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# Canadian Association of Radiologists Technical Standards for Bone Mineral Densitometry Reporting

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The standards of the Canadian Association of Radiologists are not rules but are guidelines that attempt to define principles of practice that should generally produce radiologic care. The physician may modify an existing standard as determined by the individual patient and available resources. Adherence to Canadian Association of Radiologists standards will not assure a successful outcome in every situation. The standards should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed to obtaining the same results. The standards are not intended to establish a legal standard of care or conduct, and deviation from a standard does not, in and of itself, indicate or imply that such medical practice is below an acceptable level of care. The ultimate judgement regarding the propriety of any specific procedure or course of

conduct must be made by the physician and medical physicist in light of all circumstances presented by the individual situation.

## 1. Introduction

Bone mineral density (BMD) testing by central dual-energy x-ray absorptiometry (DXA) is the fundamental technology for the diagnosis, treatment, and monitoring of osteoporosis, and is a useful adjunct in the management of other metabolic bone diseases [1–9]. The Canadian Association of Radiologists (CAR) BMD guidelines are issued here as technical standards and represent the current expectations for BMD testing and reporting in Canada. These standards must be met to be accredited by the CAR BMD Accreditation Program. Changes have been made to the 2010 CAR Technical Standards for Bone Mineral Densitometry Reporting to incorporate principles from the 2010 Clinical Practice Guidelines for the Diagnosis and Management of Osteoporosis in Canada from Osteoporosis Canada: Summary [1,2].

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## 2. Information That Should Be Provided by Referring Physicians

BMD consultation requests should include patient demographics, the indication for BMD testing, factors of relevance to scan assessment (joint replacement, bone surgery, or bone disease in scan regions), osteoporosis medication history, factors of relevance to fracture risk determination in patients 50 years old or older (fragility fracture history, glucocorticoid history), and any other pertinent medical information [1,2,6,10]. On follow-up scans done on patients receiving osteoporosis drug therapy, it is particularly helpful if BMD requests indicate the scan year of primary interest for comparison, with details of current osteoporosis drug therapy and duration [2,6,11,12]. Although this level of information is often not provided, a thorough patient history from the referring physician is to be encouraged [1,2,6].

## 3. Adult Patient Questionnaire

A template questionnaire that acquires the appropriate information necessary for BMD testing in adults (defined as those 18 years old or older) is presented in Appendix 1 [1,2]. This questionnaire can either be filled in by patients and then clarified by trained facility staff or a history can be directly taken by facility staff. The specific items on the questionnaire are intended to collect the minimum information needed to analyse a BMD scan and determine absolute fracture risk in those 50 years old or older [1,2]. Additional history items that are of relevance to individual patients should also be collected, such as menopausal history, medication history, and illnesses [1,2,6].

## 4. BMD Report Contents

Report contents will differ, depending on whether it is an adult (18 years old or older) or a pediatric study that is being reported and whether it is a baseline or follow-up study.

### 4.1. Components of a First-Time Adult BMD Report

The components of a first-time adult BMD report are shown in Appendix 2 [1,2].

#### 4.1.1. Demographics

Demographics should include patient name, date of birth, sex, provincial health care number or other identifier, height, weight, scan date, report date, name of the referring physician, name of the reporting physician, and BMD facility name and location [2,6,13]. Weight and height should be measured at the BMD facility [1,2]. Neither values reported by the patient nor measurements provided by other medical practitioners should be used, other than in exceptional circumstances in which it is not possible to carry out the measurements (such as if the patient cannot stand). If height

or weight data were not measured directly by the BMD facility, then this should be indicated in the report.

Weight can be measured with either a mechanical or an electronic scale that is medical grade. Facilities are encouraged to use wall-mounted height measuring devices, referred to as stadiometers, and to use standardized positioning of patients [7,14,15]. It also is encouraged that 3 height measurements be made, with repositioning between each measurement and that the average be used as the height value. The reason for this is that, just as with bone density quantitation, height measurements have significant precision error, and this is minimized by averaging several assessments [14,15]. Currently, this height measurement methodology is a recommendation and is not a requirement for accreditation.

#### 4.1.2. Diagnostic category

The current standard for reporting the diagnostic category is shown in Appendix 3 [2]. The diagnostic category is determined by using the lowest T-score (for individuals 50 years old or older) or Z-score (for individuals younger than 50 years of age) from the available results for the lumbar spine, total hip, femoral neck, 1/3 (or 33%) radius, and total body (see section BMD Data and Appendix 3 for details) [2]. The trochanteric region and Ward's region of the proximal femur are not to be used [16]. T-scores or Z-scores for diagnostic categorization should be derived by using a white female reference database for women and a white male reference database for men.

#### 4.1.3. Fracture risk category

The absolute fracture risk category should be reported for men and women 50 years old and older when a relevant history is available [1,2]. The current standard for determining absolute fracture risk uses the 2010 version of the CAR/Osteoporosis Canada risk tables (CAROC 2010) [1,2]. The CAROC 2010 risk tables are provided in Appendix 4, along with instructions on how to use them. This risk determination incorporates BMD results from the femoral neck, age, sex, fragility fracture history after age 40 years, and glucocorticoid history. The spine BMD T-score also is used in certain circumstances. There are several clinical circumstances in which the fracture risk is deemed to be high, regardless of BMD. There also are clinical circumstances in which fracture risk cannot be assigned. Details are provided below. For individuals younger than age 50 years old, absolute risk assessment is not available, and a fracture risk category should not be reported [13,16].

**CAROC 2010 table.** Fracture risk is determined on the CAROC 2010 tables by using the femoral neck T-score. For both women and men, T-scores for fracture risk determination by using CAROC 2010 are derived from a white female reference database. Note that this approach differs from that used to determine the diagnostic category for men (section Diagnostic Category), in which a white male reference database is used. BMD data for males, therefore, will need to

be analysed on both white male and white female reference databases.

**Fragility fracture history.** The absolute fracture risk categories were derived by using data from 4 types of fractures: forearm, vertebra, proximal femur, and proximal humerus [3]. Fractures at these sites should generally be regarded as fragility fractures if they occur subsequent to a fall from standing or sitting heights. Generally, craniofacial fractures and fractures of the hands and feet are not considered fragility fractures. Other types of fractures have weaker relationships to osteoporosis but may be regarded as fragility fractures if the history suggests that the fracture occurred with a degree of trauma that would not normally be expected to lead to a broken bone [2,17]. Only fractures that occurred after age 40 years should be considered in determining risk [2,17].

**Glucocorticoid history.** Glucocorticoid history is considered positive if prednisone (or other glucocorticoids in terms of prednisone equivalents) was in use at a dose equal to more than 7.5 mg per day for more than 3 cumulative months in the prior 12 months (ie, for more than 90 total days of the preceding 365 days, not necessarily consecutive) [1,2]. Patients with hypoadrenalism and who are on replacement glucocorticoids should not be considered to have a positive glucocorticoid history for fracture risk determination regardless of glucocorticoid dose [18].

**High risk regardless of BMD.** There are several clinical situations that relate to fracture history in which an individual should be classified as having a high fracture risk regardless of the BMD result. These include a history of 1 fragility fracture and a positive glucocorticoid history, history of fragility hip fracture, history of fragility vertebral fracture, and history of 2 or more fragility fractures [1,2].

**Use of the spine T-score.** If the fracture risk category has been determined to be low after determining the fracture risk category when using the femoral neck T-score on the CAROC 2010 table, fracture history, and glucocorticoid history, the spine T-score is assessed. If the spine T-score is less than or equal to -2.5, then the risk category is increased to moderate [1,2]. A white male reference database is used for this purpose for men, and a white female reference databases used for women.

**Use of sites other than femoral neck and spine.** Sites other than the femoral neck and the spine are not used to generate the fracture risk category, although they are used for determining diagnostic category [1,2].

**Undefined clinical scenarios.** When using the approach of Osteoporosis Canada, it will not be possible to generate a fracture risk category in certain clinical scenarios [1,2]. In particular, this will occur when the femoral neck and the spine are not available or when the femoral neck is not available while the spine is available but has a T-score higher

than −2.5. In addition, there are scenarios in which the fracture risk is likely higher than determined by the femoral neck, as when the spine T-score is much lower than −2.5 or T-scores of other skeletal sites are much lower than the value at the femoral neck. In these circumstances, the reporting physician should provide guidance in the interpretation section.

**Use of FRAX.** Although FRAX (the World Health Organization fracture risk system) has validity for fracture prediction, both Osteoporosis Canada and CAR have endorsed CAROC 2010 as the method of choice for reporting BMD results [1−3,19−26]. CAROC 2010 is to be used for fracture risk reporting [1,2].

**Integrating fracture risk determination by using the Osteoporosis Canada paradigm.** A flow chart of one approach to systematically integrating these principles is provided in Appendix 5.

**Bone-active drug therapy.** Bone-active drug therapy may alter fracture risk if the drug is taken regularly, if it is taken correctly, and if it is achieving the desired effects, although some evidence that indicates that fracture risk determination might remain valid in the short term, even when medications are in use [2,27,28]. If a patient who undergoes BMD testing for the first time is already on bone-active drug therapy, then the fracture risk category should be provided, but a statement should be included that indicates that the risk may be lower than calculated if osteoporosis drug therapy is effective [1,2,28].

*4.1.4. History used for risk determination*

For individuals 50 years old and older, the report should state the specific history used in risk determination when either the fragility fracture status or the glucocorticoid history is positive [1,2]. This transparency allows the referring physician to understand how the fracture risk was achieved and allows the referring physician to provide clarification or additional information if appropriate.

*4.1.5. BMD data*

Care must be taken in all technical aspects of how scanning is performed, including adherence to manufacturer protocols, proper positioning, subregion assignment, bone tracing, determination of regions of interest, and quality assurance [2,6,13]. A minimum of 2 skeletal sites should be scanned and reported [2,6,9]. The usual sites would be the lumbar spine and the proximal femur [2,6,9]. When analysing the lumbar spine, L1 to L4 should be used unless the decision is made to exclude 1 or 2 vertebrae because of technical artifacts [2,13]. A minimum of 2 vertebrae should be used. Interpretation should not be based on a single vertebra [2,13]. If a report includes graphic representation of results, then the graph must present data and reference curves for the vertebrae actually used in interpretation [29]. Consideration can be given to excluding a particular vertebra if the T-score of that vertebra is more than 1 standard

deviation more than the T-score of the vertebra with the next highest value [29]. It is not mandatory that a high-density vertebra be excluded, but it should be evaluated for causes of artifact, and a decision should be made as to whether it should be retained in the vertebral analysis.

For the proximal femur, the left side should be measured unless it is not available or is invalid, or if the right hip was previously measured [2]. Results should be reported for the total hip and femoral neck [2,13]. If either the spine or the hip site is not available or is invalid because of artifact, another site should be substituted [2,6,13]. The nondominant forearm is the site of choice and the 1/3 (or 33%) radius should be reported [2,6,13]. If the nondominant forearm is not available or is invalid, then the dominant side may be used. If the wrist cannot be measured, then the total body BMD can be assessed [29]. The head may be included or excluded when analysing the scan. If the head is excluded, then this should be noted in the report. If the spine cannot be measured and neither forearm nor total body measurements are available, then bilateral hip measurements may be made [6,13,29]. The 2 hip measurements should be reported separately, not as an averaged value [29]. When applying hip data to determine the diagnostic category or fracture risk category, the lowest of the relevant values from the 2 sides should be used. For patients whose weight exceeds the limit of the DXA equipment, bilateral forearm studies may be done unless 1 side is not available or is invalid, although it will not be possible to determine fracture risk [29].

For each skeletal site with a valid scan, reported density results should include absolute BMD (in g/cm$^2$, to 3 decimal places) and either a T-score (to 1 decimal place) for those 50 years old or older, or a Z-score (to 1 decimal place) for those younger than 50 years of age [10,13,16,29]. For women, T-scores and Z-scores should be derived by using the manufacturer's white female reference database. For men older than age 50 years, T-scores used for diagnostic classification should be derived by using a white male reference database; the femoral neck T-score used for risk determination should be derived from a white female reference database, whereas the spine T-score used to alter the risk category from low to moderate if the value is less than or equal to -2.5 should be derived from a white male reference database. Both femoral neck T-scores must be reported. For men younger than age 50 years old, Z-scores should be derived by using a white male reference database. Nonwhite reference databases should not be used. The reference databases and versions should be specified in the report [6,29].

### 4.1.6. Limitations

Any structural abnormalities, anatomic variants, artifacts, suboptimal positioning, or other issues that impact scan reliability and interpretation need to be considered when interpreting BMD results [2,6,10,13]. A judgement needs to be made as to whether these issues render results invalid or impact on the interpretation. Some sources of artifact are preventable, and care should be taken to assess these before scanning (such as metal on clothes or in pockets, or recent

barium or nuclear medicine studies) and either remove the source of artifact or postpone the scan to a future date. Sources of artifact relevant to the scan should be noted in the report. Skeletal size can affect BMD readings, with larger bones producing falsely high values and smaller bones producing falsely low values [29]. There is no accepted means of correcting for skeletal size, but height or weight outside the normal range should be noted and should be considered in the interpretation of results.

### 4.1.7. Interpretation

A narrative section on interpretation and implications of BMD results should be provided. This should not be a simple restatement of data. In individuals older than age 50 years in whom an absolute fracture risk cannot be assigned by using the Osteoporosis Canada paradigm, the reporting physician should integrate the available information and provide an indication of fracture risk when this is possible. Guidance as to therapeutic considerations can also be provided within the context of Osteoporosis Canada guidelines to the degree appropriate to the knowledge and experience of the reporting physician [1,2].

### 4.1.8. Recommended follow-up date

A recommendation should be included for the timing of the next DXA study [2,13]. The timing of serial testing should be driven by the expected rate of bone loss. The intention of serial monitoring is to provide a sufficient period of time for anticipated changes in density to exceed the precision error of the DXA method, which also renders a stable density informative [1,2,4,6,13]. A guide is provided in Appendix 6, although this needs to be applied in the context of local provincial health insurance plan restrictions. When indicating recommended timing of the subsequent BMD test, consideration should be given to specifying the year of recommended follow-up rather than a time interval because this makes the report more readily implementable by referring physicians. For follow-up periods of less than 2 years, the month of recommended follow-up could also be included. This approach is not a requirement for accreditation at this time.

### 4.1.9. Definitions

Any terminology or abbreviation used in the report should be defined. Some examples are the following:

T-score: The number of standard deviations above (+) or below (−) the mean peak density.
Z-score: The number of standard deviations above (+) or below (−) the mean density for an individual of that age and sex.
Fracture risk: High fracture risk is 10-year absolute fracture risk >20%; moderate fracture risk is a 10-year absolute fracture risk in the range of a 10%-20%; low fracture risk is a 10-year absolute fracture risk <10%.
TBLH: Total body less head, assessment of the entire body minus the head region.

### 4.1.10. Machine identification

Machine identification should include DXA brand, model, and serial number.

## 4.2. Components of a Follow-up Adult BMD Report

The components of a follow-up adult BMD report are shown in Appendix 7. A follow-up adult BMD report should include all the components of a first-time adult report. In addition, items specific to follow up also need to be described, including changes in density, statistical parameters that relate to measurement error, aspects of interpretation that relate density changes to the clinical situation, and definitions relevant to follow up.

### 4.2.1. Demographics

Change in height as measured at the BMD facility should be noted [1,2,13,15]. In particular, measured height loss that exceeds 2 cm over 3 or fewer years should be emphasized because this amount of height change has been shown to have a high predictive value for incident vertebral fractures that have developed during the monitoring period [2,15], which may be an indication to perform spine radiographs or vertebral fracture assessment by DXA [2]. Change in weight should also be noted because this can create artifactual changes in BMD values [2,30]. There is no consensus as to what the threshold should be for flagging a change in weight as being of potential importance as a source of artifact, with some physicians using percentage change in weight and others using absolute change in weight. A suggested threshold is 10% change in weight over the period of monitoring [29]. The use of this weight-change threshold is only a recommendation and is not a requirement for accreditation. Each reporting physician, however, must define a weight-change threshold and use it in all serial reporting and apply it to each pair of BMD measurements for which change in BMD is reported.

### 4.2.2. Fracture risk category

The absolute fracture risk category should be reported for men and women 50 years old and older, regardless of the therapy that may be in use [1,2]. If bone-active drug therapy is in use, then the fracture risk category should be provided, but a statement should be included that indicates that the risk may be lower than calculated if osteoporosis drug therapy is effective [1,2].

### 4.2.3. Changes in density

When comparing serial assessments, the same machine should be used when possible [2,12,13], and positioning and subregion assignment must be consistent [2,12,13]. The same reference population database should be used for serial studies when possible [29]. If the reference database must be changed, this should be noted in the report. The description of density change should include the absolute density change (in g/cm$^2$, to 3 decimal places) and percentage change (to 1 decimal place) [10,13,29]. Percentage change must be derived by using absolute density (g/cm$^2$), not T-scores or Z-scores [4]. An

annualized rate of change may be reported, but this is optional. The skeletal sites for which changes in density are to be reported are the lumbar spine (by using whichever vertebrae are considered valid, with a minimum of 2 vertebrae) and the total proximal femur [2,13]. Hip subregions should not be used [2]. If either the spine or the hip is not available, then it is permissible to report changes at a single site. If the forearm or total body BMD is being monitored in lieu of the spine or hip, then the change can be reported for the 1/3 (or 33%) proximal radius or for the total body BMD [10,29]. It must be recognized that the change profile at these sites may not parallel changes at the spine and hip, and may not correlate as well with drug responses [10,29]. This will need to be addressed in the interpretation section.

Changes in density must be reported in relation to (1) the first study on file, (2) the most recent previous study, and (3) the study done closest to the initiation of the current clinical treatment regimen (if any), if this can be ascertained. The latter BMD change is the one of greatest importance for patients on drug therapy; it also is relevant to patients who started lifestyle and nutritional supplements for bone health [1,2]. Ideally, the comparison study of primary interest should be indicated on the requisition by the referring physician, but, if it is not provided, then the reporting physician is responsible for obtaining this information by patient history.

Statistical significance must be reported for each BMD skeletal-site comparison, and must indicate whether the difference is considered significant at a 95% level of confidence [2,4,6]. The manufacturer's software determination of statistical significance is not to be used [2]. Each facility must determine precision error for each DXA machine and for each skeletal site (including the forearm and the total body if these sites are measured by the facility and are used for serial monitoring) by using the least significant change (LSC) methodology and use this value when determining statistical significance [2,13]. It is permissible to apply results derived from precision testing on 1 side (forearm or hip) to serial scans done by using the opposite side of the body [13]. A follow-up BMD report should state the LSC in absolute values (g/cm$^2$, to 3 decimal places) for each skeletal site for which change is reported [10,13,29]. Whenever possible, the same instrument should be used for serial studies of an individual patient [29]. Comparisons between measurements done on different machines can be made only if intermachine precision between the 2 devices has been determined [13,29].

### 4.2.4. Interpretation

The clinical implications of density change or stability must be incorporated into the interpretation section of the report [1,2,6,29]. This is of greatest importance for patients who are using osteoporosis drug therapy, when BMD is often being used to assist in monitoring drug actions [1,2,10]. The primary BMD outcome of interest in this circumstance is the net change in density from the time that the current drug regimen was initiated [1,11]. In general, net stability or a gain in density is considered a positive drug effect, whereas net loss of density is considered evidence of drug failure

[1,11]. Secondary changes in the BMD profile that may differ from the net change on a drug regimen, such as a change from the most recent prior study, also need to be considered in the interpretation [31]. For serial studies in those patients not on osteoporosis drug therapies, there are similar implications for the effects of nutritional supplements, lifestyle changes, and exercise regimens [1,11].

There are insufficient data at this time to define the relationship between the amount of loss and the resulting change in fracture risk, so loss of density is not incorporated into the absolute fracture risk methodology [32]. The reported absolute fracture risk should not be altered because of loss in density. Rather, the implications of density loss should be discussed in the interpretation of results.

### 4.2.5. Definitions

LSC Least significant change is the amount by which 1 BMD value must differ from another for the difference to be statistically significant at a 95% level of confidence.

### 4.3. Components of a First-Time Pediatric BMD Report

The pediatric population is defined as individuals younger than 18 years old. The components of a first-time pediatric BMD report are shown in Appendix 8. Components that are similar to the content of an adult first-time BMD report include demographics, machine identification, and limitations [1,2,6,7,13,33]. There are differences concerning BMD data and interpretation, and specific definitions apply to reporting in this age group [6,7,13,33,34]. There are no guidelines on timing of follow-up studies, so a recommended follow-up date is not mandatory, although it may be included at the discretion of the reporting physician [7,29,33]. A pediatric history sheet is not provided because there are no mandatory items incorporated into the report (as with adult absolute risk determination), but the adult history sheet can be adapted. A history that is relevant to the individual pediatric patient should be collected and may include fracture history, medications, and illnesses [7,13,33]. Height and weight measurements in younger children require special devices and procedures [33]. If these are not available, then it is acceptable in younger children to use values provided by other medical practitioners. If height or weight were not measured directly by the BMD facility, then this should be indicated in the report.

### 4.3.1. Diagnostic category

The current standard for reporting the diagnostic category in the pediatric population is shown in Appendix 3 [2,29]. The diagnostic category is based on the lowest adjusted Z-score from the results for the lumbar spine and total body by using either bone mineral content (BMC) or BMD at the discretion of the reporting physician [6,7,13,29,33]. See section BMD Data for clarification of Z-score adjustment. The T-score is not to be used in pediatric reporting [7,13,29,33]. If either the spine or the total body value is not available or is invalid, then this should be reported as a limitation. Forearm measurements (1/3 or 33% of the site)

may be used if either the spine or the total body value is not available but only if a reference population database is available from which forearm Z-scores can be derived [6,7,13,29,33]. Proximal femur measurements are not to be used to generate the diagnostic category in the pediatric population, although it may be clinically useful to begin measuring hip density in older adolescents to transition into the adult mode of monitoring [2,13,29,33].

### 4.3.2. BMD data

Care must be taken in all technical aspects of how scanning is performed, including adherence to manufacturer protocols, proper positioning, subregion assignment, bone tracing, determination of regions of interest, and quality assurance [6,7,13,29,33]. Results should be reported for the lumbar spine and the total body, including BMC and BMD for each site [7,13,29,33]. When analysing the lumbar spine, L1 to L4 should be used unless the decision is made to exclude 1 or 2 vertebrae because of technical artifacts [2,29]. A minimum of 2 vertebrae should be used [2,29]. Interpretation should never be based on a single vertebra [2,29]. If a report includes graphic representation of results, then the graph must present data and reference curves for the vertebrae actually used in interpretation [2,29]. Consideration can be given to excluding a particular vertebra if the Z-score of that vertebra is more than 1 standard deviation more than the Z-score of the vertebra with the next highest value [29]. It is not mandatory that the high-density vertebra be excluded, but it should be evaluated for causes of artifact and a decision made as to whether it should be included in the vertebral analysis. On some manufacturers' databases, Z-scores may not be available if vertebrae are excluded. In this circumstance, it is appropriate to include L1 to L4 to generate a Z-score, but the interpretation section must address the accuracy of the spine measurement and the ways in which the Z-score may have been perturbed by the abnormal vertebrae. For the total body measurement, the head may be included or excluded when analysing the scan [6,29,33,34]. If the head is excluded, then this should be noted in the report. For adolescent patients whose weight exceeds the limit of the DXA equipment, bilateral forearm studies may be done unless one side is not available or is invalid, in which case a single side can be measured [29,33,34].

For each skeletal site with a valid scan, reported density results should include the absolute BMD (in $g/cm^2$, to 3 decimal places), the BMD Z-score (to 1 decimal place), and the adjusted BMD Z-score (to 1 decimal place); and the BMC (in grams, to 2 decimal places), BMC Z-score (to 1 decimal place), and adjusted BMC Z-score (to 1 decimal place) [6,13]. The Z-score adjustment is done to correct for relative skeletal size or maturation. There is no consensus at this time as to the specific adjustment that should be made, so the nature of the adjustment is at the discretion of the reporting physician. Adjustment can be based on height, weight, body mass index, bone area, bone age, pubertal stage, lean body mass, or a combination of these parameters [6,7,13,29,33–41]. The method of adjustment should be

noted in the report, and, if a multivariable method is used, then a published reference should be provided. The assignment of diagnostic category should be based on the adjusted Z-scores by using the BMC Z-score, the BMD Z-score, or the lower of the 2, at the discretion of the reporting physician. Some manufacturers provide height or weight corrections as part of the DXA software. For those whose DXA software does not provide such corrections, an approach to correcting for bone age or height age is described in Appendix 9 [7,29,33]. Each method of correction has limitations and constraints, and these need to be considered in the interpretation [29,33].

Bone area, corrected bone area, and area Z-scores are not required but can be included at the discretion of the reporting physician [7,13,29,33,42]. All Z-scores should be derived by using a white female reference database for girls and a white male database for boys [29]. Nonwhite reference databases should not be used. The reference database and version should be specified in the report [6,7,29,33]. If the reference database that is used to generate Z-scores is not one provided by the manufacturer, then a published reference should be provided. Z-scores may not be available for certain skeletal sites at young ages and so do not need to be reported.

### 4.3.3. Definitions

Any terminology or abbreviations used in the report should be defined.

## 4.4. Components of a Follow-up Pediatric BMD Report

The components of a follow-up pediatric BMD report are shown in Appendix 10. A follow-up pediatric BMD report should include all of the components of a first-time pediatric report. In addition, items specific to follow-up also need to be described, including changes in density, statistical parameters that relate to measurement error, and aspects of interpretation that relate to the changes in density.

### 4.4.1. Changes in density

When comparing serial assessments, positioning and subregion assignment must be consistent [29,40,41]. The same reference population database should be used for serial studies whenever possible [13,33]. If the reference population database must be changed, then this should be noted in the report. The description of density change should include the absolute density change (in $g/cm^2$, to 3 decimal places), percentage change (to 1 decimal place, derived by using absolute density, not Z-scores), change in Z-score, and change in adjusted Z-score [13,29]. Annualized rates of change may be reported, but this is optional [29,42]. The skeletal sites for which changes in density are to be reported are the lumbar spine (by using whichever vertebrae are considered valid, with a minimum of 2 vertebrae) and the total body [29,33,34]. If the forearm is being monitored in lieu of the spine or the total body, then change can be reported for the 1/3 or 33% proximal radius [29,34,40]. It must be recognized that the change profile at the forearm may not parallel changes at the spine and total body, and may not

correlate as well with drug responses. This will need to be addressed in the interpretation section, if applicable.

Changes in density must be reported in relation to (1) the first study on file, and (2) the most recent previous study. Pediatric osteoporosis drug treatment regimens are not well defined, and, if information is not provided by the referring physician, then it can be difficult to ascertain the timing of the BMD study that corresponds to the initiation of a clinical treatment regimen. It is therefore not mandatory at this time that changes be reported in relation to the initiation of treatment. This can be provided at the discretion of the reporting physician if it is thought that an appropriate comparison study can be defined in relation to treatment.

Statistical significance must be reported for each BMD skeletal site comparison, which indicates whether the difference is considered significant at a 95% level of confidence [29,33,43]. The manufacturer's software determination of statistical significance is not to be used [13,29]. Each facility must determine precision error for each DXA machine and for each skeletal site (including the forearm if this site is measured by the facility and used for serial monitoring) by using the LSC methodology and use this value when determining statistical significance [13,29,33]. It is permissible to apply results derived from precision testing of the forearm on one side to serial scans done by using the opposite side of the body. Facilities are encouraged to derive precision by using pediatric-age subjects, particularly facilities that perform only pediatric clinical tests. In the absence of data that proves that precision differs between adults and children, however, it is acceptable at this time for all facilities to use precision derived from adult subjects [29,33]. If precision is derived by using adult subjects, then this should be noted in the report. A follow-up pediatric BMD report should state the LSC in absolute values ($g/cm^2$, to 3 decimal places for BMD; grams, to 2 decimal places for BMC) for each skeletal site for which change is reported and for both BMD and BMC [13,29]. Whenever possible, the same instrument should be used for serial studies on an individual patient [29]. Comparisons between measurements done on different machines can be made only if intermachine precision between the 2 devices has been determined [13,29].

There is no accepted methodology at this time for evaluating the statistical significance of Z-score differences at different time points. The change in Z-score between comparison BMD studies should be noted. An opinion as to whether the difference is clinically meaningful should be incorporated into the Interpretation section. It is not necessary to report changes in either height or weight.

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## Appendix 1. Patient Questionnaire

Please complete this questionnaire while waiting for your bone mineral density test.
This document will be reviewed with you. A staff member will measure your height and weight.

Name _____ Date _____

Date of birth _____ ☐ Female ☐ Male

*If you answer yes to any of the following 3 questions, please speak to the receptionist immediately:*

1. Is there any chance that you are pregnant? ☐ Yes ☐ No
2. Have you had a barium enema or barium drink in the past 2 weeks? ☐ Yes ☐ No
3. Have you had a nuclear medicine scan or x-ray dye in the past week? ☐ Yes ☐ No

*The following information will help us to assess your future risk for fracture.*

4. Have you ever had a bone density test before? ☐ Yes ☐ No
   If yes, when and where? _____

5. Have you ever had surgery of the spine or hips? ☐ Yes ☐ No
6. Have you ever broken any bones? ☐ Yes ☐ No
   If yes, please state:

| Bone Broken | Age Bone Broke | Cause of Broken Bone |
|---|---|---|
|  |  |  |
|  |  |  |

7. Have you taken steroid pills (such as prednisone or cortisone) for more than 3 months in the past 12 months? ☐ Yes ☐ No
   If yes, are you currently taking steroid pills? ☐ Yes ☐ No

   How long have you been taking them? _____
   What is your current dose? _____

   What is the reason that you take steroid pills?_____

8. Have you ever been treated with medication(s) for osteoporosis? ☐ Yes ☐ No
   If yes, which medication(s) and for how long?

---

***Do not write in this box***

Additional History

_____
_____

Reviewed by: _____ Signature: _____

## Appendix 2. Components of a First-Time Adult Bone Mineral Density Report

All first-time adult (18 years old or older) bone mineral density (BMD) reports should include the following components in this recommended order of presentation:

*Demographics*
◆ name
◆ date of birth
◆ sex
◆ provincial health care number or other identifier
◆ height
◆ weight
◆ scan date
◆ report date
◆ referring physician
◆ reporting physician
◆ facility name and location

*Diagnostic Category*
*Fracture Risk Category (if 50 years old or older)*
*History Used for Risk Determination*
*BMD Data*
◆ BMD
◆ BMD T-score for those 50 years of age or older/Z-score for those younger than age 50 years
◆ reference database used

Note: For men 50 years of age or older, there will be 2 sets of BMD T-scores and 2 reference databases listed: a white male reference database for diagnostic categorization and a white female reference database for risk determination.

*Limitations*
*Interpretation*
*Recommended Follow-up Date*
*Definitions*
*Machine Identification*
   ◆ brand
   ◆ model
   ◆ serial number

## Appendix 3. Bone Mineral Density Diagnostic Categories

| Patient group | Category name | T-score value | Z-score value |
|---|---|---|---|
| 50 years old and older | Normal | ≥ –1.0 | |
| | Low bone mass | Between –1 and –2.5 | |
| | Osteoporosis | ≤ –2.5 | |
| Younger than 50 years old | Within expected range for age | | > –2.0 |
| | Below expected range for age | | ≤ –2.0 |

For adults 50 years of age and older, the diagnostic category is determined by using the lowest T-score for the lumbar spine, total hip, femoral neck, 1/3 (or 33%) radius, and total body. T-scores are derived by using a white female reference database for women and a white male reference database for men.

For adults aged 18 years to younger than 50 years old, the diagnostic category is determined by using the lowest Z-score for the lumbar spine, total hip, femoral neck, 1/3 (or 33%) radius, and total body. Z-scores are derived by using a white female reference database for women and a white male reference database for men.

For children, defined as being younger than age 18 years old, the Z-scores require adjustment for one or more of height, weight, body mass index, bone area, bone age, pubertal stage, and lean body mass. The diagnostic category is determined by using the lowest adjusted Z-score for the lumbar spine and total body. Z-scores are derived by using a white female reference database for girls and a white male reference database for boys.

## Appendix 4. How to Determine an Individual's 10-Year Absolute Fracture Risk

1. Begin with the table appropriate for the patient's sex.
2. Identify the row that is closest to the patient's age.
3. Determine the individual's fracture risk category by using the femoral neck T-score.
4. For ages intermediate between values in the table, interpolate T-score thresholds.
5. If either fragility fracture history or glucocorticoid history is positive, then the individual is moved up to the next highest risk category.
6. Fracture risk for an individual is high regardless of the CAROC 2010 risk result when

   - both fragility fracture history after age 40 years and glucocorticoid history are positive
   - there has been a fragility hip fracture after age 40 years
   - there has been a fragility vertebral fracture after age 40 years
   - there have been 2 or more fragility fractures after age 40 years.

7. If the fracture risk category is low after these steps, then the lumbar spine T-score is considered (by using a white male reference database for men and a white female reference database for women). If the lumbar spine T-score is ≤ −2.5, then the risk is increased to moderate.

## CAROC 2010 Ten-Year Fracture Risk for Women

| | Femoral neck T-score | | |
|---|---|---|---|
| Age (y) | Low risk (<10%) | Moderate risk (10% to 20%) | High risk (> 20%) |
| 50 | Greater than −2.5 | −2.5 to −3.8 | Less than −3.8 |
| 55 | Greater than −2.5 | −2.5 to −3.8 | Less than −3.8 |
| 60 | Greater than −2.3 | −2.3 to −3.7 | Less than −3.7 |
| 65 | Greater than −1.9 | −1.9 to −3.5 | Less than −3.5 |
| 70 | Greater than −1.7 | −1.7 to −3.2 | Less than −3.2 |
| 75 | Greater than −1.2 | −1.2 to −2.9 | Less than −2.9 |
| 80 | Greater than −0.5 | −0.5 to −2.6 | Less than −2.6 |
| 85 | Greater than +0.1 | +0.1 to −2.2 | Less than −2.2 |

## CAROC 2010 Ten-Year Fracture Risk for Men

| | Femoral neck T-score | | |
|---|---|---|---|
| Age (y) | Low risk (<10%) | Moderate risk (10%-20%) | High risk (>20%) |
| 50 | Greater than −2.5 | −2.5 to −3.9 | Less than −3.9 |
| 55 | Greater than −2.5 | −2.5 to −3.9 | Less than −3.9 |
| 60 | Greater than −2.5 | −2.5 to −3.7 | Less than −3.7 |
| 65 | Greater than −2.4 | −2.4 to −3.7 | Less than −3.7 |
| 70 | Greater than −2.3 | −2.3 to −3.7 | Less than −3.7 |
| 75 | Greater than −2.3 | −2.3 to −3.8 | Less than −3.8 |
| 80 | Greater than −2.1 | −2.1 to −3.8 | Less than −3.8 |
| 85 | Greater than −2.0 | −2.0 to −3.8 | Less than −3.8 |

Values in the table are taken from the Osteoporosis Canada 2010 guidelines for the assessment of fracture risk (Ref. 2).

### Notes

For both women and men, the femoral neck T-score used to determine fracture risk must be derived by using a white female reference database. If the femoral neck T-score produces a low risk of fracture and a spine T-score of −2.5 or less is used to assign fracture risk, then the spine T-score is derived from a white female reference database for women and a white male reference database for men.
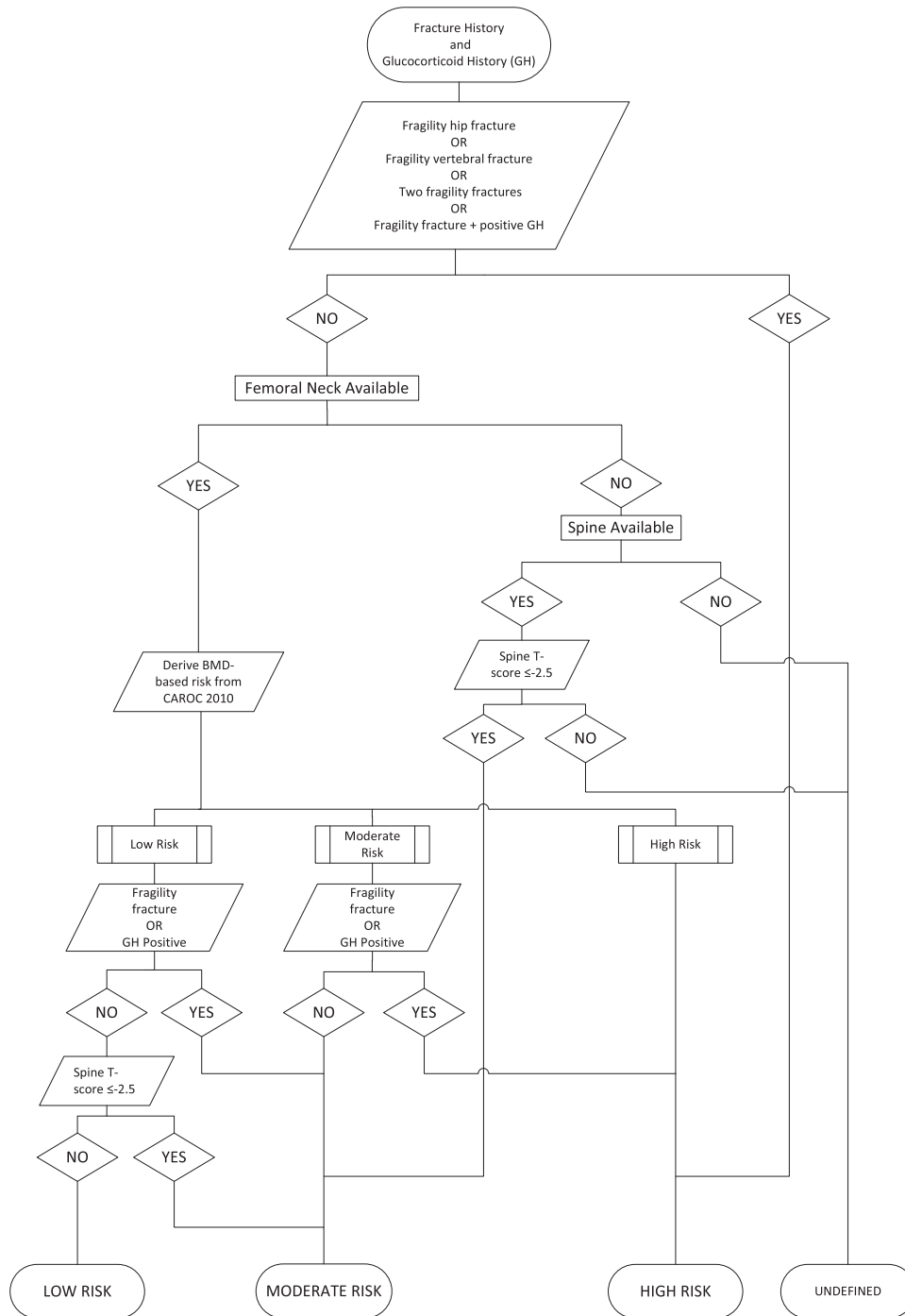
Fractures of the forearm, vertebra, proximal femur, and proximal humerus are usually fragility fractures if they occurred subsequent to a fall from a standing or sitting height. Generally, craniofacial fractures and fractures of the hands and feet are not considered fragility fractures. Other types of fractures may be regarded as fragility fractures if the history

suggests that the fracture occurred with a degree of trauma that would not normally be expected to lead to a broken bone.

Glucocorticoid history is considered positive if prednisone (or other glucocorticoids in terms of prednisone equivalents) was in use at a dose ≥7.5 mg per day for more than 3 cumulative months in the prior 12 months. Patients with hypoadrenalism on replacement glucocorticoids should not be considered to have a positive glucocorticoid history for fracture risk determination regardless of glucocorticoid dose.

## Appendix 5. The Osteoporosis Canada Approach to Determining an Individual's 10-Year Absolute Fracture Risk

*Osteoporosis Canada Approach for Risk Determination*



GH = glucocorticoid history (7.5 mg/d prednisone or equivalent for 3 cumulative months in the prior year).
The initial risk category by using CAROC 2010 is derived from the T-score for the femoral neck.
For both women and men, the femoral neck T-score used to determine fracture risk must be derived by using a white female reference database. If the femoral neck T-score produces a low risk of fracture and a spine T-score of -2.5 or less is used to assign fracture risk, then the spine T-score is derived from a white female reference database for women and a white male reference database for men.

## Appendix 6. Recommended Timing of Follow-up Bone Mineral Density Tests

| Expected rate of BMD change | Clinical example | Timing of follow-up |
|---|---|---|
| Very high | Moderate-to-high dose of glucocorticoids, anabolic agent | 6-12 mo |
| High | Osteoporosis drug therapy initiated or changed, low-to-moderate dose of glucocorticoids | 1-3 y |
| Moderate | Therapy with nutritional supplements or lifestyle improvements | 1-3 y |
| Low | Stability documented on nutritional supplements or lifestyle improvements and with no change in clinical status; drug therapy shown to be effective | 3-5 y |
| Very low | Normal results or low fracture risk and no clinical risks | 5-10 y |

In some jurisdictions, the timing of follow-up may be restricted by provincial health insurance plans. In these circumstances, follow-up recommendations need to be applied in the context of local restrictions.

## Appendix 7. Components of a Follow-up Adult Bone Mineral Density Report

All follow-up adult (age 18 years old or older) bone mineral density (BMD) reports should include the following components in this recommended order of presentation:

*Demographics*
◆ name
◆ date of birth
◆ sex
◆ provincial health care number or other identifier
◆ height
◆ weight
◆ scan date
◆ report date
◆ referring physician
◆ reporting physician
◆ facility name and location
*Diagnostic Category*
*Fracture Risk Category (if 50 years of age or older)*
*History Used for Risk Determination*
*BMD Data*
◆ BMD
◆ BMD T-score for those 50 years of age or older/ Z-score for those younger than 50 years old
◆ reference database used
◆ Note: For men 50 years of age or older, there will be 2 sets of femoral neck BMD T-scores and 2 reference databases listed: a white male reference database for diagnostic categorization and a white female reference database for risk determination.

*Changes in Density*
◆ BMD change
◆ percentage BMD change
◆ statistical significance
◆ least significant change
*Limitations*
*Interpretation*
*Recommended Follow-up Date*
*Definitions*
*Machine Identification*
◆ brand
◆ model
◆ serial number

## Appendix 8. Components of a First-Time Pediatric Bone Mineral Density Report

All first-pediatric (under age 18 years) bone mineral density (BMD) reports should include the following components in this recommended order of presentation:

*Demographics*
◆ name
◆ date of birth
◆ sex
◆ provincial health care number or other identifier
◆ height
◆ weight
◆ scan date
◆ report date
◆ referring physician
◆ reporting physician
◆ facility name and location
*Diagnostic Category*
*BMD Data*
◆ bone mineral content (BMC)
◆ BMC Z-score
◆ adjusted BMC Z-score
◆ BMD
◆ BMD Z-score
◆ adjusted BMD Z-score
◆ reference database used
*Limitations*
*Interpretation*
*Definitions*
*Machine Identification*
◆ brand
◆ model
◆ serial number

## Appendix 9. Method for Adjusting Z-score for Bone Age or Height Age

### Z-score Adjustment for Bone Age

1. Determine Z-score for all scan sites based on chronological age.

2. Perform wrist radiographs and derive bone age.
3. Use point estimate of bone age to determine "adjusted birthdate" for patient.
4. If bone age differs from chronological age by more than 1 year, then change the birthdate to "adjusted birthdate" in the dual-energy x-ray absorptiometry (DXA) program and determine adjusted Z-scores for all scan sites.
5. Report for all scan sites the Z-scores based on chronological age and the bone age-adjusted Z-scores. If bone age does not differ from chronological age by more than 1 year, then this should be noted in the report and a bone age-adjusted Z-score need not be reported.

*Example*

A boy with a birthdate of January 10, 2005; a DXA scan date of July 10, 2012. Chronological age on the scan date: 7 years 6 months. Z-scores were derived by using the chronological age.

Bone age by wrist radiographs: 5 years 6 months. The adjusted birthdate assigned as January 10, 2007. Bone-age adjusted Z-scores were derived by using the bone age.

The report for each skeletal site includes bone mineral density (BMD) (in g/cm$^2$, to 3 decimal places), the BMD Z-score (to 1 decimal place), and the bone age-adjusted BMD Z-score (to 1 decimal place); and bone mineral content (BMC) (in grams, to 2 decimal places), BMC Z-score (to 1 decimal place), and bone age-adjusted BMC Z-score (to 1 decimal place).

*Z-score Adjustment for Height Age*

1. Determine Z-score for all scan sites based on chronological age.
2. Determine "height age" by using growth charts for the child's sex (available at www.cdc.gov/GrowthCharts).
3. Measure height 3 times and use the average value as the patient's height.
4. By using the patient's height on the vertical axis of the Centers for Disease Control (CDC) growth chart, locate where this height line intersects the 50th percentile growth curve. By extrapolating to the horizontal axis, determine the age that corresponds to the point on the 50th percentile growth curve. This is the patient's "height age."
5. If height age differs from chronological age by more than 1 year, then change the birthdate to "adjusted birthdate" in the DXA program and determine adjusted Z-scores for all scan sites.
6. Report for all scan sites the Z-scores based on chronological age and the height age-adjusted Z-scores. If height age does not differ from chronological age by more than 1 year, then this should be noted in the report and a height age-adjusted Z-score need not be reported.

*Example*

A girl with a birthdate of January 10, 2001. DXA scan date of July 10, 2012. Chronological age on scan date: 11 years 6 months. Z-scores were derived by using the chronological age.

Height was measured 3 times by using a stadiometer, with repositioning between measurements: 134.4 cm, 133.8 cm, 135.3 cm; average height of 134.5 cm.

On CDC Growth Chart "Stature-for-age percentiles: girls, 2 to 20 years," a height of 134.5 cm corresponds to an age of 9 years 3 months at the 50th percentile.

The adjusted birthdate was assigned as April 10, 2003. The height age-adjusted Z-scores were derived by using height age.

Report for each skeletal site includes the BMD (in g/cm$^2$, to 3 decimal places), the Z-score (to 1 decimal place), and the height age-adjusted Z-score (to 1 decimal place); and the BMC (in grams, to 2 decimal places), BMC Z-score (to 1 decimal place), and height age-adjusted BMC Z-score (to 1 decimal place).

**Appendix 10. Components of a Follow-up Pediatric Bone Mineral Density Report**

All follow-up pediatric (under age 18 years) bone mineral density (BMD) reports should include the following components in this recommended order of presentation:

*Demographics*
◆ name
◆ date of birth
◆ sex
◆ provincial health care number or other identifier
◆ height
◆ weight
◆ scan date
◆ report date
◆ referring physician
◆ reporting physician
◆ facility name and location
*Diagnostic Category*
*BMD Data*
◆ bone mineral content (BMC)
◆ BMC Z-score
◆ adjusted BMC Z-score
◆ BMD
◆ BMD Z-score
◆ adjusted BMD Z-score
◆ reference database used
*Changes in Density*
◆ BMC change
◆ percentage of BMC change
◆ change in BMC Z-score

◆ statistical significance of BMC change
◆ BMC least significant change (LSC)
◆ BMD change
◆ percentage BMD change
◆ change in BMD Z-score
◆ statistical significance of BMD change
◆ BMD LSC

*Limitations*
*Interpretation*
*Definitions*
*Machine Identification*
◆ brand
◆ model
◆ serial number