Bone Densitometry Equipment Operator

The purpose of the bone densitometry equipment operator examination, which is developed and administered by The American Registry of Radiologic Technologists (ARRT) on behalf of state licensing agencies, is to assess the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required of operators of bone densitometry equipment at entry into the profession. ARRT administers the examination to state approved candidates under contractual arrangement with the state and provides the results directly to the state. This examination is not associated with any type of certification and registration by the ARRT.

The knowledge and skills covered by the examination were determined by administering a comprehensive practice analysis survey to a nationwide sample of bone densitometrists and adopting a list of tasks for bone densitometry equipment operators as the task inventory. The task inventory appears in Attachment A of this document.[1]

The content specifications identify the knowledge areas underlying performance of the tasks on the bone densitometry equipment operator task inventory. Every content category can be linked to one or more activities on the task inventory.

The table below presents the major categories covered on the examination, along with the number of test questions in each category. The remaining pages of this document list the Specific topics addressed within each category are addressed in the remaining pages of the content specifications.

Section	Number of Scored Questions[2]
Patient Care	12
Safety	8
Image Production	15
Procedures	25
Total	**60**

[1.] A special debt of gratitude is due to the hundreds of professionals participating in the project as committee members, survey respondents, and reviewers.

[2.] The exam includes an additional 25 unscored (pilot) questions.

Patient Care

1. Osteoporosis
  A. World Health Organization (WHO) Definition
  B. Primary
  C. Secondary

2. Bone Physiology
  A. Functions of Bone
    1. structural support and protection
    2. storage of essential minerals
  B. Structural Anatomy
  C. Types of Bone
    1. cortical bone
    2. trabecular bone
  D. Bone Remodeling Cycle
    1. resorption/formation
    2. osteoblasts/osteoclasts
    3. factors affecting remodeling (e.g., age, hormones, pathology)

3. Bone Health and Patient Education
  A. Prevention and Treatment
    1. exercise
    2. nutrition
    3. smoking cessation
    4. fall prevention
  B. Risk Factors
    1. controllable (*e.g., smoking, alcohol, calcium, vitamin D, hormone therapy, medications)
    2. uncontrollable (genetics, race, gender, age, medical conditions)

4. Patient Preparation
  A. Patient Instructions and Explanation of Procedure
  B. Patient History
    1. medical history (e.g., bone disorder, hyperparathyroidism, prosthesis, peak height)
    2. medications use (e.g., long term steroid use, hormone therapy, osteoporosis treatment)
    3. current height and weight
    4. contraindications (e.g., recent contrast agents, calcium supplements,)
    5. possible pregnancy
    6. clinical indications and guidelines (Bone Mass Measurement Act)
  C. Patient Factors
    1. limited mobility or mental impairment
    2. unusual anatomy, pathology, or body habitus
    3. removable artifacts
    4. pediatric patients
  D. Operator Ergonomics
    1. body mechanics (e.g., balance, alignment, movement)
    2. patient transfer techniques
  E. Infection Control (e.g., disinfect work area and equipment)

* The abbreviation "e.g.," is used to indicate that examples are listed in parenthesis, but that it is not a complete list of all possibilities.

Safety

1. Fundamental Principles
  A. ALARA
  B. Basic Methods of Protection
    1. time
    2. distance
    3. shielding

2. Biological Effects of Radiation
  A. Long-Term Effects
  B. Radiosensitive Tissues/Organs

3. Units of Measurement
  A. Absorbed Dose (e.g., mGy)
  B. Dose Equivalent (e.g., mSv)

4. Radiation Protection
  A. General Protection Issues
    1. radiation signs posted
    2. door closed
    3. limit unnecessary people in room
  B. Occupational Protection
    1. scanner-operator distance
    2. personnel monitoring
    3. exposure records
  C. Patient Protection
    1. comparison levels of radiation
      a. peripheral DXA
      b. axial DXA
      c. natural background radiation
    2. strategies to minimize patient exposure
      a. patient instructions
      b. correct exam performance

Image Production

1. Fundamentals of X-ray Production
- A. Properties of X-ray Beam (e.g., scatter, mass, wavelength, frequency)
- B. X-ray Energy Production

2. DXA Systems
- A. Dual Photon Energies
- B. DXA Components
   1. x-ray production
      a. k-edge filtration
      b. energy switching
   2. radiation detector system
- C. Fan Beam
   1. mechanics of fan beam
   2. geometry of fan beam

3. Quality Control
- A. Equipment Safety (electrical, pinch points, emergency stop)
- B. Use of Phantoms
   1. frequency
   2. types
- C. Calibration
   1. recalibration (e.g., relocation)
   2. cross-calibration (e.g., new scanner, software upgrade)
- D. Troubleshooting and Actions
   1. shift or drift
   2. pass/fail criteria
   3. need for service
- E. Record Maintenance

4. Measuring BMD
- A Scan Analysis Algorithm
   1. bone edge detection
   2. definition and calculation of BMC, area, and BMD
- B. Basic Statistical Concepts
   1. mean
   2. standard deviation
   3. coefficient of variation
- C. Reporting Patient Results
   1. Z-score
   2. T-score
   3. WHO diagnostic criteria
- D. FRAX® (WHO Fracture Risk Assessment Tool)
- E. Vertebral Fracture Assessment (VFA)
- F. Pediatric/Adolescent Scanning (ages 5-19)

5. Determining Quality in BMD
- A. Precision
- B. Accuracy
- C. Factors Related to Accuracy and Precision
   1. scanner (e.g., speed/mode)
   2. operator
      a. in vivo precision study
      b. positioning
   3. patient variables (e.g., body habitus, variant anatomy)

6. File and Database Management
- A. Storage and Retrieval of Data
- B. Back-up and Archiving

Procedures

1. DXA Scanning of Lumbar Spine
A. Anatomy
1. regions of interest
2. bony landmarks
3. radiographic appearance
4. significant adjacent structures (e.g., pelvis, ribs, T12)
B. Scan Acquisition
1. patient instructions
2. patient positioning
3. compensation for variations in anatomy, body habitus, pathology, or low bone density
C. Common Problems and Potential Causes
1. poor bone edge detection
2. nonremovable artifacts
3. variant anatomy
4. fractures or pathology
5. aortic and other calcifications
D. Scan Analysis
1. accurate ROI placement
2. BMC, area, and BMD
3. T-score, Z-score
4. graphical display
5. exclusion of vertebrae
E. Follow-Up Scans
1. unit of comparison
   a. BMD
   b. T-score
2. reproduce baseline study

2. DXA Scanning of Proximal Femur
A. Anatomy
1. regions of interest
2. bony landmarks
3. radiographic appearance
4. significant adjacent structures (e.g., pelvis)
B. Scan Acquisition
1. patient instructions
2. femur selection (right versus left or dual)
3. patient positioning
   a. femoral neck rotation
   b. femoral shaft placement
4. compensation for variations in anatomy, body habitus, pathology, or low bone density
C. Common Problems and Potential Causes
1. poor bone edge detection
2. nonremovable artifacts

3. variant anatomy (e.g., short femoral neck, inadequate space between ischium and femur)
4. fractures or pathology
D. Scan Analysis
1. accurate ROI placement
2. BMC, area, and BMD
3. T-score, Z-score
4. graphical display
E. Follow-Up Scans
1. unit of comparison
   a. BMD
   b. T-score
2. reproduce baseline study

3. DXA Scanning of Forearm
A. Anatomy
1. regions of interest
2. bony landmarks
3. radiographic appearance
4. significant adjacent structures (e.g., carpal bones, soft tissue)
B. Scan Acquisition
1. patient instructions
2. selection (right versus left)
3. forearm length
4. patient positioning
5. compensation for variations in anatomy, body habitus, pathology, or low bone density
C. Common Problems and Potential Causes
1. poor bone edge detection
2. nonremovable artifacts
3. variant anatomy
4. fractures or pathology
D. Scan Analysis
1. accurate ROI placement
2. BMC, area, and BMD
3. T-score, Z-score
4. graphical display

Attachment A
Task Inventory for Bone Densitometry Equipment Operator

	Activity	**Content Categories** Legend: PC = Patient Care S = Safety, IP = Image Production, P = Procedures
1.	Perform routine QC tests on scanning equipment according to manufacturer guidelines.	IP.3.
2.	Record results of QC tests in binder, chart, or database.	IP.3.E.
3.	Inspect and interpret results of routine QC tests and determine need for corrective action.	IP.3.
4.	Arrange for corrective action or repairs based on the results of the QC tests as needed.	IP.3.D.3.
5.	Coordinate software upgrades with manufacturer when recommended.	IP.3.C.2.
6.	Troubleshoot equipment errors (e.g., contact manufacturer for guidance) if needed.	IP.3.D.
7.	Troubleshoot computer software errors (e.g., contact manufacturer for guidance) as needed.	IP.3.D.
8.	Inspect equipment to make sure it is safe and operable (*e.g., cables, cords, table pads).	IP.3.A.
9.	Ensure that cross-calibration between new/existing machines is performed as needed.	IP.3.C.2.
10.	Clean and disinfect work area facilities and equipment.	PC.4.E.
11.	Verify current clinical indications meet specifications of CMS billing and coding guidelines if appropriate.	PC.4.B.6.
12.	Import previously archived or baseline studies for direct comparison.	IP.6.A.
13.	Educate new residents, staff technologists, ancillary staff, or students regarding bone densitometry.	PC.1., PC.2., PC.3.
14.	Answer basic questions put forth by the patient, patient's family, or authorized representative (or refer them to the appropriate resources) concerning bone health, fall prevention, exercise, and nutrition.	PC.3., PC.4.
15.	Direct patients to where they can find more information about low bone density.	PC.1., PC.2., PC.3.
16.	Provide assistance to patients with disabilities or limited mobility.	PC.4.C.
17.	Use proper body mechanics and/or ergonomic devices to promote personnel safety.	PC.4.D.
18.	Explain procedure of DXA exam including positioning, duration, and notification policy of results.	PC.4.A.

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Content Categories

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	Activity	Content Categories
19.	Review patient records and provider's request to determine appropriate anatomical sites to scan.	PC.4.B.
20.	Record patient history relevant to bone densitometry.	PC.4.B.
21.	Ask patients about their peak height, maximum height, or height loss.	PC.4.B.1.
22.	Measure and record patient's current height.	PC.4.B.3.
23.	Measure and record patient's current weight.	PC.4.B.3.
24.	Determine if patient has recently received a radiopaque contrast agent or radionuclide.	PC.4.B.4.
25.	Determine if patient has recently ingested contraindicated medications or supplements (e.g., calcium).	PC.4.B.2., PC.4.B.4.
26.	Screen female patients of childbearing age about possibility of pregnancy.	PC.4.B.5.
27.	Enter accurate patient data necessary to initiate scan to utilize correct reference data.	P.1.B., P.2.B., P.3.B.
28.	Review prior scans and reproduce patient positioning during follow-up scan appointments.	P.1.E., P.2.E.
29.	Ensure that artifact-producing objects (e.g., zippers, buttons, jewelry, medical devices) within scan area have been removed from the patient when possible.	PC.4.C.3.
30.	Determine if patient anatomy, pathology, or other limitations require special consideration in patient positioning.	PC.4.C., P.1.B, P.2.B., P.3.B.
31.	Position patient to scan desired region of interest (ROI) using bony landmarks and surface anatomical features.	P.1.A., P.2.A., P.3.A.
32.	Use positioning aids as needed to reduce patient movement and/or promote patient safety.	IP.5.
33.	Record positioning details in patient records to ensure consistency.	P.1.E., P.2.E.
34.	Take appropriate precautions to minimize occupational radiation exposure.	S.4.B.
35.	Take appropriate precautions to minimize radiation exposure to the patient.	S.
36.	Keep all unnecessary persons out of the immediate area during radiation exposure.	S.4.B.
37.	Select appropriate exam modes and perform necessary scans.	IP.1., P.
38.	Perform bone densitometry scans using a fan beam system.	IP.2.
39.	Perform and analyze bone densitometry scans of the lumbar spine - PA utilizing DXA equipment.	P.1.

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	Activity	
40.	Perform and analyze bone densitometry scans of the proximal femur utilizing DXA equipment.	P.2.
41.	Perform and analyze bone densitometry scans of the forearm utilizing DXA equipment.	P.3.
42.	Perform bone densitometry scans of the spine – VFA (vertebral fracture assessment) utilizing DXA equipment.	IP.4.E.
43.	Perform and analyze bone densitometry scans on pediatric patients (ages 5-19) utilizing DXA equipment.	PC.4.C.4., IP.4.F.
44.	Enhance or modify image appearance.	P.1.D., P.2.D., P.3.D.
45.	Evaluate automatic placement of region of interest (ROI) and modify if necessary (e.g., vertebral body exclusions, hardware).	IP.4.A.
46.	Review scan results to identify bone density measurements that may be inaccurate due to artifacts, unusual anatomy, pathology, or positioning errors and rescan if necessary.	IP.4.A.
47.	Evaluate scan results for technical problems (e.g., incorrect scan mode or site) and take corrective action.	IP.5.
48.	Review scan results to determine if scanning an additional site is required in order to obtain more precise bone density measurements.	IP.4.
49.	Evaluate accuracy of vertebral labels and intervertebral markers for scan of lumbar spine and modify if necessary.	P.1.D.
50.	Compare bone density measurements from two different occasions (for same patient) to assess changes over time.	P.1.E., P.2.E.
51.	Identify bone density measurements that require interpreting provider's attention (e.g., low T-score, unreliable results).	IP.5.
52.	Identify exam-limiting patient anatomy or pathology that requires interpreting provider's attention (e.g., scoliosis, severe arthritis).	P.1.C., P.2.C., P.3.C.
53.	Perform an in vivo precision study.	IP.5.C.2.A.
54.	Operate electronic digital imaging devices and record keeping information technology system devices including PACS and medical information systems.	IP.6.
55.	Conduct system backup and archive as recommended by the manufacturer (e.g., external hard drive, DVD).	IP.6.A.
56.	Utilize FRAX® tool to assess 10-year fracture risk.	IP.4.D.