005	FALSE
1284	1284	6-Jun-2022 00:00	1.1940		OK	OK	OK	OK	0.9999	FALSE
1285	1285	7-Jun-2022 00:00	1.1910		OK	OK	OK	OK	0.9997	FALSE
1286	1286	8-Jun-2022 00:00	1.1920		OK	OK	OK	OK	0.9996	FALSE
1287	1287	11-Jun-2022 00:00	1.1910		OK	OK	OK	OK	0.9998	FALSE
1288	1288	12-Jun-2022 00:00	1.1960		OK	OK	OK	OK	0.9992	FALSE
1289	1289	13-Jun-2022 00:00	1.1950		OK	OK	OK	OK	0.9989	FALSE
1290	1290	14-Jun-2022 00:00	1.1910		OK	OK	OK	OK	0.9987	FALSE
1291	1291	16-Jun-2022 00:00	1.1890		OK	OK	OK	OK	0.9985	FALSE
1292	1292	16-Jun-2022 00:00	1.1960		OK	OK	OK	OK	0.9982	FALSE
1293	1293	17-Jun-2022 00:00	1.1970		OK	OK	OK	OK	0.9985	FALSE
1294	1294								#VALUE!	FALSE
1295	1295								#VALUE!	FALSE

Figure 4. *John Cormack's Flinders Medical Centre DXA Statistical Control Spreadsheet reporting the DXA machine is ok to use Details on how to setup the first QC measure and correlating excel spreadsheet can be found in* ***Appendix 1****.*

Major Service or Replacement of a Part

If a major service occurs or a part is replaced, the BMD values of the phantom spine should be verified by completing 10x QC phantom spine checks prior to, and after the service is complete. If there is a difference ≥2%, pause all scanning of athletes and notify your DXA Lead Technician who will liaise with their service contact or customer support at Getz Healthcare – 1800 886 385. **Do not conduct any further scans until the issue is resolved by Getz Healthcare.**

Note: The DXA machine should be powered on at all times. If the machine has been switched off for any reason, turn it back on, and allow the temperature to stabilise before carrying out QAQC procedures. If the machine has been turned off briefly (less than 10-minutes), allow a minimum of 1-hour before proceeding. If the DXA machine has been off for an extended period of time (more than 10-minutes), a delay in proceeding may be required to allow the temperature to stabilise.

ATHLETE ENGAGEMENT

The safety and wellbeing of athletes should be always a priority. The role of the Technician in capturing and processing the DXA scan involves important interaction with the athlete and plays a central role in the athlete experience. Consideration must be given to several issues including athlete informed consent, mandatory pre-scan checks and guidance on athlete presentation for a scan. Protocols should be established and implemented before, during and after assessments of body composition to mitigate risk to athlete well-being. As such, DXA Technicians need to undertake due diligence in creating a safe environment for any athlete they scan.

Professional Communication/Practice

Assessment of body composition provides a useful tool to determine the impact of nutrition strategies and training interventions. However, in some athletes, such activities have the potential to cause harm and it is impossible to understand which athletes may be vulnerable to this simply by looking at them. The following guidelines comply with the **Disordered Eating in High Performance Sport Position Statement**, which includes specific guidance on body composition considerations. The guidelines set clear boundaries on what is acceptable language and behaviour for DXA Technicians and administrative staff when working with athletes.

- Avoid directly critiquing or commenting on the physical form, shape, size, mass or stature of the athlete, regardless of whether it is believed to be true or helpful.
- Upon arrival, confirm the athlete is wearing suitable clothing for the DXA scan. Lightweight clothing with no metal artefacts provides a balance between integrity of data capture and athlete privacy. As necessary, provide access to a suitable room for the athlete to get changed in advance of, and following, the scan. Minimise the time frame the athlete is to wear the attire required for scanning.
- Ensure the scanning room temperature is adjusted to accommodate the athlete wearing only lightweight clothing. Maintaining temperature between 22-24°C is likely to be comfortable for the athlete and suitable for the scanner.
- Unless explicitly specified otherwise, indicate to the athlete that scan results will be sent to their referring Practitioner for detailed feedback, with no report or verbal results provided by the Technician.
- Scan results should be forwarded to the referring Practitioner in a timely manner (same day as scan was undertaken) to support timely feedback of data to the athlete.

HYGIENE PRACTICES

It is important that good hygiene is practiced throughout the entirety of the total body composition scan procedure. Specific protocols should be instituted according to the larger environmental issues (e.g. COVID protocols), but should include:

- Cleaning the DXA bed and positioning aids with hospital grade detergent and disinfectant between athletes.
- Sanitising hands between athletes.
- Wearing gloves when positioning the athlete, measuring urine specific gravity (USG), and/or cleaning the DXA bed and positioning aids with hospital grade detergent and disinfectant.

INFORMED CONSENT

Athletes (and their parent/guardian if <18 years) must be fully informed of the procedure and risks of DXA, and must complete an informed consent form prior to a DXA scan.

Before collecting consent, it is important that athletes are provided with sufficient information about the procedure to make a truly informed decision on whether to proceed with a DXA scan. While specific content of the information may vary depending on the specific DXA machine being used, it should include information about the DXA procedure, the amount of radiation exposure, any other risks, and the athlete's rights including why the DXA scan has been requested and how their data will be handled. All athletes should have the opportunity to ask questions of the scan independently. The AIS participant information letter and consent form is available in **Appendix 2**.

PRE-SCAN CHECK

Referring Practitioners must ensure athletes are eligible for scanning and confirm this with the Technician prior to scheduling a scan via the Practitioner referral **(Appendix 3)**. Prior to the scan, athletes must complete a screening questionnaire **(Appendix 4)** and provide this to the Technician. This questionnaire will explore issues such as radiation history, upcoming medical procedures, pregnancy etc., that would contraindicate a DXA scan proceeding, but also identify potential issues that may assist the Technician with scan acquisition and/or analysis, such as orthopaedic implants.

GE Lunar DXA Machine Limits

GE Lunar Prodigy

Maximum patient stature (length): 195cm
Maximum patient body mass supported: 159kg
Width of scan bed: 60cm

GE Lunar iDXA

Maximum patient stature (length): 195cm
Maximum patient body mass supported: 204kg
Width of scan bed: 66cm

SCAN ACQUISITION

There are several considerations necessary for appropriate acquisition and analysis of a total body composition DXA scan.

Athlete Preparation

- Athletes are to present in an overnight fasted state (no food or fluid for at least 8 hours). This means they must not eat or drink anything on the morning of their test. However, they should be glycogen replete, with dietary guidance to facilitate this process the day prior to their scan.
- Athletes are to present in a rested state with no exercise on the morning of the scan, and no intense exercise undertaken since lunchtime the day prior.
- Athletes are to present in an euhydrated state (well hydrated). To help facilitate this, athletes should be advised to drink one to two glasses of water with each meal/snack the day before the scan. Confirmation of hydration status can be assessed by a waking mid-stream urine sample for the analysis of USG, or via bioelectrical impedance.

Athlete Presentation

- Athletes must empty their bladder prior to scanning.
- Athletes are to wear lightweight cotton clothing with no metal artefacts or residues such as chlorine, salt water or sweat. Examples include underwear or tight shorts, and crop tops or tight singlets without bra clips or underwire. For longitudinal assessments, same clothing is preferred.
- Athletes must remove all jewellery and clothing that contains metal (e.g., hair clips, watches, zips, underwire).
- Athletes are required to untie hair if it is tied up.

Scan Mode

- The athlete should be weighed on calibrated scales wearing minimal clothing, followed by an assessment of stature using a calibrated stadiometer. This allows an estimation of athlete thickness (as inferred from body mass index) and thus the appropriate scan mode i.e., thick, standard, or thin.
- When an athlete returns for a repeated scan, body mass and stature should be measured again, however it is important to ensure scan mode is consistent to previous scans. If a significant change in body mass occurs that results in a change in automated scan mode, manually change this.

Ethnicity

- Given the limited ethnicity options in the enCORE software (Asian, Black, Hispanic, White, Other), it may be inappropriate to ask the athlete to select their ethnicity.
- In most cases selecting an ethnicity other than 'White', will have little, if any, impact on body composition results. The exception to this is selecting 'Black'. It is to be noted that selecting 'Black' will compare the athlete to an African American patient group.

Reference Database

- The ISCD advocate the use of the National Health and Nutrition Examination Survey (NHANES) 1999-2004 data as most appropriate for different races, both sexes and across the age span. However, it remains to be verified which is the most appropriate reference database for highly trained athletes, given their unique physique traits. This is confirmed by the ISCD, stating 'it does an athlete little good to compare him/her with the population average'.
- Each manufacturer has different reference databases available, so it is recommended that great consideration is taken when selecting a reference database to use, and consistency is maintained across athletes and longitudinal scans. Comparisons between scan results generated by different reference databases are not appropriate.

- No reference database has been verified as appropriate for highly trained athletes and their unique physique traits. As such, it is recommended the combined Geelong/Lunar database derived from an Australian population be selected. The reference database should NOT be adjusted thereafter.

Repeat Measures

- When conducting repeat measures for assessment, care should be taken to use the same DXA machine and software, same scan mode and reference database, the same protocol of data capture (including subject presentation and scan mode), and where possible the same Technician.

Positioning Aids

- The use of radiolucent positioning aids **(Appendix 5)** assists to standardise positioning of athletes and ensures consistency between scans. They also assist in appropriate separation of regions of interest (ROIs), which allow the Technician to manipulate correctly.

Athlete Scan Profile

At each athlete's initial scan, a profile must be setup in the enCORE software to allow longitudinal capture of body composition **(Figure 5)**. Prior to initiation of the scan procedure, confirmation should be sought on the reference database.

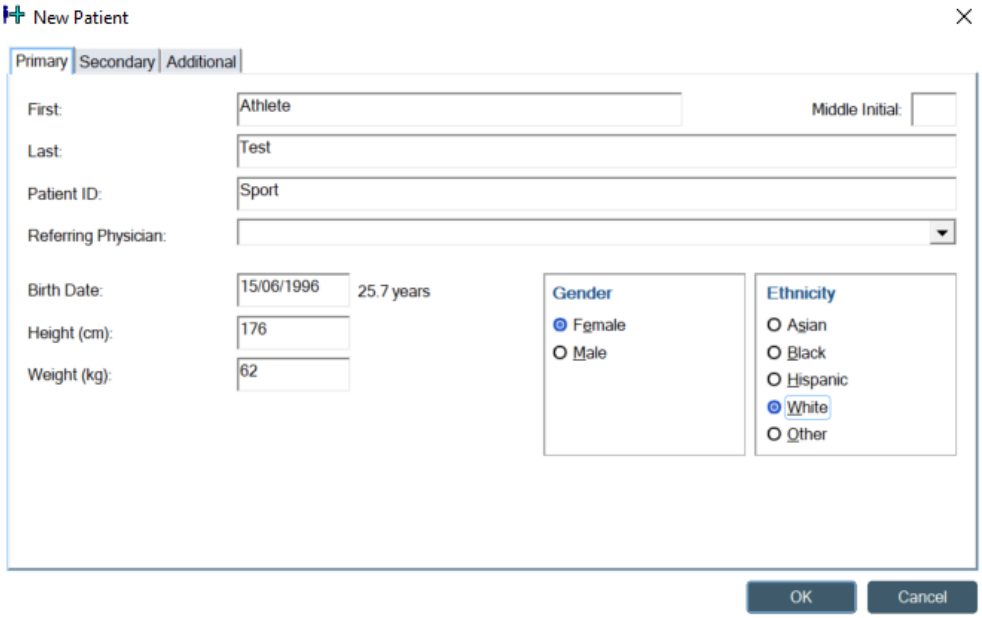


Figure 5. *enCORE software version 18, new patient profile.*

1. Click *New* in the appropriate database to create a new athlete profile.
2. In the Primary tab enter First name, Last name, Birth date, Gender, and Ethnicity, from the details provided on the pre-DXA questionnaire.
   Tip: These details should remain consistent across longitudinal scans. To ensure consistency across longitudinal scans, and to avoid duplicates of athletes in multiple profiles, athlete's birth name should be recorded.
3. A calibrated stadiometer and body mass scales should be located in the DXA room. Measure athlete's stature, ensuring their head is positioned in the Frankfort Plane, plus shoes and socks are removed **(Figure 6)**. It is particularly important for growing athletes that stature is measured at each repeat DXA total body composition scan.
   Tip: The Frankfort Plane is defined by the International Society for the Advancement of Kinanthropometry's (ISAK) International Standards for Anthropometric Assessment as positioning the head so that the lower edge of the eye socket is in the same horizontal plane as the notch superior to the tragus of the ear.

4. Measure body mass while the athlete is in minimal clothing that they will be scanned in, ensuring all jewellery has been removed.
5. Enter stature and scale mass into the primary tab of the athlete profile, which will provide an estimation of athlete thickness (as inferred from body mass index) and identify the appropriate scan mode - thick (>25 cm), standard (15 – 25 cm), or thin (<15 cm).
6. Enter the athlete's sport in the patient ID of the primary tab.
7. In the secondary tab record the Technician completing the scan and any further details that will assist in analysis and/or interpretation of the current and subsequent scans:
   - Presence of artefacts (e.g., Orthopaedic implants – screws, pins, plates; pacemaker; protheses; jewellery unable to be removed; breast implants; etc.);
   - Details of positioning if modifications are required, particularly useful for Para-athletes to ensure consistency across scans;
   - Assessment of hydration status, such as USG measured by the Technician from the athlete's waking, mid-stream urine sample;
   - Current injuries etc.

Figure 6. *Correct positioning of the head in the Frankfort Plane.*

Repeated Athlete Scans

To ensure longitudinal data can be obtained, it is necessary to complete repeat scans using the same athlete profile. When an athlete returns for longitudinal DXA scans, use the search function in the *Directory* to locate the athlete's profile created at their initial scan. There are several considerations when an athlete returns for longitudinal DXA scans:

- If an athlete's details change (e.g., change of name), this should be recorded in enCORE to avoid duplicate profiles. Athletes with more than one profile make it difficult to track longitudinal body composition. If changes are made (e.g., an athlete changes sport), these can be noted in the secondary tab of their profile.
- Measure stature and body mass at every subsequent scan and enter these in the athlete's profile prior to starting the scan. Do this by right clicking on the athlete profile and click Edit.
- Care must be taken to use the same **DXA machine, reference database, scan mode, protocol of data capture**, and where possible, the same **Technician** and **software version**.
  - When software version is updated, all historical scans should be re-analysed using the batch analysis function in enCORE.

Scan Acquisition – Total Body Composition Scan

1. To start a total body composition scan, double click on the athlete profile, highlight the total body skeleton, and click *Position*.
2. Facilitating a straight spine, position the athlete's body in a supine position within the white lines of the scan bed **(Figure 7)**. Ensure the athlete is aligned centrally in the scanning area, with the crown of the head positioned at the top end of the table just below (allow ~1cm) the upper scan margin.

Figure 7. *Athlete positioned correctly for total body composition scan.*

1. Position the athlete's head in the Frankfort Plane position as previously described.
2. Place the athlete's feet in custom-made radiolucent Styrofoam blocks to maintain a constant distance of 15 cm between the feet for each scan **(Figure 7)**.
3. Place the underarm positioning aids on each side, ensuring they are secure under the athlete's underarm.
4. Place the athlete's hands in shaped Styrofoam blocks, so they are in a mid-prone position with a consistent gap of 3 cm between the palms and trunk.
5. Use Velcro straps to minimise any athlete movement during the scan and to provide a consistent body position for subsequent scans:
   - Secure one strap around the ankles above the foot positioning pad;
   - Secure the second strap around the trunk at the level of the mid-forearms.

   Tip: Place the longer Velcro strap on the bed prior to the athlete laying in a supine position.
6. Complete a final check that the athlete is in the correct position and within the boundary lines of the DXA bed.
7. Ensure the **'smart scan'** feature is turned on in the enCORE Software.
8. Click *Start*. As the scan proceeds, check the screen to ensure that all tissue is captured and that the athlete is positioned straight. A standard total body composition scan should take approximately 7-minutes.

Note: When time permits, the Technician should analyse the total body scan prior to the athlete leaving their scheduled appointment. If this is not possible, a minimum scan check should be carried out before the athlete leaves.

- Ensure that all tissue is captured – from the head, feet, and either side of the athlete;
- Scale body mass is within 1% of the DXA total mass on the enCORE software. This should be the case for total body composition scans captured using the standard protocol described, or for broad athletes. This check cannot be performed for tall athletes measured as total body less head (TBLH); details of which are provided below. If disparity in mass is >1%, start by reconfirming scale mass, and that scales are within calibration.

New versions of enCORE software have settings to include a ScanCheck that are automatically generated at the completion of a scan.

Total Body Composition Positioning Tips

- Prior to the athlete sitting on the DXA bed, place the longer Velcro strap from the DXA positioning aid kit on the bed. This Velcro strap should sit at the level of the athlete's forearms. To achieve this, place the strap approximately halfway up the scan bed. The positioning may need to be adjusted once the athlete lays on the bed, which can easily be done by asking the athlete to slightly lift their back and/or hips.
- To ensure a central position on the bed ask the athlete to sit on the bed, ensuring the mid-line of the DXA bed dissects the left and right gluteal equally.
  - Assist the athlete in lowering their back down slowly, to ensure they remain centrally aligned.
- To check hip alignment, start superior to the iliac crest, and palpate inferiorly until you identify the most superior, lateral aspect of the iliac crest, checking that both sides of the hips align.
  - If hips are uneven, ask the athlete to bring their feet up the bed until their knees are at a 90-degree angle. Ask them to lift their hips up and straight back down again.
- To assist in ensuring the athlete's spine is straight, secure their ankles with your hands, lift their legs slightly off the bed and pull them gently down the bed just a few centimeters. This will not only help straighten the spine but also bring their head inside the scanning field.
  - It is important to confirm with the athlete they have no lower body and back injuries prior to aligning their spine.
- Ensure athletes with long hair have hair untied and hair is down around their shoulders/underneath their back.
  - The density of tied up hair results in it being scanned as soft tissue.
- In addition to hygiene purposes, the use of a translucent, disposable bed sheet can assist the Technician in moving the athlete left or right to ensure they are centrally positioned and within the width of the scan bed.
- Upon your final check be sure to confirm with the athlete they are to remain as still as possible and not speak throughout the scan.

For athletes who are taller and/or broader than the dimensions of the DXA scan bed, there are a number of modifications that should be made to ensure appropriate capture of tissue.

Tall Athletes

For athletes who exceed the length of the DXA scan bed (≥195cm on both iDXA and Prodigy), the accepted solution is to measure these athlete as 'total body less head' (TBLH). This affords athletes up to ~215cm to be scanned with confidence. Given composition of the head is unlikely to change over time, the impact of this technical adjustment is likely insignificant, even when undertaking longitudinal profiling. However, there will be marked differences between TBLH estimates of mass against scale mass. This is to be expected given the head accounts for ~7% of total body mass.

1. Position the athlete in accordance with guidance provided previously, except ensuring their feet are within the scan bed while in the foot positioning aids. As such, their head will likely fall outside of the upper region of the scan field **(Figure 8)**. **Tip:** Place the feet positioning aid in position at the end of the bed prior to the athlete laying on the bed. This will ensure the athlete positions themselves so their feet are within the scan field.
2. Turn the Smart Scan feature **off** on the DXA software.
3. Start the scan as described previously for an athlete that fits within the dimensions of the scan bed including positioning of the head in the Frankfort Plane.
4. The enCORE software will stop the scan as it detects that the head falls outside of the scan field. Click *Resume*, and the scan will continue as usual to capture a TBLH scan.

Figure 8. *Tall athlete positioned to be scanned as TBLH.*

Note: For users that have enCORE 18, additional packages are available, including a 'Sports Athletics Package' which enables TBLH to be analysed automatically.

For users with older versions of enCORE or those who do not have the additional package, TBLH data will need to be calculated manually, by summing arms, trunk and legs composition manually **(Figure 9)**.

Region	Tissue [%fat]	Region [%fat]	Tissue [g]	Fat1 [g]	Lean2 [g]	BMC3 [g]	Total Mass4 [kg]
Left Arm	13.1	12.6	6,666	873	5,793	275	6.9
Left Leg	16.3	15.6	13,073	2,133	10,940	609	13.7
Left Trunk	21.9	21.2	21,256	4,645	16,611	612	21.9
Left Total	18.1	17.4	43,697	7,917	35,780	1,777	45.5
Right Arm	13.1	12.6	6,955	910	6,045	283	7.2
Right Leg	16.3	15.6	13,079	2,134	10,945	613	13.7
Right Trunk	21.8	21.2	19,920	4,348	15,572	569	20.5
Right Total	18.0	17.3	42,456	7,638	34,818	1,720	44.2
Arms	13.1	12.6	13,621	1,783	11,838	557	14.2
Legs	16.3	15.6	26,152	4,267	21,885	1,222	27.4
Trunk	21.8	21.2	41,175	8,993	32,183	1,181	42.4
Android	28.3	27.9	5,843	1,655	4,188	85	5.9
Gynoid	20.0	19.6	13,454	2,697	10,757	331	13.8
Total	**18.1**	**17.4**	**86,153**	**15,555**	**70,598**	**3,497**	**89.7**

1. To calculate "headless" total fat, manually add arms fat + legs fat + trunk fat.
2. To calculate "headless" total lean, manually add arms lean + legs lean + trunk lean.
3. To calculate "headless" total BMC, manually add arms BMC + legs BMC + trunk BMC.
4. To calculate "headless" total mass, manually add arms total mass + legs total mass + trunk total mass

Figure 9. *Manual calculation of total body less head (TBLH) composition for tall athletes.*

Note: Some disadvantages are present when body composition is acquired and analysed as TBLH for tall athletes:

1. The scale mass of athletes measured as TBLH cannot be compared to DXA total mass, as tissue from the head will be missing.
2. Athletes scanned as TBLH cannot be compared with other athletes with total body composition.

Broad Athletes

For broad athletes who exceed the width of the DXA scan bed (≥ 66cm on the iDXA and ≥60cm on the Prodigy), two different solutions are available:

1. Offset scanning procedure, known as mirroring (preferred method)
2. Acquisition of two partial scans

Offset Scanning Procedure - mirroring

Latest DXA software options allow the completion of a half body (right side) analysis while undertaking an estimate of left side (not totally imaged) by assuming symmetry of the body. **This procedure correlates well with whole-body measurements and is the preferred method given it is more time efficient and limits radiation exposure.**

1. Position the athlete as described previously for an individual who fits within the dimensions of the scan bed.
2. Ensure that that the whole right side of the body is included in the scan window, inclusive of the entire head with the spine running parallel to the scanning area centre line **(Figure 10)**.
3. Turn the Smart Scan feature **off** on the DXA software.
4. Start the scan as described above.

Figure 10. *'Broad' athlete positioned to capture the entire right side.*

1. The enCORE software will identify what regions of the athlete's body fall outside of the scanning area and will automatically apply the 'mirror' feature.
2. Mirroring can be turned on or off by selecting *ROIs* in scan analysis, and then selecting the estimate function – this will allow you to select *'estimate'* or *'do not estimate'*, with one of these options showing as *'RECOMMENDED'* based on the scan acquisition.
   - Automatic offset scanning will only mirror the part of the body that falls outside of the scan field (i.e., arm) as reflected by the (e) in **Figure 11a**.
   - Offset scanning can also be manually applied after the scan has been completed, however this method will mirror the entire left side (arm, trunk, legs) from the entire right side captured **(Figure 11b)**.

a)

COMPOSITION (ENHANCED ANALYSIS)										
	Region	Tissue (%fat)	Centile	Total Mass (kg)	Region (%Fat)	Tissue (g)	Fat (g)	Lean (g)	BMC (g)	Fat Free (g)
(e)	Arms	19.0	-	16.2	18.2	15,518	2,948	12,570	695	13,265
(e)	Arm Right	19.0	-	8.1	18.2	7,759	1,474	6,285	348	6,632
	Arm Left	19.0	-	8.1	18.2	7,759	1,474	6,285	348	6,632
	Legs	20.5	-	45.5	19.6	43,537	8,942	34,595	1,996	36,591
	Leg Right	21.1	-	22.6	20.2	21,577	4,550	17,028	992	18,020
	Leg Left	20.0	-	23.0	19.1	21,959	4,392	17,567	1,004	18,572
	Trunk	32.3	-	59.8	31.5	58,154	18,802	39,352	1,609	40,961
	Trunk Right	32.8	-	30.4	31.9	29,564	9,698	19,866	837	20,702
	Trunk Left	31.8	-	29.4	31.0	28,590	9,103	19,487	772	20,259
	Android	36.6	-	9.6	36.3	9,489	3,477	6,012	82	6,094
	Gynoid	26.3	-	20.9	25.6	20,321	5,338	14,983	531	15,514

b)

COMPOSITION (ENHANCED ANALYSIS)										
	Region	Tissue (%fat)	Centile	Total Mass (kg)	Region (%Fat)	Tissue (g)	Fat (g)	Lean (g)	BMC (g)	Fat Free (g)
(e)	Arms	19.0	-	16.2	18.2	15,518	2,948	12,570	695	13,265
(e)	Arm Right	19.0	-	8.1	18.2	7,759	1,474	6,285	348	6,632
	Arm Left	19.0	-	8.1	18.2	7,759	1,474	6,285	348	6,632
(e)	Legs	20.0	-	46.0	19.1	43,918	8,784	35,134	2,008	37,144
(e)	Leg Right	20.0	-	23.0	19.1	21,959	4,392	17,567	1,004	18,572
	Leg Left	20.0	-	23.0	19.1	21,959	4,392	17,567	1,004	18,572
(e)	Trunk	31.8	-	58.8	31.0	57,180	18,206	38,974	1,544	40,518
(e)	Trunk Right	31.8	-	29.4	31.0	28,590	9,103	19,487	772	20,259
	Trunk Left	31.8	-	29.4	31.0	28,590	9,103	19,487	772	20,259
(e)	Android	36.6	-	9.4	36.2	9,298	3,401	5,897	83	5,980
(e)	Gynoid	25.7	-	21.0	25.0	20,420	5,248	15,172	535	15,707

Figure 11. *Composition data for an athlete positioned with their right arm falling outside of the scan field, and the 'mirror' feature (a) automatically applied and (b) manually applied.*

Combining Partial Scans

Where there is a need for accurate comparison between left and right sides (e.g., symmetry issues for a broad athlete), the acquisition of two partial body scans may be appropriate, with results combined to obtain an estimate of total body composition.

Note: This method requires the acquisition of 2x total body composition scans and therefore exposes athletes to double the radiation dose.

1. Position the athlete so that the whole right side of the body is included in the scan window, inclusive of the entire head with the spine running parallel to the scanning area centre line, and elevate the left arm as previously described.

1. Turn the Smart Scan feature **off** on the DXA software.

2. Start the scan as described above.

3. Once complete, repeat the process but this time position the athlete so that the entire left side of their body is within the scanning area and run the scan again. The two scans should appear like those illustrated in **Figure 12**.

Figure 12. *Left and right-side partial scans of a broad athlete.*

1. During the analysis stage, ensure that the "mid body' demarcation line is in the centre of the body and confirm the other ROI are correctly identified.

2. Analyse the scans by adding the values for total mass, total fat, total lean and total BMC for the right and left scans **(Figure 13)**.

3. Check that summed mass is within ~1% of scale mass captured prior to the DXA scan.

[e] – Estimated

Region	Tissue [%fat]	Region [%fat]	Tissue [g]	Fat[1] [g]	Lean[2] [g]	BMC[3] [g]	Total Mass[4] [kg]
[e] Left Arm	6.1	5.8	8,195	498	7,698	379	8.6
Left Leg	11.9	11.3	16,162	1,921	14,241	811	17.0
Left Trunk	10.4	10.1	22,949	2,384	20,565	748	23.7
[e] Left Total	10.1	9.7	48,987	4,935	44,052	2,119	51.1
Right Arm	6.1	5.8	8,195	498	7,698	379	8.6
Right Leg	11.9	11.3	16,329	1,940	14,389	819	17.1
Right Trunk	10.4	10.0	20,495	2,128	18,367	692	21.2
Right Total	10.0	9.5	48,697	4,852	43,845	2,314	51.0
[e] Arms	6.1	5.8	16,391	996	15,395	759	17.1
Legs	11.9	11.3	32,491	3,862	28,630	1,630	34.1
Trunk	10.4	10.1	43,444	4,512	38,932	1,439	44.9
Android	9.5	9.4	5,546	528	5,018	79	5.6
Gynoid	14.7	14.3	14,188	2,092	12,096	436	14.6
[e] **Total**	**10.0**	**9.6**	**97,684**	**9,787**	**87,897**	**4,433**	**102.1**

[e] – Estimated

Region	Tissue [%fat]	Region [%fat]	Tissue [g]	Fat[1] [g]	Lean[2] [g]	BMC[3] [g]	Total Mass[4] [kg]
Left Arm	5.9	5.6	7,818	462	7,356	369	8.2
Left Leg	11.7	11.1	16,007	1,873	14,134	792	16.8
Left Trunk	11.2	10.9	22,754	2,559	20,194	776	23.5
Left Total	10.4	9.9	49,013	5,086	43,927	2,209	51.2
[e] Right Arm	5.9	5.6	7,818	462	7,356	369	8.2
Right Leg	11.7	11.1	16,479	1,928	14,551	815	17.3
Right Trunk	11.3	10.9	21,742	2,440	19,293	742	22.5
[e] Right Total	10.3	9.9	49,069	5,078	44,018	2,255	51.4
[e] Arms	5.9	5.6	15,635	924	14,712	737	16.4
Legs	11.7	11.1	32,486	3,801	28,685	1,606	34.1
Trunk	11.3	10.9	44,495	5,008	39,487	1,517	46.0
Android	11.2	11.1	5,493	618	4,875	77	5.6
Gynoid	14.2	13.8	14,143	2,006	12,137	428	14.6
[e] **Total**	**10.4**	**9.9**	**98,109**	**10,164**	**87,945**	**4,463**	**102.6**

1. To manually calculate “headless” fat, add right arm fat + right leg fat + right trunk fat + left arm fat + left leg fat + left trunk fat.
2. To manually calculate “headless” lean, add right arm lean + right leg lean + right trunk lean + left arm lean + left leg lean + left trunk lean.
3. To manually calculate “headless” BMC, add right arm BMC + right leg BMC + right trunk BMC + left arm BMC + left leg BMC + left trunk BMC.
4. To manually calculate “headless” mass, add right arm mass + right leg mass + right trunk mass + left arm mass + left leg mass + left trunk mass.

Figure 13. *Manual calculation of body composition for broad athletes from summation of two scans.*

Tall and Broad Athletes

For athletes who are both too tall and too broad for the scanning area, either of the protocols described for broad scans can be conducted as TBLH.

1. Position the athlete so their feet and entire right side of their body is within the scan field – this will result in their head falling outside of the scan field.
2. To ensure the athlete is aligned appropriately, have the spine running parallel to the scanning area centre line.
3. Turn the Smart Scan feature **off** on the DXA software.
4. Start the scan as described above.
5. The enCORE software will stop the scan as it detects that the head falls outside of the scan field, however, resume the scan and the scan will continue as usual to capture a TBLH scan.
6. To collect a broad TBLH composition scan, either mirror the left side from the entire right side as previously described or conduct a second scan and summate the entire left and right TBLH scans together, as previously described.
7. Data from the left arm, leg and trunk will need to be added to data from the right arm, leg and trunk to provide broad, TBLH data **(Figure 14)**.

Note: Similar to a TBLH scan, scale mass of athletes measured in this way cannot be compared to DXA total mass, as tissue from the head will be missing

[e] – Estimated

Region	Tissue [%fat]	Region [%fat]	Tissue [g]	Fat[1] [g]	Lean[2] [g]	BMC[3] [g]	Total Mass[4] [kg]
[e] Left Arm	6.1	5.8	8,195	498	7,698	379	8.6
Left Leg	11.9	11.3	16,162	1,921	14,241	811	17.0
Left Trunk	10.4	10.1	22,949	2,384	20,565	748	23.7
[e] Left Total	10.1	9.7	48,987	4,935	44,052	2,119	51.1
Right Arm	6.1	5.8	8,195	498	7,698	379	8.6
Right Leg	11.9	11.3	16,329	1,940	14,389	819	17.1
Right Trunk	10.4	10.0	20,495	2,128	18,367	692	21.2
Right Total	10.0	9.5	48,697	4,852	43,845	2,314	51.0
[e] Arms	6.1	5.8	16,391	996	15,395	759	17.1
Legs	11.9	11.3	32,491	3,862	28,630	1,630	34.1
Trunk	10.4	10.1	43,444	4,512	38,932	1,439	44.9
Android	9.5	9.4	5,546	528	5,018	79	5.6
Gynoid	14.7	14.3	14,188	2,092	12,096	436	14.6
[e] Total	**10.0**	**9.6**	**97,684**	**9,787**	**87,897**	**4,433**	**102.1**

[e] – Estimated

Region	Tissue (%fat)	Region (%fat)	Tissue (g)	Fat[1] (g)	Lean[2] (g)	BMC[3] (g)	Total Mass[4] (kg)
Left Arm	5.9	5.6	7,818	462	7,356	369	8.2
Left Leg	11.7	11.1	16,007	1,873	14,134	792	16.8
Left Trunk	11.2	10.9	22,754	2,559	20,194	776	23.5
Left Total	10.4	9.9	49,013	5,086	43,927	2,209	51.2
[e] Right Arm	5.9	5.6	7,818	462	7,356	369	8.2
Right Leg	11.7	11.1	16,479	1,928	14,551	815	17.3
Right Trunk	11.3	10.9	21,742	2,449	19,293	742	22.5
[e] Right Total	10.3	9.9	49,096	5,078	44,018	2,255	51.4
[e] Arms	5.9	5.6	15,635	924	14,712	737	16.4
Legs	11.7	11.1	32,486	3,801	28,685	1,606	34.1
Trunk	11.3	10.9	44,495	5,008	39,487	1,517	46.0
Android	11.2	11.1	5,493	618	4,875	77	5.6
Gynoid	14.2	13.8	14,143	2,006	12,137	428	14.6
[e] Total	**10.4**	**9.9**	**98,109**	**10,164**	**87945**	**4,463**	**102.6**

1. To manually calculate “headless” fat, add right arm fat + right leg fat + right trunk fat + left arm fat + left leg fat + left trunk fat.
2. To manually calculate “headless” lean, add right arm lean + right leg lean + right trunk lean + left arm lean + left leg lean + left trunk lean.
3. To manually calculate “headless” BMC, add right arm BMC + right leg BMC + right trunk BMC + left arm BMC + left leg BMC + left trunk BMC.
4. To manually calculate “headless” mass, add right arm mass + right leg mass + right trunk mass + left arm mass + left leg mass + left trunk mass.

Figure 14. *Manual calculation of body composition for tall and broad athletes*

POST SCAN ANALYSIS

Regions of Interest (ROIs)

The enCORE software undertakes an automatic analysis of scans including ROIs based on anatomical landmarks. Because the software is not sensitive to the unique physique traits of athletes, the Technician should undertake a manual analysis to confirm, or adjust where appropriate, the ROIs.

Ten standard ROIs are routinely used for the assessment and interpretation of body composition. **(Figure 15)**:

1. **Total body ROI:** the entire body including the head, arms, trunk and legs; defined by the upper, lower and lateral boundaries of the scan field.
2. **Half-body ROI:** separated into left and right sides, excluding the head; defined by the medial line passing the spine, pelvis and in between the legs, and the upper, lower, and lateral boundaries of the scan field.
3. **Trunk ROI:** the chest, abdomen and pelvis; defined by horizontal head line as the upper boundary, vertical trunk lines as the lateral boundaries, and horizontal pelvis line as the lower boundary.
4. **Android ROI:** representing the sovra-umbilical abdomen; defined by the horizontal pelvis line as the lower boundary, the vertical trunk lines as the lateral boundaries, and the upper boundary is defined by measuring 20% of the distance between the head line and pelvis line.
5. **Gynoid ROI:** representing the gluteo-femoral region; defined by a horizontal line that is placed 1.5 times the height of the android ROI from the pelvis as the upper boundary, the vertical trunk lines as the lateral boundaries, and the lower boundary defined as a horizontal line that measures twice the height of the android ROI.
6. **Arm ROIs:** the arm including the hand; defined by horizontal head line as the upper boundary, the lateral boundaries of the scan field and vertical trunk lines, and the lower boundary of the scan field.
7. **Leg ROIs:** the leg including the foot; defined by diagonal pelvis lines as the upper boundary, the vertical leg lines as the lateral boundaries and the lower boundary of the scan field.
8. **Spine ROI:** the cervical-dorsal-lumbar spine; defined by the horizontal head line as the upper boundary, the vertical spine lines as the lateral boundaries, and the horizontal pelvis line as the lower boundary.
9. **Pelvis ROI:** defined by the horizontal and diagonal pelvis lines.
10. **Rib ROIs:** separated into left and right sides; defined by the horizontal head line as the upper boundary, the vertical spine and trunk lines as the lateral boundaries, and the horizontal pelvis lines as the lower boundary.

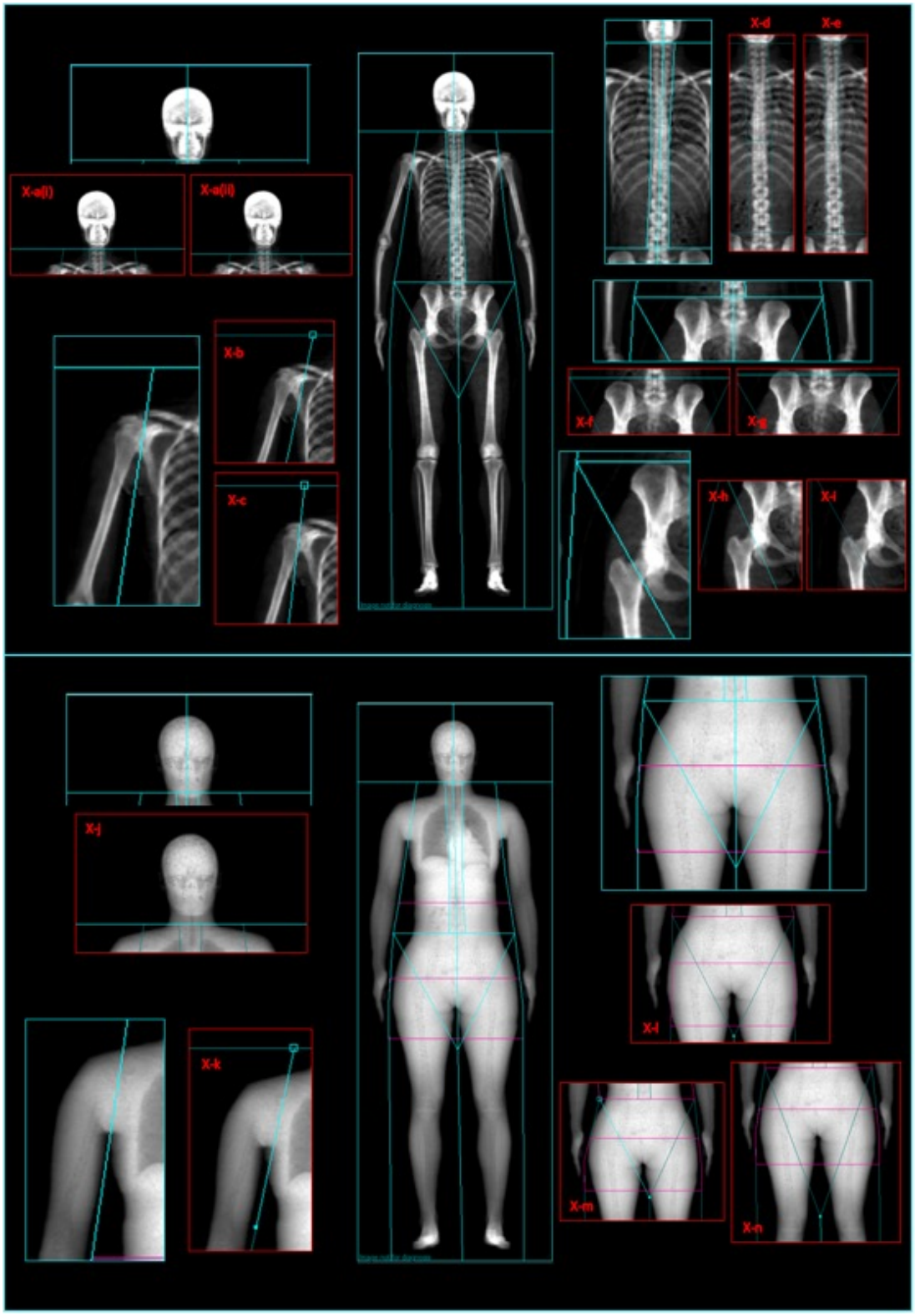


Figure 15. *Total body composition scan with markup of regions of interest (ROIs). Regions outlined in blue are correct placement of ROIs. Regions outlined in red are incorrect placement of ROIs. All ROIs are marked using bony landmarks for reference, and the soft tissue image should be used to ensure all tissue is captured in the correct ROI and symmetry is achieved.*

X-a, X-j: head line is too superior to the mandible; X-b: trunk like is too medial to the humeral-scapula joint; X-c: trunk line is too lateral to the humeral-scapula joint; X-d: spine lines are too lateral and include rib; X-e: spine lines are too medial and encroach on the spine; X-f: horizontal pelvis line is too superior; X-g: horizontal pelvis line is too inferior and encroaches on the iliac crest; X-h: diagonal pelvis line is too proximal to the pelvis and encroaches the ischium; X-i: diagonal pelvis line is too distal from the pelvis and encroaches the trochanter; X-k: trunk line is too medial and includes trunk tissue in the arm region; X-l: vertical leg lines are too medial, resulting in some leg tissue included in the arm regions; X-m: centre leg line is not centred, resulting in asymmetry of the left and right leg regions; X-n: point of the pelvis region is too superior.

The total body composition scan should be manipulated to show the ten ROIs determined by the following landmarks (adapted from Bazzochi et al., (2016) and the GE Healthcare (2019) user manual).

Regions of interest should be marked on the skeletal scan image and confirmed against the tissue scan to ensure all tissue is included within the cut lines **(Figure 15)**:

1. **Head line**: One horizontal line is placed at the most inferior point of the mandible.
   Note: if the athlete's head is correctly placed in the Frankfort plane, minimal soft tissue from the head should be present in the trunk region.
2. **Spine:** Two vertical lines are placed on the most lateral aspects of the vertebral bone profile, including minimal rib without encroaching on the spine.
   Note: for newer DXA machines, the spine ROI is divided at T12-L1 disc space, thus obtaining the lumbar ROI and the cervical-dorsal ROI in the total-body evaluation.
3. **Trunk lines:** The two vertical lines are placed around the chest/abdomen and separate the arm ROIs from the trunk and android ROIs. Using the pivot point, the upper portion of each line is placed on the most medial aspect of the humeral-scapula joint. The pivot point assists in ensuring the arm and trunk are appropriately separated, and all of the soft tissue is encapsulated.
4. **Pelvis lines:** One horizontal line is placed on the most superior aspect of the iliac crest. If the pelvis is uneven, this line is placed on the highest side. Two diagonal lines are placed to cut through the mid-point of the femoral neck, ensuring all of the pelvis is encapsulated. The point of the triangle these lines formed is positioned evenly between the left and right leg, forming the midline to ensure even comparison. The point of the triangle should be positioned as close to the groin to ensure each of the left and right legs are included in each ROI.
5. **Leg lines:** A vertical line is placed on each side of the legs, ensuring all tissue is included and the hands are intercepted.
   Note: Where possible, regional line placement should achieve left/right symmetry and all tissue components should be included at least in the right regions.

Custom ROIs

Custom ROIs provide the opportunity to examine a specific region of the body more closely. If this is identified as being required by the PST, it is the responsibility of the referring Practitioner to notify the Technician. If custom ROIs are requested, scan acquisition remains the same, and thus generating custom ROIs can occur retrospectively.

Using custom ROIs to monitor change in body composition longitudinally increases the associated noise in precision error. Therefore, it is important that when this feature is used, positioning of the athlete is standardised as previously described, and the ROIs generated are anchored to bony landmarks.

Management of Artifacts (Point-Typing)

Point typing allows artefacts to be excluded from regions that are identified as bone and tissue on the scan. Artefacts that cannot be removed prior to the scan acquisition should be considered for removal via point typing during scan analysis. These include:

- Internal or permanent artefacts (e.g., metal surgical implants following injury, silicone implants etc.)
  - In the case of longitudinal tracking of an individual with permanent artefacts, it is appropriate to retain the artifact since repeat point typing may introduce more error.
  - If the scan is to be compared to normative data, it is preferable to remove the artifact.
- External artefacts (e.g., jewellery or bra straps) that were forgotten or not able to be removed before the scan **(Figure 16)**
- Hair that has not been untied
- Clothing such as underwear with logos

The Technician should use the following protocol to undertake point typing of artefacts, after the ROIs have been corrected.

1. Select *Points* on the top menu bar.
2. Click through each of the scan options (bone, tissue, air and artifact) to ensure all tissue is marked correctly.
   Note: Altering bone and/or tissue may impact calculations and should be performed only when necessary and with extreme caution.
3. If an artefact that is appropriate to mark-up is present, select *Artefact*.
4. Reduce the size of the brush and increase the image of the scan to maximise the capacity to point type small artefacts with precision, and markup appropriately.
5. To save, select *Results* from the top menu bar and click *Save*.

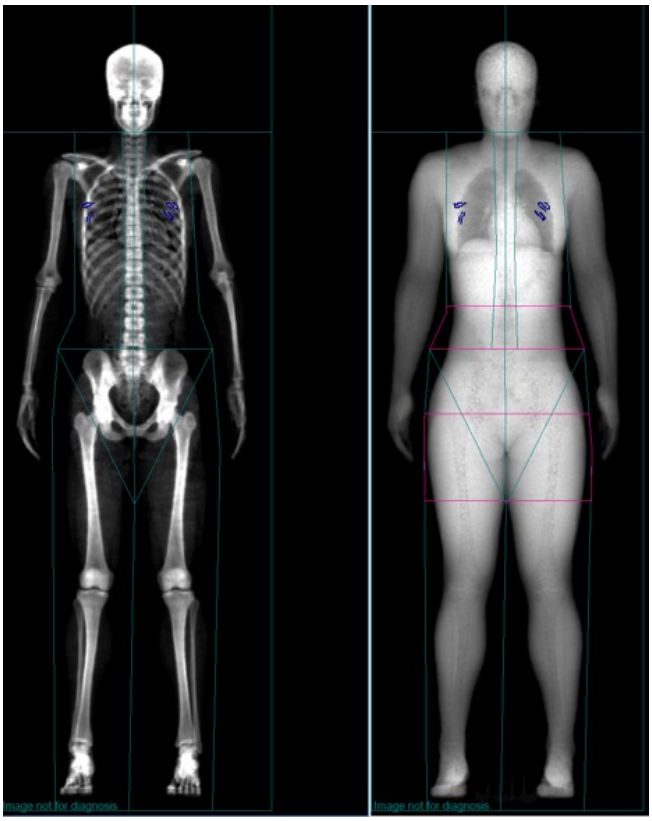


Figure 16. *Total body composition scan of an athlete wearing a bra with inappropriate clips. Bra clips are marked up as artefacts in point-typing.*

PREPARING A DXA SCAN REPORT

The Technician should generate a report providing standardised information:

1. From the saved analysed scan, select *Reports* from the top menu bar.
2. On the left panel, select which report templates are required.
   Note: These reports can be edited and saved to form custom templates.
3. Ensure athlete and scan acquisition details on the report are correct.
4. Add in required notes if these are not already present, these may include:
   a. A marker of hydration status if recorded
   b. Modifications to positioning of athlete
   c. Artefacts present
   d. Manufacturer, model and software of the DXA machine
   e. Reference data base
   f. Details of scan mode
   g. Precision error
5. Selecting *Save* will save the report to the scan file.
6. To print or save the document as a PDF to a location outside of the enCORE software, select Print and select either the printer in use or *Microsoft Print to PDF*.
   Note: To maintain athlete well-being, it is recommended that the scan image is removed from the total body composition report prior to sending this to the referring Practitioner.

Each facility can customize total body composition reports to suit their use. The data recommended to be included for interpretation of athlete composition include:

- Total composition
- Regional composition – head, trunk, left trunk, right trunk, arms, left arm, right arm, legs, left leg, right leg.

Where composition is:

- Total mass
- Total [%fat]
- Fat mass
- Lean mass
- Fat free mass
- Bone mineral content

Appendix 6 Provides an example of what a report may look like when this data is captured and entered.

ATHLETE PRIVACY AND ENGAGEMENT

- DXA reports are to be treated as confidential health data and stored in a safe and secure location, preferably electronically.
- The report should not be provided directly to the athlete. Rather it should be provided to the referring Practitioner who will schedule a time with the athlete to share data and any associated implications.
- It is encouraged that reports are not emailed, and instead shared with the appropriate person(s) via secure online folders.

DATA ARCHIVING AND BACK-UP

At the conclusion of each scanning session, the Technician should archive each database using the in-built archive function by selecting Archive from the top of the enCORE interface.

Note: Each database must be archived separately (e.g., If the phantom spine profile is located in a separate database to athlete scans, BOTH the athlete database AND the phantom database must be archived.

It is recommended that all databases are backed up on an external hard drive which is stored away from the DXA machine | and computer.

ATHLETE MANAGEMENT SYSTEM (AMS)

All DXA measured body composition data for athletes in the Australian HP Sports System, in particular athletes associated with a NIN or NSO, needs to be entered into the athlete management system (AMS). This will most likely be the responsibility of the referring Practitioner, however it is important to have this conversation with the referring Practitioner.

APPENDIX 1.
SETTING UP THE QUALITY CONTROL PROTOCOL

SETTING UP THE QUALITY CONTROL PROTOCOL

Create new profile

1. Select an appropriate database from the enCORE directory or create a new one.
2. Click *New* from the enCORE interface and enter in relevant details – First name, Last name, Birth date, Stature, Body mass, Gender and Ethnicity.
3. Click *OK*.

Start new scan

1. Double click on the spine phantom profile created.
2. Highlight the spine **(Figure 2)** and click *Position* from the top menu bar.

Standardisation of the placement of the phantom spine

1. Position the phantom spine calibration block on the scan bed, aligning it with the laser **(Figure 3)**. This should be done with the use of the forearm positioning board to ensure the block is square against the bed.
   Tip: Mark the side of the DXA machine to guide the correct placement of the forearm positioning board for each subsequent QC scan.
1. The phantom spine should be positioned so the laser runs through the middle of the L5 vertebrae.
   Tip: Use the word 'LUNAR' on L5 of the phantom spine as a guide, positioning so the horizontal laser line runs across the top of the word and the vertical laser line is immediately next to the R.
2. Click *Start* to so commence the scan.
3. Once complete, click *ROIs* from the analysis interface and adjust the ROIs accordingly. The ROIs from this scan will be copied to all subsequent QC scans.

Setting up an automated Excel Spreadsheet

1. To set reference values in this spreadsheet, the Technician should perform 25 scans, performing one every 15 minutes, or preferably, acquiring the total 25 scans over 2-3 days to reflect usual use of the DXA machine.
   Note: A typical coefficient of variation for a phantom is 0.4-0.8% (ANZBMS). If data fall outside this range, the DXA machine should not be used until Getz Healthcare Customer Support has undertaken an inspection and any required servicing.

APPENDIX 2.
DXA INFORMED CONSENT FORM

DXA INFORMED CONSENT FORM

The *[insert name of sporting organisation]*

is providing testing services to you.

The welfare of athletes is important to the

[insert name of sporting organisation]

and we only seek to undertake activities that minimises any potential harm to participants and respects their rights and integrity.

Your participation in this activity is voluntary and you may withdraw your consent freely at any time before, or during the assessment. If you become uncomfortable with any aspect of the assessment, please advise our staff who will cease all activities.

The *[insert name of sporting organisation]*

will respect your rights to restrict your information and provide you with the opportunity to ask questions and be fully informed about all aspects of the assessment.

If you are happy to continue, please read and sign the form below.

What is a DXA assessment?

DXA is a medical imaging technology that is the preferred method for assessing bone health, and more recently we've learned of its value in measuring body composition. That is the amount of lean tissue, including muscle but also internal organs, as well as bone mass and fat mass that make up your body. You may have been referred for an assessment of body composition, bone health, or both.

Trained DXA Technicians, in conjunction with radiographers and/or trained medical doctors, can use bone mineral density [BMD] scans acquired on an athlete to provide information on their bone health. BMD scans usually require a scan of an athlete's spine and one femur [hip], however in some scenarios a dual femur scan [both hips] or a forearm scan may be useful.

Among athletic populations, DXA for the assessment of body composition is best used when an estimate of absolute body composition is required, either at the whole-body level, or a specific body region. This helps monitor changes following injury and the subsequent rehab period, or to assist in assessing energy status of the body. This information can also assist in categorising athletes in weight category sports, into the most appropriate weight class to support their health and performance.

Monitoring body composition may be undertaken as it can influence your health but also performance in some sports. The impact on performance varies between sports, and it's important to recognise it's just one factor to be considered. Overemphasizing the impact of body composition on performance is inappropriate, detracting attention from far more important priorities.

What to expect?

The scan itself will only take several minutes, depending on whether you are having an assessment of bone health, body composition, or both. The DXA Technician will take their time in positioning you correctly on the scanner, helping to ensure the capture of high-quality data. To do this, they will ensure you are lying centred on the DXA scanner and will use positioning aids to ensure you are positioned the same time at every visit. There are a couple of techniques they may use to ensure your hips and spine are straight – please let your DXA Technician know if you have any current injuries.

You will be asked for your consent prior to the scan, given the sensitivities that may be associated with measurements related to your body. Females will be asked to confirm they are not pregnant prior to scanning.

How to prepare?

In order to achieve an accurate and reliable DXA scan, you will be asked to consider your diet, hydration, and exercise in the 24 hours prior to your scan. You will also be asked to undertake the DXA scan in minimal clothing and to remove jewellery. Your referring Practitioner will provide you with all necessary information in advance of your assessment.

Is a DXA scan safe?

A DXA scan does expose you to a very small amount of radiation. Everyone is exposed to naturally occurring background radiation in their everyday life. The amount of background radiation present depends on many factors, like the type of soil and rock present, altitude, latitude and an individual's diet. While this can make exposure highly variable, on average, Australians are exposed to 1700 millisievert (μSv) each year (4.7 μSv daily) from natural sources. The effective dose to an adult from a DXA scan will vary slightly depending on the manufacturer, model and scan mode used, plus type of scan, but the following provide general guidance:

- Bone mineral density DXA scan **- 4.4 μSv**
- Total body composition DXA scan **- 1 μSv**

At this dose, no harmful effects of radiation have been demonstrated as any effect is too small to measure. Thus, the risk is believed to be minimal.

All testing is undertaken in accordance with the radiation safety plan that has been approved under the confines of state-based radiation health guidelines which provide specific recommendations on accepted referral sources and scan frequency. DXA imaging comes under the regulation of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Your Technician has specialist training in the use of DXA. However, if this raises concerns for you, please discuss this with your referring Practitioner or the DXA Technician in advance of your scan.

A DXA scan should NOT be undertaken if...

Under certain circumstances, it may be inappropriate or unsafe to undergo a DXA assessment. Please check if any of the below relate to you and be sure to inform your referring Practitioner or Technician in advance of your DXA scan, preferably prior to scheduling a scan.

- ☐ **A clear rationale for testing has not been provided.** Data gained from the scan should be used to assess or inform training and/or nutrition interventions, and associated performance and/or wellbeing outcomes.
- ☐ **You (or your guardian if you are <18 yrs) are unable to provide informed consent.**
- ☐ **You are unable to lie still on your back for 5-10 minutes.**
- ☐ **You are pregnant or suspect that you may be pregnant, or are breast feeding.**
- ☐ **You have not been provided with, or are unable to comply with guidelines on appropriate preparation the day prior to, and morning of, a scheduled scan.**
- ☐ **You have had exposure to nuclear medicine examinations or radiographic agents in the previous 48 48 hours (IV agents) to two weeks (oral agents).**
- ☐ **A scan will result in an annual ionising radiation exposure that is in excess of annual limits** (>1000 μSv). Your referring Practitioner will assess this with your feedback in advance of scheduling a scan.
- ☐ **You are unable to schedule individual feedback in confidence** on the interpretation of DXA results with an appropriate member of your performance support team. Typically, this would be your referring Practitioner.
- ☐ **If there is a risk that undertaking a DXA scan may exacerbate body image concerns or your eating behaviours.**
- ☐ **Your body mass exceeds the maximum capacity of the scanner.** The weight capacity of most DXA models range between 160 and 204 kg.

When will I get the results?

Unless explicitly instructed otherwise by your referring Practitioner, the DXA Technician will not provide you with your results. Instead, follow up with your referring Practitioner for detailed feedback on your scan results and what it means for you. Results will be stored securely on the Athlete Management System (AMS). It may be appropriate to share some, or all of the results from your test with relevant members of your Performance Support Team, including your coach. However, your consent will be sought separately from your referring Practitioner before any data is shared with others. Unless explicitly specified otherwise, your data will only be made available to your referring Practitioner.

Retention of records

The *[insert name of sporting organisation]*

is required to apply the Archives Act 1983 (Cth) to maintain the security and retention of its records over time. This legally

requires the *[insert name of sporting organisation]*

to keep athlete health records (including DXA scans) and to manage them appropriately for periods up to 100 years.

Your rights

You have a right to physical privacy and respect. Please advise the DXA Technician conducting the testing of any considerations concerning bodily integrity, gender or the presence of other persons in the testing environment.

If you have questions or concerns, please feel free to reach out to your referring Practitioner to seek clarification. Remember, no testing is compulsory. If you are uncomfortable or encounter a negative experience before, during, or after your assessment, please raise this with someone you feel comfortable with. This may be the DXA Technician, your referring Practitioner, or another person in your Performance Support team. There are also independent avenues for you to seek support such as **AIS Be Heard** and the **AIS Mental Health Referral Network**.

If you are not satisfied that your rights have been upheld, you may make a confidential complaint to the Australian Sports Commission Complaints Team (**complaints@ausport.gov.au**) or through the complaints page of the ASC website.

Watch our brief video

Statement of Consent

1. I *[print name]* acknowledge and agree that:

   b. I have been provided with information relating to the use of DXA as a tool for assessing bone health and/ or body composition, which clearly describes what is involved, the potential benefits but also associated risks associated with a DXA scan. I have read and understood the contents of that document ± associated video;

   c. Relevant staff have explained to me in detail the nature, safety procedures, risks and discomforts associated with a DXA scan, and I understood their explanation; and

   d. I have been given an opportunity to ask questions, and have received a satisfactory response, about the nature, safety procedures and associated risks and discomforts of a scan, including pre- and post-scan procedures.

2. I agree that I will:

   a. present myself for the DXA scan in an appropriate condition, having abided by pre-test requirements, including diet and physical activity guidance, plus appropriate clothing clearly described to me for me by relevant staff; and

   b. advise relevant staff conducting the scan of any reasons why I should NOT undertake a DXA scan (see checkboxes under **'A DXA scan should NOT be undertaken if...'**)

3. I understand that my participation in the DXA scan is voluntary and that I may withdraw my consent freely and without prejudice (e.g. without limiting future assessment opportunities) at any time before or during the scan.

4. I understand that the information obtained during the DXA scan will be treated confidentially, respecting my rights of privacy. If it is deemed appropriate that the DXA scan results be shared with specific members of my broader performance health support team, my specific and separate consent must be sought before the data can be shared.

5. The *[insert name of sporting organisation]*

   may use broad themes, learnings and insights from DXA scans in research, education and publication to enhance our programs and practices and to improve athlete health and performance both internally and within Australian sport. Any insights created or released from DXA scans will not contain the personal information of any individual participants.

Signature of Athlete:	**Date:**
Parent/Guardian name (required if Athlete aged under 18):	
Parent/Guardian signature:	**Date:**

I, the undersigned explained to the athlete the nature of the DXA scan and to my best knowledge and belief they understood the safety procedures, risks and discomforts associated with the procedure.

Technician name:	
Technician signature:	**Date:**

Referring Practitioner or Technician to complete

Use the table below to estimate radiation exposure from imaging sources in the last 12 months. **Total exposure should NOT exceed 1000 µSv**. Furthermore, the number of DXA scans permitted in the radiation safety plan of the group in which scans are undertaken should not be exceeded, irrespective of the total annual exposure. Typically, this is 3-4 scans per annum.

RADIATION SOURCE	RADIATION EXPOSURE (µSv)	NUMBER (12 MTHS)	TOTAL EXPOSURE
DXA (total body)	1		
DXA (bone density)	4.4		
Dental x-ray	10		
Chest x-ray	20		
CT Scan	8000		
Total Exposure			

*DXA radiation exposure is based on iDXA standard scan mode. Bone density radiation exposure is based on spine + (1x) femur. Please see table below for radiation exposure from specific GE machines and different scan modes.

Indicative radiation dose to adult patients from common medical imaging procedures

REGION	PRODIGY (USV)			IDXA (USV)		
	Thin	Standard	Thick	Thin	Standard	Thick
AP Spine	0.1	0.3	0.6	0.3	1.0	2.3
Femur	0.2	0.9	1.9	0.9	3.4	7.6
Dual Femur	0.4	1.7	3.8	1.7	6.7	15.1
Forearm		0.002			0.01	
Total Body	0.1	0.1	0.3	1.0	1.0	2.0
BMD (Spine + Dual Femur)	0.5	1.8	4.1	2.7	7.7	17.1

APPENDIX 3.
DXA - PRACTITIONER REFERRAL FORM

AUSTRALIAN HIGH PERFORMANCE SPORT SYSTEM
DXA - PRACTITIONER REFERRAL FORM

Reason for Referral...

Total body composition ☐

Bone mineral density ☐ AP Spine ☐ Left femur ☐ Right femur ☐ Forearm ☐ Dual femur

Please confirm with your state-based radiation health guidelines requirements for medical referral

Athlete Details

Name:	Date of birth:
Sport:	Category/position (eg. U23 lightweight rowing):
Stature:	*If <195cm scan should be acquired capturing total body, including head. *If >195cm please measure following total body less head (TBLH) positioning protocol.
Body mass:	*Please measure body mass immediately prior to scan. If this is not possible, use body mass provided here.

> If athlete is too broad for AIS standard positioning protocol:

☐ Offset scanning procedure (mirroring) – preferred method
*estimates missing side from complete side (assuming symmetry)

☐ Two partial scans (left + right)
*requires acquisition of two TBC scans, exposing athlete to double the radiation dose

> Is a blinded scale mass measurement required?

☐ YES

☐ NO

Checklist

☐ Athlete informed of testing

☐ Athlete consent obtained

☐ Athlete 18 years of age (or over)
*If <18y parent/guardian consent required

☐ Total radiation exposure (12 months) does not exceed 1000 µSv

☐ Athlete will not be exposed to nuclear medicine examinations or radiographic agents in the 48h prior to DXA

☐ Repeat scan: Same machine, software, reference database, scan mode, and technician

☐ Machine and technician precision error is available

☐ Female only: Currently or at risk of becoming pregnant, or breastfeeding

Performance Health Support Practitioner

Name:	Date:
Email:	Organisation:

Total radiation exposure

Use the table below to estimate radiation exposure from imaging sources in the last 12 months. **Total exposure should NOT exceed 1000 µSv**. Furthermore, the number of DXA scans permitted in the radiation safety plan of the group in which scans are undertaken should not be exceeded, irrespective of the total annual exposure. Typically, this is 3-4 scans per annum.

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DXA (bone density)	4.4		
Dental x-ray	10		
Chest x-ray	20		
CT Scan	8000		
Total Exposure			

*DXA radiation exposure is based on iDXA standard scan mode. Bone density radiation exposure is based on spine + (1x) femur. Please see table below for radiation exposure from specific GE machines and different scan modes.

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Femur	0.2	0.9	1.9	0.9	3.4	7.6
Dual Femur	0.4	1.7	3.8	1.7	6.7	15.1
Forearm		0.002			0.01	
Total Body	0.1	0.1	0.3	1.0	1.0	2.0
BMD (Spine + Dual Femur)	0.5	1.8	4.1	2.7	7.7	17.1

APPENDIX 4.
DXA – MANDATORY ATHLETE SCREENING QUESTIONNAIRE

AUSTRALIAN HIGH PERFORMANCE SPORT SYSTEM
DXA - MANDATORY ATHLETE SCREENING QUESTIONNAIRE

Athlete Details

Title:	Name:
Date of birth:	Sport (category/position):
Measured stature:	Measured body mass:
Marker of hydration (USG / BIA):	

Have you had an X-Ray in the past 12-months? (eg. CT, PET, X-Ray, DXA, etc.) ☐ NO ☐ YES

If yes, please specify... type of investigation and date:

Do you have a current injury or one you are recovering from? (eg. Surgery, scoliosis, fractures, etc.)

Do you have orthopaedic pins, prosthesis, or implants? ☐ NO ☐ YES

Do you have a pacemaker? ☐ NO ☐ YES

Do you have any upcoming procedures you are preparing for? (eg. Colonoscopy, gastroscopy, etc.) ☐ NO ☐ YES

If yes, what is it?

Do you have any body piercings that can't be removed prior to scan? ☐ NO ☐ YES

Do you feel comfortable lying on your back for approximately 10-minutes? ☐ NO ☐ YES

FEMALES ONLY:

Are you currently or at risk of being pregnant? ☐ NO ☐ YES

Are you currently breastfeeding? ☐ NO ☐ YES

Total radiation exposure

Use the table below to estimate radiation exposure from imaging sources in the last 12 months. **Total exposure should NOT exceed 1000 µSv**. Furthermore, the number of DXA scans permitted in the radiation safety plan of the group in which scans are undertaken should not be exceeded, irrespective of the total annual exposure. Typically, this is 3-4 scans per annum.

RADIATION SOURCE	RADIATION EXPOSURE (µSv)	NUMBER (12 MTHS)	TOTAL EXPOSURE
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Dental x-ray	10		
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CT Scan	8000		
Total Exposure			

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BMD (Spine + Dual Femur)	0.5	1.8	4.1	2.7	7.7	17.1

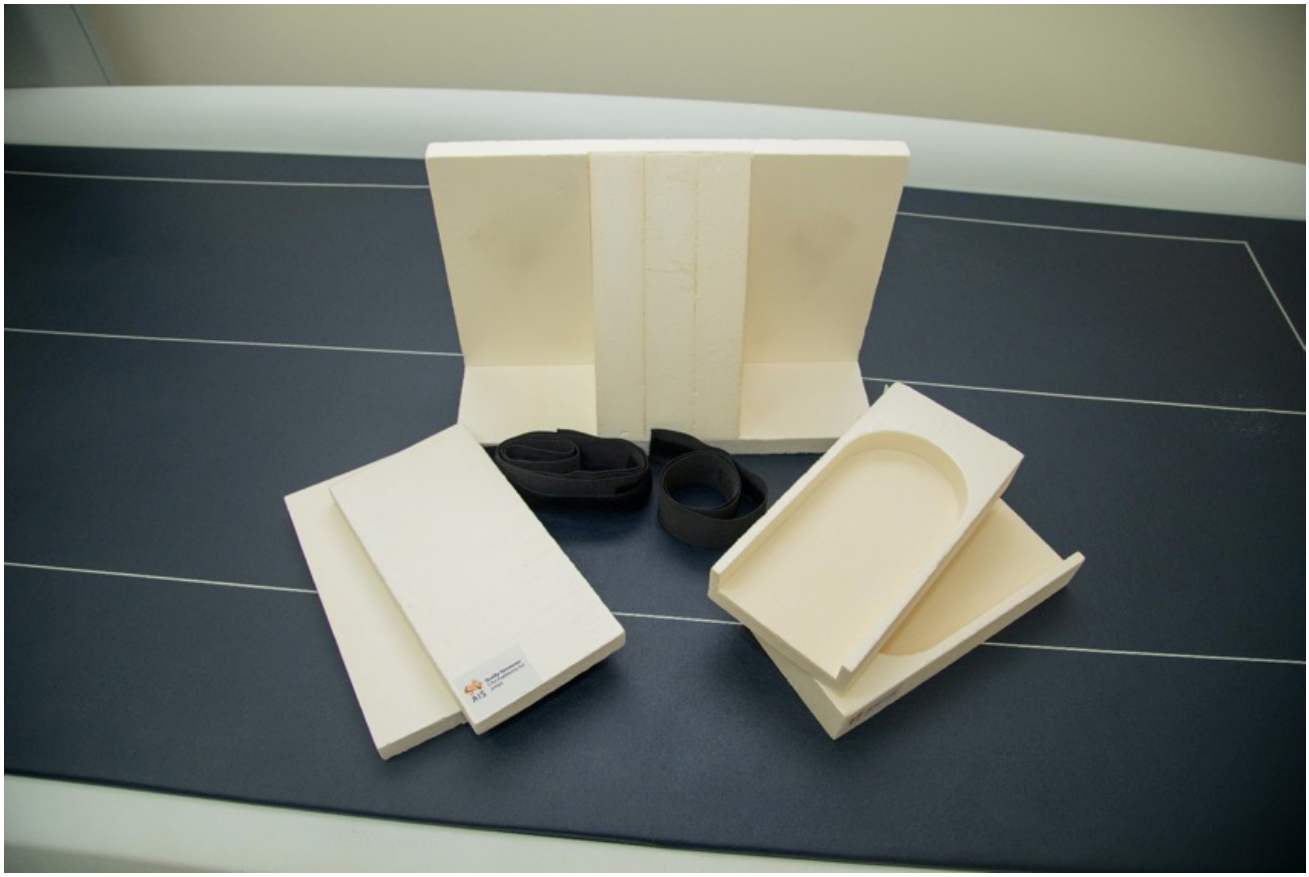
APPENDIX 5.

DIMENSIONS OF RADIOLUCENT FOAM BLOCKS, INCLUDING FEET (A), HANDS (B) AND ARM (C) POSITIONING AIDS, USED AS PART OF ROUTINE DXA SCANS, TO FACILITATE STANDARDISATION OF ATHLETE POSITIONING, WITH CLEAR SEPARATION OF DIFFERENT BODY REGIONS.

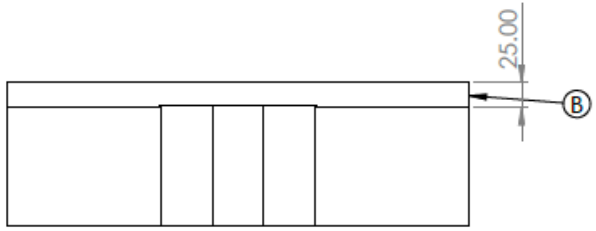
DIMENSIONS OF RADIOLUCENT FOAM BLOCKS, INCLUDING FEET (A), HANDS (B) AND ARM (C) POSITIONING AIDS, USED AS PART OF ROUTINE DXA SCANS, TO FACILITATE STANDARDISATION OF ATHLETE POSITIONING, WITH CLEAR SEPARATION OF DIFFERENT BODY REGIONS.

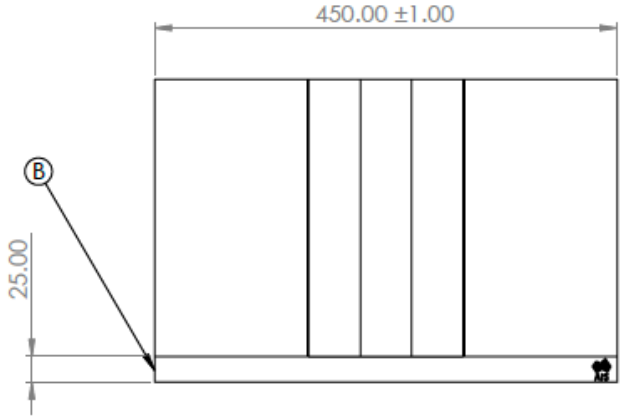
A range of foam materials have been trialled. The most translucent in the DXA scanners were Styrofoam and XPS Insulation Board (industry name "Blue Board") which is used in construction. XPS insulation board is easy to work with, most pieces involved for the positioning aids are straight cuts which should be fairly easily accomplished with a saw. 25 mm thick XPS was used for the armpit chock and foot plate and 50 mm thick XPS was used for the hand support and creating the triangles sitting inside the foot plate. The rounded insert section of the hand support is best achieved with a CNC router. Likewise, small guidance inserts were also machined around 2-3 mm to help guide positioning of the pieces when gluing.

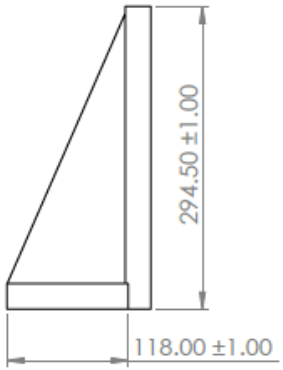
How glue interacts with the final scan results varies. What has worked best is a high tack spray adhesive that is used for upholstery and foam (such as Tensorgrip F40). Hot glue or any kind of "thick" glue appears in scans. Although the impact of this on scan interpretation is likely small, especially if the same blocks are used longitudinally. Thinner spray adhesive shows up less, while applying the spray adhesive in a staggered pattern (just outside edges of the parts and then go with a cross through the middle, zig zag pattern etc.) yields more translucent DXA results. The high tack spray adhesive is extremely strong once it bonds after 24 hrs so you could also get away with way less compared to other adhesives.



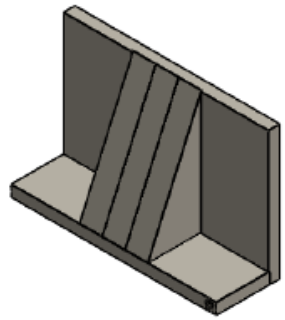
REV.	DESCRIPTION	DATE	APPROVED
A	DRAWING CREATED	03/03/2020	NP
B	UPDATED BOTTOM AND BACK PANEL THICKNESSES TO 25 MM, ADDED ADDITIONAL DIMENSION CLARITY	22/06/2021	NP







B



UNLESS OTHERWISE SPECIFIED :

PART TO BE FREE FROM BURRS AND ROUGH EDGES

FOR ALL UNDIMENSIONED FEATURES REFER TO CAD MODEL

IF IN DOUBT, ASK

CORROSION, UNWANTED DEBRIS AND DAMAGE PROTECTION MUST BE PROVIDED TO PARTS AND ASSEMBLIES DURING STORAGE AND SHIPPING

CHANGES TO DESIGN, COMPOSITION OR PROCESSING OF THE PART PREVIOUSLY APPROVED, REQUIRES APPROVAL FROM AIS QUALITY ASSURANCE

PART TO BE IDENTIFIED WITH PART NUMBER AND REVISION.
IDENTIFICATION TO BE LASER ETCHED, PAINT MARKED OR EQUIV.

GENERAL TOLERANCES
ANGULAR ± 0.25°
0 ± 0.5
0.0 ± 0.25
0.00 ± 0.10
GENERAL TOLERANCE ⌭ 0.5
MACHINING TOLERANCE ⌭ 0.1
SURFACE FINISH 3.2

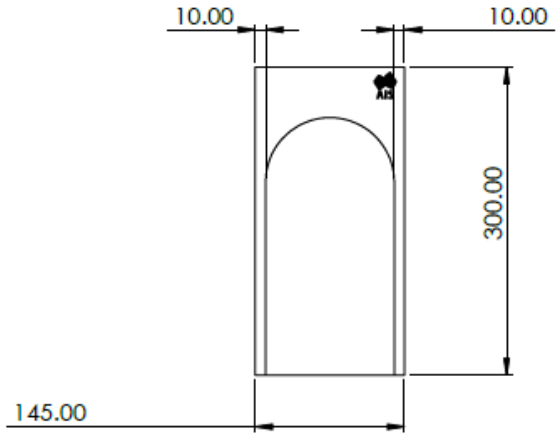
MATERIAL :	ISOBOARD FOAM BOARD
FINISH :	N/A
WEIGHT :	
PROJ. NO :	QA0001
ORIGINATOR :	NPICHSHEV
DATE :	20210622
TITLE:	DXA FOOT AID ASSEMBLY
DWG NO.	
REVISION	B
SCALE	1:5
SHEET	1 OF 1
SIZE	A3

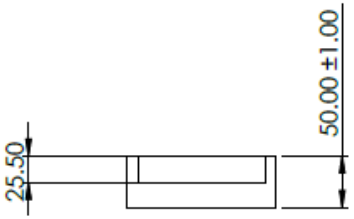
3RD ANGLE ALL DIMENSIONS IN MM

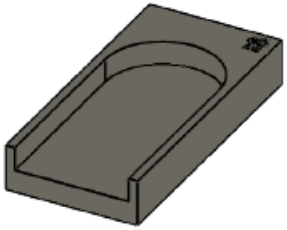
DO NOT SCALE DRAWING

AIS

REV.	CHANGE HISTORY :	DATE :	DRAWN :	CHK'D :	APPV'D :
A	DRAWING CREATED	20200303	NP		







UNLESS OTHERWISE SPECIFIED :

PART TO BE FREE FROM BURRS AND ROUGH EDGES

FOR ALL UNDIMENSIONED FEATURES REFER TO CAD MODEL

IF IN DOUBT, ASK

CORROSION, UNWANTED DEBRIS AND DAMAGE PROTECTION MUST BE PROVIDED TO PARTS AND ASSEMBLIES DURING STORAGE AND SHIPPING

CHANGES TO DESIGN, COMPOSITION OR PROCESSING OF THE PART PREVIOUSLY APPROVED, REQUIRES APPROVAL FROM AIS INNOVATION

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IDENTIFICATION TO BE LASER ETCHED, PAINT MARKED OR EQUIV.

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0 ± 0.5
0.0 ± 0.25
0.00 ± 0.10
GENERAL TOLERANCE ⌭ 0.5
MACHINING TOLERANCE ⌭ 0.1
SURFACE FINISH 3.2

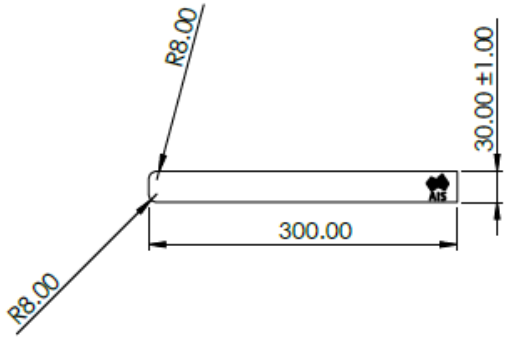
MATERIAL :	ISOBOARD FOAM BOARD
FINISH :	N/A
WEIGHT :	
PROJ. NO :	QA0001
ORIGINATOR :	NPICHSHEV
DATE :	20200303
TITLE:	DXA HAND SUPPORT
DWG NO.	
REVISION	A
SCALE	1:5
SHEET	1 OF 1
SIZE	A3

3RD ANGLE
ALL DIMENSIONS IN MM

DO NOT SCALE DRAWING

AIS

REV.	CHANGE HISTORY :	DATE :	DRAWN :	CHK'D :	APPV'D :
A	DRAWING CREATED	20200303	NP		



UNLESS OTHERWISE SPECIFIED :

PART TO BE FREE FROM BURRS AND ROUGH EDGES

FOR ALL UNDIMENSIONED FEATURES REFER TO CAD MODEL

IF IN DOUBT, ASK

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0.00 ± 0.10
GENERAL TOLERANCE ⌭ 0.5
MACHINING TOLERANCE ⌭ 0.1
SURFACE FINISH 3.2

MATERIAL :	ISOBOARD FOAM BOARD		3RD ANGLE ALL DIMENSIONS IN MM
FINISH :	N/A		
WEIGHT :			DO NOT SCALE DRAWING
PROJ. NO :	QA0001		SCALE 1:2
ORIGINATOR :	NPICHSHEV	DATE : 20200303	SHEET 1 OF 1
TITLE:	DXA ARMPIT CHOCK		
DWG NO.		REVISION A	SIZE A3

AIS

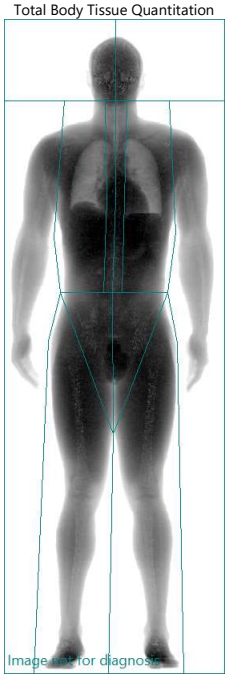
APPENDIX 6.
EXAMPLE OF TOTAL BODY COMPOSITION DXA REPORT

EXAMPLE OF TOTAL BODY COMPOSITION DXA REPORT

Physique & Fuel Centre
Australian Institute of Sport
Leverrier St, Bruce ACT 2617

Patient:	,			**Referring Physician:**	(not specified)
Birth Date:		**Age:**		**Attendant:**	
Height:	186.0 cm	**Weight:**	90.4 kg	**Measured:**	26/11/2019 6:38:21 AM (16 [SP 2])
Sex:	Male	**Ethnicity:**	White	**Analyzed:**	22/07/2022 2:04:33 PM (18 [SP 3])

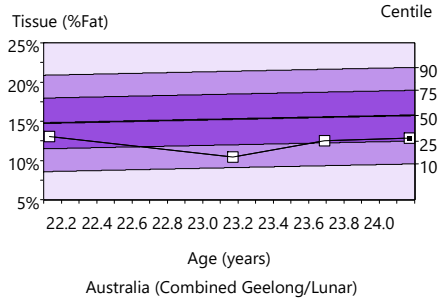
Total Body Tissue Quantitation



Composition (Enhanced Analysis)

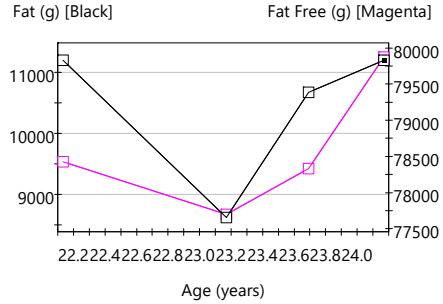
Region	Total (%Fat)	Centile	Total Mass (kg)	Fat (g)	Lean (g)	BMC (g)
Arms	9.3	-	11.5	1,065	9,822	571
Arm Right	9.1	-	5.7	524	4,932	287
Arm Left	9.5	-	5.7	541	4,890	285
Legs	12.4	-	31.4	3,874	26,010	1,468
Leg Right	13.2	-	15.8	2,092	12,961	746
Leg Left	11.5	-	15.6	1,782	13,048	721
Trunk	12.4	-	43.7	5,433	37,089	1,198
Total	12.3	28	91.1	11,190	76,016	3,859
Total Right	12.5	-	45.2	5,663	37,592	1,934
Total Left	12.0	-	45.9	5,527	38,423	1,925

Total Body: Total



Australia (Combined Geelong/Lunar)

Composition Trend: Total



Australia (Combined Geelong/Lunar) Trend: Total (Enhanced Analysis)

Measured Date	Age (years)	Total (%Fat)	Centile	Total Mass (kg)	Tissue (g)	Fat (g)	Lean (g)	BMC (g)	Fat Free (g)
26/11/2019	24.1	12.3	28	91.1	87,206	11,190	76,016	3,859	79,874
4/06/2019	23.6	12.0	27	89.0	85,194	10,665	74,529	3,802	78,331
26/11/2018	23.1	10.0	16	86.3	82,485	8,624	73,861	3,838	77,699
13/11/2017	22.1	12.5	36	89.6	85,682	11,194	74,488	3,935	78,423

COMMENTS: USG: 1.033

Statistically 68% of repeat scans fall within 1SD (± 0.4 % Fat, ±150 g Tissue Mass, ±280 g Fat Mass, ±310 g Lean Mass for Total Body Total); Australia (Combined Geelong/Lunar) Total Body Composition, Male Reference Population (v113); Composition Matched for Age, Sex
Date created: 20/09/2022 12:32:58 PM 18 [SP 3]; Filename: blackr_48ij1q4igh.meb; Total Body; 100,0.19:153.85:15.6 0.00:-1.00 2.40x3.04 12.8:%Fat=12.8%; 0.00:0.00 0.00:0.00; Scan Mode: Standard; 3.0 µGy; 3.88 cGy*cm²

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