
CONTENT SPECIFICATIONS FOR THE EXAMINATION IN BONE DENSITOMETRY



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The purpose of the ARRT Examination in Bone Densitometry is to assess the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required by professional practice in this specialized area. The knowledge and skills covered by the examination were determined by administering a comprehensive practice analysis survey to a nationwide sample of technologists working in bone densitometry¹. The results of the practice analysis are reflected in this document.

This document consists of two related segments. The first segment, the *Content Outline*, specifies the topics to be included in the examination. The table below presents the six major content categories along with the number of test questions allocated to each category. Subsequent pages provide a detailed listing of specific topics within each content category (see notes below).

The second segment identifies *Practice Responsibilities and Sample Cognitive Objectives*. This segment lists 15 clinical activities (practice responsibilities) required of technologists specializing in bone densitometry. Following each practice responsibility are one or more codes (e.g., C.2) to indicate the sections of the content outline to which each practice responsibility corresponds. This segment also presents a few of the cognitive objectives associated with each practice responsibility. This list of cognitive objectives is not exhaustive, but is intended to provide just a sample of the material covered by the exam.

This document is not a curriculum guide. Although certification programs and educational programs may have related purposes, their functions are clearly different. Educational programs are generally broader in scope and address subject matter not included in these content specifications.

Content Category	Number of Questions²
A. Osteoporosis and Bone Health	15
B. Equipment Operation and Quality Control	16
C. Patient Preparation and Safety	4
D. DXA Scanning of Lumbar Spine	16
E. DXA Scanning of Proximal Femur	16
F. DXA Scanning of Forearm	<u>8</u>
Total	75

1. A special debt of gratitude is due to the hundreds of professionals participating in this project as committee members, survey respondents, and reviewers.
2. Each exam includes an additional 15 unscored (pilot) questions. On the pages that follow, the approximate number of test questions allocated to each content category appears in parentheses.

A. Osteoporosis and Bone Health (15)

1. Definition and Types (1)

- a. definition according to World Health Organization (WHO)
- b. primary
- c. secondary

2. Bone Physiology (3)

- a. functions of bone
- b. structural anatomy
- c. types of bone
 - 1) cortical bone
 - 2) trabecular bone
- d. cellular structure
 - 1) osteoclasts
 - 2) osteoblasts
- e. bone remodeling
 - 1) remodeling cycle
 - 2) factors affecting remodeling (e.g., age, hormones, pathology)

3. Risk Factors (2)

- a. genetic
- b. endocrine
- c. nutritional
- d. lifestyle
- e. medications (e.g., steroids, thyroid, hormones, anticoagulants)

4. Bone Mass Measurement Act (1)

- a. clinical indications
- b. guidelines

5. Evaluation and Diagnosis (6)

- a. basic statistical concepts
 - 1) mean
 - 2) standard deviation
 - 3) coefficient of variation
- b. standard scores
 - 1) Z-scores
 - 2) T-scores
- c. methods for evaluating BMD (*basic concepts and major features*)
 - 1) dual energy x-ray absorptiometry (DXA)
 - 2) quantitative computed tomography (QCT)
 - 3) quantitative ultrasound (QUS)
- d. WHO diagnostic criteria
- e. laboratory tests (e.g., biochemical markers)
- f. vertebral fracture assessment (VFA)

6. Prevention and Treatment (2)

- a. lifestyle factors
 - 1) nutrition
 - 2) exercise
 - 3) smoking cessation
- b. fall prevention
- c. drug therapies
 - 1) antiresorptive
 - 2) formation

B. Equipment Operation and Quality Control (16)

1. **Dual Photon Energies (1)**
 - a. typical energy levels
 - b. advantages and limitations
2. **DXA Components (2)**
 - a. x-ray production
 - 1) k-edge filtration
 - 2) energy switching
 - b. radiation detection
 - 1) scintillation detector systems
 - 2) solid state detector systems
3. **Pencil Beam versus Fan Beam (2)**
 - a. mechanics of pencil beam
 - 1) beam collimation
 - 2) detector system
 - 3) scan arm motion
 - b. mechanics of fan beam
 - 1) beam collimation
 - 2) detector system
 - 3) scan arm motion
 - c. geometry of fan beam
 - 1) source-object-detector distances
 - 2) magnification and distortion
 - 3) object centering
 - 4) estimated BMC and area
4. **Scan Analysis Algorithms (1)**
 - a. computation of soft-tissue density
 - b. bone edge detection
 - c. definition and calculation of BMC, area, and BMD
5. **Factors Affecting Accuracy and Precision (5)**
 - a. quality of bone density measurements
 - 1) precision
 - 2) sources of precision error
 - 3) accuracy
 - b. equipment characteristics
 - 1) scanner speed /mode
 - 2) current
 - 3) scanner calibration/stability
 - c. operator and patient characteristics
 - 1) positioning
 - 2) geometry (e.g., centering, ROI size)
 - 3) body habitus; variant anatomy
 - 4) pathology
 - 5) in vivo precision studies
- d. follow-up scanning
 - 1) update baseline biography (patient height, weight; operator identification)
 - 2) reproduce baseline study (acquisition parameters, positioning, ROI placement)
 - 3) changes affecting scan validity
6. **Equipment QC and Maintenance (3)**
 - a. purposes of quality control
 - 1) scanner function and calibration
 - 2) timely repairs and recalibration
 - b. types of QC
 - 1) internal vs. external calibration
 - 2) baseline vs. longitudinal phantom
 - c. types of phantoms
 - 1) aluminum
 - 2) anthropomorphic
 - 3) calibration standard
 - d. analysis of QC results
 - 1) pass/fail criteria
 - 2) need for repeat QC tests
 - 3) need for service
7. **Maintenance, Repair, and Upgrade (1)**
 - a. relocation
 - 1) recalibration
 - 2) reestablish baseline data
 - b. equipment safety
 - 1) electrical
 - 2) emergency stop button
8. **Basic Computer Concepts (1)**
 - a. major components
 - 1) input devices
 - 2) CPU
 - 3) storage devices
 - 4) output and display devices
 - b. file and database management
 - 1) storage and retrieval of data
 - 2) back-up and archiving
 - c. types of software
 - 1) operating system
 - 2) application (e.g., physician reporting systems)
 - 3) software upgrades

C. Patient Preparation and Safety (4)

1. Patient Preparation (2)

- a. special needs
 - 1) fall prevention and mobility assistance
 - 2) mental impairment or disorientation
- b. patient instructions
 - 1) explanation of procedure
 - 2) number and duration of scans
 - 3) motion and breathing requirements
- c. patient history relevant to scan
 - 1) medical history (e.g., bone disorder, prostheses)
 - 2) recent contrast agents or radiopharmaceuticals
 - 3) possible pregnancy

- d. scan preparation
 - 1) entry of patient data
 - 2) removal of artifact-producing clothing
- e. documentation of unusual positioning, acquisition, or analysis
 - 1) anatomy, pathology, body habitus
 - 2) nonremovable artifacts

2. Radiation Safety (2)

- a. basic principles
 - 1) ALARA
 - 2) workstation – scanner distance
- b. levels of radiation in DXA
 - 1) entrance dose (mrem)
 - 2) effective dose (mrem)
 - 3) relationship to other types of imaging studies

D. DXA Scanning of Lumbar Spine (16)

1. Anatomy Related to Scanning (4)

- a. vertebral anatomy
- b. regions of interest in DXA
- c. bony landmarks
- d. radiographic appearance
- e. significant adjacent structures (pelvis, ribs, T12)

2. Scan Acquisition (3)

- a. scan parameters
 - 1) standard technique
 - 2) compensation for variation in anatomy, body habitus, pathology, or low bone density
- b. patient positioning
 - 1) regions to scan
 - 2) positioning aids (e.g., leg block)
 - 3) common challenges (e.g., scoliosis)

3. Lumbar Spine Analysis and Printout (3)

- a. ROI placement
- b. types of measurements (e.g., BMC, T-score, percent of mean, sBMD)
- c. graphical displays

4. Problems Related to Positioning, ROI Placement, and Analysis (6)

- a. types of problems
 - 1) poor bone edge detection
 - 2) intervertebral spaces obscured
 - 3) nonremovable artifacts
 - 4) inaccurate BMC or BMD values
- b. potential causes
 - 1) variant anatomy
 - 2) fractures
 - 3) pathological processes (e.g., scoliosis, arthritis, facet hypertrophy)
 - 4) aortic and other calcifications
 - 5) surgery (e.g., biomechanical devices, laminectomy, fusion)

E. DXA Scanning of Proximal Femur (16)

1. **Anatomy Related to Scanning (4)**
 - a. femoral neck anatomy
 - b. regions of interest in DXA
 - c. bony landmarks
 - d. radiographic appearance
 - e. significant adjacent structures (e.g., pelvis)
 2. **Scan Acquisition (3)**
 - a. femur selection (right vs. left)
 - b. scan parameters
 - 1) standard technique
 - 2) compensation for variation in anatomy, body habitus, pathology, or low bone density
 - c. patient positioning
 - 1) femoral neck rotation
 - 2) femoral shaft placement
 - 3) positioning aids
 - 4) common challenges (e.g., arthritis)
 3. **Scan Analysis and Printout (3)**
 - a. ROI placement
 - b. types of measurements (e.g., BMC, T-score, percent of mean, sBMD)
 - c. graphical displays
 4. **Problems Related to Positioning, ROI Placement, and Analysis (6)**
 - a. types of problems
 - 1) poor bone edge detection
 - 2) nonremovable artifacts
 - 3) ischium underlying neck
 - 4) inaccurate BMC or BMD values
 - b. potential causes
 - 1) variant anatomy (e.g., short femoral neck, inadequate space between ischium and femur)
 - 2) fractures
 - 3) pathological processes (e.g., arthritis, joint disease)
 - 4) surgery (e.g., biomechanical devices)
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F. DXA Scanning of Forearm (8)

1. **Anatomy Related to Scanning (2)**
 - a. forearm anatomy
 - b. regions of interest in DXA
 - c. bony landmarks
 - d. radiographic appearance
 - e. significant adjacent structures (e.g., carpal bones, soft tissue)
2. **Scan Acquisition (2)**
 - a. selection (right vs. left)
 - b. scan parameters
 - 1) standard technique
 - 2) compensation for variations in anatomy, body habitus, pathology, or low bone density
 - c. patient positioning
 - 1) radius – ulna orientation
 - 2) positioning aids
 - 3) common challenges (e.g., kyphosis)
3. **Scan Analysis and Printout (2)**
 - a. ROI placement
 - b. types of measurements (e.g., BMC, T-score, percent of mean, sBMD)
 - c. graphical displays
4. **Problems Related to Positioning, ROI Placement, and Analysis (2)**
 - a. types of problems
 - 1) poor bone edge detection
 - 2) nonremovable artifacts
 - 3) inaccurate BMC or BMD values
 - b. potential causes
 - 1) low bone density
 - 2) pathological processes (e.g., arthritis, joint disease)

Practice Responsibilities and Sample Cognitive Objectives for Bone Densitometry

January 2001

A. Patient Preparation and Environmental Safety

1. Prepare the patient for scanning by explaining the procedure, obtaining relevant patient history (including height and weight), and questioning female patients about possibility of pregnancy as appropriate. *(Content B5, C1)*

Sample objectives

- The candidate will identify that current height and weight are important details to note in the patient's record at each scan event, considering that osteoporosis is both a metabolic and degenerative disease.
 - Given a list of risk factors, the candidate will correctly identify which ones increase the risk of osteoporosis.
2. Remove all artifact-producing objects from patient and determine if the patient has recently received radiopaque contrast or radionuclides. *(Content C1)*

Sample objectives

- Given a selection of artifact-producing items, the candidate will identify which may cause an artifact in a scan of the hip, spine, or forearm.
 - Given a list of physical disabilities, the candidate will identify which ones may cause positioning difficulties.
3. Maintain controlled access to restricted area during radiation exposure. *(Content C2)*

Sample objectives

- Given a choice of effective dose values (mrem), the candidate will identify the approximate or typical range for lumbar spine, hip and forearm DXA techniques.
- The candidate will identify appropriate procedures to assure that patients and other staff are not unnecessarily exposed to radiation during a bone densitometry exam.

B. Instrumentation and Quality Control

1. Regularly inspect equipment for safety and operability and troubleshoot mechanical equipment problems. *(Content B2, B3, B6-B8)*

Sample objectives

- The candidate will recognize the importance of inspecting equipment daily before starting patient exams.
- The candidate will identify "follow manufacturers' guidelines" for instructions on the specific daily prerequisite activities before proceeding with patient exams.

2. Perform and interpret various QC procedures, including routine (daily) checks, phantom and in vivo QC tests, and QC tests performed prior to or following service. (*Content A5, B1-B7*)

Sample objectives

- The candidate will identify the correct definition of the terms “precision”, “accuracy”, and “%CV” as important parameters in the correct operation of DXA equipment, and correctly apply these terms to actual QC data.
- The candidate will identify the recommended procedure for conducting an *in vivo* precision study.
- The candidate will recognize patient characteristics that adversely affect precision (e.g. thick body mass; abnormal anatomy).
- The candidate will understand the reasons for performing a QC test both before and after a service visit.

3. Troubleshoot computer hardware problems and download manufacturer software upgrades as directed. (*Content B7, B8*)

Sample objectives

- The candidate will recognize the importance of installing manufacturer software upgrades according to instructions when such packages are received from the manufacturer.
- The candidate will identify troubleshooting strategies (e.g., turn everything off, then back on again) when the computer locks up or if a device fails.

C. Scanning and Analysis

1. Enter accurate patient information necessary to utilize correct reference data. (*Content B5, C1*)

Sample objectives

- Given a selection of patient biographical data, the candidate will identify which inputs are required to correctly utilize reference population data.
- Given photos of reference population curves, the candidate will identify the correct value that represents the T score, Z score and WHO classification.

2. Select appropriate immobilization devices or positioning aids to position patient correctly and record extraordinary positioning or scan mode details. (*Content C1, D1, D2, E1, E2, F1, F2*)

Sample objectives

- The candidate will correctly identify the purpose for employing unique positioning devices for each scan type.
- Given a series of photos depicting patient positioning for a specific type of DXA scan, the examinee will identify the correct combination of accessory and patient position.
- The candidate will recognize the importance of recording positioning details in patient records.

3. Perform bone densitometry scans of the lumbar spine, proximal femur and forearm utilizing DXA equipment. (*Content A5, B4, B5, D1, D2, E1, E2, F1, F2*)

Sample objectives

- The candidate will recognize that reviewing the patient records and the physician's request to confirm appropriate anatomical sites to scan is one of the customary activities before scanning the patient.
 - The candidate will identify the upper and lower limits of the scan field for each type of DXA scan.
 - The candidate will identify the types of motion artifact that may require repeating a DXA scan.
4. Review scan results to identify inaccurate results and their cause; identify and report problematic measurements (femur, spine, forearm). (*Content A5, B4, B5, D3, D4, E3, E4, F3, F4*)

Sample objectives

- The candidate will identify the potential errors with BMD calculation if scan results show dense metallic artifacts overlying soft tissue.
 - Given a photo of a scan image with a motion artifact, the candidate will identify what action should be taken.
 - The candidate will recognize the importance of establishing routine protocols with the interpreting physician.
5. Evaluate each step of the analysis for accuracy, and modify as necessary. (*Content A2, A5, B4, B5, D3, E3, F3*)

Sample objectives

- The candidate will differentiate correct from incorrect ROI placements.
 - The candidate will identify that if a scan analysis is completed with incorrect vertebral labels, then the reference curve displayed with the results will be misleading.
 - The candidate will recognize that modifying the brightness and contrast is a visual adjustment and will have no affect on BMD calculations.
6. Reproduce positioning for follow-up scans to compare bone density measurements and determine percent change over time. (*Content B5*)

Sample objectives

- The candidate will identify effective methods for minimizing errors and improving precision in follow-up scan results.
- The candidate will correctly determine rate of change in BMD given a baseline scan and a follow-up scan.

7. Archive and retrieve scan images or data to data storage devices. (*Content B8*)

Sample objectives

- The candidate will recognize that since DXA results are considered a medical record, a permanent and secure record must be kept indefinitely.
- The candidate will identify that archiving DXA scan results onto electronic media using a data storage device is a requirement, since computers have a finite amount of temporary storage.
- The candidate will recognize that it is necessary to retrieve scan images to use the “compare” or “rate of change” feature in analyzing results on a patient who returns for a follow-up scan.

D. Patient and Community Education

1. Answer questions about nutrition, exercise, fall prevention, drug therapies and lifestyle choices related to bone health. (*Content A1-A4, A6*)

Sample objectives

- The candidate will identify the recommended total daily calcium intake (RDA) for post-menopausal women.
- The candidate will identify that weight-bearing and resistance exercises are important for building and maintaining bone mass and density.
- The candidate will recognize that currently available medications for prevention and treatment of osteoporosis affect the bone remodeling cycle.

2. Instruct new residents, staff technologists, ancillary staff, or students regarding DXA and other bone density measurement technologies. (*Content A5*)

Sample objectives

- The candidate will identify that sampling at two different x-ray energies is the underlying principle for dual energy x-ray absorptiometry (DXA) technology.
- The candidate will identify the three bone densitometry parameters and their corresponding measurement unit, (area in cm^2 , BMC in grams, BMD in g/cm^2 reported on DXA printouts).
- The candidate will identify QCT as a Quantitative Computed Tomography technique that measures either the spine or the appendicular skeleton and provides volumetric results in g/cm^3 .
- The candidate will identify why DXA is recognized as the gold standard (e.g. reproducibility, low relative cost, low patient dose).