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| **Body Composition by Dual-Energy X-Ray Absorptiometry** | |
| **Protocol Id** | 020301 |
| **Description of Protocol** | If a dual-energy x-ray absorptiometry (DXA) examination is not feasible, the PhenX Anthropometrics Working Group (WG) noted that other body composition assessment methods may be considered. For example, bioelectrical impedance analysis (BIA) and skinfold thickness measures (see the Anthropometrics Supplemental Information in https://www.phenxtoolkit.org/index.php?pageLink=browse.si&id=20000) are potentially useful, albeit less precise and valid as indicators of body composition. |
| **Specific Instructions** | Study-specific protocols and equipment descriptions should be reviewed carefully.  In the National Health and Nutrition Examination Survey (NHANES) a certified radiologic technician positions the participant and operates the DXA scanner device.  Due to concerns about radiation exposure to the unborn fetus, urine pregnancy tests or self-reported pregnancy history were used to exclude pregnant females from the NHANES DXA component.  Equipment limitations excluded NHANES participants who weighed more than 300 lbs or were more than 6’5" tall. Individuals with amputations other than fingers and toes were also excluded from the NHANES DXA exam.  The technician should determine if the participant is wearing metallic items such as jewelry or eyeglasses, had implanted medical devices such as a pacemaker or artificial joint, or had undergone certain types of medical tests that might affect the scan results. The NHANES DXA Procedures Manual describes the protocol, exclusions, and screening questions in detail.  Rigorous quality control procedures are needed to monitor the performance of the DXA scanner, the performance of the certified radiology technologists who performed the DXA scan, and the quality of the DXA scans. The NHANES DXA Procedures Manual describes the quality assurance and quality control measures that were used in NHANES. |
| **Protocol Text** | A downloadable PDF of the full NHANES Body Composition Procedures Manual is available here: https://www.phenxtoolkit.org/toolkit\_content/documents/domains/anthropometrics/body\_composition/NHANES\_BodyCompositionManual.pdf  The following is a summary version of the full NHANES protocol.                                            There are several overarching, critical issues for high-quality data collection of anthropometric measures which optimize the data in gene-environment etiologic research. These issues include: (1) the need for training (and retraining) of study staff in anthropometric data collection; (2) duplicate collection of measurements, especially under field conditions; (3) use of more than one person for proper collection of measurements where required; (4) accurate recording of the protocols and the measurement units of data collection; and (5) use of required and properly calibrated equipment.  **NOTE:** Dual-energy x-ray absorptiometry (DXA) measurement is complex and requires costly hardware, specialized software to analyze the DXA scans, rigorous quality control, certified examiners, continuous equipment calibration and monitoring, and scan quality control monitoring. Although excerpts of the National Health and Nutrition Examination Survey (NHANES) protocol are provided for informational purposes, investigators should review all facets of the protocol prior to undertaking DXA examinations in a study.  A detailed description of the NHANES protocol is available from the Centers for Disease Control and Prevention (CDC) website. The following excerpts from the NHANES 1999-2006 protocols refer to a specific make and model DXA scanner. Several brands of DXA scanners are available and manufacturer-specific software, calibration, and quality control practices should be followed.  **DXA Equipment:** Several DXA densitometer devices are marketed commercially. The Hologic™ QDR 4500A fan beam X-ray bone densitometer has been used in NHANES 1999-2009.   **Whole Body DXA Scan:**   * Record the participant information and relevant information about the DXA machine and software. * Check to see if the participant is positioned correctly for the whole body scans. * Check one more time to ensure that no objects will interfere with the movement of the table or the runner belt. * Check to ensure the correct positioning of the participant for the DXA scan.   **Conducting the Scan:**   * Conduct a whole body scan according to the directions specified by the DXA machine manufacturer. * The machine will complete the scan. * After the scan is completed, a screen displaying the skeletal features of the participant appears. View the scan image to determine if the quality of the scan is acceptable. The scan may be repeated once under certain circumstances if the participant agrees. (The conditions under which a scan may or may not be repeated are outlined below in the section entitled Ensuring Quality of Scan.)   **Ensuring Quality of Scan** The conditions under which a scan may or may not be repeated include:   * **Participant movement during the exam:** If the participant moves during the exam, complete the first scan. If the participant agrees and if you think the participant can remain quiet, complete a second exam. Explain the procedure again with an emphasis on the importance of remaining quiet throughout the scan. * **Positioning problem:** If you complete a scan and upon review, notice a problem with the position of the participant that can be corrected, get permission from the participant and repeat the scan. In some cases, you may not be able to correct the positioning problem. For example, if the participant has a curvature of the spine or other physical condition that might limit ideal positioning, repeating the scan will not improve the positioning problem. * **Hands positioned along sides, not flat:** If the participant is too wide for the table and the hands cannot be positioned flat, you can position the hands along the sides. There is no need to repeat a scan if you have already noted this in the comments. * **Too tall for the table, feet cut out of the scan:** If the participant is too tall for the table and you cannot get the entire body in the scan, make sure you get the entire head in the scan. There is no need to repeat a scan if you have checked this comment unless you can get the feet completely within the scan border. * **Pillow used for head support:** If the participant has trouble lying flat due to back problems or difficulty breathing when lying flat, use the radiolucent pillow to support the head. There is no need to repeat a scan if you have checked this comment. If the pillow is used correctly, the scan is valid. * **Equipment failure:** If you have an equipment problem during the scan and it is something you can fix immediately, you can check this comment and complete a second scan. If you cannot fix the equipment during the session, check this comment and also check that you cannot repeat the scan. * **Getting Consent for a Second Exam:** If the scan can be repeated based on the conditions outlined above, you need to obtain permission from the participant to compete a second scan. The standard script for obtaining permission is stated below. This script is printed on laminated cards in the DXA room.   **Consent for Second Scan (Standard Script):** English Version "The image quality of your whole body scan is not adequate for reporting your bone density results. I see from your scan that [*fill in the problem observed*]. With your permission, I would like to repeat the scan to improve the image quality. The amount of radiation from this scan is about 1 millirem, or the amount you would receive for 2 hours on a coast-to-coast airplane flight. This scan is voluntary and there is no penalty for refusing. Do I have your permission to repeat the scan?"  **Completing the Second Scan** Once you have obtained consent for completing a second exam, reposition the participant as necessary. Focus on the cause for repeating the scan and make the necessary modifications (reposition, remove jewelry or objects, etc.). Before starting the scan, make sure that all corrections have been made. If a problem occurs with this scan, you will not be able to repeat the exam on this participant again.  **Results** NCHS contracts for the review of the NHANES scan. This contract also includes training for radiologic technicians and monitoring of technician performance to ensure quality control of the data.  DXA is the preferred method for assessing bone mineral content (BMC) and bone mineral density (BMD). The posterior-anterior (PA) spine and total body less head (TBLH) are the most accurate and reproducible skeletal sites for performing BMC and areal BMD measurements. Soft tissue measures in conjunction with whole body scans may be helpful in evaluating patients with chronic conditions associated with malnutrition (such as anorexia nervosa, inflammatory bowel disease, cystic fibrosis), or with both muscle and skeletal deficits (such as idiopathic juvenile osteoporosis). The hip (including total hip and proximal femur) is not a reliable site for measurement in growing children due to significant variability in skeletal development and lack of reproducible Region of Interest (ROI). In children with linear growth or maturational delay, spine and TBLH BMC and areal BMD results should be adjusted for absolute height or height age, or compared to pediatric reference data that provide age-, gender-, and height-specific Z-scores.  SOURCE: The International Society for Clinical Densitometry. http://www.iscd.org/Visitors/pdfs/ISCD2007OfficialPositions-Combined-AdultandPediatric.pdf Page 25 |
| **Selection Rationale** | The PhenX Anthropometrics Working Group considers dual-energy x-ray absorptiometry (DXA) to be the current gold standard for obtaining a measurement of a person’s percentage body fat and muscle mass. |
| **Source** | Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). (2003-2004). National Health and Nutrition Examination Survey Body Composition Procedures Manual. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. |
| **Language** | English, Spanish |
| **Participant** | Dual-energy x-ray absorptiometry (DXA) methods have been used in clinical and field studies with children and adults. In the National Health and Nutrition Examination Survey, persons ≥8 years in 2000-2009 were eligible for the DXA component. |
| **Personnel and Training Required** | Technicians should be certified radiology technologists. Additionally, study personnel should receive specialized training in the basic techniques of anthropometric measurements, the operation of the specific make and model of the dual-energy x-ray absorptiometry (DXA) machine used in the study, and the survey protocol.  Device-specific education and training should be provided to the operators and interpreters prior to clinical use. Quality control procedures should be performed regularly. Source: International Society for Clinical Densitometry. http://www.iscd.org/Visitors/pdfs/ISCD2007OfficialPositions-Combined-AdultandPediatric.pdf, Page 18. (*Accessed February 23, 2009*) |
| **Equipment Needs** | Several dual-energy x-ray absorptiometry (DXA) machines are marketed commercially. According to the International Society for Clinical Densitometry, "Bone density measurements from different devices cannot be directly compared." Because there are many manufacturers, models, and software versions of the DXA machine, investigators must report those they are using. Regular (i.e., weekly at a minimum for large studies) scans using DXA phantoms are recommended as an independent assessment of system calibration. Studies that use more than one scanner device should also implement a plan to monitor inter-scanner differences at baseline and at regular intervals during the study.                       Note: Manufacturers of DXA equipment are constantly striving to improve and update both their equipment and software with the latest technological advances. The recommended equipment for this protocol in PhenX is current as of June 2009. Please refer to the DXA specifications for your model number to ensure the level of information collected is compatible with the PhenX protocol.  SOURCE: International Society for Clinical Densitometry. http://www.iscd.org/Visitors/pdfs/ISCD2007OfficialPositions-Combined-AdultandPediatric.pdf, Page 9. (*Accessed February 23, 2009*) |
| **Standards** | |  |  |  |  | | --- | --- | --- | --- | | **Standard** | **Name** | **ID** | **Source** | | Common Data Elements (CDE) | Person Dual X-ray Absorptometry Body Composition Value | 2936520 | [CDE Browser](https://cdebrowser.nci.nih.gov/CDEBrowser/search?elementDetails=9&FirstTimer=0&PageId=ElementDetailsGroup&publicId=2936520&version=1.0) | | Logical Observation Identifiers Names and Codes (LOINC) | DXA proto | 63520-1 | [LOINC](http://s.details.loinc.org/LOINC/63520-1.html?sections=Web) | |
| **General References** | 2007 Official Positions and Pediatric Official Positions of the International Society for Clinical Densitometry.  National Institute of Diabetes and Digestive and Kidney Diseases. (2007). *Body composition.* Retrieved April 8, 2009, from http://www2.niddk.nih.gov/Research/ClinicalResearch/MCRU/MCRUBodyComposition.htm  Lohman, T. G., & Chen, Z. (2005). Dual-energy x-ray absorptiometry. In S. Heymsfield, T. G. Lohman, Z. Wang, & S. B. Going (Eds.), *Human Body Composition* (pp. 63-78). Champaign, IL: Human Kinetics.  University of Vermont, Department of Nutrition and Food Sciences. (n.d.). *Dual energy x-ray absorptiometry (DEXA).* Retrieved April 8, 2009 from http://nutrition.uvm.edu/bodycomp/dexa/ **NOTE:** This protocol uses single beam DXA rather than the fan beam DXA used in NHANES. The fan beam DXA scan used in NHANES takes only 3 minutes and has less radiation exposure.  Tufts University Nutritional Collective, Center for Drug Abuse and AIDS Research (TNC-CDAAR). (2003). *Dual energy x-ray absorptiometry (DEXA) for evaluation of body composition: Protocol. Retrieved April 8, 2009, from*http://www.tufts.edu/med/nutrition-infection/tnc-cdaar/protocols/DEXA2.pdf) |
| **Protocol Type** | Noninvasive radiologic assessment |
| **Derived Variables** | Bone Mineral Density (BMD), Bone Mass, Body Fat, Lean Body Mass; and Bone, Fat, and Body Mass of specific anatomical regions |
| **Requirements** | |  |  | | --- | --- | | **Requirement Category** | **Required** | | Average time of greater than 15 minutes in an unaffected individual  Average time of greater than 15 minutes in an unaffected individual | **Yes** | | Major equipment  This measure requires a specialized measurement device that may not be readily available in every setting where genome wide association studies are being conducted. Examples of specialized equipment are DEXA, Echocardiography, and Spirometry | **Yes** | | Specialized requirements for biospecimen collection  This protocol requires that blood, urine, etc. be collected from the study participants. | No | | Specialized training  This measure requires staff training in the protocol methodology and/or in the conduct of the data analysis. | **Yes** | |