DEXA in Sport & Exercise Medicine

Osteoporosis is a common disorder characterised by reduced bone mass and altered bone structure (quantity and quality of bone) resulting in decreased bone strength and increased risk of fracture.

DEXA (Dual Energy Xray Absorptiometry) has been available for over 30 years and is now the investigation of choice for measuring bone mineral density (BMD). As BMD only addresses bone quantity, DEXA technology has been developed to provide a measure of bone quality, namely the Trabecular Bone Score (TBS). So far this has only been reliably developed for trabecular bone in the lumbar spine and its role in diagnosing osteoporosis and predicting fracture risk is not yet fully established.

DEXA can also provide a measure of body composition, including measures of body fat and fat-free mass (muscle mass) and therefore has a role in Sports Medicine and Science.

It is a painless procedure with the subject lying face-up on a cushioned table while the scanner passes above. It usually takes about 20 minutes.

DEXA uses a thin beam of x-rays which exposes the recipient to a very low radiation dose. There are two different x-ray beam methods. The pencil beam system gives a radiation dose of less than 1 µSv for a standard DEXA (Spine and Hip). The fan beam system gives a radiation dose, for a similar test, between 1 - 10 µSv. (By comparison the dose for a chest xray is between 20 - 50 µSv). The dose for a whole-body DEXA can vary between about 10 – 60 µSv.

DEXA provides a very reproducible measurement with a coefficient of variation of 1 – 3%. Due to the low radiation dosage, repeat measurements on the same patient are not usually a problem. However, the smallest detectable difference in bone density means that there should be a gap of at least one year between scans, ideally longer. The time difference may be less for body composition measurements, but this has not yet been established.

By providing an accurate measure of bone mineral density, typically in the lumbar spine and hip, it is used to assess bone health, aiding in the diagnosis and management of osteoporosis. Usually, the DEXA records the BMD in 1^{st} - 4^{th} lumbar vertebrae (calculating an average of the 4) and takes a range of different measurements around the hip. Changes are easier to identify in trabecular rather than cortical bone.

i. The BMD can be recorded using the T- and Z-scores. The T-score is the best measure for a skeletally mature adult, i.e. from about 30 years onwards, whereas the Z-score should be used in a younger population. DEXA scanning

is less reliable as a measure of BMD in children and gradually becomes more reliable during the teenage years.

ii. The T-score measures the BMD relative to the adult mean value and then documents it in terms of Standard Deviations (SD) above or below that mean value, i.e. (measured BMD – young adult mean BMD)/ young adult population SD.

iii. The Z-score measures the BMD relative to an age matched mean value and then documents it in terms of Standard Deviations above or below the mean value, i.e. (measured BMD – aged matched mean BMD)/ age-matched population SD.

iv. For an adult, a T-score of -1.0 to -2.5 is regarded as osteopenia and a score of less than -2.5 as osteoporosis.

v. For a younger person, a Z-score of less than -2.0 is regarded as abnormal. Some argue that a Z-score of less than -1.0 should be regarded as low for an athlete.

Although DEXA BMD T- and Z- scores are used to diagnose Osteoporosis, it cannot quantify the risk of developing an osteoporotic fracture. This can be done using the FRAX tool, a sophisticated risk assessment instrument developed by the University of Sheffield. By entering data about a patient, ideally with the femoral neck BMD, an estimation of the 10 year risk for developing an osteoporotic fracture can be provided. Although it can be used for any adult, it is most reliable for patients aged 40 – 90 years old. The reliability of the tool for an athlete has not been tested. There is growing interest in the possibility of adding the Trabecular bone score to further improve the estimation.

Over the next few years, DEXA will increasingly provide the TBS as an additional measure of bone health. There are a growing number of examples where the TBS may provide a better measure of fracture risk than BMD. This includes Diabetes, Growth hormone-related disorders, Hyperparathyroidism, Cushing's disease and Obesity. This is work in progress and should lead to a better understanding of how to use TBS in the next few years.

Additional information that can be provided by DEXA include lateral spine imaging (compared to the AP view that is routinely used) which can be used to identify structural abnormalities of the vertebrae such as crush fractures. Whole body DEXA provides measurements in different regions of the skeleton and therefore can highlight regional differences in BMD.

DEXA can also provide a reliable estimate of body composition including body fat and fat-free mass (a measure of muscle mass). It is better than most other techniques as a measure of body fat and can therefore be used as a tool to assess patients with eating disorders and other nutritional problems. It can also be used in the assessment of training and performance. There is an inverse correlation between distance running

performance and body fat. There is a correlation between muscle mass and BMD but not between muscle mass and muscle strength.

It is important to be aware of situations where DEXA may provide an inaccurate measurement of BMD. This includes:

i. Patients with degenerative and inflammatory back disease where osteophyte and syndesmophyte formation may falsely elevate the BMD reading in the lumbar spine and/or Hip.
ii. Calcification of the aorta may falsely elevate lumbar spine BMD.
iii. Patients with a previous fracture in the region being measured.
iv. DEXA software issues. The BMD reading is dependent on the computer software accurately drawing the region of interest from which the measurement is taken. Sometimes this is incorrectly drawn. Therefore, it is important to view the images to confirm that the region of interest is accurate. It is also important to confirm that the BMD in each of the 4 vertebrae provide similar measurements. If one is very different from the other 3 it is important to know why and, if necessary, exclude it from the final measurement of spinal BMD.

DEXA is now a well validated tool able to provide information regarding BMD and body composition. This can be helpful in patients and athletes with low body weight, those with RED-S syndrome, bone stress injuries and stress fractures and in monitoring response to training.

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References:

Blake GM, Fogelman I. The role of DXA bone density scans in the diagnosis and treatment of osteoporosis. Postgrad Med J 2007; 83:509–517.

Mattila VM, Tallroth K et al. Physical fitness and performance. Body composition by DEXA and its association with physical fitness in 140 conscripts. Medicine and Science in Sports and Exercise. 2007; 39(12):2242-2247.

El Maghraoui A, Roux C. Review: DXA scanning in clinical practice. Q J Med. 2008; 101:605–617.

Shevroja E, Cafarelli FP et al. DXA parameters, Trabecular Bone Score (TBS) and Bone Mineral Density (BMD), in fracture risk prediction in endocrine-mediated secondary osteoporosis. Endocrine (2021) 74:20–28.

https://frax.shef.ac.uk/FRAX/tool.aspx