AIS

AUSTRALIAN HIGH PERFORMANCE SPORT SYSTEM

DUAL-ENERGY X-RAY ABSORPTIOMETRY

Technician Best Practice Protocols for DXA Assessment of Body Composition - Hologic

CONTRIBUTORS

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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 Hologic DXA machines, including the Horizon and Discovery. 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 populations. Best practice also takes into consideration, and prioritizes, 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

USG – Urine Specific Gravity

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 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 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, 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 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 clear justification for data collection is provided.
- **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 CONTROL PROTOCOLS FOR THE DXA MACHINE

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. For information on the QC protocols for the DXA machine, refer to **Appendix 1**.

ATHLETE ENGAGEMENT

The safety and wellbeing of athletes should always be 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, 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 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:

- Use of a translucent, disposable bed sheet for each athlete.
- Cleaning the DXA table 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 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.

Hologic DXA Machine Limits

Hologic Discovery

Maximum patient stature (length): 195.5cm
Maximum patient body mass supported: 226kg
Width of scan area: 65cm

Hologic Horizon

Maximum patient stature (length): 195.5cm
Maximum patient body mass supported: 204kg
Width of scan area: 65cm

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.

Ethnicity

- The Hologic APEX software contains relevant body composition data from Australian*, Black, Hispanic and White cohorts, hence only those from these 4 groups will present with population specific data if the setting has decided to ethnically specify.

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. However, it is generally recommended to adhere to a consistent standard given the result variability between databases, i.e., Australian ABC* or White, depending on clinical preference.

NHANES Calibration Status

Following the period when Hologic developed the NHANES body composition data (1999-2004) an alternative calculation method was developed attempting to correlate certain body composition results to other criterion methods which were tested during this period. A resulting calibration adjustment can be applied via Utilities – System Configuration – Analyze (see **Figure 1**).

The effect of applying this setting will adjust body fat % results, raising them to approximately 5% higher than their former 'Classic calibration' values.

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*Kirk, B., Bani Hassan, E., Brennan-Olsen, S., Vogrin, S., Bir, S., Zanker, J., Phu, S., Meerkin, J., Heymsfield, S., & Duque, G. (2021). Body composition reference ranges in community-dwelling adults using dual-energy X-ray absorptiometry: the Australian Body Composition (ABC) Study. Journal of Cachexia, Sarcopenia and Muscle 2021, 12, 880–890.

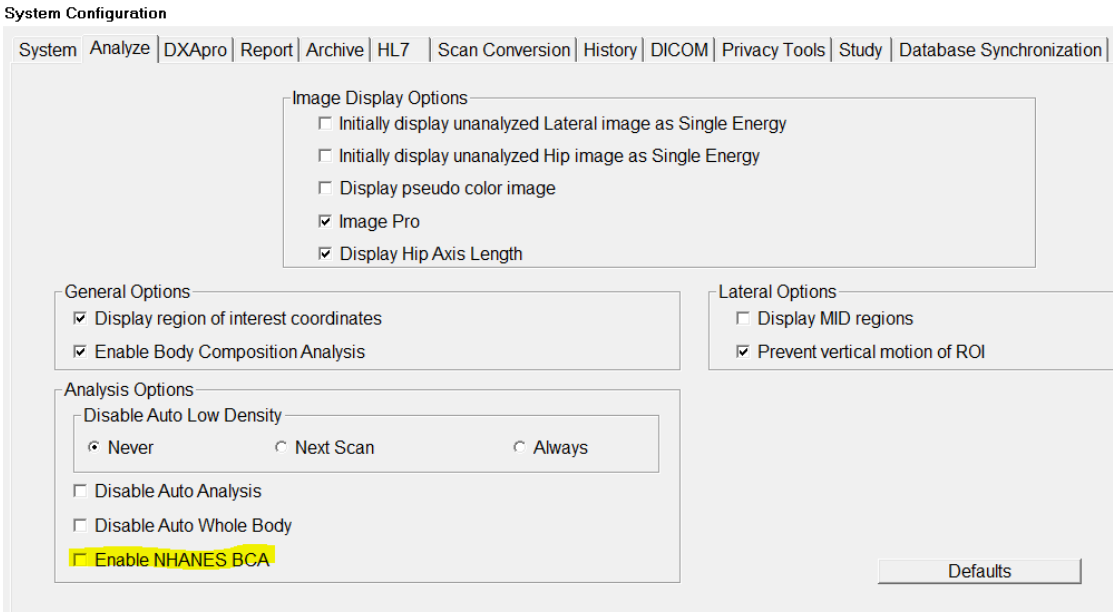


Figure 1. *NHANES BCA Setting.*

Although a more recent study has formed a basis to advise keeping this setting DISABLED, in any case it is important to be aware of how to confirm its status.

If the NHANES calibrated results have been applied to a given scan, an indication will appear on the lower left of the report as shown on **Figure 2**.

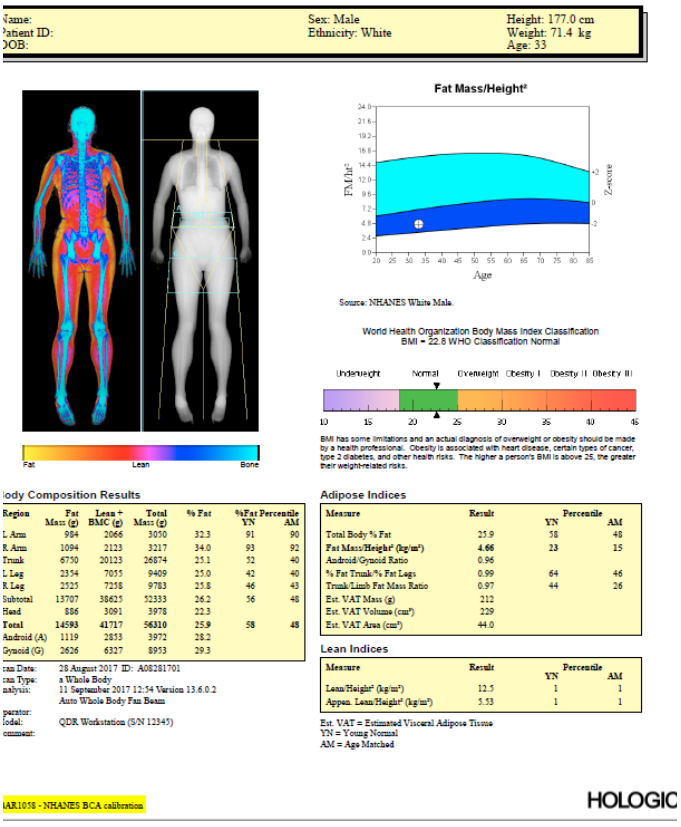


Figure 2. *Confirmation of NHANES BCA Calibration being applied to a body composition scan (highlighted on the lower left corner).*

Repeat Measures

When conducting repeat measures for assessment, care should be taken to use the same DXA machine and software, plus reference database, the same protocol of data capture, 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 APEX software to allow longitudinal capture of body composition (**Figure 3**). Prior to initiation of the scan procedure, confirmation should be sought on the reference database.

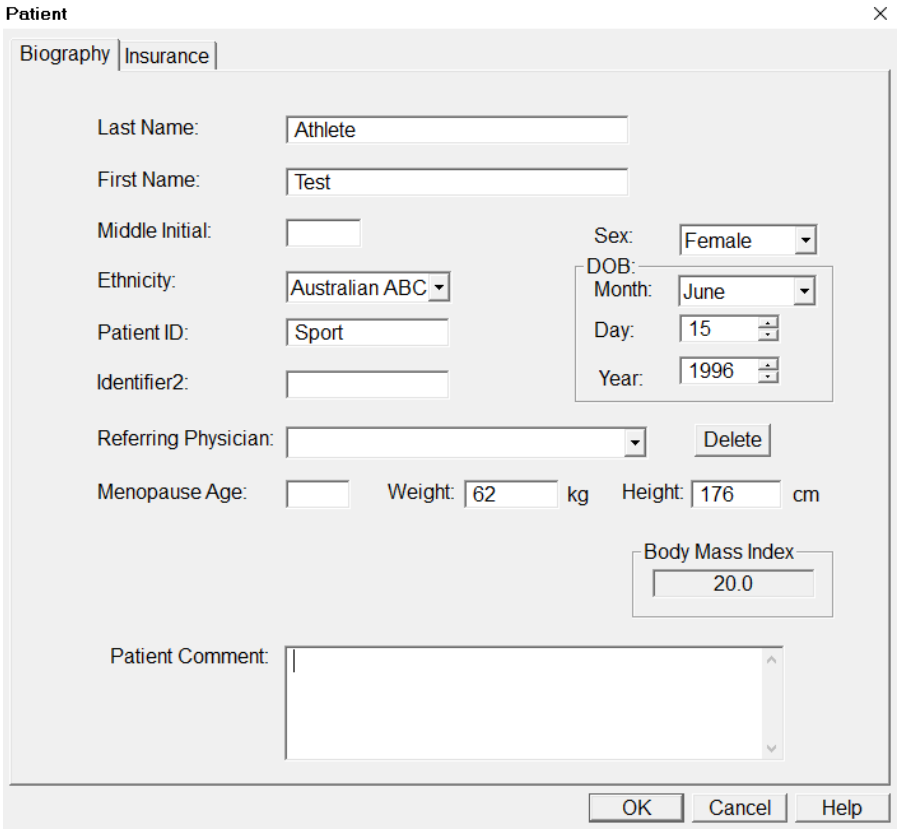


Figure 3. *APEX software version 5.6.1.3, new patient profile.*

1. From the main screen, click 'Perform exam' then 'New Patient' to create a new athlete profile.
2. In the Biography tab enter First name, Last name, DOB and Sex, from the details provided on the DXA Mandatory Athlete Screening questionnaire. Seek guidance from the athlete on the Ethnicity they identify with.
   - 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 reference population.

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 or near by to the DXA room. Measure athlete's stature, ensuring their head is positioned in the Frankfort Plane, plus shoes and socks are removed **(Figure 4)**. 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).
6. Enter the athlete's sport in the patient ID of the primary tab.
7. Also record any further details that will assist in analysis and/or interpretation of the current and subsequent scans via the 'patient comment' cell. Examples include:
   - 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.
8. Select 'OK' at the base of the patient profile window which will reveal a secondary profile screen. Record the name of the Technician in the 'operator' cell.
9. Select 'OK' to progress to the scan selection screen in preparation for scan acquisition.

Figure 4. *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, select 'perform exam' from the main screen and search for the returning athlete's surname via the 'patient name' search bar. 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 APEX 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 their profile.
- Measure stature and body mass at every subsequent scan and enter these in the athlete's profile prior to starting the scan. The patient profile screen can be accessed by selecting 'perform exam', searching for and highlighting the patient's profile and selecting 'edit patient'.
- Care must be taken to use the same **DXA machine, reference database, protocol of data capture,** and where possible, the same **Technician** and **software version.**
  - When software version is updated, the patient database should be refreshed using the 'reconcile' function in APEX.

SCAN ACQUISITION – TOTAL BODY COMPOSITION SCAN

1. To start a total body composition scan, select 'perform exam', locate and select the patient profile, click 'OK' at the base of the questionnaire screen, select 'whole body' from the scan selection list and click 'OK'.
2. Facilitating a straight spine, position the athlete's body in a supine position within the black lines of the scan table **(Figure 5**). 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 the upper scan margin.

Figure 5. *Athlete positioned correctly for total body composition scan.*

3. Position the athlete's head in the Frankfort Plane position as previously described.
4. 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 5**).
5. Place the underarm positioning aids on each side, ensuring they are secure under the athlete's underarm.

6. 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.
7. 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.

8. Complete a final check that the athlete is in the correct position and within the boundary lines of the DXA bed.
9. Instruct the athlete to remain still for the scan duration.
10. 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 3 (Horizon A) to 7-minutes (Horizon W/Wi).

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 APEX 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.

Total Body Composition Positioning Tips

- Prior to the athlete sitting on the DXA table, place the longer Velcro strap from the DXA positioning aid kit on the table. This Velcro strap should sit at the level of the athlete's forearms. To achieve this, place the strap approximately halfway up the table. The positioning may need to be adjusted once the athlete lays on the table, which can easily be done by asking the athlete to slightly lift their back and/or hips.
- To ensure a central position on the table ask the athlete to sit on the table, ensuring the mid-line of the DXA table 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 table 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 table and pull them gently down the table 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 table.
- 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 table, 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 table (≥195cm), 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 table while in the foot positioning aids. As such, their head will likely fall outside of the upper region of the scan field (**Figure 6**).

> **Tip:** Place the feet positioning aid in position at the end of the table prior to the athlete laying on the table. This will ensure the athlete positions themselves so their feet are within the scan field.

2. Start the scan as described previously for an athlete that fits within the dimensions of the scan table including positioning of the head in the Frankfort Plane.

Figure 6. *Tall athlete positioned for body composition scanning.*

TBLH data is automatically calculated by summing arms, trunk and legs composition (**Figure 7**).

DXA Results Summary:

Region	BMC (g)	Fat Mass (g)	Lean Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat
L Arm	297.41	631.9	4555.0	4852.5	5484.4	11.5
R Arm	297.77	633.1	4633.9	4931.7	5564.8	11.4
Trunk	1128.73	4241.3	32977.5	34106.2	38347.6	11.1
L Leg	644.65	2067.9	14460.6	15105.3	17173.2	12.0
R Leg	661.68	1861.8	14484.5	15146.2	17008.0	10.9
Subtotal	3030.25	9436.1	71111.7	74141.9	83578.0	11.3
Head	505.33	1083.4	3665.2	4170.5	5253.9	20.6
Total	**3535.57**	**10519.4**	**74776.8**	**78312.4**	**88831.9**	**11.8**

TBAR1557

Figure 7. *Excerpt from a DXA report showing automated total body less head (TBLH) composition (area in red box) 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 table scanning area (≥ 70cm), OR if an athlete has a prosthetic arm/leg causing significantly asymmetric results, the software will automatically trigger the 'reflection' feature. This allows Technicians to duplicate either arm or leg if there is at least a 15% difference detected between the arms or a 25% difference detected between the legs. The procedure for data capture is exactly the same, except that athletes must be positioned to the left hand side of the scanning area (**Figure 8**), enabling the entire right side to be captured.

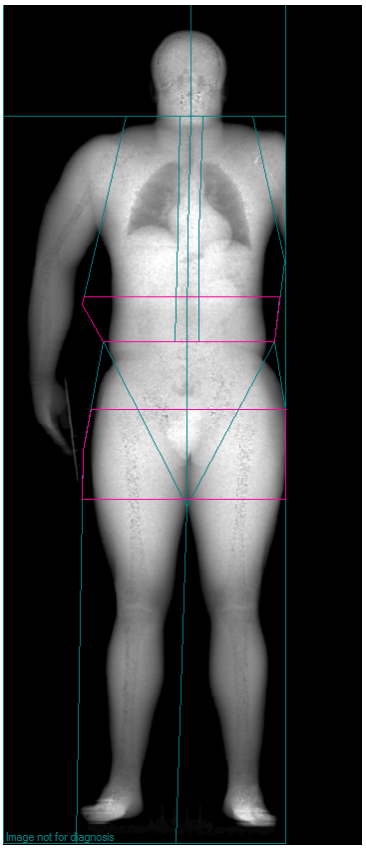


Figure 8. *Broad athlete positioned for body composition scanning.*

1. Position the athlete so their feet and entire right side of their body is within the scan field.
2. To ensure the athlete is aligned appropriately, have the spine running parallel to the scanning area centre line.
3. Following analysis of a scan acquired accordingly, the message below will be displayed, allowing the Technician to choose the desired outcome **Figure 9**.

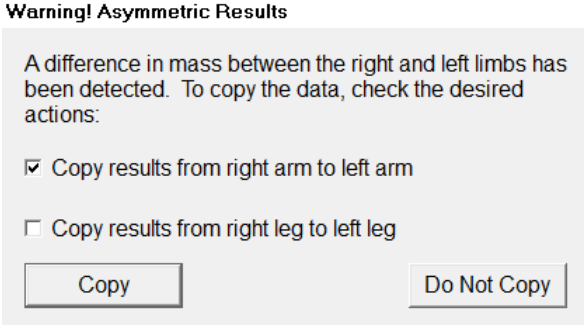


Figure 9. *Software warning - Asymmetric results.*

4. Once the desired outcome is selected, the athlete's adjusted results can be immediately reviewed from the analysis screen as per the example below **Figure 10**.

C.F. Region	1.025 Area(cm²)	1.006 BMC(g)	1.000 BMD(g/cm²)
L Arm	413.32	359.79	0.870
R Arm	413.32	359.79	0.870
L Ribs	106.92	82.96	0.776
R Ribs	119.69	85.06	0.711
T Spine	151.21	153.34	1.014
L Spine	65.43	77.63	1.186
Pelvis	191.90	242.63	1.264
L Leg	375.02	436.56	1.164
R Leg	198.28	264.23	1.333
Sub Tot	2035.09	2062.00	1.013
Head	210.65	597.70	2.837
TOTAL	2245.74	2659.70	1.184

Figure 10. *Software display of athlete's adjusted results.*

Due to assumptions being made with the offset scanning procedure, summed mass may be >1% different to scale mass captured prior to the DXA scan.

Tall and Broad Athletes

For athletes who are both too tall and too broad for the scanning area, the protocol 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. Start the scan as described above.
4. To collect a broad TBLH composition scan, mirror the left side from the entire right side as previously described using the reflection feature.

POST SCAN ANALYSIS

Regions of Interest (ROIs)

The APEX 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.

Twelve standard ROIs are routinely used for the assessment and interpretation of body composition. (**Figure 11**):

1. **Left arm ROI:** the left 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.
2. **Right arm ROI:** the right 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.
3. **Left rib ROI:** defined by the horizontal head line as the upper boundary, the vertical spine and trunk lines of the left side as the lateral boundaries, and the horizontal pelvis lines as the lower boundary.
4. **Right rib ROI:** defined by the horizontal head line as the upper boundary, the vertical spine and trunk lines of the right side as the lateral boundaries, and the horizontal pelvis lines as the lower boundary.
5. **Thoracic spine ROI:** the cervical-thoracic spine; defined by the horizontal head line as the upper boundary, the vertical spine lines as the lateral boundaries, and the horizontal lowest thoracic vertebrae line as the lower boundary.
6. **Lumbar spine ROI:** the lumbar spine; defined by the horizontal highest lumbar vertebrae line as the upper boundary, the vertical spine lines as the lateral boundaries, and the horizontal pelvis line as the lower boundary.
7. **Pelvis ROI:** defined by the horizontal and diagonal pelvis lines.
8. **Left leg ROI:** the left 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.
9. **Right leg ROI:** the right 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.
10. **Head ROI:** defined by the horizontal head line as the lower boundary.
11. **Sub-total ROI:** defined by the horizontal head line as the upper boundary and the lower and lateral boundaries of the scan field.
12. **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.

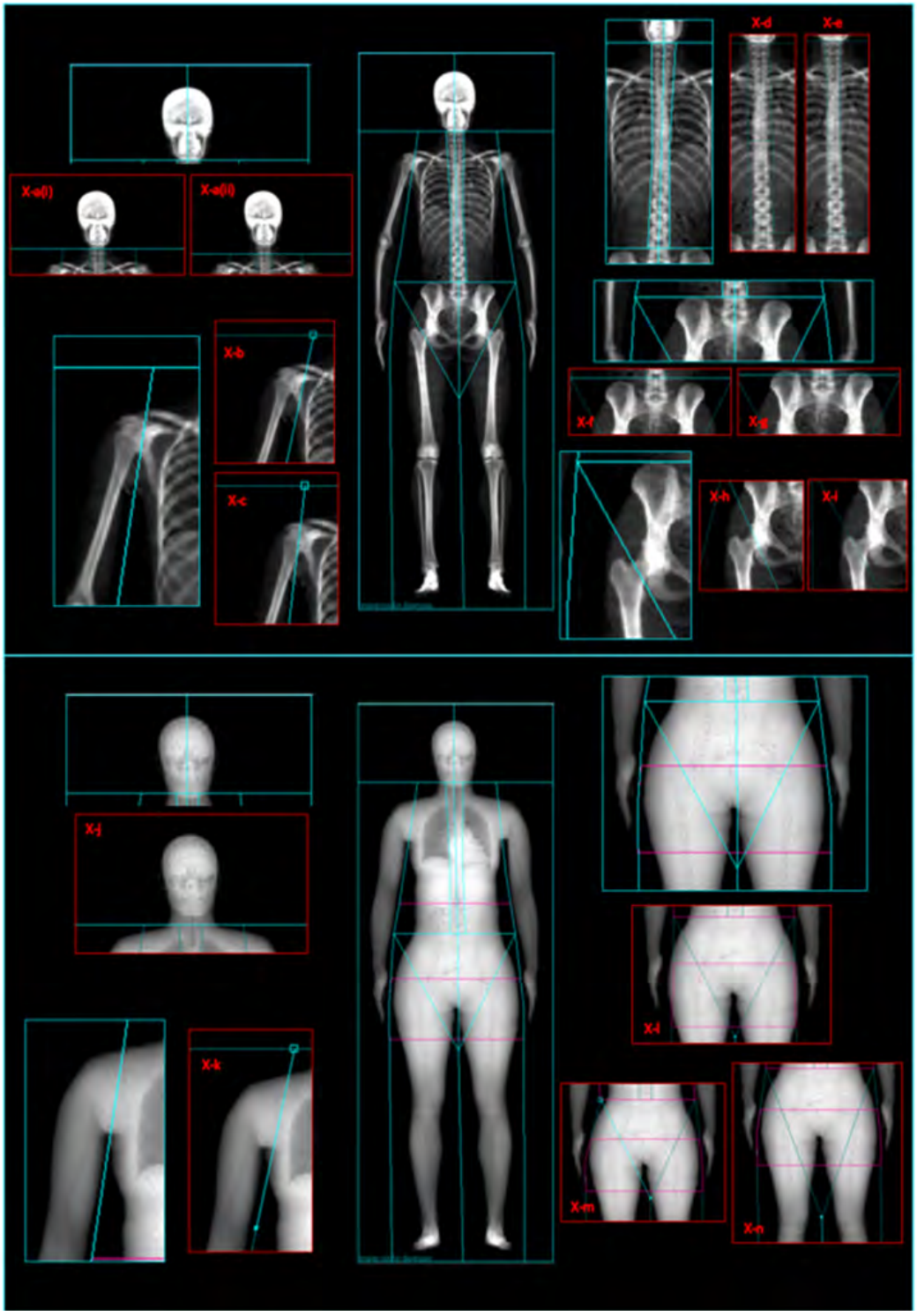


Figure 11. *Total body composition scan with markup of regions of interest (ROIs). Regions outlined in blue are correct placement of ROIs. Regions outlined in red are incorrect placement of ROIs. All ROIs are marked using bony landmarks for reference, and the soft tissue image should be used to ensure 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.

Refining Regions of Interest (ROIs)

Regions Tab

As shown in **Figure 12** starting from the 'Regions' tab, position all dividers as shown in the image, keeping in mind that all horizontal lines must remain completely horizontal:

- Neck line should be touching the inferior edge of the mandible
- T12-L1 line should be placed as best as possible between T12 & L1
- Upper pelvic line should above the superior iliac border
- Lower pelvic lines should be against the ischial borders
- All other lines should divide arms/legs as evenly as possible

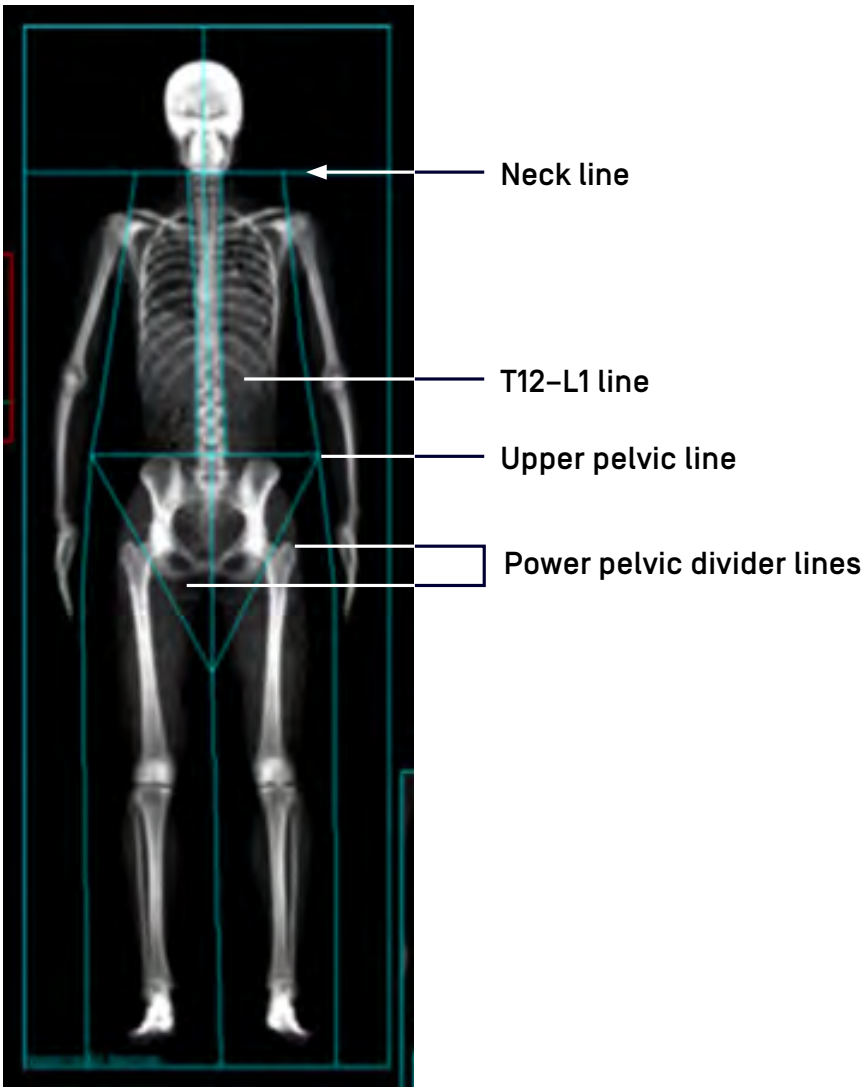


Figure 12. *Correct placement of whole-body regions of interest (ROIs)*

A/G (Android Gynoid) Regions

As shown in **Figure 13** from the 'A/G Regions'(android/gynoid) tab, there is no need to alter the android/gynoid regions as they are placed based on automatic calculation. However, this tab also allows refinement of visceral adipose tissue (VAT) markers. There are three in total shown in the images (A, B & C) all of which can be selected through 'Whole Mode' and adjusted through 'Line Mode'.

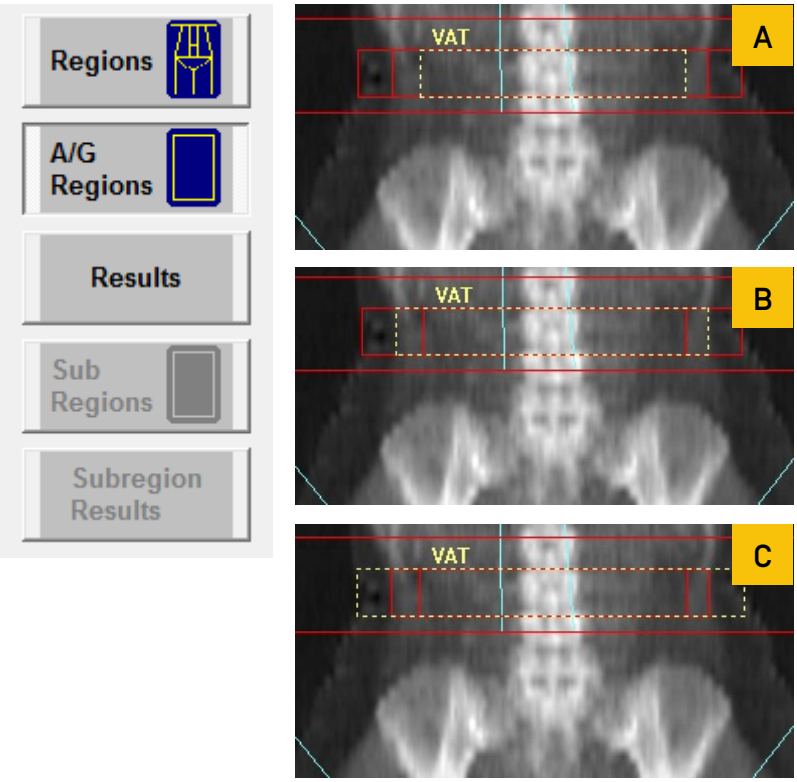


Figure 13. *A/G (Android Gynoid) Region tab and correct placement of Visceral Adipose Tissue (VAT) markers.*

- Marker A (inner) needs to be touching the inside edge of the abdominal wall (oblique muscle)
- Marker B (intermediate) needs to be touching the outside edge of the abdominal wall (oblique muscle)
- Marker C (outer) needs to be touching the outside edge of the subcutaneous border, i.e., skin line.

Custom Regions of Interest & Rulers

Following the 'Results' tab, adding rulers or custom sub regions can also be manually added to any whole body analysis.

Rulers can be added from the 'Results' tab: simply select 'Rulers' and place where desired.

- Sub Regions can be added from the 'Sub Regions' tab: simply click the 'plus (+)' button to add a region and resize/position as needed. Regions can be deleted by having the unwanted region selected and clicking 'minus (-)'

After any desired rulers/regions are added, proceed to 'Subregion Results' where the results can be reviewed and the analysis can be closed.

> Hologic software do not have an option for post-scan removal of artifacts like metal inserts. As such, it remains critical that athletes remove all clothing and jewellery containing metal. Internal artifacts such as metal implants will likely remain permanent, and thus have little impact on the efficacy longitudinal monitoring.

PREPARING A DXA SCAN REPORT

The Technician should generate a report providing standardised information:

1. From the main APEX screen select *Report* on the lower right.
2. Browse for the athlete's name in the search bar shown on the upper section of the screen, highlight the athlete's name and click 'next'.
3. Select the scan to be reported on (scan dates, analysis dates and scan types will be displayed for each entry) and click 'next'.
4. Add in required notes by making use of the 'edit comment' button on the top right. If these are not already present, these may include:
    - A marker of hydration status if recorded
    - Modifications to positioning of athlete
    - Artefacts present
    - Manufacturer, model and software of the DXA machine
    - Reference data base
    - Details of scan mode
    - Precision error
5. To print or save the document as a PDF to a location outside of the APEX 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:

- Compartmental trending
- Total body %Fat
- Total Fat Mass
- Total Lean
- Total Mass

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 lower right of the APEX interface.

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

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

Quality Control Protocols for the DXA Machine

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 Control

Quality control requires use of an anthropomorphic spine phantom issued with the DXA machine as guided by the machine software (**Figure 14**). All other checks will run automatically once the process has started.

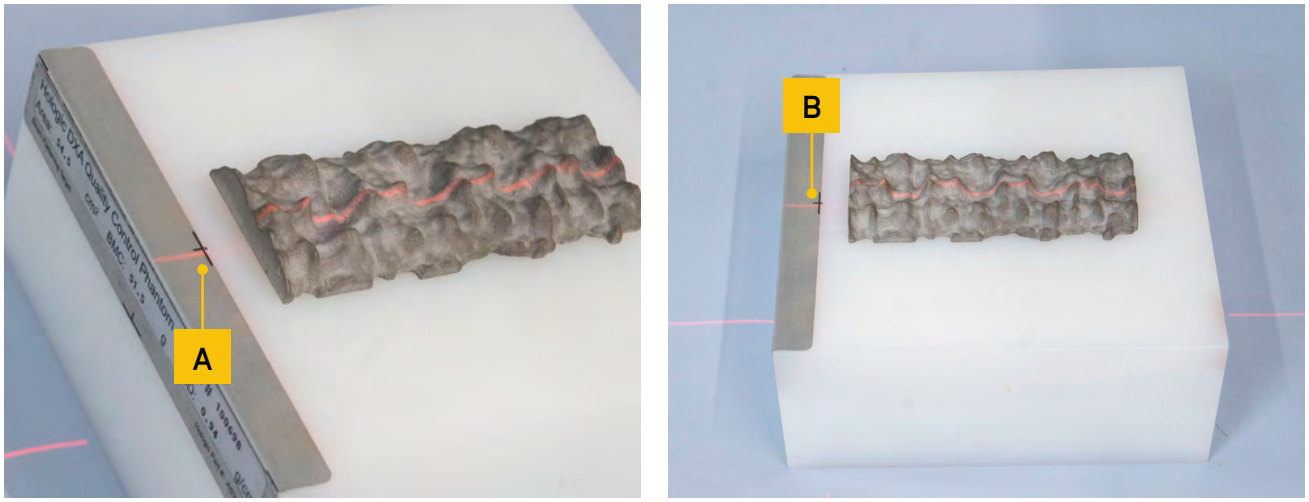


Figure 14. *Anthropomorphic spine phantom.*

1. In the APEX software interface, click **Daily QC**.
2. Place the spine phantom on the table with the registration mark (see 'A' in **Figure 14**) pointing to the foot end of the mattress.
3. Position the phantom parallel to the back of the table.
4. Align the crosshair (see 'B' in **Figure 14**) with the registration mark.
5. Click **Continue**

Once the QC scan has been completed, the software will indicate a 'Pass' or 'Fail'. In the instance of a pass, the software will then display relevant QC information as depicted in **Figure 15** which can be optionally printed/saved if required.

Particular attention should be given to monitoring QC plots in the instance that any drift may be apparent, where the plots may be consistently tracking towards the red dashed limit lines (upper and lower tolerance) which are set at ±1.5% of the referenced BMD mean.

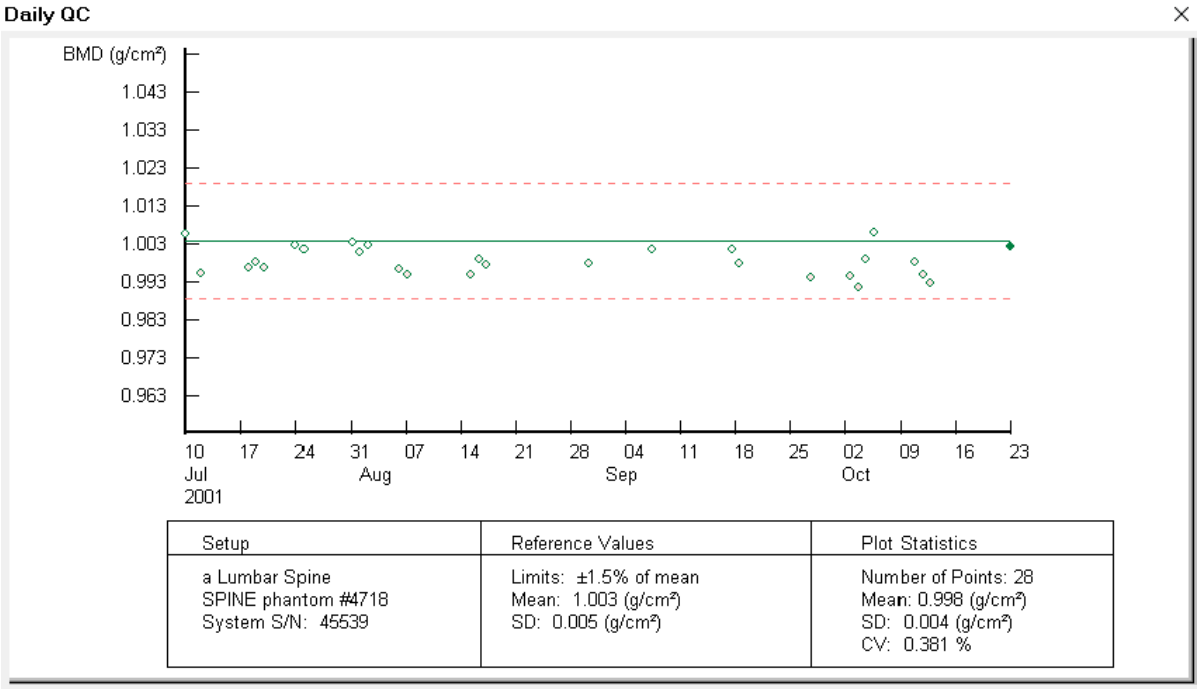


Figure 15. *QC Plot – displaying results of all QC phantom scans.*

In the instance of a 'Fail', follow the steps below:

1. Upon the initial QC failure: Repeat the QC scan. If this reports a 'Pass' – proceed to scan athletes as normal.
2. If the QC fails a 2nd time – restart the DXA system and repeat the QC scan. If this reports a 'Pass' – proceed to scan athletes as normal.
3. If the QC fails a 3rd time – contact Hologic on 1800 264 073 for further steps.

Note: In the instance of a QC 'Fail' the APEX software will not allow scanning to proceed.

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 10 x 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 Hologic – **1800 264 073. Do not conduct any further scans until the issue is resolved by Hologic.**

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 QC 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 stabilize.

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 microsievert (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 **2-14 μSv**
- Total body composition DXA scan **3-8 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:**

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.

> GE LUNAR ONLY: 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.

RADIATION SOURCE	RADIATION EXPOSURE (µSv)	NUMBER (12 MTHS)	TOTAL EXPOSURE
DXA (total body)	3		
DXA (bone density)	9		
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 Hologic machines and different scan modes.

Indicative radiation dose to adult patients from common medical imaging procedures

REGION	HORIZON WI/W			HORIZON A (USV)		
	Express	**Fast Array**	**Aray**	**Express**	**Fast Array**	**Aray**
AP Spine	5	7	14	5	7	14
Femur	1.5	2	4	1.5	2	4
Dual Femur	3	4	8	3	4	8
Forearm	0.01					
Total Body	8			3		
BMD (Spine + Dual Femur)	8	11	22	8	11	22

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

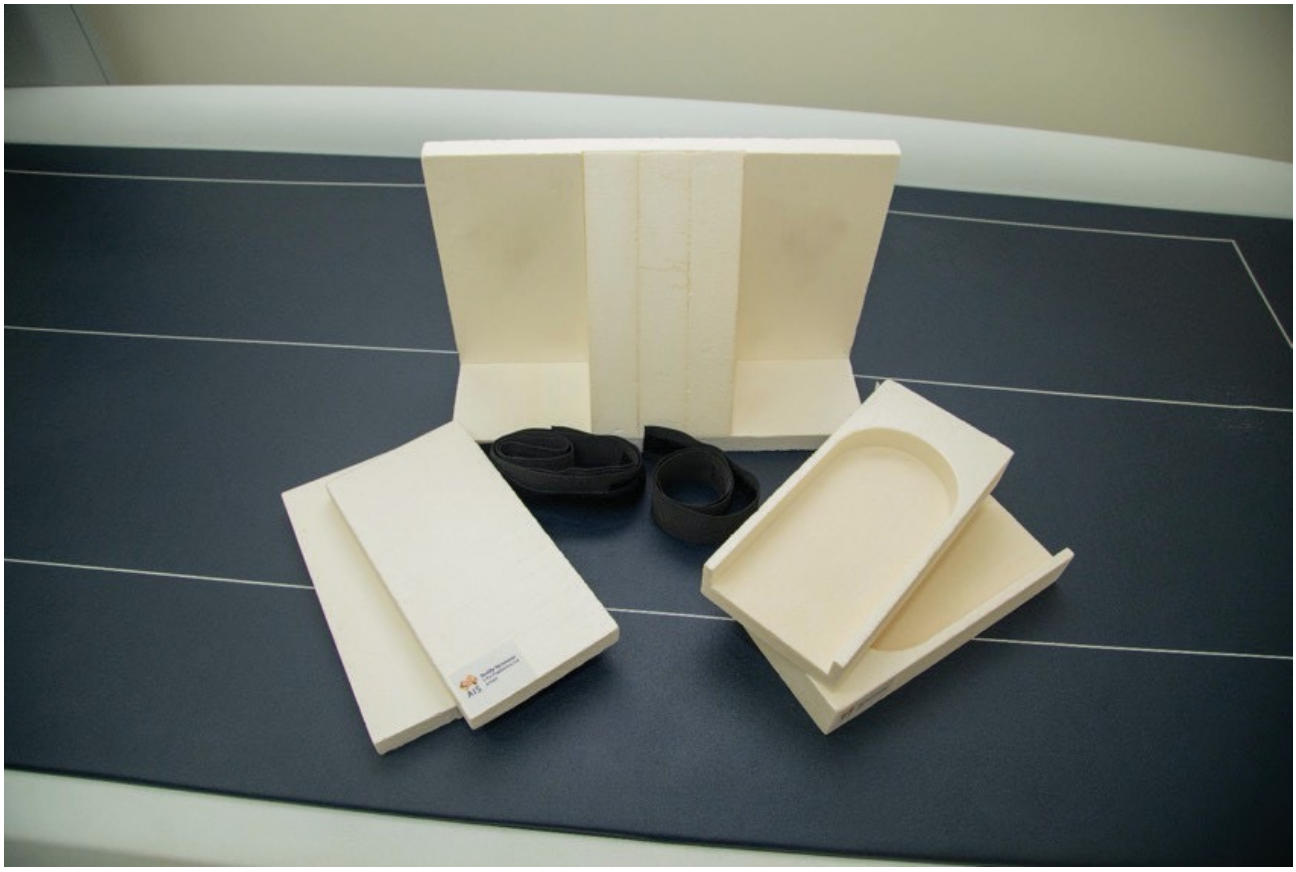
Are you currently breastfeeding? ☐ NO ☐ YES

APPENDIX 5.
RADIOLUCENT FOAM BLOCKS

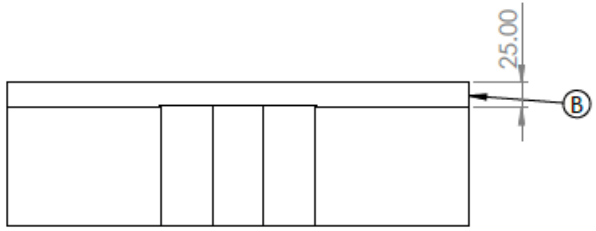
RADIOLUCENT FOAM BLOCKS

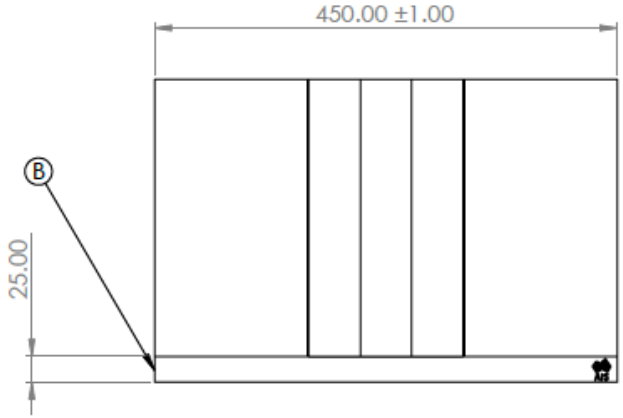
A range of foam materials have been trialed. The most translucent in the DXA scanners were Styrofoam and XPS Insulation Board (industry name "Blue Board") which is used in construction. XPS insulation board is easy to work with and, most pieces involved for the positioning aids are straight cuts. 25 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.

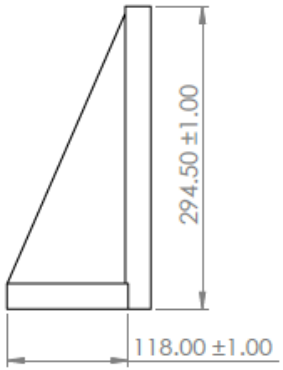
How glue interacts with the final scan results varies. What has worked best is a high tack spray adhesive that is used for upholstery and foam (such as Tensorgrip F40). Hot glue or any kind of "thick" glue appears in scans. Although the impact of this on scan interpretation is likely small, especially 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.



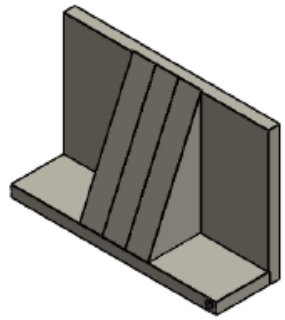
REV.	DESCRIPTION	DATE	APPROVED
A	DRAWING CREATED	03/03/2020	NP
B	UPDATED BOTTOM AND BACK PANEL THICKNESSES TO 25 MM, ADDED ADDITIONAL DIMENSION CLARITY	22/06/2021	NP







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
MACHINING TOLERANCE
SURFACE FINISH

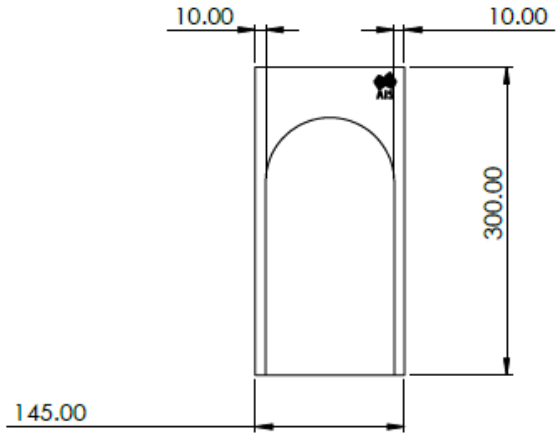
MATERIAL :	ISOBOARD FOAM BOARD
FINISH :	N/A
WEIGHT :	
PROJ. NO :	QA0001
ORIGINATOR :	NPICHSHEV
DATE :	20210622
TITLE:	DXA FOOT AID ASSEMBLY
DWG NO.	
REVISION	B
SCALE	1:5
SHEET	1 OF 1
SIZE	A3

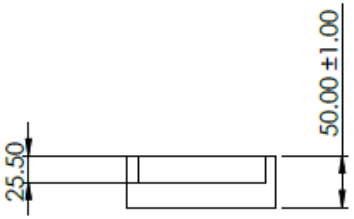
3RD ANGLE
ALL DIMENSIONS IN MM

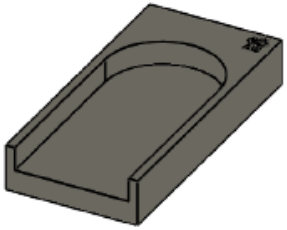
DO NOT SCALE DRAWING

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

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

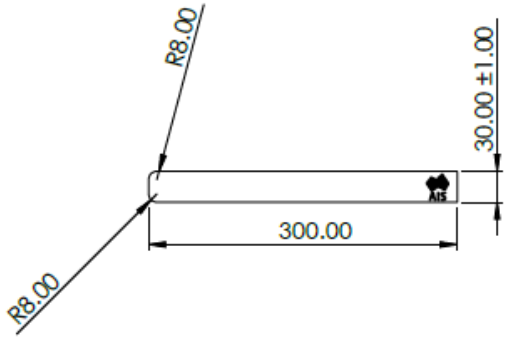
MATERIAL :	ISOBOARD FOAM BOARD
FINISH :	N/A
WEIGHT :	
PROJ. NO :	QA0001
ORIGINATOR :	NPICHSHEV
DATE :	20200303
TITLE:	DXA HAND SUPPORT
DWG NO.	
REVISION	A
SCALE	1:5
SHEET	1 OF 1
SIZE	A3

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

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

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		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

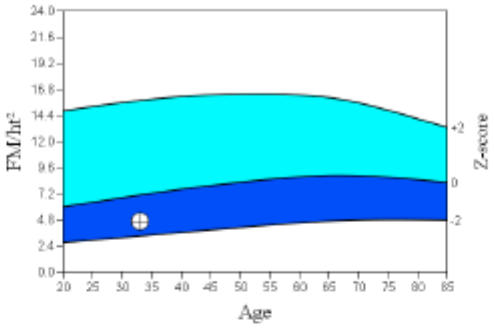
AIS

APPENDIX 6.
EXAMPLE OF TOTAL BODY COMPOSITION DXA REPORT

EXAMPLE OF TOTAL BODY COMPOSITION DXA REPORT

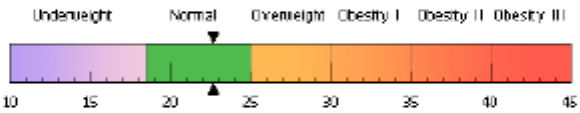
Name:	Sex: Male	Height: 177.0 cm
Patient ID:	Ethnicity: White	Weight: 71.4 kg
DOB:		Age: 33

Fat Mass/Height²



Source: NHANES White Male.

World Health Organization Body Mass Index Classification
BMI = 22.8 WHO Classification Normal



BMI has some limitations and an actual diagnosis of overweight or obesity should be made by a health professional. Obesity is associated with heart disease, certain types of cancer, type 2 diabetes, and other health risks. The higher a person's BMI is above 25, the greater their weight-related risks.

Body Composition Results

Region	Fat Mass (g)	Lean + BMC (g)	Total Mass (g)	% Fat	%Fat Percentile YN	%Fat Percentile AM
L Arm	984	2066	3050	32.3	91	90
R Arm	1094	2123	3217	34.0	93	92
Trunk	6750	20123	26874	25.1	52	40
L Leg	2354	7055	9409	25.0	42	40
R Leg	2525	7258	9783	25.8	46	43
Subtotal	13707	38625	52333	26.2	56	48
Head	886	3091	3978	22.3		
Total	**14593**	**41717**	**56310**	**25.9**	**58**	**48**
Android (A)	1119	2853	3972	28.2		
Gynoid (G)	2626	6327	8953	29.3		

Scan Date: 28 August 2017 ID: A08281701
Scan Type: a Whole Body
Analysis: 11 September 2017 12:54 Version 13.6.0.2
Auto Whole Body Fan Beam
Operator:
Model: QDR Workstation (S/N 12345)
Comment:

Adipose Indices

Measure	Result	Percentile YN	Percentile AM
Total Body % Fat	25.9	58	48
Fat Mass/Height² (kg/m²)	**4.66**	**23**	**15**
Android/Gynoid Ratio	0.96		
% Fat Trunk/% Fat Legs	0.99	64	46
Trunk/Limb Fat Mass Ratio	0.97	44	26
Est. VAT Mass (g)	212		
Est. VAT Volume (cm³)	229		
Est. VAT Area (cm²)	44.0		

Lean Indices

Measure	Result	Percentile YN	Percentile AM
Lean/Height² (kg/m²)	12.5	1	1
Appen. Lean/Height² (kg/m²)	5.53	1	1

Est. VAT = Estimated Visceral Adipose Tissue
YN = Young Normal
AM = Age Matched

TBAR10538 - NHANES BCA calibration

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