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SPIROMETRY IN OCCUPATIONAL HEALTH PROGRAMS

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SPIROMETRY IN OCCUPATIONAL HEALTH PROGRAMS

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* This bulletin supersedes TB MED 509, 24 December 1986.

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APPENDICES

CHAPTER 1

INTRODUCTION

1–1. Purpose

a. This bulletin—

(1) Outlines the role of spirometry in occupational health surveillance and respiratory surveillance.

(2) Describes the proper methods for—

(a) Calibrating the spirometer.

(b) Performing spirometry.

(c) Calculating spirometric parameters.

(d) Maintaining calibration results.

(e) Incorporating spirometric data into the medical record.

(3) Establishes training and quality assurance requirements for personnel administering spirometric testing.

(4) Defines the minimum acceptable spirometer specifications.

(5) Discusses the use of spirometry in determining the medical suitability of personnel for wearing respirators.

b. This document applies to all Active Army, U.S. Army National Guard, and U.S. Army Reserve medical treatment facilities (MTFs) which provide occupational spirometry testing to specific military and civilian populations. The MTFs providing spirometric surveillance for personnel exposed to airborne concentrations of pulmonary hazardous materials in excess of the action levels (as defined in existing Federal, Department of Defense (DOD), and Army Occupational Safety and Health Standards), and when indicated for those requiring respirator medical clearance for contingency respirator use, are included in the scope of this bulletin.

c. This bulletin is intended to provide an introduction to the use of spirometry in occupational health surveillance. It was written for use by physicians, physician assistants, nurses, and spirometry technicians. This document is not intended to replace the education requirements for spirometry technicians outlined in chapter 7.

1–2. References

A list of required and related publications is provided in appendix A.

1–3. Explanation of abbreviations and terms

Abbreviations and special terms used in this bulletin are defined in the glossary.

1–4. Responsibilities

a. Commanders of U.S. Army Medical Department Activities/Medical Centers (MEDDAC/MEDCEN) providing occupational health surveillance—

(1) Ensure that all occupational health nurses and respiratory technicians have completed a National Institute of Occupational Safety and Health (NIOSH)-approved course in spirometry and have been trained to perform spirometry as detailed in chapter 7.

(2) Ensure that providers interpreting spirograms generated as part of occupational health surveillance have, as a minimum, pulmonary function decrement assessment expertise equivalent

to that described in chapter 5. Chapter 5 focuses on the calculation of these values and their interpretation and assessment as they apply to impairment parameters.

(3) Ensure that all MTFs providing occupational health surveillance are supplied with spirometers meeting the minimum specifications outlined in chapter 3.

b. Providers interpreting spirograms—

(1) Ensure that the spirometry examination is complete, is valid, meets repeatable criteria, and is of acceptable quality prior to rendering an assessment of pulmonary function as described in chapter 4.

(2) Ensure that spirometric data are incorporated into the medical record as described in chapter 6.

(3) Implement procedures (described in chapter 7) to ensure that the spirometry technician's proficiency is maintained.

(4) Conduct "use" tests with the worker wearing an assigned respirator when abnormal spirometry results are obtained as part of the medical evaluation of a respirator user as outlined in chapter 8.

(5) Ensure that the written scope of practice for non-physician health care providers who perform spirometry includes this additional duty (Army Regulation (AR) 40-68).

c. When performing spirometry, spirometry technicians carry out the techniques, calibrations, calculations and interpretations, equipment checks, and recordkeeping procedures described in this bulletin.

d. Physicians, physician assistants, or nurse supervisors knowledgeable in the performance and interpretation spirometry testing ensure that the quality assurance procedures for technician proficiency are accomplished per chapter 7.

1–5. Introduction to spirometry in occupational health surveillance

a. The assessment of ventilatory function with a spirometer is part of the accepted standard of practice of occupational health. Spirometry is an essential component of respiratory surveillance programs for workers exposed to hazardous pulmonary substances. In combination with respiratory and occupational health histories and physical examination, spirometry can identify the job applicant with preexisting pulmonary disease and facilitate proper job placement. Routine follow-up studies in workers exposed to amounts of hazardous airborne substances above the established action levels can detect respiratory impairment in its earliest stages, when workplace interventions are more likely to be beneficial. Spirometry may be used in periodic medical surveillance examinations of workers potentially exposed to airborne pulmonary hazards to validate the effectiveness of exposure controls or to identify the failure of those controls before the worker becomes symptomatic of disease.

b. The Occupational Safety and Health Administration (OSHA) requires spirometry as part of the medical surveillance for employees exposed to asbestos, cadmium, coke oven emissions, formaldehyde, and cotton dust. In addition, DOD 6055.05-M recommends spirometry examinations for workers exposed to a wide range of chemical substances at levels above the action level (appendix C). Furthermore, workers wearing respirators designed to prevent exposure to toxic substances must be evaluated to determine if they are physiologically able to withstand increased inspiratory and expiratory airway resistance, that is, the added work of breathing associated with certain types of respiratory protection. Spirometry is a key component of occupational health surveillance at installations where personnel are exposed to hazardous pulmonary substances.

CHAPTER 2

SPIROMETRY AND RESPIRATORY SURVEILLANCE

2–1. The role of spirometry in occupational health surveillance

a. The objectives of spirometry in occupational health surveillance are to—

(1) Identify personnel with a preexisting functional pulmonary impairment.

(2) Detect occupational pulmonary diseases and obstructive or restrictive impairments at an early stage when therapeutic or workplace interventions are most likely to be beneficial.

(3) Identify hazardous working conditions and underscore the need for improvements in primary prevention exposure control strategies.

(4) Reduce the human and economic toll of occupational pulmonary disease.

(5) Ensure compliance with legal and regulatory requirements for spirometry/pulmonary function testing.

b. The first objective of any ongoing surveillance effort is to identify preexisting functional impairment during a preplacement evaluation of a Service member or civilian worker. It is the occupational healthcare provider's role to determine the medical suitability of a potential worker to perform essential job functions. The ultimate authority and final fitness-for-duty decision rest solely with the Civilian Personnel Advisory Center (CPAC) and/or supervisor or the Service member's commander. Employment-related decisions are fundamentally managerial, not medical. The provider should provide the CPAC or supervisor with sufficient information to ensure proper placement of the individual in the workplace. This information includes any duty limitations or restrictions with respect to a toxic inhalation exposure potential or the use of respiratory protective devices as part of an exposure control strategy. The occupational healthcare provider determines whether the worker is capable of performing the essential functions of a particular job without substantial risk of danger to the worker or to others. The respiratory surveillance program screens individuals for any preexisting pulmonary disease that may place them at increased risk of illness or injury due to potential job-related exposures or create difficulties in the proper wearing of required respiratory protective devices.

c. The second objective of occupational health surveillance is to detect occupational pulmonary disease or obstructive or restrictive impairments in their earliest stages. Pulmonary function data should be analyzed longitudinally for each worker and across similar exposure groups (painters using isocyanate-based paints, for example). The goal is to enhance the likelihood of successful therapeutic intervention should an occupational exposure cause an adverse health effect. For some chronic occupational pulmonary diseases, early detection of disease and removal from exposure may be of limited value. For other exposures that can cause acute, reversible decrements in airflow rates, spirometry surveillance (pre- and post-shift, monthly, quarterly, or annually) may prevent short-term impairments or longer term permanent airway damage.

d. The third objective of occupational health surveillance is to identify work conditions requiring improvements in primary preventive strategies or other exposure control methods, such as isolation of process, use of local exhaust or cascade ventilation systems, substitution of less hazardous chemicals, or use of respiratory protection. Even firm adherence to OSHA-permissible exposure limits (PEL) or American Conference of Government Industrial Hygienists (ACGIH®) threshold limit values (TLVs®) may not protect everyone in the workplace. (ACGIH and TLV are registered trademarks of the American Conference of Governmental Industrial

Hygienists.) Because of variations in individual susceptibility, a small percentage of workers may experience discomfort or develop disease at exposure concentrations well below the prescribed limit for a particular substance. For example, workers who have become sensitized to toluene diisocyanate may develop symptoms with exposures to 0.001 parts per million (ppm), well below the present OSHA PEL of 0.02 ppm (ceiling). Respiratory surveillance will help identify those personnel who require additional safeguards in the workplace.

e. Finally, the overall goal of occupational health surveillance is to reduce the human and economic toll of occupational disease. Direct expenses for the Army include Federal Employees Compensation Act (FECA) chargeback costs from medical bills and disability payments. Indirect expenses, such as clerical and administrative costs and lost productivity, may actually exceed direct expenses. Properly managed respiratory surveillance programs through the use of spirometry can play an important role in reducing the disease burden on employees and the associated costs of occupational lung disease on the Army.

2–2. Elements of a respiratory surveillance program within occupational health surveillance

a. The elements for an initial evaluation of a respiratory surveillance program include—

(1) An individual's respiratory history, emphasizing past pulmonary disease, seasonal allergies, atopic skin diseases, use of prescribed inhalers or oral medications for bronchospasm, present respiratory symptoms (including sputum production patterns, presence or absence of cold- or exercise-induced bronchospasm), and a detailed history of smoking.

(2) A comprehensive occupational health history of the individual, detailing prior exposure to hazardous pulmonary substances or jobs requiring respirator use. Include additional information on any hobbies, part-time jobs, or recreational activities that may result in hazardous pulmonary exposures. Document any adverse health effects related to these exposures in the individual's medical record.

(3) A review of the employee's health hazard inventory in Defense Occupational and Environmental Health Readiness System–Industrial Hygiene (DOEHRS–IH), or the survey and similar exposure group (SEG) reports provided by industrial hygiene, to identify potential workplace inhalation hazards above established action levels.

(4) A careful examination of the chest to include inspection, auscultation, and percussion.

(5) Spirometry testing, to include forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and ratio of FEV_1 to FVC, expressed as (FEV_1/FVC)%. The interpretation of spirometry data is limited. A full evaluation of a worker is incomplete without the additional information obtained from the above-listed elements.

b. The periodic health evaluation of workers engaged in occupations with potentially pulmonary hazards is similar to the initial evaluation, with an emphasis on the respiratory and occupational health history; a focused physical examination of the lungs; and longitudinal spirometry. Spirometry testing is only one element of the program. The interpretation of spirometry data may be limited without additional information from a respiratory history; a list of occupational exposures; and either a chest radiograph or careful auscultation of the chest. The other program elements may be used to focus spirometry screening on populations at increased risk of pulmonary impairment.

2–3. The role of spirometry in respiratory surveillance

a. Spirometry is the most basic and frequently performed test of pulmonary function; it measures one's ability to move air into and out of the lungs. Within a respiratory surveillance program, spirometry serves as a screening tool. A screening examination is not necessarily equivalent to a diagnostic one. The key distinction between the two is that a diagnostic test is performed on a patient because of a specific medical complaint or finding; a screening test is conducted on a worker at risk from a specific occupational exposure.

b. The strengths and weaknesses of spirometry must be considered when the results of screening examinations are interpreted. Its greatest sensitivity is in detecting lung diseases, such as asthma, which primarily affect the airways. Conversely, spirometry is relatively insensitive in detecting some of the pneumoconioses (such as uncomplicated silicosis and simple coal-workers' pneumoconiosis) in which radiographic changes are frequently present without abnormal spirometry. Careful review of the individual's respiratory history, smoking habits, past occupational and non-occupational exposures, and physical examination should be undertaken before a definitive clinical assessment is made.

c. Spirometry plays an important role in the primary, secondary, and tertiary prevention of respiratory disease in the workplace.

(1) In the primary prevention of respiratory disease, spirometry can be a component of the medical clearance for respiratory protection for personnel who have been identified in either a pre-placement, periodic job-related, or fitness-for-duty examination as having been exposed to pulmonary hazards. Spirometry may also be used in primary prevention of respiratory disease in sensitive populations with respiratory complaints in environments where the pulmonary hazards are below an action level. In such instances, periodic spirometric evaluations may be conducted across the work shift or over the course of the workweek. Assessment of the efficacy of primary prevention strategies in the workplace requires cross-sectional analysis of pulmonary function results from groups of workers within the same SEG.

(2) In the secondary prevention of respiratory disease, periodic spirometric evaluations (such as those mentioned above) can be used in medical surveillance programs when workplace exposures place workers at risk of developing occupationally related respiratory disorders. Respiratory surveillance programs require that a baseline be established and that workers be re-tested periodically.

(3) In the tertiary prevention of respiratory disease, spirometry is used in the clinical evaluation of symptomatic individuals. Pulmonary diseases manifest themselves as restrictive, obstructive or combined ventilatory defects. Spirometry allows for quantification and helps to categorize lung function abnormalities, if present.

CHAPTER 3

SPIROMETER SPECIFICATIONS

3–1. Introduction

The American Thoracic Society/European Respiratory Society (ATS/ERS) and NIOSH have developed minimum spirometer specifications for respiratory surveillance programs. Any spirometer, whether volumetric or flow measuring, used for occupational spirometry must meet the minimum requirements outlined in this chapter.

3–2. Requirements for equipment performance

a. OSHA and the American College of Occupational and Environmental Medicine (ACOEM) (*JOEM*, 2011) recommend that spirometers (either volumetric or flow measuring) used for occupational spirometry tests provide—

(1) A real-time display of both flow-volume and volume-time curves which meets or exceeds ATS/ERS minimum size dimensions;

(2) Spirographs in hard-copy printouts that meet ATS/ERS-recommended minimum real-time display and hard-copy graph sizes for flow-volume and volume-time curves; and

(3) Standard electronic spirometer output of results and curves.

b. Beyond meeting these ATS/ERS minimum recommendations, ACOEM also recommends that spirometers used for occupational spirometry tests—

(1) Save all information from as many as eight maneuvers in a subject test session;

(2) Permit later editing and deletion of earlier flawed test results;

(3) Provide a complete spirometry test report for review of technical quality, which includes all flow-volume and volume-time curves; and test results from at least the 3 best maneuvers, and, preferably, from all saved efforts;

(4) Provide, as an option, a separate final spirometry summary report for interpretation of the best test results;

(5) Provide computer-derived technical quality indicators and sensor error messages;

(6) Provide a dedicated routine for verifying spirometer calibration; and

(7) Save a comprehensive electronic record of all calibration and calibration verification results.

3–3. Requirements for volume and flow

a. The spirometer must be capable of measuring volumes up to at least 8 liters after Body Temperature and Ambient Pressure, Saturation (BTPS) correction, independent of flow rate for flows between 0 to 14 liters per second.

b. The FVC and FEV_1 measured volume should be within 3.5 percent of the calibrated volume or 65 milliliters (mL), whichever is greater.

c. The spirometer must be capable of accumulating volume for at least 15 seconds at a paper speed of 20 millimeters (mm) per second or greater.

d. The resistance to airflow at 14 liters per second must be less than 1.5 centimeter (cm) of water per liter per second.

3–4. Recorder requirements

a. The spirometer must be capable of generating tracings for incorporation into the medical record. The instrument used must provide a tracing of volume-versus-time and flow-versus-volume for the entire forced expiration.

b. For volume versus time tracings, the recorder must be capable of displaying the entire FVC maneuver at a constant speed for at least 10 seconds after the start of the maneuver.

c. The recorder must have a paper speed of at least 20 mm per second.

d. Volume sensitivity of the recorder must be at least 10 mm per liter of volume, and flow sensitivity must be at least 4 mm per liter per second of flow.

e. For volume-versus-time tracings, the recorder must be capable of being activated and up to speed before a forced expiration begins.

3–5. Microprocessor and software requirements

a. Most spirometers purchased today have microprocessor units which calculate FVC, FEV_1, and percentage of predicted normal values. These microprocessor units are capable of correcting for room or spirometer temperature and comparing actual spirometry results to a set of age, height, sex, and ethnicity-adjusted values to calculate percent predicted results for FVC, FEV_1, and FEV_1%.

b. ATS/ERS and ACOEM recommend using microprocessor units with software that contains reference values generated from the Third National Health and Nutrition Examination Survey (NHANES III). Using spirometry testing of high technical quality, the NHANES III studied a random sample of “never-smokers” from across the United States, including three ethnic/racial groups. As a result, race-specific NHANES III reference equations are available for Caucasians, African-Americans, and Mexican-Americans. Tables of NHANES III predicted values may be obtained from www.cdc.gov/niosh/topics/spirometry/nhanes.html.

c. The microprocessor may serve as a useful aid in expediting calculations and packaging data for healthcare providers. However, the technician is solely responsible for the quality of testing. The accuracy of data obtained is contingent upon the technician's attention, perseverance, and care in conducting the forced expiratory maneuver.

CHAPTER 4

CALIBRATION AND TEST TECHNIQUE

4–1. Introduction

a. To obtain a valid test, the spirometer must be properly calibrated, and the spirometry technician must devote meticulous effort to subject preparation, testing technique, and the generation of acceptable tracings. This chapter summarizes the methods to be used for checking spirometer calibration, preparing the patient, and administering the tests.

b. The 2005 ATS/ERS Spirometry Statement requires that the accuracy of both the volume- and flow-type spirometers be checked at least daily before either is used for occupational health surveillance. The ACOEM also recommends that facilities performing spirometry maintain a procedure manual documenting the details of the different types of calibration checks, a log of technical problems found and solved, service and repair records, and standing operating procedures for calibration and troubleshooting.

4–2. Calibration

Calibration is the procedure for establishing the relationship between sensor-determined values of flow or volume and the actual flow or volume. The spirometer calibration check is essential prior to any spirometry test. Instrument inaccuracy is an unacceptable source of error that can be detected and corrected easily. To preclude the potential for introducing spirometer error, institute the series of equipment checks and procedures listed below. If the equipment does not pass, do not test workers until the cause of failure has been identified and corrected.

a. Spirometer calibration. Calibrate the spirometer in the environment in which workers will be tested, and do so at least daily when the following conditions apply:

(1) When workers are to be tested;

(2) Whenever the equipment (such as a breathing hose) is changed or relocated;

(3) Before the first test; and

(4) At least every 4 hours on days when large numbers of tests are conducted. This practice prevents an undetected problem from invalidating large numbers of test results.

b. Volumetric spirometer calibration check.

(1) The purpose of the first daily check of a volume spirometer is to determine whether it is airtight. Inject about 3 liters (L) of air into the spirometer, and apply a small amount of positive pressure (as recommended by the manufacturer) for one minute while the spirometer outlet (that is, end of the breathing hose) is blocked. A volume loss of more than .03 liters per minute (L/min) indicates a leak that should be corrected before workers are tested.

(2) Next, test the accuracy of the spirometer by the injecting 3.00 L of air from a calibration syringe. If the spirometer's recorded volume is within +/- 3.5 percent of the injected 3 L, or 2.90 – 3.10 L, the spirometer is within acceptable limits.

(3) Check volume linearity quarterly; this tests the spirometer's accuracy over large volumes. Manually draw a volume of air into the spirometer, 2 liters, for example, and record that number. Next, use the calibration syringe to inject 3.0 liters of room air into the spirometer. The amount recorded should increase by 2.90 – 3.10 L. This can be accomplished in 3 steps, starting with 0, 2, and 4 liters of air already in the spirometer before injecting the additional 3.0 liters with the calibration syringe.

(4) If a chart drive is used, check it quarterly, also. Check that the pen takes 10 seconds +/- 2 percent or 9.8 – 10.2 seconds to traverse a strip of chart paper that is marked 10 seconds in length.

(5) The ACOEM recommends saving calibration tracings and records *indefinitely*, as well as documenting all changes in protocol, computer software, or equipment.

c. Flow-measuring spirometer calibration checks. Check flow-type spirometers daily by injecting 3.0 L of air with a calibration syringe at three different speeds. Empty the syringe once in approximately .5 seconds, once in 3 seconds and once in 6 seconds. For each of the three speeds, the spirometer should read within +/- 3.5% or 2.90 – 3.10 L. A spirometer that fails at any speed should not be used for testing until it can pass at all speeds. If using disposable sensors, use a new sensor for each day's calibration check since the accuracy of sensors can vary within and between batches.

d. Calibration syringe test.

(1) The calibration syringe should be tested monthly for leaks by attempting to empty it with the outlet corked. If a leak is discovered, the syringe should be returned to the manufacturer for repair and recalibration. Return the syringe to the manufacturer periodically for recalibration using a method recognized by the National Institute of Standards and Technology. The frequency of syringe recalibration should be per the manufacturer's recommendations but no less frequently than every 3 years. In addition, return the syringe for recalibration whenever the syringe is dropped, damaged, or when its adjustable stops are reset or accidentally moved. Store the calibration syringe with the spirometer so that both are in the same environment but not exposed to direct sunlight, heat, or cold.

(2) Before performing accuracy checks, spirometer users need to determine whether a 3-L syringe injection simply verifies the spirometer's accuracy or whether, in fact, it resets the spirometer's calibration. Many spirometers that are currently available only permit the users to check calibration; that is, the calibration itself cannot be altered. However, some spirometers' settings are changed when a calibration syringe is injected, and other spirometers' settings are automatically changed if the spirometer fails to pass its accuracy check. When altering the calibration, users need to carefully follow manufacturer instructions and then check the spirometer's accuracy using a different routine and following the instructions outlined earlier in this chapter.

e. Results. Record the results of each equipment check in a log as described in chapter 6.

f. Corrections. Ensure that any inaccuracies identified during equipment checks are corrected prior to further use of the spirometer in patient testing.

4–3. Infection control

Since there is a potential risk for transmission of infection through spirometry equipment, technicians should follow the manufacturer's recommendations for spirometry cleaning and maintenance. NIOSH recommends the following steps:

a. Wash hands before and after the test.
b. Instruct workers to attach, remove and discard the disposable mouthpiece themselves.
c. Use disposable or sterilized nose clips.
d. Do not test workers who have active respiratory infections.
e. Use a clean breathing tube for each worker being tested with a volume spirometer.
f. Consider using disposable spirometry filters for volume spirometers.
g. Do not reuse flow sensors designed for single-patient use for flow spirometers.

h. Follow manufacturer's recommendations for cleaning and disinfecting the equipment.
i. Disinfect hard surfaces by wiping them with antimicrobial cleaners.

4–4. Patient preparation

a. Prior to beginning the spirometry examination, the spirometry technician should interview the worker, review his or her medical records, and possibly consult with a physician to ensure that the worker can safely perform the test.

b. Spirometry should not be performed if the worker has had a myocardial infarction within the past month or if any of the following are present:

(1) Chest or abdominal pain;
(2) Oral or facial pain that is aggravated by the mouthpiece;
(3) Stress incontinence; or
(4) Dementia/confusion.

c. Spirometry should be deferred for—

(1) One hour after smoking, using a bronchodilator, or eating a heavy meal;
(2) Three days after recovering from an illness that lasted three weeks or less;
(3) Three weeks after a severe respiratory illness or ear infection; and
(4) Six or more weeks after eye, ear, chest, or abdominal surgery, unless released by the competent medical authority.

d. After determining the safety of the procedure, the technician should—

(1) Obtain the worker's vital signs, including pulse oximetry. Any abnormal vital signs should be reviewed by a competent medical authority before proceeding.
(2) Record the worker's age and race;
(3) Measure the worker's height, and weigh the worker without shoes;
(4) Advise the worker to loosen tight clothing or remove loose dentures;
(5) Check for any dental work or piercings that may interfere with mouthpiece placement and lip seal, and
(6) Apply disposable nose clips.

e. Workers may sit or stand during the test. The spirometry technician should record the worker's posture as changes in test posture need to be taken into account when longitudinal test results are interpreted. The NIOSH, OSHA, and ACOEM recommend that workers stand during the test, and studies have shown that slightly larger lung values may be obtained when patients are standing. In 2005, however, the ATS/ERS recommended that patients sit for safety reasons. If a worker stands for the test, place a sturdy chair without wheels behind the worker; watch the worker during testing for signs of light-headedness; be prepared to steady the worker if necessary; and stop the test if any signs of stress are observed. Workers who exhibit signs of light-headedness should receive all future tests while seated. Whether a worker sits or stands, the posture should be upright, with the chin slightly elevated and the lips tightly sealed around the mouthpiece.

4–5. Performing the forced expiratory maneuver

a. The procedure should be explained to the patient in simple terms. The brief statement "I want to test how much air your lungs hold and how hard and fast you can blow the air out" may not be physiologically precise, but it is usually the only explanation necessary.

b. Instruct the worker to take the deepest possible breath, place the mouthpiece on the tongue and between the teeth, and purse the lips on the mouthpiece. Instruct the worker to elevate his/her chin slightly and to blast the air, without hesitating, into the mouthpiece as hard, fast, and completely as possible for as long as possible or until told to stop.

c. It is often helpful to demonstrate the maneuver for the worker even if he/she has performed spirometry before.

d. As the worker performs the test, coach him/her through the effort. The worker may rest as long as necessary between each effort. The goal is to obtain three acceptable tests (see below); up to eight attempts to obtain these can be made unless the worker cannot or should not continue.

e. A valid spirometry examination is one in which three acceptable, "repeatable" (see below) tests (that is, free from cough, hesitation, variable effort, early termination, or baseline artifact) have been obtained. The spirometry technician should be able to recognize the curves of acceptable and unacceptable tests. See figures 4–1 through 4–4 for examples.

f. Spirometry results are considered "repeatable" when the difference between the largest FVC minus the second largest FVC, and the largest FEV_1 minus the second largest FEV_1 taken from the acceptable curves is 0.15L or less. Lack of repeatability is often caused by the patient's failure to inhale maximally before each maneuver, or variable effort. Very poor repeatability may indicate zero-flow errors.

g. Use the largest FVC and FEV_1 from the patient's acceptable efforts to calculate the FEV_1/FVC ratio. The FVC and FEV_1 need not be taken from the same curve.

4–6. Avoiding sensor errors during spirometry tests

a. Although a spirometer may pass its calibration check, worker test results can be invalidated by equipment errors occurring during the forced expiratory maneuver. Townsend, et al. (*JOEM*, 2011) identified two major types of errors that are common during screening spirometry with flow-measuring spirometry: contamination or blockage of a flow-measuring spirometer's sensor; and flawed setting of the zero-flow reference point. If a subject's fingers, secretions, or water vapor either block or contaminate a flow-type spirometer's sensor, thus increasing its resistance, the test results will be falsely increased and become invalid. Spirometers currently available do not identify contaminated sensor problems as errors, so users need to visually recognize such problems and subsequently delete the affected tests.

b. Most flow-measuring spirometers set a zero-flow reference point either before each forced expiratory maneuver or before each set of maneuvers. All flows during a worker's subsequent expirations are measured relative to this reference point. If a low level of airflow passes through the sensor in either direction while "zeroing" is in progress, the "zero" flow reference point will be incorrect. Slight sensor motion, background fans, or forced air ventilation might cause such low-level airflow. Unless a zero-flow error is large, most spirometers do not alert the user to this problem. During zeroing, if a low level of airflow moves through the sensor toward the patient in the direction opposite to that of the patient's airflow during expiration, the spirometer will set a negative flow as "zero-flow." This negative flow will not be reached during the subsequent expiration, so the expiratory volume-time curves will climb at a constant rate (never reaching "zero"), and the expiratory flow-volume curve will draw a long limb to the right, showing increasing "volume" at a constant, very small flow rate. In contrast, if a low level of airflow moves through the sensor away from the subject during zeroing, in the same direction as the subject's air will move during expiration, the spirometer will set a small positive flow as "zero-

flow." This positive flow will be reached during the subsequent expiration before the subject actually exhales to zero flow; the expiratory volume-time curve will plateau early and begin to descend as the subject's slowing airflow becomes increasingly negative relative to the erroneous "zero-flow" point. Occluding the sensor during "zeroing" will prevent this problem. Zero-flow errors can also be caused by the movement of a gravity-sensitive pressure transducer during the subject test, disconnected or loose pressure tubing, a degrading sensor, or unstable electronics. If the zero-flow reference point is not set accurately, subsequent test results will be falsely increased or decreased, rendering them invalid.

c. Since these errors typically are not detected by spirometer software, healthcare professionals need to recognize the effects of contaminated sensors and zero-flow errors on test results and curve shapes. Both types of errors may produce very inconsistent results (failing to meet repeatability criteria), at times in conjunction with very large percentages of predicted values, exceeding 130–140 percent, for example. Such erroneous curves need to be deleted immediately (not saved) to prevent their results from being reported as the largest results from the test session. The ACOEM strongly recommends that users of flow-type spirometers become thoroughly familiar with the flawed patterns and institute protocols of preventive actions as well as corrective actions to be taken if such patterns are observed. Additional detailed information on these specific issues, as well as troubleshooting approaches, is available (Townsend, 2011).

d. Recommend placing a copy of NIOSH Publication 2011-135 (poster) where spirometry is conducted to provide a ready reference of valid spirometry results and of common testing errors and how to correct them.

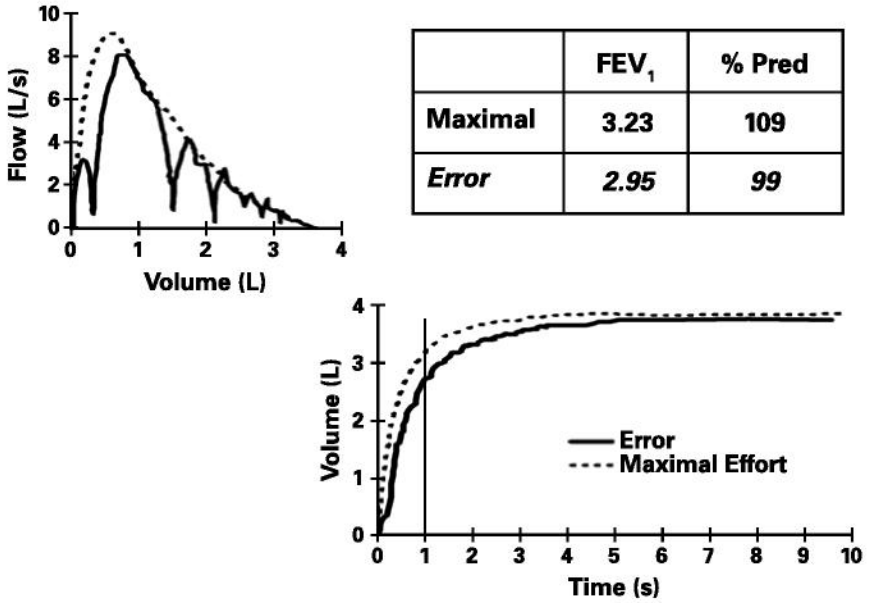
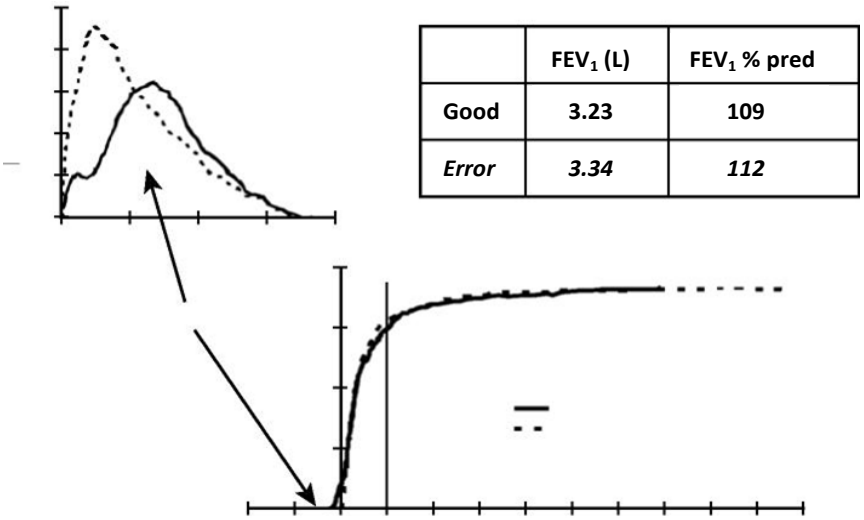
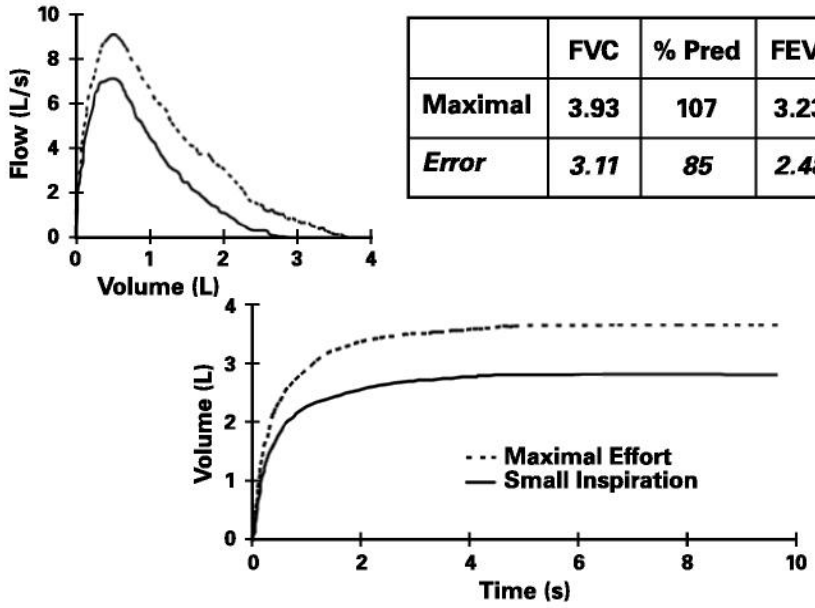


Figure 4–1. Unacceptable tracing-cough
Source: OSHA



	FEV_1 (L)	FEV_1 % pred
Good	3.23	109
Error	*3.34*	*112*

Figure 4–2. Unacceptable tracing-hesitant start
Source: *OSHA*



	FVC	% Pred	FEV_1	% Pred
Maximal	3.93	107	3.23	109
Error	*3.11*	*85*	*2.48*	*83*

Figure 4–3. Unacceptable tracing—inconsistent effort
Source: *OSHA*

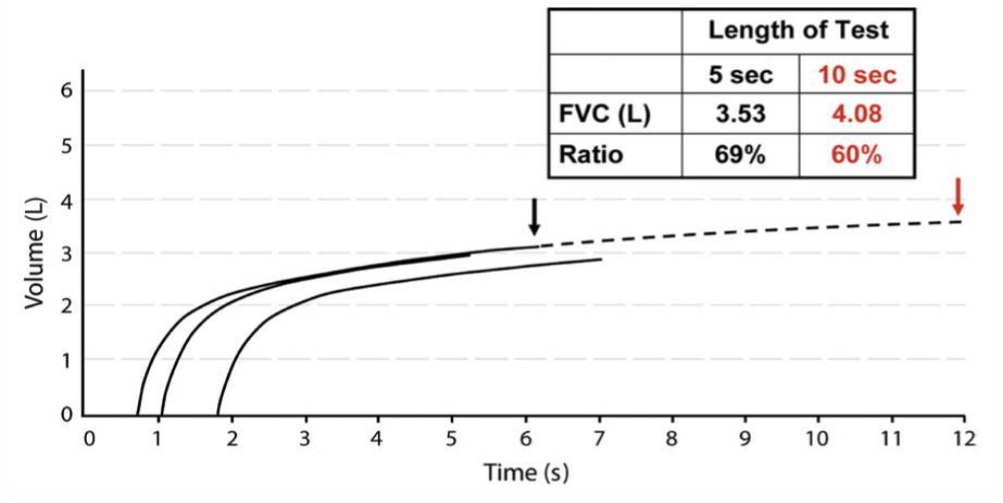


Figure 4–4. Unacceptable tracing—early termination of expiration and failure to "plateau"
Source*: OSHA*

Table 4–1. Criteria for a valid spirometry examination

Criteria	Comments
Three acceptable forced expiratory maneuvers free from—	
Coughing	None.
Hesitant or false starts	None.
Inconsistent or variable effort	Active coaching is essential throughout the duration of the patient's effort.
Early termination of expiration	Test ends when a plateau is noted in the tracing, with less than 25mL volume change in 0.5 seconds.
Excessive variability	The two best FVC or FEV readings should not vary by more than 0.15 L (150 cc).
Baseline artifact	The recording pen must begin tracing the subject's effort at the zero volume line.

CHAPTER 5

CALCULATION AND INTERPRETATION

5–1. Introduction

Several spirometric indices can be calculated from the volume-time and flow-volume tracings, including the FVC, FEV_1, and (FEV_1/FVC)%. This chapter focuses on the calculation of these values since they are the parameters most commonly used for interpreting the spirogram.

5–2. Forced vital capacity

The FVC is the volume of air that can be exhaled forcefully after full inspiration. In most individuals, the vital capacity (VC) and FVC values are nearly identical. In patients with severe obstructive pulmonary disease, however, the FVC is often smaller than the VC because of expiratory slowing, air trapping, and hyperinflation. In the absence of airway obstruction, reduction of the FVC is usually described as a restrictive ventilatory defect. This term encompasses conditions in which there is an actual reduction in the volume of air that can be inspired. Extrapulmonary factors, such as neuromuscular disorders (Guillain-Barré), morbid obesity, or chest wall abnormalities (kyphoscoliosis) can interfere with full expansion of the chest. Replacement or removal of functional lung tissue by tumor, fluid, or surgery directly diminishes lung volume. Interstitial fibrosis stiffens the lungs, lowering pulmonary compliance. These conditions interfere with the ability to achieve full inspiration, thereby decreasing the FVC.

5–3. Forced expiratory volume

a. Determination of the FEV_1 is influenced by the point selected as the start of the test, known as the zero time point. To maintain consistency of results, a uniform method of selecting this point is required. In its 2005 published statement on the standardization of spirometry, the ATS identified the back extrapolation method as the most consistent and accepted technique for determining the zero time point. The ATS recommended the use of back extrapolation until other methods have been demonstrated to produce equivalent results. Exceptionally hesitant expiratory starts may prevent accurate back extrapolation and determination of the zero time point. Any tracing with an extrapolated volume in excess of 10 percent of the total FVC or 100 mL, whichever is greater, should be repeated. In actual practice, such tracings rarely occur.

b. Decrements in FEV_1 usually occur in obstructive disease. Resistance to airflow in the bronchial tree can result from airway collapse secondary to the loss of elastic tissue in the lung parenchyma, as seen in emphysema cases. Alternatively, the bronchial lumen may be narrowed by retained mucous or spasm of the bronchial smooth musculature, as seen in asthma or chronic bronchitis cases.

5–4. The FEV_1 as a percentage of FVC

a. Calculation of (FEV_1/FVC) % is particularly useful in cases of severe restrictive pulmonary disease where the reduction in FEV_1 may falsely suggest airway obstruction. A normal individual should be able to expire 70 to 80 percent of the FVC in 1 second, depending on age and sex. An (FEV_1/FVC) % of 80 percent in a patient with low values for FVC and FEV_1 suggests restrictive disease. By contrast, an (FEV_1/FVC) % of less than 70 percent in the presence of low FEV_1 suggests obstructive disease.

b. In determining $FEV_{1,}$ FVC, and (FEV_1/FVC) %, the largest FEV_1 and the largest FVC should be used regardless of the curve(s) on which they occur. That is, in the calculation of the (FEV_1/FVC) %, the FEV_1, and the FVC need not be taken from the same curve.

c. The patient's observed (obs) FEV_1 can be expressed as a percentage of the total observed FVC, as shown in the following equation:

$$\frac{\text{obsFEV}_1}{\text{obsFVC}} \times 100 = (FEV_1 / FVC)\%$$

5–5. Determination of the percentage of predicted normal values

a. After measuring the FVC and FEV_1, an interpretation of these observed indices is appropriate. The decision as to whether spirometric tests are "normal" is usually made by comparing them to a set of published predicted normal values. Several sets of predicted normal values have been compiled, most notably those by Knudson (1976) and Hankinson (1999). Knudson's reference standards are required by OSHA Part 1910.1043, Title 29, Code of Federal Regulations (29 CFR 1910.1043) for the cotton dust industry. However, these values should not be used except when mandated by that standard. The ACOEM endorses the use of reference values based on data collected by NHANES III and published in 1999 by Hankinson. Because they were developed from diverse populations and under strict quality control, OSHA recommends using the NHANES III values to interpret occupational spirometry results unless a specific standard requires a different reference group.

b. Setting the lower limit of normality (LLN) at 95 percent of the predicted value may result in a small proportion of the normal population being labeled as "abnormal." The LLN is defined so that 95 percent of a "normal" nonsmoking population will have values above the LLN, and only 5 percent of a "normal" population will have values below the LLN. The ACOEM recommends that occupational health practitioners follow the ATS/ERS algorithm for separating normal and abnormal test results. The presence of airways obstruction is indicated by an FEV_1/FVC below the worker's LLN, and the presence of possible restrictive impairment is indicated by an FVC less than the LLN. Practitioners need to remember that an FEV_1/FVC that is barely abnormal, in the presence of both FEV_1 and FVC more than 100 percent of predicted, may indicate a normal physiologic variant pattern in healthy nonsmoking populations, such as emergency responders. However, if such healthy workers are exposed to known respiratory hazards, it is recommended that the possibility of airways obstruction also be considered when an abnormal FEV_1/FVC is observed.

c. In all studies of predicted normal values, several factors affecting lung capacity and flow rates have been identified, including age, height, sex, and race. Even in the absence of superimposed disease processes, pulmonary function declines predictably with advancing age. Men generally have larger lung volumes than women of the same age and height. In addition, the FEV_1 and FVC of non-Caucasians are approximately 15 percent lower than those of Caucasians of the same age, height, and sex. This difference has been noted for both African-Americans and individuals of Asian descent. The explanation for this phenomenon is not clear although differences in thoracic configuration and diaphragmatic position may account for differences in lung volume. Allowance of ethnic variation must be made to avoid errors in interpretation.

d. Since NHANES III reference values were generated specifically for Caucasians, African-Americans, and Mexican-Americans, the predicted values and LLNs are not adjusted when

workers of these races/ethnicities are tested. However, race-specific NHANES reference values are not available for Asian (that is, Chinese, Japanese, East Indian, or Pakistani) workers. Though less desirable than race-specific values, Caucasian-predicted values and LLNs for FVC and FEV_1 need to be multiplied by a scaling factor to account for the larger thoracic cages observed in Caucasians as compared to Asians of the same age, height, and gender. Based on two small studies, the ATS/ERS recommended a scaling factor of 0.94, and there is recent evidence that this factor may not be optimal. Studies reported since 2005 indicate that the previously used scaling factor of 0.88 may still be the most appropriate choice for Asians as well as for African-Americans. No ethnic correction factor is necessary for the FEV_1/FVC ratio since it is less affected by race.

e. An example of the calculation of percentage of predicted normal is demonstrated in appendix C. The observed FVC or FEV_1 is divided by the appropriate predicted value based on the patient's age, height, sex, and race. This ratio is multiplied by 100 to obtain the percentage of predicted normal FEV_1 and FVC. One widely used method of defining the limits of normal spirometric indices is to set the lower limits of normal for FEV_1 and FVC at 80 percent of the predicted value. For the FEV_1/FVC ratio, a value greater than 70 percent is considered normal.

5–6. Obstructive impairments

a. The first step in interpreting spirometry test results is to determine whether a valid test has been performed or if additional maneuvers may be necessary. Once the test's validity has been established, the next step is to calculate the FEV_1/FVC to distinguish between obstructive and non-obstructive patterns. When both the FEV_1/FVC and FEV_1 are less than their LLNs, airways obstruction is present. However, when the FEV_1/FVC is less than its LLN, but the FEV_1 is greater than its LLN, borderline obstruction or a normal physiologic variant may exist. The ATS/ERS cautions that an FEV_1/FVC below the LLN, in combination with FVC and FEV_1 more than 100 percent of predicted, is sometimes seen in healthy subjects, including athletes, and may be due to disynaptic growth of the alveoli. This pattern is labeled as a possible normal physiologic variant and is not unusual among physically fit nonsmoking emergency responders, firefighters, and police. However, if these healthy workers are exposed to known hazardous substances, the possibility of obstructive impairment needs to be considered when a reduced FEV_1/FVC is observed.

b. All grading schemes for the severity of airways obstruction rely on the FEV_1 % of predicted, applying one of several definitions. Widely-used schemes are based on the 1986 ATS respiratory impairment categories, which define an FEV_1 down to 60 percent of predicted as mild obstruction, an FEV_1 between 41 and 59 percent of predicted as moderate obstruction, and an FEV_1 of 40 percent or less of predicted as severe obstruction, as named in the 2000 ACOEM statement. While these levels are consistent with those named in the OSHA cotton dust standard, they are lower than those from the sample method presented by the ATS/ERS in 2005 (para 5–7).

5–7. Restrictive impairments

a. In the absence of airways obstruction (FEV_1/FVC $\geq$ LLN), the next step is to evaluate the FVC to determine if restrictive impairment may exist. If the FVC is less than the LLN, restrictive impairment is possible and may need to be confirmed by additional tests of pulmonary function, such as lung volume measurements. In the presence of airways obstruction (FEV_1/FVC < LLN), an FVC less than the LLN indicates a possible mixed impairment pattern,

and its restrictive component may also need to be confirmed by additional pulmonary function tests.

b. In 2005, the ATS/ERS recommended grading restrictive impairment, as well as airways obstruction, using the FEV_1 % of predicted. From a practical standpoint, this may be reasonable since both the FVC and FEV_1 are reduced as restrictive impairment progresses, and the common technical problems of early termination of maneuvers and zero-flow errors are less likely to impair the accuracy of the FEV_1 than that of the FVC. However, for workers with mixed impairment patterns, grading the restrictive impairment using FEV_1% of predicted might slightly overstate the severity of restriction due to the coexisting obstructive reduction of the FEV_1. Relying on the FEV_1 % of predicted, the ATS/ERS 2005 definitions of restrictive impairment severity label an FVC between 60 and 69 percent of predicted as mild restriction, an FVC between 51 and 59 percent of predicted as moderate restriction, and an FVC between 45 and 50 percent of predicted as severe restriction. These levels differ significantly from those of the ATS 1986 respiratory impairment definitions (stated in para 5–6).

5–8. Calculation of changes in follow-up spirograms

a. Although comparison of an individual's test results to a set of reference standards is useful, an even more desirable approach is to compare the patient's present values to his or her own previous performance. This approach provides greater sensitivity for detecting decrements in lung function since the coefficient of variation for an individual on a given test is much smaller than the population coefficient of variation for the same test. Spirometry performed over the course of a work shift or from day to day can detect acute transient decrements in lung functions. Longitudinal studies performed over longer intervals (such as annually) may discover more insidious, chronic changes at the earliest possible stage.

b. When comparing current spirometric values to previous values, the technician may express the difference as an absolute change in liters or as a percent change. For example, in an annual respiratory surveillance program for asbestos workers, a 24-year-old woman is found to have an FVC of 3.59 liters. Her previous year's FVC was 4.17 liters. The calculations for absolute and percent change are shown below. The annual percent change in FEV_1, FVC, and (FEV_1/FVC) % should be calculated and recorded as described in chapter 6.

$$\begin{aligned} ABSOLUTE\ CHANGE &= Previous\ FVC - Current\ FVC \\ &= 4.17 - 3.59 \\ &= 0.58 \text{ liters, or a loss of } 0.58 \text{ liters} \end{aligned}$$

$$PERCENT\ CHANGE = \frac{\text{Previous FVC} - Current\ FVC}{\text{Previous FVC}}\ x\ 100$$

$$= \frac{4.17 \quad - 3.59}{4.17}\ x\ 100 = 13.9\ \%, \text{ or a decline of } 13.9\ \%$$

c. There are many etiologies, other than occupational or non-occupational lung disorder, for longitudinal decrements in FVC and FEV_1. Cross-sectional studies of normal populations have

indicated that both FEV_1 and FVC may decrease by 30 mL each year due to normal aging. Seasonal and diurnal variations in lung volumes and flow rates have been observed. Cigarette smoking may transiently alter certain pulmonary function tests, particularly force expiratory flow rates. Patients' recent use of aerosolized bronchodilators can produce misleading results. Large fluctuations in ambient temperature over the course of a work shift can result in spurious changes in FEV_1. Despite all of these factors, however, inconsistent technique in combination with fluctuating patient effort is the single most important source of variability in spirometry test results. Adherence to the procedures described in chapter 4 should minimize any variability due to inconsistent technique, fluctuating patient effort, and/or spirometer inaccuracy.

d. The following guidelines are helpful for interpreting the results of follow-up spirometry tests. Either an annual percentage decline in FEV_1 or an FVC of greater than 15 percent should be regarded as potentially abnormal. This 15-percent criterion should distinguish significant lung function decline from the usual variability in spirometry performance that occurs in many spirometry testing programs. Similarly, an annual decrease in (FEV_1/FVC) % greater than 5 percent should also be considered abnormal. Because the FEV_1/FVC is affected by factors that impact both the FEV_1 and FVC, the (FEV1/FVC) % is not the outcome of choice for following a change in function over time.

e. Any abnormal results in either baseline or follow-up spirometry should be verified by repeat testing with careful attention paid to patient preparation and technique.

f. Pulmonary function tests are nonspecific; a diagnosis can seldom be made based on spirometric findings alone. The total clinical presentation, including the respiratory and occupational health histories, physical examination, chest radiograph, and appropriate laboratory studies, must be considered when spirometry tests are evaluated. It is seldom justifiable to deny a worker employment or transfer the worker to another job solely on the basis of minimally abnormal spirometry. Smoking, non-occupational pulmonary disease, and other variables noted above are common causes of alterations in pulmonary function.

CHAPTER 6

RECORDKEEPING

6–1. Introduction

Adequate recordkeeping is a critical component of a good spirometry program. This chapter provides the recordkeeping requirements associated with the use of spirometry in occupational health surveillance and with the spirometry technician's proficiency. Recommended recordkeeping components are 1) spirometry test reports and medical clearance for respirator use, 2) equipment calibration and maintenance records, and 3) personnel training and evaluation records. Use DA Form 7761, Employee Monitoring Data Sheet, to record an individual's spirometry evaluation results (see below and appendix E), and use DA Form 7760, Medical Clinic Clearance for Respirator Use, to document an individual's eligibility or non-eligibility for respirator use (see appendix E). These forms will become a permanent part of the individual's medical records.

6–2. Spirometry test reports

a. A tracing of the patient's forced expiratory maneuver (spirogram) is necessary to determine whether the patient has performed the test properly. Incorporate the three acceptable spirograms produced by the patient, along with any manual calculations or microprocessor results obtained by the technician, into the patient's medical record for future medical review. As a minimum, record the following information on DA 7761 for each spirogram: patient's name, employee number, age, weight, sex, and race; room or spirometer temperature; technician's name; test date and time; spirometer type used; test posture (sitting or standing); evaluation of patient effort (poor, good, or excellent) and cooperation; and the date of the last calibration check. In addition, note on DA 7761 any potentially disqualifying fact, such as recent cigarette smoking, a meal, a lower respiratory infection, or bronchodilation medication use.

b. The FEV_1 and FVC values should be expressed in liters rounded to 2 decimal places (such as 5.61 liters). The values for FEV_1/FVC % and all percents of predicted normal are rounded to 1 decimal place (such as 85.4%). Changes in spirometric values over time should be expressed as a percent change—either an increase (+) or a decrease (-) in volume or flow.

c. OSHA standards (29 CFR 1910.1020) require that spirometry results be maintained in the employee's medical record for the duration of his/her employment plus a period of 30 years.

d. Record serial spirometric results on Department of the Army (DA) Form 5551-R (Spirometry Flow Sheet). Doing so enables longitudinal tracking of results and aids in monitoring trends in the testing over time.

6–3. Equipment calibration and equipment maintenance records

a. Record the daily, weekly, or quarterly calibration and equipment checks (as described in paragraph 3-2) on DA Form 5550-R (Spirometer Calibration Log). Local reproduction of this form on 8$^{1/2}$ by 11-inch paper is authorized. If the results of a calibration check are abnormal, discontinue use of the spirometer until it has been repaired. Note any such occurrence in the remarks column of the log, including the dates that the spirometer was out of service.

b. Equipment maintenance records support the accuracy of the spirometry test results. These records assist in the troubleshooting of problems relating to the test results and are especially

important when periodic testing is conducted. As most computerized systems store this information automatically, reports can be run during calibration checks.

c. The maintenance records should include the quality control log (the dates of calibration checks, maintenance, repairs, and upgrades), along with the spirometer's model, serial number, and hardware/software version(s).

d. The DA Form 5550-R is maintained in the occupational health clinic and is used to verify and validate calibration. It also accompanies the spirometer should further repairs be necessary.

6–4. Personnel training and evaluation records

The supervisor of each spirometry technician maintains documentation that the technician has completed a NIOSH-approved spirometry training course and is qualified to perform spirometry. Chapter 7 provides the technician training requirements and qualification procedures.

CHAPTER 7

TRAINING AND QUALIFICATION REQUIREMENTS FOR SPIROMETRY TECHNICIANS

7–1. General characteristics

The process of obtaining acceptable, reproducible spirograms calls for technicians who are trained to perform spirometry and act with sensitivity for the patient's welfare. The patient must expend considerable effort to produce a valid spirogram. As it may require up to eight efforts by the patient to achieve the three best tracings, the technician must be sensitive to any discomfort or fatigue that the patient may experience. At the same time, the technician must also be forceful, encouraging, and enthusiastic while coaching the patient to attain the best possible forced expiratory maneuvers.

7–2. Initial training and qualification

a. As a minimum, every individual who performs occupationally related spirometry must complete a training course for spirometry technicians, with refresher training every 5 years. The curriculum of this course must be NIOSH-approved and taught by qualified personnel. Technicians may fulfill this training requirement in one of two ways:

(1) Attendance at one of the existing NIOSH-approved courses offered by private institutions.

(2) Attendance at a DOD-developed, NIOSH-approved course for spirometry technicians.

b. A certificate of course completion must be maintained for each technician performing spirometry in the occupational health clinic. Completion of a NIOSH-approved course in spirometry is a minimum training requirement although further training and experience with knowledgeable technicians may be desirable.

c. Military Respiratory Specialists (military occupational specialty (MOS) 68V) do not attend a NIOSH-approved spirometry technician course; rather, they are trained in the performance of spirometry testing as part of their MOS schooling. Where the OH service uses 68V personnel assigned to local pulmonary service departments, tests performed by these specialists should be accepted for medical surveillance purposes.

7–3. Quality assurance procedures for technician proficiency

Establish the following procedures to ensure adequate technician proficiency and sufficient quality assurance.

a. A supervisor knowledgeable in the performance and interpretation of spirometry testing randomly reviews spirometry examinations in several medical records for each technician on an annual basis. This review includes—

(1) An evaluation of spirogram acceptability (that is, free from cough, hesitation, false starts, variable effort, early termination of expiration, or baseline artifact) (see table 4–1).

(2) An assessment of the completeness of the demographic data.

(3) A judgment as to the accuracy of calculations from the tracings.

(4) A check to ascertain that appropriate predicted values were used and that three acceptable tracings meeting repeatability criteria were included for each spirometry examination that appears in the medical record.

(5) An assessment of the adequacy of calibration records.

b. OSHA recommends that supervisors and directors of spirometry programs understand the elements of valid testing and be able to recognize flawed results. The goal is to ensure that 100 percent of spirometry examinations are technically valid. Supervisors and directors who interpret test results periodically conduct a formal qualification test for each spirometry technician. This procedure consists of an actual spirometry examination with the supervisor as patient. Focus attention on patient preparation, technique, coaching, tracing acceptability, and the accuracy of calculations. The technician demonstrates calibration procedures, as described in chapter 4, to the supervisor. At the conclusion of the test, the supervisor and technician discuss any deficiencies found or areas needing improvement.

c. The technician's supervisor maintains written documentation of the annual medical records review and qualification test, and the technician receives copies of these evaluations. Following each review or qualification test, the supervisor also addresses the need for any necessary remedial training.

CHAPTER 8

USE OF SPIROMETRY IN THE MEDICAL EVALUATION OF THE RESPIRATOR USER

8–1. Introduction

a. A large number of different respiratory protective devices are in use at Army installations throughout the world. The classification and use of respiratory protective devices are discussed extensively in 29 CFR 1910.134 and AR 11–34. Although these devices protect the user from exposure to hazardous pulmonary environments, the respirator creates several significant burdens for the user.

b. Aside from the psychological intolerance to respirators experienced by some respirator users, all respirators decrease the user's mobility and visibility, resulting in safety concerns. Open-circuit, self-contained breathing apparatuses (SCBAs) contain cylinders, which may weigh up to 35 pounds. Because the mask wearer carries these cylinders, his or her work capacity may be reduced by up to 20 percent. All respirators increase the physiologic workload of ventilation (breathing). Ventilation effectiveness can be the rate-limiting factor in physical activity—either peak or endurance. Air-purifying respirators may significantly increase airway resistance on inspiration. Pressure-demand, supplied-air respirators may cause increased expiratory airway resistance. The regulators on current SCBAs do not supply the high instantaneous flow rates that may be required during firefighting or rescue operations, thus further impairing work capacity. The dead volume of some respirators' masks will also increase the user's respiratory workload. These factors increase the work of breathing to varying degrees depending on the respirator and the minute ventilation rate.

c. Whether the excess work associated with respirator use will unacceptably impact job performance and safety depends on—

(1) The decrement from additional respiratory load that occurs with respirator use. This depends on the magnitude of the workload (minute ventilation required for task) and duration of task, as well as the type of respirator in use.

(2) Other factors such as heat or wearing personal protective equipment, both of which effectively increase the workload of the task. Either factor will increase the impact of any decrement from respiratory load.

(3) Criticality of the task, which determines the margin of safety needed for clearance for respiratory use. For example, a task such as use of fixed air supply at a spray booth can easily be interrupted with minimal risk if medical issues arise. In comparison, first responders cannot interrupt the task without potentially life-threatening risk to themselves and others. Muscular fitness is one determinant of the safety margin for the workload of the task, as is cardiac fitness. An individual who can perform the task repeatedly with nominal change in respiratory rate will tolerate the extra load of the respirator better than an individual whose respiratory rate increases by 50 percent and who thus cannot sustain the task because of shortness of breath.

d. Spirometry is only one factor in determining respiratory fitness, and, therefore, is only one factor in granting a medical clearance for respirator use. A patient's spirometry performance cannot be considered apart from other factors when determining whether he or she is medically capable of using a specific respirator for a specific task. Spirometry should be used as one screening tool to identify that population of workers who may have difficulty wearing a respirator.

8–2. Medical aspects of a respiratory protection program

a. As part of a Respirator Protection Program, a medical clearance (DA 7760) is granted for specific tasks and for a specific respirator. AR 11–34 states that workers should not be assigned to tasks requiring respirators until it has been determined by medical questionnaire (29 CFR 1910.134, appendix C) that they are physically and physiologically able to perform their work while wearing a respirator. Spirometry tests have been recommended as part of a medical evaluation. Individuals who routinely wear respiratory protection as part of their duties should have a baseline spirometry examination in their medical record. The frequency of subsequent spirometry examinations will depend on the medical and occupational history obtained at yearly intervals, as well as the general health of the patient as noted in the medical questionnaire by means of the following:

(1) Has the patient had any problems breathing while wearing the respirator during the past year?

(2) Have any newly acquired respiratory symptoms appeared?

(3) Has the patient developed cardiovascular disease in the intervening period?

(4) Have recent examinations shown the patient's lung function declining at a greater rate than expected?

b. The individual's answers to the questionnaire and related follow-up questions must be factored into a decision about the frequency of the tests. (Note: Individuals exposed to hazardous pulmonary substances (asbestos, for example) at a level above the action level may require annual spirometry, regardless of their age or health). Review all of the routine respirator user's spirometry results, regardless of how often the individual undergoes spirometry testing or why.

8–3. Guidelines

a. Having generated the spirograms, the provider next interprets these data in the context of the respirator user. The first critical issues are whether valid tests have been obtained and whether the individual's medical record includes past spirometry results for comparison.

b. If no past spirometry data are available, use normative standards. Although these form the weaker basis for assessing spirometry results, all tests must be assessed. When interpreting spirometry results, address the selection and consistent application of appropriate reference values to define the normal range for FVC, FEV_1, and (FEV/FVC) % as well as an algorithm to categorize the spirometry results as either "normal" or "abnormal." This designation is not

diagnostic but rather serves as a basis for the screening use of the results. Evaluate all of the spirometry test results for an individual relative to a single set of reference values, regardless of which set is selected. Abnormal values suggest underlying respiratory pathology, which may limit lung function and progress to serious illness. Evaluate and exclude this possibility to clear an individual not only for critical job assignments but also for limited, low-risk respirator use.

c. If baseline data is available, the significance of decrements can be assessed with greater strength of indication of pulmonary pathology.

d. Spirometry is a screening test for respirator clearances. Decrements in spirometry can be an indication of a wide range of serious respiratory function problems. If a spirometry examination result is that of a significantly obstructive or restrictive defect, the competent medical authority should consider administering a respirator use test before clearing the individual to wear the required type of respiratory protection. An example of a respirator use test standing operating procedure (SOP) is provided in appendix E.

APPENDIX A

REFERENCES

Section I
Required References

Department of Defense manuals are available online from the Defense Technical Information Center Web site at http://www.dtic.mil/whs/directives/. Army regulations are available online from the U.S. Army Publishing Directorate Web site at http://www.apd.army.mil/. Codes of Federal Regulations are available online from the Electronic Code of Federal Regulations Web site at http://www.ecfr.gov/. Occupational Safety and Health Administration regulations are available online from the OSHA Web site at https://www.osha.gov/Publications/. National Institute of Occupational Safety and Health publications are available online from the Centers for Disease Control and Prevention Web site at http://www.cdc.gov/niosh/docs/.

29 CFR 1910. 1020
Access to employee exposure and medical records (Cited in para 6–2*c*.)

29 CFR 1910.1043
Occupational Safety and Health Administration Cotton Dust Standard (Cited in para 5–5*a*.)

29 CFR 1910.134
Respiratory Protection (Cited in paras 8–1*a*, 8–2*a*.)

AR 11–34
The Army Respiratory Protection Program (Cited in paras 8–1*a*, 8–2*a*.)

AR 40–68
Clinical Quality Management (Cited in para 1–4*b*.)

DOD 6055.05-M
Occupational Medical Examinations and Surveillance Manual (Cited in para 1–5*b*.)

Hankinson JL, Odencrantz JR, Fedan KB. Spirometric Reference Values from a Sample of the General US Population. *Am J Respir Crit Care Med.* 1999; 159:179–187 (Cited in para 5–5*a*.)

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Get Valid Spirometry Results EVERY Time (Cited in para 4–6*d*.)

Townsend MC. American College of Occupational and Environmental Medicine (ACOEM) Occupational and Environmental Lung Disorders Committee. Spirometry in the Occupational Health Setting–2011 update. *J Occup Environ Med*. 2011; 53(5):569–584 (Cited in paras 4–6*a*, 4–6*b*.)

Section II
Related References

A related publication is a source of additional information. The user does not have to read it to understand this publication. American Thoracic Society/European Respiratory Society publications are available online from the ATS/ERS Web site at http://www.thoracic.org/. Department of Defense issuances are available online from the Defense Technical Information Center Web site at http://www.dtic.mil/. Department of the Army publications are available online from the U.S. Army Publishing Directorate Web site at http://www.apd.army.mil/. Codes of Federal Regulations are available online from the Electronic Code of Federal Regulations Web site at http://www.ecfr.gov/. National Institute of Occupational Safety and Health publications are available online from the Centers for Disease Control and Prevention Web site at http://www.cdc.gov/niosh/docs/. Occupational Safety and Health Administration regulations are available online from the OSHA Web site at https://www.osha.gov/Publications/.

National Institute of Occupational Safety and Health (NIOSH)
Criteria for a Recommended Standard: Occupational Exposure to Respirable Coal Mine Dust

NIOSH
Spirometry Training Guide

OSHA 3637-03 2013
Spirometry Testing in Occupational Health Programs—Best Practices for Healthcare Professionals

DODI 1000.30
Reduction of Social Security Number (SSN) Use Within DoD

AR 385-10
The Army Safety Program

DA PAM 385-10
Army Safety Program

American Thoracic Society/European Respiratory Society
General considerations for lung function testing. *Eur Respir J*. 2005;26:153–161.

ATS/ERS
Standardisation of spirometry. *Eur Respir J*. 2005;26:319–338.

Section III
Prescribed Forms
Unless otherwise indicated, DA forms are available on the Army Publishing Directorate (APD) Web site (http://www.apd.army.mil/).

DA Form 5550-R
Spirometer Calibration Log (Cited in paras 6–3*a,* 6–3*d.*)

DA Form 5551-R
Spirometry Flow Sheet (Cited in para 6–2*d.*)

DA Form 7760
Medical Clinic Clearance for Respirator Use (Cited in paras 6–1, 8–2*a*.)

DA Form 7761
Employee Monitoring Data Sheet (Cited in paras 6–1, 6–2*a*.)

Section IV
Referenced Forms

This section has no entries.

APPENDIX B

SUBSTANCES FOR WHICH SPIROMETRY TESTING IS RECOMMENDED

The recommendations in DOD 6055.05-M may be implemented for those substances listed below which do not have legal standards for medical examination. Baseline spirometry is indicated particularly for those unprotected workers who are exposed to greater than or equal to one-half of the established 8-hour time-weighted average exposure limit, such as the OSHA PEL, ACGIH® TLV®, or NIOSH Recommended Exposure Limit (REL). The periodicity of follow-on spirometric assessments should be made by the competent medical authority based upon the magnitude, frequency, and duration of occupational exposures, as documented by the industrial hygienist.

ALLYL CHLORIDE
AMMONIA
ANTIMONY
ASBESTOS
BENZOYL PEROXIDE
BENZYL CHLORIDE
BERYLLIUM
BORON TRIFLUORIDE
1-BROMOPROPANE
CADMIUM
CARBARYL (SEVIN;
1-NAPHTHY-N-METHYL
CARBAMATE) CARBON BLACK
CARBON DISULFIDE
CHLORINE B-CHLOROPRENE
(2-CHLORO-1,
3-BUTADIENE)
CHROMIC ACID AND CHROMIUM (IV)
COBALT (METAL FUME DUST, OXIDE,
SULFIDE,
CHLORIDE)
CRESOL (CRESYLIC ACID, MIXED
0, M, P ISOMERS)
DIACETYL (AND SUBSTITUTES)
EPICHLOROHYDRIN
ETHYLENE DIBROMIDE
(1, 2-DIBROMOETHANE)
ETHYLENE DICHLORIDE
ETHYLENEIMINE
(1, 2-DICHLOROETHANE)
ETHYLENE OXIDE
FIBROUS GLASSZINC OXIDE
FORMALDEHYDE
GLYCIDYL ETHERS
(2, 3-EPOXYPROPL ETHERS)
HYDROGEN CYANIDE AND CYANIDE
SALTS
HYDROGEN FLUORIDE
HYDROGEN SULFIDE
HYDRAZINES
ISOCYANATES
ISOPROPYL ALCOHOL
MANGANESE (AND COMPOUNDS)
4, 4 1 -METHYLENE BIS
(2 CHLOROANILINE) (MOCA)
METHYL BROMIDE
METHYL CHLOROMETHYL ETHER

METHYLENE CHLORIDE
(DICHLOROMETHANE)
METHYL (N-AMYL) KETONE
(2-HEPTANONE)
2-NITROPROPANE
NICKEL CARBONYL
NICKEL (INORGANIC)
NITRIC ACID
NITROGEN OXIDES
ORGANIC TIN COMPOUNDS
PHOSGENE (CARBONYL CHLORIDE)
SILICA (CRYSTALLINE)
SODIUM HYDROXIDE
STYRENE

SULFUR DIOXIDE

SULFURIC ACID
TETRYL
TOLUENE-2, 4-DIISOCYANATE (TDI)
(AND ALL ORGANIC
ISOCYNATES)
1, 1, 1-TRICHLOROETHYLENE
TUNGSTEN AND CEMENTED
TUNGSTEN
CARBIDE
VANADIUM
VINYL ACETATE
VINYL CHLORIDE (CHLOROETHANE)
XYLENE ZINC OXIDE

APPENDIX C

SPIROMETRY CALCULATION OUTLINE

C–1. Measure FVC in each tracing from baseline to plateau.

C–2. Ensure that the criteria to establish validity are met (that is, three tracings free from cough, early termination of effort, or baseline artifact, which meet ATS repeatability criteria).

C–3. Select the largest FVC from the three acceptable tracings.

C–4. Measure FEV_1 in each curve.

C–5. Select the largest FEV_1 from the three tracings. (The largest FEV_1 is usually found on the same curve as the largest FVC.)

C–6. Determine FEV_1 predicted and FVC predicted from the tables in appendix E, using race, sex, height, and age.

C–7. Divide as follows:

$$FEV_{1\ obs} \div FEV_{1\ pred} \times 100 = FEV_1\% \text{ predicted normal}$$

$$FVC_{.obs} \div FVC_{\ pred} \times 100 = FVC\% \text{ predicted normal}$$

C–8. For (FEV_1/FVC) %, divide as follows:

$$FEV_{1\ obs} \div FVC_{\ obs} \times 100 = (FEV_1/FVC)\%$$

Note: Use the largest FEV_1 and FVC in this calculation, even if they do not come from the same curve.

C–9. Summary:

$$FEV_{1\ obs} / FVC_{.obs} \times 100 = (FEV_1/FVC)\ \%$$

$$FEV_{1\ obs}./ FEV_{1\ pred} \times 100 = FEV_1\% \text{ predicted normal}$$

$$FVC._{obs} / FVC_{pred} \times 100 = FVC\% \text{ predicted normal}$$

APPENDIX D

PREDICTED VALUES

The following tables were generated by NIOSH using the Hankinson et al. 1999 prediction equations for Caucasians, African-Americans, and Mexican-Americans. (**Note:** For Asian-Americans, apply a scaling ("race-adjustment") factor of 0.88 to Caucasian-predicted values and LLNs for FVC and FEV_1 to obtain appropriate reference values.)

Table D–1. Predicted FVC (L)–Caucasian males–NHANES III

Height (Inches)	Age																											
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
58.0	3.40	3.76	3.74	3.71	3.69	3.66	3.63	3.60	3.56	3.53	3.49	3.45	3.40	3.36	3.31	3.26	3.21	3.16	3.10	3.04	2.98	2.92	2.86	2.79	2.72	2.65	2.58
59.0	3.54	3.90	3.88	3.85	3.83	3.80	3.77	3.74	3.70	3.67	3.63	3.59	3.55	3.50	3.45	3.40	3.35	3.30	3.24	3.19	3.13	3.06	3.00	2.93	2.86	2.79	2.72
60.0	3.68	4.04	4.02	4.00	3.97	3.94	3.91	3.88	3.85	3.81	3.77	3.73	3.69	3.64	3.60	3.55	3.50	3.44	3.39	3.33	3.27	3.21	3.14	3.08	3.01	2.94	2.86
61.0	3.83	4.19	4.17	4.14	4.12	4.09	4.06	4.03	3.99	3.96	3.92	3.88	3.83	3.79	3.74	3.69	3.64	3.59	3.53	3.47	3.41	3.35	3.29	3.22	3.15	3.08	3.01
62.0	3.97	4.34	4.31	4.29	4.26	4.24	4.21	4.17	4.14	4.10	4.07	4.03	3.98	3.94	3.89	3.84	3.79	3.74	3.68	3.62	3.56	3.50	3.44	3.37	3.30	3.23	3.16
63.0	4.12	4.49	4.46	4.44	4.42	4.39	4.36	4.33	4.29	4.25	4.22	4.18	4.13	4.09	4.04	3.99	3.94	3.89	3.83	3.77	3.71	3.65	3.59	3.52	3.45	3.38	3.31
64.0	4.28	4.64	4.62	4.59	4.57	4.54	4.51	4.48	4.44	4.41	4.37	4.33	4.29	4.24	4.19	4.14	4.09	4.04	3.98	3.93	3.87	3.80	3.74	3.67	3.60	3.53	3.46
65.0	4.43	4.79	4.77	4.75	4.72	4.70	4.67	4.63	4.60	4.56	4.52	4.48	4.44	4.40	4.35	4.30	4.25	4.19	4.14	4.08	4.02	3.96	3.89	3.83	3.76	3.69	3.61
66.0	4.59	4.95	4.93	4.91	4.88	4.85	4.82	4.79	4.76	4.72	4.68	4.64	4.60	4.55	4.51	4.46	4.41	4.35	4.30	4.24	4.18	4.12	4.05	3.98	3.92	3.85	3.77
67.0	4.75	5.11	5.09	5.07	5.04	5.01	4.98	4.95	4.92	4.88	4.84	4.80	4.76	4.71	4.67	4.62	4.57	4.51	4.46	4.40	4.34	4.28	4.21	4.14	4.08	4.01	3.93
68.0	4.91	5.27	5.25	5.23	5.20	5.18	5.15	5.11	5.08	5.04	5.00	4.96	4.92	4.88	4.83	4.78	4.73	4.67	4.62	4.56	4.50	4.44	4.37	4.31	4.24	4.17	4.09
69.0	5.08	5.44	5.42	5.39	5.37	5.34	5.31	5.28	5.24	5.21	5.17	5.13	5.09	5.04	4.99	4.94	4.89	4.84	4.78	4.73	4.66	4.60	4.54	4.47	4.40	4.33	4.26
70.0	5.24	5.61	5.58	5.56	5.53	5.51	5.48	5.44	5.41	5.37	5.34	5.30	5.25	5.21	5.16	5.11	5.06	5.01	4.95	4.89	4.83	4.77	4.71	4.64	4.57	4.50	4.43
71.0	5.41	5.77	5.75	5.73	5.70	5.68	5.65	5.61	5.58	5.54	5.51	5.46	5.42	5.38	5.33	5.28	5.23	5.18	5.12	5.06	5.00	4.94	4.88	4.81	4.74	4.67	4.60
72.0	5.58	5.95	5.93	5.90	5.88	5.85	5.82	5.79	5.75	5.72	5.68	5.64	5.59	5.55	5.50	5.45	5.40	5.35	5.29	5.23	5.17	5.11	5.05	4.98	4.91	4.84	4.77
73.0	5.76	6.12	6.10	6.08	6.05	6.02	5.99	5.96	5.93	5.89	5.85	5.81	5.77	5.72	5.68	5.63	5.58	5.52	5.47	5.41	5.35	5.29	5.22	5.16	5.09	5.02	4.94
74.0	5.94	6.30	6.28	6.25	6.23	6.20	6.17	6.14	6.10	6.07	6.03	5.99	5.95	5.90	5.85	5.80	5.75	5.70	5.64	5.58	5.52	5.46	5.40	5.33	5.26	5.19	5.12
75.0	6.12	6.48	6.46	6.43	6.41	6.38	6.35	6.32	6.28	6.25	6.21	6.17	6.12	6.08	6.03	5.98	5.93	5.88	5.82	5.76	5.70	5.64	5.58	5.51	5.44	5.37	5.30
76.0	6.30	6.66	6.64	6.61	6.59	6.56	6.53	6.50	6.46	6.43	6.39	6.35	6.31	6.26	6.21	6.16	6.11	6.06	6.00	5.95	5.89	5.82	5.76	5.69	5.62	5.55	5.48
77.0	6.48	6.84	6.82	6.80	6.77	6.74	6.71	6.68	6.65	6.61	6.57	6.53	6.49	6.44	6.40	6.35	6.30	6.24	6.19	6.13	6.07	6.01	5.94	5.88	5.81	5.74	5.66
78.0	6.67	7.03	7.01	6.98	6.96	6.93	6.90	6.87	6.83	6.80	6.76	6.72	6.68	6.63	6.58	6.53	6.48	6.43	6.37	6.32	6.26	6.19	6.13	6.06	5.99	5.92	5.85
79.0	6.86	7.22	7.20	7.17	7.15	7.12	7.09	7.06	7.02	6.99	6.95	6.91	6.87	6.82	6.77	6.72	6.67	6.62	6.56	6.51	6.45	6.38	6.32	6.25	6.18	6.11	6.04
80.0	7.05	7.41	7.39	7.36	7.34	7.31	7.28	7.25	7.21	7.18	7.14	7.10	7.06	7.01	6.96	6.91	6.86	6.81	6.75	6.70	6.64	6.57	6.51	6.44	6.37	6.30	6.23

Table D–2. LLN for FVC (L)–Caucasian males–NHANES III

Height (Inches)	Age																											
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
58.0	2.76	3.12	3.10	3.07	3.05	3.02	2.99	2.96	2.92	2.89	2.85	2.81	2.77	2.72	2.67	2.62	2.57	2.52	2.46	2.41	2.35	2.28	2.22	2.15	2.08	2.01	1.94
59.0	2.87	3.24	3.22	3.19	3.17	3.14	3.11	3.08	3.04	3.01	2.97	2.93	2.88	2.84	2.79	2.74	2.69	2.64	2.58	2.52	2.46	2.40	2.34	2.27	2.20	2.13	2.06
60.0	3.00	3.36	3.34	3.31	3.29	3.26	3.23	3.20	3.16	3.13	3.09	3.05	3.00	2.96	2.91	2.86	2.81	2.76	2.70	2.64	2.58	2.52	2.46	2.39	2.32	2.25	2.18
61.0	3.12	3.48	3.46	3.43	3.41	3.38	3.35	3.32	3.29	3.25	3.21	3.17	3.13	3.08	3.03	2.99	2.93	2.88	2.82	2.77	2.71	2.64	2.58	2.51	2.44	2.37	2.30
62.0	3.24	3.60	3.58	3.56	3.53	3.51	3.48	3.44	3.41	3.37	3.33	3.29	3.25	3.21	3.16	3.11	3.06	3.00	2.95	2.89	2.83	2.77	2.70	2.64	2.57	2.50	2.43
63.0	3.37	3.73	3.71	3.69	3.66	3.63	3.60	3.57	3.54	3.50	3.46	3.42	3.38	3.33	3.29	3.24	3.19	3.13	3.08	3.02	2.96	2.90	2.83	2.76	2.70	2.63	2.55
64.0	3.50	3.86	3.84	3.81	3.79	3.76	3.73	3.70	3.67	3.63	3.59	3.55	3.51	3.46	3.41	3.37	3.31	3.26	3.20	3.15	3.09	3.02	2.96	2.89	2.82	2.75	2.68
65.0	3.63	3.99	3.97	3.95	3.92	3.89	3.86	3.83	3.80	3.76	3.72	3.68	3.64	3.59	3.55	3.50	3.44	3.39	3.34	3.28	3.22	3.15	3.09	3.02	2.96	2.88	2.81
66.0	3.76	4.12	4.10	4.08	4.05	4.02	3.99	3.96	3.93	3.89	3.85	3.81	3.77	3.72	3.68	3.63	3.58	3.52	3.47	3.41	3.35	3.29	3.22	3.16	3.09	3.02	2.94
67.0	3.90	4.26	4.24	4.21	4.19	4.16	4.13	4.10	4.06	4.03	3.99	3.95	3.90	3.86	3.81	3.76	3.71	3.66	3.60	3.54	3.48	3.42	3.36	3.29	3.22	3.15	3.08
68.0	4.03	4.39	4.37	4.35	4.32	4.30	4.27	4.23	4.20	4.16	4.12	4.08	4.04	4.00	3.95	3.90	3.85	3.79	3.74	3.68	3.62	3.56	3.49	3.43	3.36	3.29	3.22
69.0	4.17	4.53	4.51	4.49	4.46	4.43	4.40	4.37	4.34	4.30	4.26	4.22	4.18	4.13	4.09	4.04	3.99	3.93	3.88	3.82	3.76	3.70	3.63	3.57	3.50	3.43	3.35
70.0	4.31	4.67	4.65	4.63	4.60	4.58	4.55	4.51	4.48	4.44	4.40	4.36	4.32	4.28	4.23	4.18	4.13	4.07	4.02	3.96	3.90	3.84	3.77	3.71	3.64	3.57	3.50
71.0	4.45	4.82	4.79	4.77	4.75	4.72	4.69	4.66	4.62	4.59	4.55	4.51	4.46	4.42	4.37	4.32	4.27	4.22	4.16	4.10	4.04	3.98	3.92	3.85	3.78	3.71	3.64
72.0	4.60	4.96	4.94	4.92	4.89	4.86	4.83	4.80	4.77	4.73	4.69	4.65	4.61	4.56	4.52	4.47	4.42	4.36	4.31	4.25	4.19	4.13	4.06	4.00	3.93	3.86	3.78
73.0	4.75	5.11	5.09	5.06	5.04	5.01	4.98	4.95	4.91	4.88	4.84	4.80	4.76	4.71	4.66	4.61	4.56	4.51	4.45	4.39	4.33	4.27	4.21	4.14	4.07	4.00	3.93
74.0	4.89	5.26	5.24	5.21	5.19	5.16	5.13	5.10	5.06	5.03	4.99	4.95	4.90	4.86	4.81	4.76	4.71	4.66	4.60	4.54	4.48	4.42	4.36	4.29	4.22	4.15	4.08
75.0	5.05	5.41	5.39	5.36	5.34	5.31	5.28	5.25	5.21	5.18	5.14	5.10	5.05	5.01	4.96	4.91	4.86	4.81	4.75	4.69	4.63	4.57	4.51	4.44	4.37	4.30	4.23
76.0	5.20	5.56	5.54	5.52	5.49	5.46	5.43	5.40	5.37	5.33	5.29	5.25	5.21	5.16	5.12	5.07	5.01	4.96	4.91	4.85	4.79	4.73	4.66	4.59	4.53	4.46	4.38
77.0	5.35	5.72	5.69	5.67	5.65	5.62	5.59	5.56	5.52	5.48	5.45	5.41	5.36	5.32	5.27	5.22	5.17	5.12	5.06	5.00	4.94	4.88	4.82	4.75	4.68	4.61	4.54
78.0	5.51	5.87	5.85	5.83	5.80	5.77	5.74	5.71	5.68	5.64	5.60	5.56	5.52	5.47	5.43	5.38	5.33	5.27	5.22	5.16	5.10	5.04	4.97	4.91	4.84	4.77	4.69
79.0	5.67	6.03	6.01	5.99	5.96	5.93	5.90	5.87	5.84	5.80	5.76	5.72	5.68	5.63	5.59	5.54	5.49	5.43	5.38	5.32	5.26	5.20	5.13	5.07	5.00	4.93	4.85
80.0	5.83	6.19	6.17	6.15	6.12	6.09	6.06	6.03	6.00	5.96	5.92	5.88	5.84	5.79	5.75	5.70	5.65	5.59	5.54	5.48	5.42	5.36	5.29	5.23	5.16	5.09	5.01

Table D–3. Predicted FEV_1 (L)–Caucasian males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
58.0	3.03	3.28	3.24	3.20	3.16	3.11	3.07	3.02	2.97	2.92	2.87	2.82	2.76	2.71	2.65	2.59	2.53	2.47	2.41	2.34	2.28	2.21	2.14	2.07	2.00	1.93	1.86
59.0	3.13	3.39	3.35	3.31	3.26	3.22	3.17	3.13	3.08	3.03	2.98	2.92	2.87	2.81	2.76	2.70	2.64	2.58	2.51	2.45	2.39	2.32	2.25	2.18	2.11	2.04	1.96
60.0	3.24	3.50	3.46	3.42	3.37	3.33	3.28	3.23	3.19	3.14	3.08	3.03	2.98	2.92	2.86	2.81	2.75	2.69	2.62	2.56	2.49	2.43	2.36	2.29	2.22	2.15	2.07
61.0	3.35	3.61	3.57	3.53	3.48	3.44	3.39	3.34	3.30	3.25	3.19	3.14	3.09	3.03	2.97	2.92	2.86	2.80	2.73	2.67	2.60	2.54	2.47	2.40	2.33	2.26	2.18
62.0	3.46	3.72	3.68	3.64	3.59	3.55	3.50	3.46	3.41	3.36	3.31	3.25	3.20	3.14	3.09	3.03	2.97	2.91	2.84	2.78	2.72	2.65	2.58	2.51	2.44	2.37	2.29
63.0	3.58	3.83	3.79	3.75	3.71	3.66	3.62	3.57	3.52	3.47	3.42	3.37	3.31	3.26	3.20	3.14	3.08	3.02	2.96	2.89	2.83	2.76	2.69	2.63	2.55	2.48	2.41
64.0	3.69	3.95	3.91	3.87	3.82	3.78	3.73	3.69	3.64	3.59	3.54	3.48	3.43	3.37	3.32	3.26	3.20	3.14	3.07	3.01	2.94	2.88	2.81	2.74	2.67	2.60	2.52
65.0	3.81	4.07	4.03	3.98	3.94	3.90	3.85	3.80	3.75	3.70	3.65	3.60	3.55	3.49	3.43	3.37	3.31	3.25	3.19	3.13	3.06	3.00	2.93	2.86	2.79	2.72	2.64
66.0	3.93	4.19	4.15	4.10	4.06	4.02	3.97	3.92	3.87	3.82	3.77	3.72	3.66	3.61	3.55	3.49	3.43	3.37	3.31	3.25	3.18	3.11	3.05	2.98	2.91	2.83	2.76
67.0	4.05	4.31	4.27	4.22	4.18	4.14	4.09	4.04	3.99	3.94	3.89	3.84	3.79	3.73	3.67	3.61	3.56	3.49	3.43	3.37	3.30	3.24	3.17	3.10	3.03	2.96	2.88
68.0	4.17	4.43	4.39	4.35	4.30	4.26	4.21	4.17	4.12	4.07	4.02	3.96	3.91	3.85	3.80	3.74	3.68	3.62	3.55	3.49	3.42	3.36	3.29	3.22	3.15	3.08	3.00
69.0	4.30	4.55	4.51	4.47	4.43	4.38	4.34	4.29	4.24	4.19	4.14	4.09	4.03	3.98	3.92	3.86	3.80	3.74	3.68	3.61	3.55	3.48	3.41	3.35	3.27	3.20	3.13
70.0	4.42	4.68	4.64	4.60	4.56	4.51	4.46	4.42	4.37	4.32	4.27	4.21	4.16	4.10	4.05	3.99	3.93	3.87	3.81	3.74	3.68	3.61	3.54	3.47	3.40	3.33	3.26
71.0	4.55	4.81	4.77	4.73	4.68	4.64	4.59	4.55	4.50	4.45	4.40	4.34	4.29	4.23	4.18	4.12	4.06	4.00	3.93	3.87	3.80	3.74	3.67	3.60	3.53	3.46	3.38
72.0	4.68	4.94	4.90	4.86	4.81	4.77	4.72	4.68	4.63	4.58	4.53	4.47	4.42	4.36	4.31	4.25	4.19	4.13	4.06	4.00	3.93	3.87	3.80	3.73	3.66	3.59	3.51
73.0	4.81	5.07	5.03	4.99	4.95	4.90	4.85	4.81	4.76	4.71	4.66	4.60	4.55	4.49	4.44	4.38	4.32	4.26	4.20	4.13	4.07	4.00	3.93	3.86	3.79	3.72	3.65
74.0	4.95	5.20	5.16	5.12	5.08	5.03	4.99	4.94	4.89	4.84	4.79	4.74	4.68	4.63	4.57	4.51	4.45	4.39	4.33	4.27	4.20	4.13	4.07	4.00	3.93	3.85	3.78
75.0	5.08	5.34	5.30	5.26	5.21	5.17	5.12	5.08	5.03	4.98	4.93	4.87	4.82	4.76	4.71	4.65	4.59	4.53	4.46	4.40	4.34	4.27	4.20	4.13	4.06	3.99	3.91
76.0	5.22	5.48	5.44	5.40	5.35	5.31	5.26	5.21	5.17	5.12	5.06	5.01	4.96	4.90	4.84	4.79	4.73	4.66	4.60	4.54	4.47	4.41	4.34	4.27	4.20	4.13	4.05
77.0	5.36	5.62	5.58	5.53	5.49	5.45	5.40	5.35	5.30	5.25	5.20	5.15	5.10	5.04	4.98	4.92	4.86	4.80	4.74	4.68	4.61	4.55	4.48	4.41	4.34	4.26	4.19
78.0	5.50	5.76	5.72	5.68	5.63	5.59	5.54	5.49	5.45	5.40	5.34	5.29	5.24	5.18	5.12	5.07	5.01	4.94	4.88	4.82	4.75	4.69	4.62	4.55	4.48	4.41	4.33
79.0	5.64	5.90	5.86	5.82	5.78	5.73	5.68	5.64	5.59	5.54	5.49	5.43	5.38	5.32	5.27	5.21	5.15	5.09	5.02	4.96	4.90	4.83	4.76	4.69	4.62	4.55	4.48
80.0	5.79	6.05	6.00	5.96	5.92	5.88	5.83	5.78	5.73	5.68	5.63	5.58	5.52	5.47	5.41	5.35	5.29	5.23	5.17	5.11	5.04	4.97	4.91	4.84	4.77	4.69	4.62

Table D–4. LLN for FEV_1 (L)–Caucasian males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
58.0	2.49	2.74	2.70	2.66	2.62	2.57	2.53	2.48	2.43	2.38	2.33	2.28	2.22	2.17	2.11	2.05	1.99	1.93	1.87	1.80	1.74	1.67	1.60	1.53	1.46	1.39	1.32
59.0	2.57	2.83	2.79	2.75	2.71	2.66	2.61	2.57	2.52	2.47	2.42	2.36	2.31	2.25	2.20	2.14	2.08	2.02	1.96	1.89	1.83	1.76	1.69	1.62	1.55	1.48	1.41
60.0	2.66	2.92	2.88	2.84	2.79	2.75	2.70	2.66	2.61	2.56	2.51	2.45	2.40	2.34	2.29	2.23	2.17	2.11	2.04	1.98	1.92	1.85	1.78	1.71	1.64	1.57	1.49
61.0	2.75	3.01	2.97	2.93	2.88	2.84	2.79	2.75	2.70	2.65	2.60	2.54	2.49	2.43	2.38	2.32	2.26	2.20	2.13	2.07	2.01	1.94	1.87	1.80	1.73	1.66	1.59
62.0	2.84	3.10	3.06	3.02	2.98	2.93	2.89	2.84	2.79	2.74	2.69	2.64	2.58	2.53	2.47	2.41	2.35	2.29	2.23	2.16	2.10	2.03	1.96	1.89	1.82	1.75	1.68
63.0	2.94	3.20	3.16	3.11	3.07	3.03	2.98	2.93	2.88	2.83	2.78	2.73	2.68	2.62	2.56	2.50	2.44	2.38	2.32	2.26	2.19	2.12	2.06	1.99	1.92	1.84	1.77
64.0	3.03	3.29	3.25	3.21	3.17	3.12	3.08	3.03	2.98	2.93	2.88	2.82	2.77	2.71	2.66	2.60	2.54	2.48	2.42	2.35	2.29	2.22	2.15	2.08	2.01	1.94	1.87
65.0	3.13	3.39	3.35	3.31	3.26	3.22	3.17	3.12	3.08	3.03	2.97	2.92	2.87	2.81	2.75	2.70	2.64	2.57	2.51	2.45	2.38	2.32	2.25	2.18	2.11	2.04	1.96
66.0	3.23	3.49	3.45	3.40	3.36	3.32	3.27	3.22	3.17	3.12	3.07	3.02	2.96	2.91	2.85	2.79	2.73	2.67	2.61	2.55	2.48	2.41	2.35	2.28	2.21	2.13	2.06
67.0	3.33	3.59	3.55	3.50	3.46	3.42	3.37	3.32	3.27	3.22	3.17	3.12	3.06	3.01	2.95	2.89	2.83	2.77	2.71	2.65	2.58	2.51	2.45	2.38	2.31	2.23	2.16
68.0	3.43	3.69	3.65	3.60	3.56	3.52	3.47	3.42	3.37	3.32	3.27	3.22	3.17	3.11	3.05	2.99	2.93	2.87	2.81	2.75	2.68	2.62	2.55	2.48	2.41	2.33	2.26
69.0	3.53	3.79	3.75	3.71	3.66	3.62	3.57	3.53	3.48	3.43	3.38	3.32	3.27	3.21	3.16	3.10	3.04	2.98	2.91	2.85	2.78	2.72	2.65	2.58	2.51	2.44	2.36
70.0	3.64	3.89	3.85	3.81	3.77	3.72	3.68	3.63	3.58	3.53	3.48	3.43	3.37	3.32	3.26	3.20	3.14	3.08	3.02	2.95	2.89	2.82	2.75	2.68	2.61	2.54	2.47
71.0	3.74	4.00	3.96	3.92	3.87	3.83	3.78	3.74	3.69	3.64	3.58	3.53	3.48	3.42	3.37	3.31	3.25	3.19	3.12	3.06	2.99	2.93	2.86	2.79	2.72	2.65	2.57
72.0	3.85	4.11	4.07	4.02	3.98	3.94	3.89	3.84	3.79	3.74	3.69	3.64	3.58	3.53	3.47	3.41	3.35	3.29	3.23	3.17	3.10	3.03	2.97	2.90	2.83	2.75	2.68
73.0	3.96	4.21	4.17	4.13	4.09	4.04	4.00	3.95	3.90	3.85	3.80	3.75	3.69	3.64	3.58	3.52	3.46	3.40	3.34	3.28	3.21	3.14	3.08	3.01	2.93	2.86	2.79
74.0	4.07	4.32	4.28	4.24	4.20	4.15	4.11	4.06	4.01	3.96	3.91	3.86	3.80	3.75	3.69	3.63	3.57	3.51	3.45	3.39	3.32	3.25	3.19	3.12	3.05	2.97	2.90
75.0	4.18	4.44	4.40	4.35	4.31	4.27	4.22	4.17	4.12	4.07	4.02	3.97	3.92	3.86	3.80	3.74	3.68	3.62	3.56	3.50	3.43	3.36	3.30	3.23	3.16	3.08	3.01
76.0	4.29	4.55	4.51	4.47	4.42	4.38	4.33	4.29	4.24	4.19	4.14	4.08	4.03	3.97	3.92	3.86	3.80	3.74	3.67	3.61	3.54	3.48	3.41	3.34	3.27	3.20	3.12
77.0	4.41	4.66	4.62	4.58	4.54	4.49	4.45	4.40	4.35	4.30	4.25	4.20	4.14	4.09	4.03	3.97	3.91	3.85	3.79	3.72	3.66	3.59	3.52	3.46	3.38	3.31	3.24
78.0	4.52	4.78	4.74	4.70	4.65	4.61	4.56	4.52	4.47	4.42	4.37	4.31	4.26	4.20	4.15	4.09	4.03	3.97	3.90	3.84	3.78	3.71	3.64	3.57	3.50	3.43	3.35
79.0	4.64	4.90	4.86	4.82	4.77	4.73	4.68	4.63	4.59	4.54	4.48	4.43	4.38	4.32	4.26	4.21	4.15	4.08	4.02	3.96	3.89	3.83	3.76	3.69	3.62	3.55	3.47
80.0	4.76	5.02	4.98	4.93	4.89	4.85	4.80	4.75	4.70	4.65	4.60	4.55	4.50	4.44	4.38	4.32	4.26	4.20	4.14	4.08	4.01	3.95	3.88	3.81	3.74	3.66	3.59

Table D–5. Predicted FVC (L)–African-American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
60.0	3.07	3.35	3.31	3.28	3.24	3.20	3.17	3.13	3.09	3.06	3.02	2.99	2.95	2.91	2.88	2.84	2.80	2.77	2.73	2.69	2.66	2.62	2.58	2.55	2.51	2.48	2.44
61.0	3.20	3.48	3.44	3.41	3.37	3.33	3.30	3.26	3.22	3.19	3.15	3.12	3.08	3.04	3.01	2.97	2.93	2.90	2.86	2.82	2.79	2.75	2.71	2.68	2.64	2.61	2.57
62.0	3.34	3.61	3.58	3.54	3.50	3.47	3.43	3.39	3.36	3.32	3.28	3.25	3.21	3.17	3.14	3.10	3.07	3.03	2.99	2.96	2.92	2.88	2.85	2.81	2.77	2.74	2.70
63.0	3.47	3.75	3.71	3.67	3.64	3.60	3.56	3.53	3.49	3.45	3.42	3.38	3.35	3.31	3.27	3.24	3.20	3.16	3.13	3.09	3.05	3.02	2.98	2.94	2.91	2.87	2.84
64.0	3.61	3.88	3.85	3.81	3.77	3.74	3.70	3.66	3.63	3.59	3.55	3.52	3.48	3.45	3.41	3.37	3.34	3.30	3.26	3.23	3.19	3.15	3.12	3.08	3.04	3.01	2.97
65.0	3.75	4.02	3.98	3.95	3.91	3.87	3.84	3.80	3.77	3.73	3.69	3.66	3.62	3.58	3.55	3.51	3.47	3.44	3.40	3.37	3.33	3.29	3.26	3.22	3.18	3.15	3.11
66.0	3.89	4.16	4.12	4.09	4.05	4.02	3.98	3.94	3.91	3.87	3.83	3.80	3.76	3.72	3.69	3.65	3.62	3.58	3.54	3.51	3.47	3.43	3.40	3.36	3.32	3.29	3.25
67.0	4.03	4.30	4.27	4.23	4.19	4.16	4.12	4.09	4.05	4.01	3.98	3.94	3.90	3.87	3.83	3.79	3.76	3.72	3.68	3.65	3.61	3.58	3.54	3.50	3.47	3.43	3.39
68.0	4.17	4.45	4.41	4.38	4.34	4.30	4.27	4.23	4.19	4.16	4.12	4.08	4.05	4.01	3.98	3.94	3.90	3.87	3.83	3.79	3.76	3.72	3.68	3.65	3.61	3.57	3.54
69.0	4.32	4.60	4.56	4.52	4.49	4.45	4.41	4.38	4.34	4.30	4.27	4.23	4.20	4.16	4.12	4.09	4.05	4.01	3.98	3.94	3.90	3.87	3.83	3.79	3.76	3.72	3.69
70.0	4.47	4.75	4.71	4.67	4.64	4.60	4.56	4.53	4.49	4.45	4.42	4.38	4.34	4.31	4.27	4.24	4.20	4.16	4.13	4.09	4.05	4.02	3.98	3.94	3.91	3.87	3.83
71.0	4.62	4.90	4.86	4.82	4.79	4.75	4.71	4.68	4.64	4.61	4.57	4.53	4.50	4.46	4.42	4.39	4.35	4.31	4.28	4.24	4.20	4.17	4.13	4.10	4.06	4.02	3.99
72.0	4.77	5.05	5.01	4.98	4.94	4.90	4.87	4.83	4.80	4.76	4.72	4.69	4.65	4.61	4.58	4.54	4.50	4.47	4.43	4.39	4.36	4.32	4.29	4.25	4.21	4.18	4.14
73.0	4.93	5.21	5.17	5.13	5.10	5.06	5.02	4.99	4.95	4.91	4.88	4.84	4.81	4.77	4.73	4.70	4.66	4.62	4.59	4.55	4.51	4.48	4.44	4.40	4.37	4.33	4.30
74.0	5.09	5.36	5.33	5.29	5.25	5.22	5.18	5.15	5.11	5.07	5.04	5.00	4.96	4.93	4.89	4.85	4.82	4.78	4.74	4.71	4.67	4.64	4.60	4.56	4.53	4.49	4.45
75.0	5.25	5.52	5.49	5.45	5.41	5.38	5.34	5.31	5.27	5.23	5.20	5.16	5.12	5.09	5.05	5.01	4.98	4.94	4.90	4.87	4.83	4.80	4.76	4.72	4.69	4.65	4.61
76.0	5.41	5.69	5.65	5.61	5.58	5.54	5.50	5.47	5.43	5.39	5.36	5.32	5.29	5.25	5.21	5.18	5.14	5.10	5.07	5.03	4.99	4.96	4.92	4.88	4.85	4.81	4.78
77.0	5.57	5.85	5.81	5.78	5.74	5.70	5.67	5.63	5.60	5.56	5.52	5.49	5.45	5.41	5.38	5.34	5.30	5.27	5.23	5.19	5.16	5.12	5.09	5.05	5.01	4.98	4.94
78.0	5.74	6.02	5.98	5.94	5.91	5.87	5.83	5.80	5.76	5.73	5.69	5.65	5.62	5.58	5.54	5.51	5.47	5.43	5.40	5.36	5.32	5.29	5.25	5.22	5.18	5.14	5.11
79.0	5.91	6.19	6.15	6.11	6.08	6.04	6.00	5.97	5.93	5.89	5.86	5.82	5.78	5.75	5.71	5.68	5.64	5.60	5.57	5.53	5.49	5.46	5.42	5.38	5.35	5.31	5.27

Table D–6. LLN for FVC (L)–African-American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
60.0	2.38	2.66	2.62	2.59	2.55	2.51	2.48	2.44	2.40	2.37	2.33	2.29	2.26	2.22	2.19	2.15	2.11	2.08	2.04	2.00	1.97	1.93	1.89	1.86	1.82	1.78	1.75
61.0	2.49	2.77	2.73	2.69	2.66	2.62	2.58	2.55	2.51	2.47	2.44	2.40	2.37	2.33	2.29	2.26	2.22	2.18	2.15	2.11	2.07	2.04	2.00	1.96	1.93	1.89	1.86
62.0	2.60	2.87	2.84	2.80	2.76	2.73	2.69	2.66	2.62	2.58	2.55	2.51	2.47	2.44	2.40	2.36	2.33	2.29	2.26	2.22	2.18	2.15	2.11	2.07	2.04	2.00	1.96
63.0	2.71	2.98	2.95	2.91	2.88	2.84	2.80	2.77	2.73	2.69	2.66	2.62	2.58	2.55	2.51	2.47	2.44	2.40	2.37	2.33	2.29	2.26	2.22	2.18	2.15	2.11	2.07
64.0	2.82	3.10	3.06	3.02	2.99	2.95	2.91	2.88	2.84	2.81	2.77	2.73	2.70	2.66	2.62	2.59	2.55	2.51	2.48	2.44	2.40	2.37	2.33	2.30	2.26	2.22	2.19
65.0	2.93	3.21	3.17	3.14	3.10	3.06	3.03	2.99	2.96	2.92	2.88	2.85	2.81	2.77	2.74	2.70	2.66	2.63	2.59	2.55	2.52	2.48	2.45	2.41	2.37	2.34	2.30
66.0	3.05	3.33	3.29	3.25	3.22	3.18	3.14	3.11	3.07	3.03	3.00	2.96	2.93	2.89	2.85	2.82	2.78	2.74	2.71	2.67	2.63	2.60	2.56	2.52	2.49	2.45	2.42
67.0	3.17	3.44	3.41	3.37	3.33	3.30	3.26	3.22	3.19	3.15	3.12	3.08	3.04	3.01	2.97	2.93	2.90	2.86	2.82	2.79	2.75	2.71	2.68	2.64	2.61	2.57	2.53
68.0	3.29	3.56	3.53	3.49	3.45	3.42	3.38	3.34	3.31	3.27	3.23	3.20	3.16	3.13	3.09	3.05	3.02	2.98	2.94	2.91	2.87	2.83	2.80	2.76	2.72	2.69	2.65
69.0	3.41	3.68	3.65	3.61	3.57	3.54	3.50	3.46	3.43	3.39	3.36	3.32	3.28	3.25	3.21	3.17	3.14	3.10	3.06	3.03	2.99	2.95	2.92	2.88	2.85	2.81	2.77
70.0	3.53	3.81	3.77	3.73	3.70	3.66	3.62	3.59	3.55	3.51	3.48	3.44	3.40	3.37	3.33	3.30	3.26	3.22	3.19	3.15	3.11	3.08	3.04	3.00	2.97	2.93	2.90
71.0	3.65	3.93	3.89	3.86	3.82	3.78	3.75	3.71	3.67	3.64	3.60	3.57	3.53	3.49	3.46	3.42	3.38	3.35	3.31	3.27	3.24	3.20	3.17	3.13	3.09	3.06	3.02
72.0	3.78	4.06	4.02	3.98	3.95	3.91	3.87	3.84	3.80	3.76	3.73	3.69	3.66	3.62	3.58	3.55	3.51	3.47	3.44	3.40	3.36	3.33	3.29	3.25	3.22	3.18	3.15
73.0	3.91	4.18	4.15	4.11	4.07	4.04	4.00	3.97	3.93	3.89	3.86	3.82	3.78	3.75	3.71	3.67	3.64	3.60	3.56	3.53	3.49	3.46	3.42	3.38	3.35	3.31	3.27
74.0	4.04	4.31	4.28	4.24	4.20	4.17	4.13	4.10	4.06	4.02	3.99	3.95	3.91	3.88	3.84	3.80	3.77	3.73	3.69	3.66	3.62	3.59	3.55	3.51	3.48	3.44	3.40
75.0	4.17	4.44	4.41	4.37	4.34	4.30	4.26	4.23	4.19	4.15	4.12	4.08	4.04	4.01	3.97	3.94	3.90	3.86	3.83	3.79	3.75	3.72	3.68	3.64	3.61	3.57	3.53
76.0	4.30	4.58	4.54	4.51	4.47	4.43	4.40	4.36	4.32	4.29	4.25	4.21	4.18	4.14	4.10	4.07	4.03	4.00	3.96	3.92	3.89	3.85	3.81	3.78	3.74	3.70	3.67
77.0	4.44	4.71	4.68	4.64	4.60	4.57	4.53	4.49	4.46	4.42	4.39	4.35	4.31	4.28	4.24	4.20	4.17	4.13	4.09	4.06	4.02	3.98	3.95	3.91	3.88	3.84	3.80
78.0	4.57	4.85	4.81	4.78	4.74	4.70	4.67	4.63	4.59	4.56	4.52	4.49	4.45	4.41	4.38	4.34	4.30	4.27	4.23	4.19	4.16	4.12	4.08	4.05	4.01	3.98	3.94
79.0	4.71	4.99	4.95	4.92	4.88	4.84	4.81	4.77	4.73	4.70	4.66	4.62	4.59	4.55	4.51	4.48	4.44	4.41	4.37	4.33	4.30	4.26	4.22	4.19	4.15	4.11	4.08

Table D–7. Predicted FEV_1 (L)–African-American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
60.0	2.73	2.94	2.90	2.85	2.81	2.76	2.71	2.67	2.62	2.57	2.53	2.48	2.44	2.39	2.34	2.30	2.25	2.20	2.16	2.11	2.07	2.02	1.97	1.93	1.88	1.84	1.79
61.0	2.83	3.05	3.00	2.95	2.91	2.86	2.82	2.77	2.72	2.68	2.63	2.58	2.54	2.49	2.45	2.40	2.35	2.31	2.26	2.22	2.17	2.12	2.08	2.03	1.98	1.94	1.89
62.0	2.94	3.15	3.11	3.06	3.01	2.97	2.92	2.87	2.83	2.78	2.74	2.69	2.64	2.60	2.55	2.50	2.46	2.41	2.37	2.32	2.27	2.23	2.18	2.14	2.09	2.04	2.00
63.0	3.04	3.26	3.21	3.17	3.12	3.07	3.03	2.98	2.93	2.89	2.84	2.80	2.75	2.70	2.66	2.61	2.57	2.52	2.47	2.43	2.38	2.33	2.29	2.24	2.20	2.15	2.10
64.0	3.15	3.37	3.32	3.27	3.23	3.18	3.14	3.09	3.04	3.00	2.95	2.90	2.86	2.81	2.77	2.72	2.67	2.63	2.58	2.53	2.49	2.44	2.40	2.35	2.30	2.26	2.21
65.0	3.26	3.48	3.43	3.38	3.34	3.29	3.24	3.20	3.15	3.11	3.06	3.01	2.97	2.92	2.88	2.83	2.78	2.74	2.69	2.64	2.60	2.55	2.51	2.46	2.41	2.37	2.32
66.0	3.37	3.59	3.54	3.49	3.45	3.40	3.36	3.31	3.26	3.22	3.17	3.13	3.08	3.03	2.99	2.94	2.89	2.85	2.80	2.76	2.71	2.66	2.62	2.57	2.53	2.48	2.43
67.0	3.49	3.70	3.65	3.61	3.56	3.52	3.47	3.42	3.38	3.33	3.28	3.24	3.19	3.15	3.10	3.05	3.01	2.96	2.92	2.87	2.82	2.78	2.73	2.68	2.64	2.59	2.55
68.0	3.60	3.82	3.77	3.72	3.68	3.63	3.58	3.54	3.49	3.45	3.40	3.35	3.31	3.26	3.22	3.17	3.12	3.08	3.03	2.98	2.94	2.89	2.85	2.80	2.75	2.71	2.66
69.0	3.72	3.93	3.89	3.84	3.79	3.75	3.70	3.65	3.61	3.56	3.52	3.47	3.42	3.38	3.33	3.29	3.24	3.19	3.15	3.10	3.05	3.01	2.96	2.92	2.87	2.82	2.78
70.0	3.84	4.05	4.00	3.96	3.91	3.87	3.82	3.77	3.73	3.68	3.63	3.59	3.54	3.50	3.45	3.40	3.36	3.31	3.27	3.22	3.17	3.13	3.08	3.03	2.99	2.94	2.90
71.0	3.96	4.17	4.12	4.08	4.03	3.99	3.94	3.89	3.85	3.80	3.75	3.71	3.66	3.62	3.57	3.52	3.48	3.43	3.39	3.34	3.29	3.25	3.20	3.15	3.11	3.06	3.02
72.0	4.08	4.29	4.25	4.20	4.15	4.11	4.06	4.01	3.97	3.92	3.88	3.83	3.78	3.74	3.69	3.65	3.60	3.55	3.51	3.46	3.41	3.37	3.32	3.28	3.23	3.18	3.14
73.0	4.20	4.42	4.37	4.32	4.28	4.23	4.18	4.14	4.09	4.05	4.00	3.95	3.91	3.86	3.82	3.77	3.72	3.68	3.63	3.58	3.54	3.49	3.45	3.40	3.35	3.31	3.26
74.0	4.33	4.54	4.49	4.45	4.40	4.36	4.31	4.26	4.22	4.17	4.12	4.08	4.03	3.99	3.94	3.89	3.85	3.80	3.76	3.71	3.66	3.62	3.57	3.52	3.48	3.43	3.39
75.0	4.45	4.67	4.62	4.58	4.53	4.48	4.44	4.39	4.34	4.30	4.25	4.21	4.16	4.11	4.07	4.02	3.97	3.93	3.88	3.84	3.79	3.74	3.70	3.65	3.61	3.56	3.51
76.0	4.58	4.80	4.75	4.70	4.66	4.61	4.57	4.52	4.47	4.43	4.38	4.33	4.29	4.24	4.20	4.15	4.10	4.06	4.01	3.96	3.92	3.87	3.83	3.78	3.73	3.69	3.64
77.0	4.71	4.93	4.88	4.83	4.79	4.74	4.70	4.65	4.60	4.56	4.51	4.46	4.42	4.37	4.33	4.28	4.23	4.19	4.14	4.09	4.05	4.00	3.96	3.91	3.86	3.82	3.77
78.0	4.84	5.06	5.01	4.97	4.92	4.87	4.83	4.78	4.73	4.69	4.64	4.60	4.55	4.50	4.46	4.41	4.37	4.32	4.27	4.23	4.18	4.13	4.09	4.04	4.00	3.95	3.90
79.0	4.98	5.19	5.15	5.10	5.05	5.01	4.96	4.91	4.87	4.82	4.78	4.73	4.68	4.64	4.59	4.55	4.50	4.45	4.41	4.36	4.31	4.27	4.22	4.18	4.13	4.08	4.04

Table D–8. LLN for FEV_1 (L)–African-American males–NHANES III

Height (Inches)	Age																											
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
60.0	2.12	2.33	2.29	2.24	2.19	2.15	2.10	2.06	2.01	1.96	1.92	1.87	1.82	1.78	1.73	1.69	1.64	1.59	1.55	1.50	1.45	1.41	1.36	1.32	1.27	1.22	1.18
61.0	2.20	2.41	2.37	2.32	2.28	2.23	2.18	2.14	2.09	2.05	2.00	1.95	1.91	1.86	1.81	1.77	1.72	1.68	1.63	1.58	1.54	1.49	1.44	1.40	1.35	1.31	1.26
62.0	2.28	2.50	2.45	2.41	2.36	2.31	2.27	2.22	2.18	2.13	2.08	2.04	1.99	1.94	1.90	1.85	1.81	1.76	1.71	1.67	1.62	1.57	1.53	1.48	1.44	1.39	1.34
63.0	2.37	2.58	2.54	2.49	2.45	2.40	2.35	2.31	2.26	2.21	2.17	2.12	2.08	2.03	1.98	1.94	1.89	1.84	1.80	1.75	1.71	1.66	1.61	1.57	1.52	1.48	1.43
64.0	2.46	2.67	2.62	2.58	2.53	2.49	2.44	2.39	2.35	2.30	2.25	2.21	2.16	2.12	2.07	2.02	1.98	1.93	1.89	1.84	1.79	1.75	1.70	1.65	1.61	1.56	1.52
65.0	2.54	2.76	2.71	2.67	2.62	2.57	2.53	2.48	2.43	2.39	2.34	2.30	2.25	2.20	2.16	2.11	2.07	2.02	1.97	1.93	1.88	1.83	1.79	1.74	1.70	1.65	1.60
66.0	2.63	2.85	2.80	2.75	2.71	2.66	2.62	2.57	2.52	2.48	2.43	2.39	2.34	2.29	2.25	2.20	2.15	2.11	2.06	2.02	1.97	1.92	1.88	1.83	1.79	1.74	1.69
67.0	2.72	2.94	2.89	2.85	2.80	2.75	2.71	2.66	2.61	2.57	2.52	2.48	2.43	2.38	2.34	2.29	2.25	2.20	2.15	2.11	2.06	2.01	1.97	1.92	1.88	1.83	1.78
68.0	2.82	3.03	2.98	2.94	2.89	2.85	2.80	2.75	2.71	2.66	2.61	2.57	2.52	2.48	2.43	2.38	2.34	2.29	2.24	2.20	2.15	2.11	2.06	2.01	1.97	1.92	1.88
69.0	2.91	3.12	3.08	3.03	2.98	2.94	2.89	2.85	2.80	2.75	2.71	2.66	2.62	2.57	2.52	2.48	2.43	2.38	2.34	2.29	2.25	2.20	2.15	2.11	2.06	2.01	1.97
70.0	3.00	3.22	3.17	3.13	3.08	3.03	2.99	2.94	2.89	2.85	2.80	2.76	2.71	2.66	2.62	2.57	2.53	2.48	2.43	2.39	2.34	2.29	2.25	2.20	2.16	2.11	2.06
71.0	3.10	3.31	3.27	3.22	3.18	3.13	3.08	3.04	2.99	2.94	2.90	2.85	2.81	2.76	2.71	2.67	2.62	2.58	2.53	2.48	2.44	2.39	2.34	2.30	2.25	2.21	2.16
72.0	3.20	3.41	3.37	3.32	3.27	3.23	3.18	3.13	3.09	3.04	3.00	2.95	2.90	2.86	2.81	2.76	2.72	2.67	2.63	2.58	2.53	2.49	2.44	2.40	2.35	2.30	2.26
73.0	3.30	3.51	3.46	3.42	3.37	3.33	3.28	3.23	3.19	3.14	3.09	3.05	3.00	2.96	2.91	2.86	2.82	2.77	2.73	2.68	2.63	2.59	2.54	2.49	2.45	2.40	2.36
74.0	3.40	3.61	3.56	3.52	3.47	3.43	3.38	3.33	3.29	3.24	3.19	3.15	3.10	3.06	3.01	2.96	2.92	2.87	2.83	2.78	2.73	2.69	2.64	2.59	2.55	2.50	2.46
75.0	3.50	3.71	3.67	3.62	3.57	3.53	3.48	3.43	3.39	3.34	3.30	3.25	3.20	3.16	3.11	3.07	3.02	2.97	2.93	2.88	2.83	2.79	2.74	2.70	2.65	2.60	2.56
76.0	3.60	3.81	3.77	3.72	3.68	3.63	3.58	3.54	3.49	3.45	3.40	3.35	3.31	3.26	3.21	3.17	3.12	3.08	3.03	2.98	2.94	2.89	2.85	2.80	2.75	2.71	2.66
77.0	3.71	3.92	3.87	3.83	3.78	3.73	3.69	3.64	3.60	3.55	3.50	3.46	3.41	3.36	3.32	3.27	3.23	3.18	3.13	3.09	3.04	3.00	2.95	2.90	2.86	2.81	2.76
78.0	3.81	4.02	3.98	3.93	3.89	3.84	3.79	3.75	3.70	3.66	3.61	3.56	3.52	3.47	3.42	3.38	3.33	3.29	3.24	3.19	3.15	3.10	3.05	3.01	2.96	2.92	2.87
79.0	3.92	4.13	4.09	4.04	3.99	3.95	3.90	3.85	3.81	3.76	3.72	3.67	3.62	3.58	3.53	3.49	3.44	3.39	3.35	3.30	3.25	3.21	3.16	3.12	3.07	3.02	2.98

Table D–9. Predicted FVC (L)–Mexican American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
56.0	3.28	3.59	3.56	3.52	3.49	3.45	3.41	3.37	3.33	3.29	3.24	3.20	3.15	3.10	3.05	3.00	2.94	2.89	2.83	2.77	2.71	2.65	2.59	2.53	2.46	2.40	2.33
57.0	3.41	3.72	3.69	3.65	3.62	3.58	3.54	3.50	3.46	3.42	3.37	3.33	3.28	3.23	3.18	3.13	3.07	3.02	2.96	2.90	2.84	2.78	2.72	2.66	2.59	2.53	2.46
58.0	3.54	3.85	3.82	3.79	3.75	3.71	3.67	3.63	3.59	3.55	3.50	3.46	3.41	3.36	3.31	3.26	3.21	3.15	3.09	3.04	2.98	2.92	2.85	2.79	2.72	2.66	2.59
59.0	3.68	3.99	3.96	3.92	3.89	3.85	3.81	3.77	3.73	3.68	3.64	3.59	3.55	3.50	3.45	3.39	3.34	3.28	3.23	3.17	3.11	3.05	2.99	2.92	2.86	2.79	2.72
60.0	3.81	4.13	4.09	4.06	4.02	3.98	3.95	3.91	3.86	3.82	3.78	3.73	3.68	3.63	3.58	3.53	3.48	3.42	3.37	3.31	3.25	3.19	3.13	3.06	3.00	2.93	2.86
61.0	3.95	4.27	4.23	4.20	4.16	4.12	4.09	4.04	4.00	3.96	3.91	3.87	3.82	3.77	3.72	3.67	3.62	3.56	3.50	3.45	3.39	3.33	3.26	3.20	3.14	3.07	3.00
62.0	4.09	4.41	4.37	4.34	4.30	4.27	4.23	4.19	4.14	4.10	4.06	4.01	3.96	3.91	3.86	3.81	3.76	3.70	3.65	3.59	3.53	3.47	3.41	3.34	3.28	3.21	3.14
63.0	4.24	4.55	4.52	4.48	4.45	4.41	4.37	4.33	4.29	4.24	4.20	4.15	4.11	4.06	4.01	3.95	3.90	3.85	3.79	3.73	3.67	3.61	3.55	3.49	3.42	3.35	3.29
64.0	4.38	4.70	4.66	4.63	4.59	4.56	4.52	4.48	4.43	4.39	4.35	4.30	4.25	4.20	4.15	4.10	4.05	3.99	3.94	3.88	3.82	3.76	3.70	3.63	3.57	3.50	3.43
65.0	4.53	4.84	4.81	4.78	4.74	4.70	4.66	4.62	4.58	4.54	4.49	4.45	4.40	4.35	4.30	4.25	4.20	4.14	4.08	4.03	3.97	3.91	3.84	3.78	3.71	3.65	3.58
66.0	4.68	5.00	4.96	4.93	4.89	4.85	4.82	4.77	4.73	4.69	4.65	4.60	4.55	4.50	4.45	4.40	4.35	4.29	4.23	4.18	4.12	4.06	3.99	3.93	3.87	3.80	3.73
67.0	4.84	5.15	5.12	5.08	5.04	5.01	4.97	4.93	4.89	4.84	4.80	4.75	4.70	4.65	4.60	4.55	4.50	4.44	4.39	4.33	4.27	4.21	4.15	4.08	4.02	3.95	3.88
68.0	4.99	5.30	5.27	5.24	5.20	5.16	5.12	5.08	5.04	5.00	4.95	4.91	4.86	4.81	4.76	4.71	4.65	4.60	4.54	4.48	4.43	4.36	4.30	4.24	4.17	4.11	4.04
69.0	5.15	5.46	5.43	5.39	5.36	5.32	5.28	5.24	5.20	5.16	5.11	5.06	5.02	4.97	4.92	4.87	4.81	4.76	4.70	4.64	4.58	4.52	4.46	4.40	4.33	4.26	4.20
70.0	5.31	5.62	5.59	5.55	5.52	5.48	5.44	5.40	5.36	5.32	5.27	5.22	5.18	5.13	5.08	5.02	4.97	4.92	4.86	4.80	4.74	4.68	4.62	4.56	4.49	4.42	4.36
71.0	5.47	5.78	5.75	5.72	5.68	5.64	5.60	5.56	5.52	5.48	5.43	5.39	5.34	5.29	5.24	5.19	5.13	5.08	5.02	4.96	4.91	4.84	4.78	4.72	4.65	4.59	4.52
72.0	5.63	5.95	5.91	5.88	5.84	5.81	5.77	5.73	5.69	5.64	5.60	5.55	5.50	5.45	5.40	5.35	5.30	5.24	5.19	5.13	5.07	5.01	4.95	4.88	4.82	4.75	4.68
73.0	5.80	6.11	6.08	6.05	6.01	5.97	5.93	5.89	5.85	5.81	5.76	5.72	5.67	5.62	5.57	5.52	5.46	5.41	5.35	5.30	5.24	5.18	5.11	5.05	4.98	4.92	4.85
74.0	5.97	6.28	6.25	6.22	6.18	6.14	6.10	6.06	6.02	5.98	5.93	5.89	5.84	5.79	5.74	5.69	5.63	5.58	5.52	5.46	5.41	5.34	5.28	5.22	5.15	5.09	5.02
75.0	6.14	6.45	6.42	6.39	6.35	6.31	6.27	6.23	6.19	6.15	6.10	6.06	6.01	5.96	5.91	5.86	5.81	5.75	5.69	5.64	5.58	5.52	5.45	5.39	5.32	5.26	5.19
76.0	6.32	6.63	6.60	6.56	6.52	6.49	6.45	6.41	6.37	6.32	6.28	6.23	6.18	6.13	6.08	6.03	5.98	5.92	5.87	5.81	5.75	5.69	5.63	5.56	5.50	5.43	5.36
77.0	6.49	6.80	6.77	6.74	6.70	6.66	6.62	6.58	6.54	6.50	6.45	6.41	6.36	6.31	6.26	6.21	6.15	6.10	6.04	5.99	5.93	5.87	5.80	5.74	5.67	5.61	5.54
78.0	6.67	6.98	6.95	6.91	6.88	6.84	6.80	6.76	6.72	6.68	6.63	6.59	6.54	6.49	6.44	6.39	6.33	6.28	6.22	6.16	6.10	6.04	5.98	5.92	5.85	5.79	5.72

Table D–10. LLN for FVC (L)–Mexican American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
56.0	2.70	3.01	2.98	2.94	2.91	2.87	2.83	2.79	2.75	2.71	2.66	2.61	2.57	2.52	2.47	2.41	2.36	2.31	2.25	2.19	2.13	2.07	2.01	1.95	1.88	1.81	1.75
57.0	2.81	3.12	3.09	3.05	3.02	2.98	2.94	2.90	2.86	2.81	2.77	2.72	2.68	2.63	2.58	2.52	2.47	2.42	2.36	2.30	2.24	2.18	2.12	2.05	1.99	1.92	1.86
58.0	2.92	3.23	3.20	3.16	3.13	3.09	3.05	3.01	2.97	2.92	2.88	2.83	2.79	2.74	2.69	2.63	2.58	2.53	2.47	2.41	2.35	2.29	2.23	2.17	2.10	2.03	1.97
59.0	3.03	3.34	3.31	3.28	3.24	3.20	3.16	3.12	3.08	3.04	2.99	2.95	2.90	2.85	2.80	2.75	2.69	2.64	2.58	2.52	2.47	2.40	2.34	2.28	2.21	2.15	2.08
60.0	3.15	3.46	3.43	3.39	3.35	3.32	3.28	3.24	3.20	3.15	3.11	3.06	3.01	2.96	2.91	2.86	2.81	2.75	2.70	2.64	2.58	2.52	2.46	2.39	2.33	2.26	2.19
61.0	3.26	3.57	3.54	3.51	3.47	3.43	3.39	3.35	3.31	3.27	3.22	3.18	3.13	3.08	3.03	2.98	2.93	2.87	2.81	2.76	2.70	2.64	2.57	2.51	2.44	2.38	2.31
62.0	3.38	3.69	3.66	3.63	3.59	3.55	3.51	3.47	3.43	3.39	3.34	3.30	3.25	3.20	3.15	3.10	3.04	2.99	2.93	2.87	2.82	2.75	2.69	2.63	2.56	2.50	2.43
63.0	3.50	3.81	3.78	3.75	3.71	3.67	3.63	3.59	3.55	3.51	3.46	3.42	3.37	3.32	3.27	3.22	3.16	3.11	3.05	3.00	2.94	2.88	2.81	2.75	2.68	2.62	2.55
64.0	3.62	3.94	3.90	3.87	3.83	3.80	3.76	3.72	3.67	3.63	3.59	3.54	3.49	3.44	3.39	3.34	3.29	3.23	3.18	3.12	3.06	3.00	2.94	2.87	2.81	2.74	2.67
65.0	3.75	4.06	4.03	3.99	3.96	3.92	3.88	3.84	3.80	3.76	3.71	3.66	3.62	3.57	3.52	3.46	3.41	3.36	3.30	3.24	3.18	3.12	3.06	3.00	2.93	2.86	2.80
66.0	3.87	4.19	4.15	4.12	4.08	4.05	4.01	3.97	3.92	3.88	3.84	3.79	3.74	3.69	3.64	3.59	3.54	3.48	3.43	3.37	3.31	3.25	3.19	3.12	3.06	2.99	2.92
67.0	4.00	4.32	4.28	4.25	4.21	4.17	4.14	4.09	4.05	4.01	3.97	3.92	3.87	3.82	3.77	3.72	3.67	3.61	3.55	3.50	3.44	3.38	3.31	3.25	3.19	3.12	3.05
68.0	4.13	4.45	4.41	4.38	4.34	4.30	4.27	4.23	4.18	4.14	4.10	4.05	4.00	3.95	3.90	3.85	3.80	3.74	3.68	3.63	3.57	3.51	3.44	3.38	3.32	3.25	3.18
69.0	4.26	4.58	4.54	4.51	4.47	4.44	4.40	4.36	4.32	4.27	4.23	4.18	4.13	4.08	4.03	3.98	3.93	3.87	3.82	3.76	3.70	3.64	3.58	3.51	3.45	3.38	3.31
70.0	4.40	4.71	4.68	4.64	4.61	4.57	4.53	4.49	4.45	4.41	4.36	4.32	4.27	4.22	4.17	4.12	4.06	4.01	3.95	3.89	3.83	3.77	3.71	3.65	3.58	3.52	3.45
71.0	4.53	4.85	4.81	4.78	4.74	4.71	4.67	4.63	4.59	4.54	4.50	4.45	4.40	4.35	4.30	4.25	4.20	4.14	4.09	4.03	3.97	3.91	3.85	3.78	3.72	3.65	3.58
72.0	4.67	4.99	4.95	4.92	4.88	4.84	4.81	4.77	4.72	4.68	4.64	4.59	4.54	4.49	4.44	4.39	4.34	4.28	4.22	4.17	4.11	4.05	3.98	3.92	3.86	3.79	3.72
73.0	4.81	5.13	5.09	5.06	5.02	4.98	4.95	4.90	4.86	4.82	4.78	4.73	4.68	4.63	4.58	4.53	4.48	4.42	4.36	4.31	4.25	4.19	4.12	4.06	4.00	3.93	3.86
74.0	4.95	5.27	5.23	5.20	5.16	5.13	5.09	5.05	5.00	4.96	4.92	4.87	4.82	4.77	4.72	4.67	4.62	4.56	4.51	4.45	4.39	4.33	4.27	4.20	4.14	4.07	4.00
75.0	5.10	5.41	5.38	5.34	5.31	5.27	5.23	5.19	5.15	5.11	5.06	5.01	4.97	4.92	4.87	4.81	4.76	4.71	4.65	4.59	4.53	4.47	4.41	4.35	4.28	4.21	4.15
76.0	5.24	5.56	5.52	5.49	5.45	5.42	5.38	5.34	5.29	5.25	5.21	5.16	5.11	5.06	5.01	4.96	4.91	4.85	4.80	4.74	4.68	4.62	4.56	4.49	4.43	4.36	4.29
77.0	5.39	5.70	5.67	5.64	5.60	5.56	5.52	5.48	5.44	5.40	5.35	5.31	5.26	5.21	5.16	5.11	5.05	5.00	4.94	4.89	4.83	4.77	4.70	4.64	4.57	4.51	4.44
78.0	5.54	5.85	5.82	5.79	5.75	5.71	5.67	5.63	5.59	5.55	5.50	5.46	5.41	5.36	5.31	5.26	5.20	5.15	5.09	5.03	4.98	4.91	4.85	4.79	4.72	4.66	4.59

Table D–11. Predicted FEV_1 (L)–Mexican American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
56.0	2.86	3.10	3.04	2.98	2.93	2.87	2.81	2.75	2.69	2.63	2.57	2.52	2.46	2.40	2.34	2.28	2.22	2.16	2.11	2.05	1.99	1.93	1.87	1.81	1.75	1.70	1.64
57.0	2.97	3.21	3.15	3.09	3.04	2.98	2.92	2.86	2.80	2.74	2.68	2.63	2.57	2.51	2.45	2.39	2.33	2.27	2.22	2.16	2.10	2.04	1.98	1.92	1.86	1.81	1.75
58.0	3.08	3.32	3.26	3.21	3.15	3.09	3.03	2.97	2.91	2.85	2.80	2.74	2.68	2.62	2.56	2.50	2.44	2.39	2.33	2.27	2.21	2.15	2.09	2.03	1.98	1.92	1.86
59.0	3.20	3.44	3.38	3.32	3.26	3.20	3.14	3.09	3.03	2.97	2.91	2.85	2.79	2.73	2.68	2.62	2.56	2.50	2.44	2.38	2.32	2.27	2.21	2.15	2.09	2.03	1.97
60.0	3.31	3.55	3.49	3.44	3.38	3.32	3.26	3.20	3.14	3.08	3.03	2.97	2.91	2.85	2.79	2.73	2.67	2.62	2.56	2.50	2.44	2.38	2.32	2.26	2.21	2.15	2.09
61.0	3.43	3.67	3.61	3.55	3.50	3.44	3.38	3.32	3.26	3.20	3.14	3.09	3.03	2.97	2.91	2.85	2.79	2.73	2.68	2.62	2.56	2.50	2.44	2.38	2.32	2.27	2.21
62.0	3.55	3.79	3.73	3.67	3.62	3.56	3.50	3.44	3.38	3.32	3.26	3.21	3.15	3.09	3.03	2.97	2.91	2.85	2.80	2.74	2.68	2.62	2.56	2.50	2.44	2.39	2.33
63.0	3.67	3.91	3.85	3.80	3.74	3.68	3.62	3.56	3.50	3.44	3.39	3.33	3.27	3.21	3.15	3.09	3.03	2.98	2.92	2.86	2.80	2.74	2.68	2.62	2.57	2.51	2.45
64.0	3.80	4.04	3.98	3.92	3.86	3.80	3.74	3.68	3.63	3.57	3.51	3.45	3.39	3.33	3.28	3.22	3.16	3.10	3.04	2.98	2.92	2.87	2.81	2.75	2.69	2.63	2.57
65.0	3.92	4.16	4.10	4.04	3.99	3.93	3.87	3.81	3.75	3.69	3.64	3.58	3.52	3.46	3.40	3.34	3.28	3.23	3.17	3.11	3.05	2.99	2.93	2.87	2.82	2.76	2.70
66.0	4.05	4.29	4.23	4.17	4.11	4.06	4.00	3.94	3.88	3.82	3.76	3.70	3.65	3.59	3.53	3.47	3.41	3.35	3.29	3.24	3.18	3.12	3.06	3.00	2.94	2.88	2.83
67.0	4.18	4.42	4.36	4.30	4.24	4.19	4.13	4.07	4.01	3.95	3.89	3.83	3.78	3.72	3.66	3.60	3.54	3.48	3.42	3.37	3.31	3.25	3.19	3.13	3.07	3.01	2.96
68.0	4.31	4.55	4.49	4.43	4.38	4.32	4.26	4.20	4.14	4.08	4.02	3.97	3.91	3.85	3.79	3.73	3.67	3.61	3.56	3.50	3.44	3.38	3.32	3.26	3.20	3.15	3.09
69.0	4.44	4.68	4.63	4.57	4.51	4.45	4.39	4.33	4.27	4.22	4.16	4.10	4.04	3.98	3.92	3.86	3.81	3.75	3.69	3.63	3.57	3.51	3.45	3.40	3.34	3.28	3.22
70.0	4.58	4.82	4.76	4.70	4.64	4.59	4.53	4.47	4.41	4.35	4.29	4.23	4.18	4.12	4.06	4.00	3.94	3.88	3.82	3.77	3.71	3.65	3.59	3.53	3.47	3.41	3.36
71.0	4.72	4.96	4.90	4.84	4.78	4.72	4.66	4.61	4.55	4.49	4.43	4.37	4.31	4.25	4.20	4.14	4.08	4.02	3.96	3.90	3.84	3.79	3.73	3.67	3.61	3.55	3.49
72.0	4.86	5.10	5.04	4.98	4.92	4.86	4.80	4.75	4.69	4.63	4.57	4.51	4.45	4.39	4.34	4.28	4.22	4.16	4.10	4.04	3.98	3.93	3.87	3.81	3.75	3.69	3.63
73.0	5.00	5.24	5.18	5.12	5.06	5.00	4.95	4.89	4.83	4.77	4.71	4.65	4.59	4.54	4.48	4.42	4.36	4.30	4.24	4.18	4.13	4.07	4.01	3.95	3.89	3.83	3.77
74.0	5.14	5.38	5.32	5.26	5.21	5.15	5.09	5.03	4.97	4.91	4.85	4.80	4.74	4.68	4.62	4.56	4.50	4.44	4.39	4.33	4.27	4.21	4.15	4.09	4.03	3.98	3.92
75.0	5.29	5.53	5.47	5.41	5.35	5.29	5.23	5.17	5.12	5.06	5.00	4.94	4.88	4.82	4.76	4.71	4.65	4.59	4.53	4.47	4.41	4.36	4.30	4.24	4.18	4.12	4.06
76.0	5.43	5.67	5.61	5.56	5.50	5.44	5.38	5.32	5.26	5.20	5.15	5.09	5.03	4.97	4.91	4.85	4.80	4.74	4.68	4.62	4.56	4.50	4.44	4.39	4.33	4.27	4.21
77.0	5.58	5.82	5.76	5.71	5.65	5.59	5.53	5.47	5.41	5.35	5.30	5.24	5.18	5.12	5.06	5.00	4.94	4.89	4.83	4.77	4.71	4.65	4.59	4.53	4.48	4.42	4.36
78.0	5.73	5.97	5.91	5.86	5.80	5.74	5.68	5.62	5.56	5.51	5.45	5.39	5.33	5.27	5.21	5.15	5.10	5.04	4.98	4.92	4.86	4.80	4.74	4.69	4.63	4.57	4.51

Table D–12. LLN for FEV_1 (L)–Mexican American males–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
56.0	2.37	2.61	2.55	2.49	2.43	2.37	2.32	2.26	2.20	2.14	2.08	2.02	1.96	1.91	1.85	1.79	1.73	1.67	1.61	1.55	1.50	1.44	1.38	1.32	1.26	1.20	1.14
57.0	2.46	2.70	2.64	2.58	2.53	2.47	2.41	2.35	2.29	2.23	2.17	2.12	2.06	2.00	1.94	1.88	1.82	1.76	1.71	1.65	1.59	1.53	1.47	1.41	1.35	1.30	1.24
58.0	2.55	2.79	2.74	2.68	2.62	2.56	2.50	2.44	2.38	2.33	2.27	2.21	2.15	2.09	2.03	1.97	1.92	1.86	1.80	1.74	1.68	1.62	1.57	1.51	1.45	1.39	1.33
59.0	2.65	2.89	2.83	2.77	2.71	2.66	2.60	2.54	2.48	2.42	2.36	2.30	2.25	2.19	2.13	2.07	2.01	1.95	1.89	1.84	1.78	1.72	1.66	1.60	1.54	1.48	1.43
60.0	2.75	2.99	2.93	2.87	2.81	2.75	2.69	2.64	2.58	2.52	2.46	2.40	2.34	2.28	2.23	2.17	2.11	2.05	1.99	1.93	1.88	1.82	1.76	1.70	1.64	1.58	1.52
61.0	2.85	3.09	3.03	2.97	2.91	2.85	2.79	2.74	2.68	2.62	2.56	2.50	2.44	2.38	2.33	2.27	2.21	2.15	2.09	2.03	1.97	1.92	1.86	1.80	1.74	1.68	1.62
62.0	2.95	3.19	3.13	3.07	3.01	2.95	2.89	2.84	2.78	2.72	2.66	2.60	2.54	2.48	2.43	2.37	2.31	2.25	2.19	2.13	2.07	2.02	1.96	1.90	1.84	1.78	1.72
63.0	3.05	3.29	3.23	3.17	3.11	3.06	3.00	2.94	2.88	2.82	2.76	2.70	2.65	2.59	2.53	2.47	2.41	2.35	2.29	2.24	2.18	2.12	2.06	2.00	1.94	1.88	1.83
64.0	3.15	3.39	3.33	3.28	3.22	3.16	3.10	3.04	2.98	2.92	2.87	2.81	2.75	2.69	2.63	2.57	2.51	2.46	2.40	2.34	2.28	2.22	2.16	2.10	2.05	1.99	1.93
65.0	3.26	3.50	3.44	3.38	3.32	3.26	3.21	3.15	3.09	3.03	2.97	2.91	2.85	2.80	2.74	2.68	2.62	2.56	2.50	2.44	2.39	2.33	2.27	2.21	2.15	2.09	2.03
66.0	3.36	3.61	3.55	3.49	3.43	3.37	3.31	3.25	3.20	3.14	3.08	3.02	2.96	2.90	2.84	2.79	2.73	2.67	2.61	2.55	2.49	2.43	2.38	2.32	2.26	2.20	2.14
67.0	3.47	3.71	3.66	3.60	3.54	3.48	3.42	3.36	3.30	3.25	3.19	3.13	3.07	3.01	2.95	2.89	2.84	2.78	2.72	2.66	2.60	2.54	2.48	2.43	2.37	2.31	2.25
68.0	3.58	3.82	3.77	3.71	3.65	3.59	3.53	3.47	3.41	3.36	3.30	3.24	3.18	3.12	3.06	3.00	2.95	2.89	2.83	2.77	2.71	2.65	2.59	2.54	2.48	2.42	2.36
69.0	3.70	3.94	3.88	3.82	3.76	3.70	3.64	3.59	3.53	3.47	3.41	3.35	3.29	3.23	3.18	3.12	3.06	3.00	2.94	2.88	2.82	2.77	2.71	2.65	2.59	2.53	2.47
70.0	3.81	4.05	3.99	3.93	3.87	3.82	3.76	3.70	3.64	3.58	3.52	3.46	3.41	3.35	3.29	3.23	3.17	3.11	3.05	3.00	2.94	2.88	2.82	2.76	2.70	2.64	2.59
71.0	3.92	4.17	4.11	4.05	3.99	3.93	3.87	3.81	3.76	3.70	3.64	3.58	3.52	3.46	3.40	3.35	3.29	3.23	3.17	3.11	3.05	2.99	2.94	2.88	2.82	2.76	2.70
72.0	4.04	4.28	4.22	4.17	4.11	4.05	3.99	3.93	3.87	3.81	3.76	3.70	3.64	3.58	3.52	3.46	3.40	3.35	3.29	3.23	3.17	3.11	3.05	2.99	2.94	2.88	2.82
73.0	4.16	4.40	4.34	4.28	4.23	4.17	4.11	4.05	3.99	3.93	3.87	3.82	3.76	3.70	3.64	3.58	3.52	3.46	3.41	3.35	3.29	3.23	3.17	3.11	3.05	3.00	2.94
74.0	4.28	4.52	4.46	4.40	4.35	4.29	4.23	4.17	4.11	4.05	3.99	3.94	3.88	3.82	3.76	3.70	3.64	3.58	3.53	3.47	3.41	3.35	3.29	3.23	3.17	3.12	3.06
75.0	4.40	4.64	4.58	4.53	4.47	4.41	4.35	4.29	4.23	4.17	4.12	4.06	4.00	3.94	3.88	3.82	3.76	3.71	3.65	3.59	3.53	3.47	3.41	3.35	3.30	3.24	3.18
76.0	4.53	4.77	4.71	4.65	4.59	4.53	4.47	4.42	4.36	4.30	4.24	4.18	4.12	4.06	4.01	3.95	3.89	3.83	3.77	3.71	3.65	3.60	3.54	3.48	3.42	3.36	3.30
77.0	4.65	4.89	4.83	4.77	4.72	4.66	4.60	4.54	4.48	4.42	4.36	4.31	4.25	4.19	4.13	4.07	4.01	3.95	3.90	3.84	3.78	3.72	3.66	3.60	3.54	3.49	3.43
78.0	4.78	5.02	4.96	4.90	4.84	4.78	4.73	4.67	4.61	4.55	4.49	4.43	4.37	4.32	4.26	4.20	4.14	4.08	4.02	3.96	3.91	3.85	3.79	3.73	3.67	3.61	3.55

Table D–13. Predicted FVC (L)–Caucasian females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
57.0	2.96	2.97	2.98	2.98	2.98	2.97	2.97	2.96	2.94	2.93	2.91	2.89	2.86	2.83	2.80	2.77	2.73	2.69	2.65	2.60	2.55	2.50	2.44	2.38	2.32	2.25	2.19
58.0	3.07	3.08	3.09	3.09	3.09	3.08	3.08	3.07	3.05	3.04	3.02	3.00	2.97	2.94	2.91	2.88	2.84	2.80	2.76	2.71	2.66	2.61	2.55	2.49	2.43	2.36	2.30
59.0	3.18	3.19	3.20	3.20	3.20	3.20	3.19	3.18	3.17	3.15	3.13	3.11	3.08	3.05	3.02	2.99	2.95	2.91	2.87	2.82	2.77	2.72	2.66	2.60	2.54	2.48	2.41
60.0	3.30	3.31	3.31	3.31	3.31	3.31	3.30	3.29	3.28	3.26	3.24	3.22	3.20	3.17	3.14	3.10	3.06	3.02	2.98	2.93	2.88	2.83	2.78	2.72	2.66	2.59	2.52
61.0	3.41	3.42	3.43	3.43	3.43	3.42	3.42	3.41	3.39	3.38	3.36	3.34	3.31	3.28	3.25	3.22	3.18	3.14	3.10	3.05	3.00	2.95	2.89	2.83	2.77	2.71	2.64
62.0	3.53	3.54	3.54	3.55	3.55	3.54	3.54	3.53	3.51	3.50	3.48	3.45	3.43	3.40	3.37	3.34	3.30	3.26	3.21	3.17	3.12	3.06	3.01	2.95	2.89	2.82	2.76
63.0	3.65	3.66	3.66	3.67	3.67	3.66	3.65	3.64	3.63	3.62	3.60	3.57	3.55	3.52	3.49	3.46	3.42	3.38	3.33	3.29	3.24	3.18	3.13	3.07	3.01	2.94	2.87
64.0	3.77	3.78	3.79	3.79	3.79	3.78	3.78	3.77	3.75	3.74	3.72	3.70	3.67	3.64	3.61	3.58	3.54	3.50	3.45	3.41	3.36	3.31	3.25	3.19	3.13	3.06	3.00
65.0	3.90	3.90	3.91	3.91	3.91	3.91	3.90	3.89	3.88	3.86	3.84	3.82	3.79	3.77	3.73	3.70	3.66	3.62	3.58	3.53	3.48	3.43	3.37	3.31	3.25	3.19	3.12
66.0	4.02	4.03	4.03	4.04	4.04	4.03	4.02	4.01	4.00	3.99	3.97	3.94	3.92	3.89	3.86	3.82	3.79	3.75	3.70	3.66	3.61	3.55	3.50	3.44	3.38	3.31	3.24
67.0	4.15	4.16	4.16	4.16	4.16	4.16	4.15	4.14	4.13	4.11	4.09	4.07	4.05	4.02	3.99	3.95	3.91	3.87	3.83	3.78	3.73	3.68	3.63	3.57	3.50	3.44	3.37
68.0	4.28	4.28	4.29	4.29	4.29	4.29	4.28	4.27	4.26	4.24	4.22	4.20	4.18	4.15	4.12	4.08	4.04	4.00	3.96	3.91	3.86	3.81	3.75	3.70	3.63	3.57	3.50
69.0	4.41	4.42	4.42	4.42	4.42	4.42	4.41	4.40	4.39	4.37	4.35	4.33	4.31	4.28	4.25	4.21	4.17	4.13	4.09	4.04	3.99	3.94	3.89	3.83	3.76	3.70	3.63
70.0	4.54	4.55	4.55	4.56	4.56	4.55	4.54	4.53	4.52	4.51	4.49	4.46	4.44	4.41	4.38	4.34	4.31	4.27	4.22	4.18	4.13	4.07	4.02	3.96	3.90	3.83	3.76
71.0	4.68	4.68	4.69	4.69	4.69	4.69	4.68	4.67	4.66	4.64	4.62	4.60	4.57	4.55	4.51	4.48	4.44	4.40	4.36	4.31	4.26	4.21	4.15	4.09	4.03	3.97	3.90
72.0	4.81	4.82	4.83	4.83	4.83	4.82	4.82	4.81	4.79	4.78	4.76	4.74	4.71	4.68	4.65	4.62	4.58	4.54	4.49	4.45	4.40	4.35	4.29	4.23	4.17	4.10	4.04
73.0	4.95	4.96	4.96	4.97	4.97	4.96	4.95	4.94	4.93	4.92	4.90	4.87	4.85	4.82	4.79	4.75	4.72	4.68	4.63	4.59	4.54	4.48	4.43	4.37	4.31	4.24	4.17
74.0	5.09	5.10	5.10	5.11	5.11	5.10	5.10	5.09	5.07	5.06	5.04	5.01	4.99	4.96	4.93	4.90	4.86	4.82	4.77	4.73	4.68	4.62	4.57	4.51	4.45	4.38	4.32

Table D–14. LLN for FVC (L)–Caucasian females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
57.0	2.41	2.42	2.43	2.43	2.43	2.42	2.42	2.41	2.40	2.38	2.36	2.34	2.31	2.28	2.25	2.22	2.18	2.14	2.10	2.05	2.00	1.95	1.89	1.83	1.77	1.71	1.64
58.0	2.50	2.51	2.52	2.52	2.52	2.52	2.51	2.50	2.49	2.47	2.45	2.43	2.40	2.37	2.34	2.31	2.27	2.23	2.19	2.14	2.09	2.04	1.98	1.92	1.86	1.80	1.73
59.0	2.60	2.60	2.61	2.61	2.61	2.61	2.60	2.59	2.58	2.56	2.54	2.52	2.49	2.47	2.44	2.40	2.36	2.32	2.28	2.23	2.18	2.13	2.07	2.02	1.95	1.89	1.82
60.0	2.69	2.70	2.70	2.71	2.71	2.70	2.69	2.68	2.67	2.66	2.64	2.61	2.59	2.56	2.53	2.49	2.46	2.42	2.37	2.33	2.28	2.22	2.17	2.11	2.05	1.98	1.91
61.0	2.79	2.79	2.80	2.80	2.80	2.80	2.79	2.78	2.77	2.75	2.73	2.71	2.68	2.66	2.62	2.59	2.55	2.51	2.47	2.42	2.37	2.32	2.26	2.20	2.14	2.08	2.01
62.0	2.88	2.89	2.90	2.90	2.90	2.89	2.89	2.88	2.86	2.85	2.83	2.81	2.78	2.75	2.72	2.69	2.65	2.61	2.56	2.52	2.47	2.42	2.36	2.30	2.24	2.17	2.11
63.0	2.98	2.99	2.99	3.00	3.00	2.99	2.98	2.97	2.96	2.95	2.93	2.90	2.88	2.85	2.82	2.78	2.75	2.71	2.66	2.62	2.57	2.51	2.46	2.40	2.34	2.27	2.20
64.0	3.08	3.09	3.09	3.10	3.10	3.09	3.08	3.07	3.06	3.05	3.03	3.00	2.98	2.95	2.92	2.88	2.85	2.81	2.76	2.72	2.67	2.61	2.56	2.50	2.44	2.37	2.30
65.0	3.18	3.19	3.20	3.20	3.20	3.19	3.19	3.18	3.16	3.15	3.13	3.11	3.08	3.05	3.02	2.99	2.95	2.91	2.86	2.82	2.77	2.72	2.66	2.60	2.54	2.47	2.41
66.0	3.28	3.29	3.30	3.30	3.30	3.30	3.29	3.28	3.27	3.25	3.23	3.21	3.18	3.16	3.12	3.09	3.05	3.01	2.97	2.92	2.87	2.82	2.76	2.70	2.64	2.58	2.51
67.0	3.39	3.40	3.40	3.41	3.40	3.40	3.39	3.38	3.37	3.35	3.34	3.31	3.29	3.26	3.23	3.19	3.16	3.12	3.07	3.03	2.98	2.92	2.87	2.81	2.75	2.68	2.61
68.0	3.50	3.50	3.51	3.51	3.51	3.51	3.50	3.49	3.48	3.46	3.44	3.42	3.39	3.37	3.33	3.30	3.26	3.22	3.18	3.13	3.08	3.03	2.97	2.92	2.85	2.79	2.72
69.0	3.60	3.61	3.62	3.62	3.62	3.61	3.61	3.60	3.58	3.57	3.55	3.53	3.50	3.47	3.44	3.41	3.37	3.33	3.29	3.24	3.19	3.14	3.08	3.02	2.96	2.90	2.83
70.0	3.71	3.72	3.73	3.73	3.73	3.72	3.72	3.71	3.69	3.68	3.66	3.64	3.61	3.58	3.55	3.52	3.48	3.44	3.40	3.35	3.30	3.25	3.19	3.13	3.07	3.01	2.94
71.0	3.82	3.83	3.84	3.84	3.84	3.84	3.83	3.82	3.81	3.79	3.77	3.75	3.72	3.69	3.66	3.63	3.59	3.55	3.51	3.46	3.41	3.36	3.30	3.24	3.18	3.12	3.05
72.0	3.94	3.94	3.95	3.95	3.95	3.95	3.94	3.93	3.92	3.90	3.88	3.86	3.84	3.81	3.78	3.74	3.70	3.66	3.62	3.57	3.52	3.47	3.41	3.36	3.29	3.23	3.16
73.0	4.05	4.06	4.06	4.07	4.07	4.06	4.05	4.04	4.03	4.02	4.00	3.97	3.95	3.92	3.89	3.86	3.82	3.78	3.73	3.69	3.64	3.58	3.53	3.47	3.41	3.34	3.27
74.0	4.17	4.17	4.18	4.18	4.18	4.18	4.17	4.16	4.15	4.13	4.11	4.09	4.06	4.04	4.01	3.97	3.93	3.89	3.85	3.80	3.75	3.70	3.64	3.59	3.52	3.46	3.39

Table D–15. Predicted FEV_1 (L)–Caucasian females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
57.0	2.72	2.69	2.67	2.64	2.62	2.59	2.56	2.53	2.50	2.46	2.43	2.39	2.35	2.31	2.27	2.22	2.18	2.13	2.08	2.03	1.98	1.93	1.87	1.82	1.76	1.70	1.64
58.0	2.80	2.78	2.75	2.73	2.70	2.68	2.65	2.61	2.58	2.55	2.51	2.47	2.43	2.39	2.35	2.31	2.26	2.22	2.17	2.12	2.07	2.01	1.96	1.90	1.84	1.79	1.72
59.0	2.89	2.87	2.84	2.82	2.79	2.76	2.73	2.70	2.67	2.63	2.60	2.56	2.52	2.48	2.44	2.39	2.35	2.30	2.25	2.20	2.15	2.10	2.05	1.99	1.93	1.87	1.81
60.0	2.98	2.95	2.93	2.90	2.88	2.85	2.82	2.79	2.76	2.72	2.69	2.65	2.61	2.57	2.53	2.48	2.44	2.39	2.34	2.29	2.24	2.19	2.13	2.08	2.02	1.96	1.90
61.0	3.07	3.04	3.02	2.99	2.97	2.94	2.91	2.88	2.85	2.81	2.78	2.74	2.70	2.66	2.62	2.57	2.53	2.48	2.43	2.38	2.33	2.28	2.22	2.17	2.11	2.05	1.99
62.0	3.16	3.13	3.11	3.09	3.06	3.03	3.00	2.97	2.94	2.90	2.87	2.83	2.79	2.75	2.71	2.66	2.62	2.57	2.52	2.47	2.42	2.37	2.31	2.26	2.20	2.14	2.08
63.0	3.25	3.23	3.20	3.18	3.15	3.12	3.09	3.06	3.03	3.00	2.96	2.92	2.88	2.84	2.80	2.76	2.71	2.66	2.62	2.57	2.52	2.46	2.41	2.35	2.29	2.23	2.17
64.0	3.34	3.32	3.30	3.27	3.25	3.22	3.19	3.16	3.12	3.09	3.05	3.02	2.98	2.94	2.89	2.85	2.81	2.76	2.71	2.66	2.61	2.56	2.50	2.45	2.39	2.33	2.27
65.0	3.44	3.42	3.39	3.37	3.34	3.31	3.28	3.25	3.22	3.19	3.15	3.11	3.07	3.03	2.99	2.95	2.90	2.85	2.81	2.76	2.70	2.65	2.60	2.54	2.48	2.42	2.36
66.0	3.54	3.51	3.49	3.47	3.44	3.41	3.38	3.35	3.32	3.28	3.25	3.21	3.17	3.13	3.09	3.04	3.00	2.95	2.90	2.85	2.80	2.75	2.69	2.64	2.58	2.52	2.46
67.0	3.63	3.61	3.59	3.56	3.54	3.51	3.48	3.45	3.42	3.38	3.35	3.31	3.27	3.23	3.19	3.14	3.10	3.05	3.00	2.95	2.90	2.85	2.79	2.74	2.68	2.62	2.56
68.0	3.73	3.71	3.69	3.66	3.64	3.61	3.58	3.55	3.52	3.48	3.45	3.41	3.37	3.33	3.29	3.24	3.20	3.15	3.10	3.05	3.00	2.95	2.89	2.84	2.78	2.72	2.66
69.0	3.84	3.81	3.79	3.77	3.74	3.71	3.68	3.65	3.62	3.58	3.55	3.51	3.47	3.43	3.39	3.34	3.30	3.25	3.20	3.15	3.10	3.05	2.99	2.94	2.88	2.82	2.76
70.0	3.94	3.92	3.89	3.87	3.84	3.81	3.78	3.75	3.72	3.69	3.65	3.61	3.57	3.53	3.49	3.45	3.40	3.36	3.31	3.26	3.21	3.15	3.10	3.04	2.98	2.92	2.86
71.0	4.04	4.02	4.00	3.97	3.95	3.92	3.89	3.86	3.83	3.79	3.75	3.72	3.68	3.64	3.60	3.55	3.51	3.46	3.41	3.36	3.31	3.26	3.20	3.15	3.09	3.03	2.97
72.0	4.15	4.13	4.10	4.08	4.05	4.02	4.00	3.96	3.93	3.90	3.86	3.82	3.78	3.74	3.70	3.66	3.61	3.57	3.52	3.47	3.42	3.36	3.31	3.25	3.19	3.14	3.07
73.0	4.26	4.24	4.21	4.19	4.16	4.13	4.10	4.07	4.04	4.00	3.97	3.93	3.89	3.85	3.81	3.77	3.72	3.67	3.63	3.58	3.52	3.47	3.42	3.36	3.30	3.24	3.18
74.0	4.37	4.34	4.32	4.30	4.27	4.24	4.21	4.18	4.15	4.11	4.08	4.04	4.00	3.96	3.92	3.87	3.83	3.78	3.73	3.68	3.63	3.58	3.53	3.47	3.41	3.35	3.29

Table D–16. LLN for FEV_1 (L)–Caucasian females–NHANES III

Height (Inches)	Age																											
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
57.0	2.25	2.23	2.21	2.18	2.15	2.13	2.10	2.06	2.03	2.00	1.96	1.92	1.89	1.84	1.80	1.76	1.71	1.67	1.62	1.57	1.52	1.46	1.41	1.35	1.30	1.24	1.18
58.0	2.32	2.30	2.27	2.25	2.22	2.19	2.17	2.13	2.10	2.07	2.03	1.99	1.95	1.91	1.87	1.83	1.78	1.74	1.69	1.64	1.59	1.53	1.48	1.42	1.36	1.31	1.24
59.0	2.39	2.37	2.34	2.32	2.29	2.26	2.24	2.20	2.17	2.14	2.10	2.06	2.02	1.98	1.94	1.90	1.85	1.81	1.76	1.71	1.66	1.60	1.55	1.49	1.43	1.38	1.31
60.0	2.46	2.44	2.42	2.39	2.36	2.34	2.31	2.28	2.24	2.21	2.17	2.13	2.10	2.05	2.01	1.97	1.92	1.88	1.83	1.78	1.73	1.67	1.62	1.56	1.51	1.45	1.39
61.0	2.53	2.51	2.49	2.46	2.44	2.41	2.38	2.35	2.31	2.28	2.24	2.21	2.17	2.13	2.09	2.04	2.00	1.95	1.90	1.85	1.80	1.75	1.69	1.64	1.58	1.52	1.46
62.0	2.61	2.59	2.56	2.54	2.51	2.48	2.45	2.42	2.39	2.35	2.32	2.28	2.24	2.20	2.16	2.12	2.07	2.02	1.97	1.92	1.87	1.82	1.77	1.71	1.65	1.59	1.53
63.0	2.68	2.66	2.64	2.61	2.59	2.56	2.53	2.50	2.46	2.43	2.39	2.36	2.32	2.28	2.23	2.19	2.14	2.10	2.05	2.00	1.95	1.90	1.84	1.78	1.73	1.67	1.61
64.0	2.76	2.74	2.71	2.69	2.66	2.63	2.60	2.57	2.54	2.51	2.47	2.43	2.39	2.35	2.31	2.27	2.22	2.17	2.13	2.08	2.02	1.97	1.92	1.86	1.80	1.74	1.68
65.0	2.84	2.81	2.79	2.77	2.74	2.71	2.68	2.65	2.62	2.58	2.55	2.51	2.47	2.43	2.39	2.34	2.30	2.25	2.20	2.15	2.10	2.05	1.99	1.94	1.88	1.82	1.76
66.0	2.91	2.89	2.87	2.84	2.82	2.79	2.76	2.73	2.70	2.66	2.62	2.59	2.55	2.51	2.47	2.42	2.38	2.33	2.28	2.23	2.18	2.13	2.07	2.02	1.96	1.90	1.84
67.0	2.99	2.97	2.95	2.92	2.90	2.87	2.84	2.81	2.77	2.74	2.70	2.67	2.63	2.59	2.55	2.50	2.46	2.41	2.36	2.31	2.26	2.21	2.15	2.10	2.04	1.98	1.92
68.0	3.07	3.05	3.03	3.00	2.98	2.95	2.92	2.89	2.86	2.82	2.79	2.75	2.71	2.67	2.63	2.58	2.54	2.49	2.44	2.39	2.34	2.29	2.23	2.18	2.12	2.06	2.00
69.0	3.16	3.13	3.11	3.09	3.06	3.03	3.00	2.97	2.94	2.90	2.87	2.83	2.79	2.75	2.71	2.66	2.62	2.57	2.52	2.47	2.42	2.37	2.32	2.26	2.20	2.14	2.08
70.0	3.24	3.22	3.19	3.17	3.14	3.11	3.09	3.05	3.02	2.99	2.95	2.91	2.87	2.83	2.79	2.75	2.70	2.66	2.61	2.56	2.51	2.45	2.40	2.34	2.28	2.23	2.16
71.0	3.32	3.30	3.28	3.25	3.23	3.20	3.17	3.14	3.11	3.07	3.04	3.00	2.96	2.92	2.88	2.83	2.79	2.74	2.69	2.64	2.59	2.54	2.48	2.43	2.37	2.31	2.25
72.0	3.41	3.39	3.36	3.34	3.31	3.28	3.26	3.22	3.19	3.16	3.12	3.08	3.04	3.00	2.96	2.92	2.87	2.83	2.78	2.73	2.68	2.62	2.57	2.51	2.45	2.40	2.33
73.0	3.50	3.48	3.45	3.43	3.40	3.37	3.34	3.31	3.28	3.24	3.21	3.17	3.13	3.09	3.05	3.00	2.96	2.91	2.86	2.81	2.76	2.71	2.66	2.60	2.54	2.48	2.42
74.0	3.59	3.56	3.54	3.51	3.49	3.46	3.43	3.40	3.37	3.33	3.30	3.26	3.22	3.18	3.14	3.09	3.05	3.00	2.95	2.90	2.85	2.80	2.74	2.69	2.63	2.57	2.51

Table D–17. Predicted FVC (L)–African-American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.17	2.16	2.15	2.14	2.12	2.10	2.08	2.06	2.04	2.01	1.98	1.95	1.92	1.88	1.85	1.81	1.77	1.72	1.68	1.63	1.58	1.53	1.48	1.42	1.36	1.30	1.24
54.0	2.27	2.26	2.25	2.23	2.22	2.20	2.18	2.16	2.13	2.11	2.08	2.05	2.01	1.98	1.94	1.90	1.86	1.82	1.77	1.72	1.68	1.62	1.57	1.51	1.46	1.39	1.33
55.0	2.36	2.35	2.34	2.33	2.31	2.29	2.27	2.25	2.23	2.20	2.17	2.14	2.11	2.07	2.04	2.00	1.96	1.91	1.87	1.82	1.77	1.72	1.67	1.61	1.55	1.49	1.43
56.0	2.46	2.45	2.44	2.42	2.41	2.39	2.37	2.35	2.32	2.30	2.27	2.24	2.21	2.17	2.13	2.10	2.05	2.01	1.97	1.92	1.87	1.82	1.76	1.71	1.65	1.59	1.53
57.0	2.56	2.55	2.54	2.52	2.51	2.49	2.47	2.45	2.42	2.40	2.37	2.34	2.31	2.27	2.23	2.19	2.15	2.11	2.06	2.02	1.97	1.92	1.86	1.81	1.75	1.69	1.62
58.0	2.66	2.65	2.64	2.63	2.61	2.59	2.57	2.55	2.52	2.50	2.47	2.44	2.41	2.37	2.33	2.30	2.25	2.21	2.17	2.12	2.07	2.02	1.96	1.91	1.85	1.79	1.73
59.0	2.76	2.75	2.74	2.73	2.71	2.69	2.67	2.65	2.63	2.60	2.57	2.54	2.51	2.47	2.44	2.40	2.36	2.31	2.27	2.22	2.17	2.12	2.07	2.01	1.95	1.89	1.83
60.0	2.87	2.86	2.85	2.83	2.82	2.80	2.78	2.76	2.73	2.71	2.68	2.65	2.61	2.58	2.54	2.50	2.46	2.42	2.37	2.33	2.28	2.22	2.17	2.11	2.06	2.00	1.93
61.0	2.97	2.96	2.95	2.94	2.92	2.90	2.88	2.86	2.84	2.81	2.78	2.75	2.72	2.69	2.65	2.61	2.57	2.52	2.48	2.43	2.38	2.33	2.28	2.22	2.16	2.10	2.04
62.0	3.08	3.07	3.06	3.05	3.03	3.01	2.99	2.97	2.95	2.92	2.89	2.86	2.83	2.79	2.76	2.72	2.68	2.63	2.59	2.54	2.49	2.44	2.38	2.33	2.27	2.21	2.15
63.0	3.19	3.18	3.17	3.16	3.14	3.12	3.10	3.08	3.06	3.03	3.00	2.97	2.94	2.90	2.87	2.83	2.79	2.74	2.70	2.65	2.60	2.55	2.49	2.44	2.38	2.32	2.26
64.0	3.30	3.29	3.28	3.27	3.25	3.23	3.21	3.19	3.17	3.14	3.11	3.08	3.05	3.01	2.98	2.94	2.90	2.85	2.81	2.76	2.71	2.66	2.61	2.55	2.49	2.43	2.37
65.0	3.42	3.41	3.39	3.38	3.37	3.35	3.33	3.30	3.28	3.25	3.23	3.20	3.16	3.13	3.09	3.05	3.01	2.97	2.92	2.87	2.82	2.77	2.72	2.66	2.60	2.54	2.48
66.0	3.53	3.52	3.51	3.50	3.48	3.46	3.44	3.42	3.40	3.37	3.34	3.31	3.28	3.24	3.21	3.17	3.13	3.08	3.04	2.99	2.94	2.89	2.83	2.78	2.72	2.66	2.60
67.0	3.65	3.64	3.63	3.61	3.60	3.58	3.56	3.54	3.51	3.49	3.46	3.43	3.39	3.36	3.32	3.28	3.24	3.20	3.15	3.11	3.06	3.00	2.95	2.89	2.84	2.78	2.71
68.0	3.77	3.76	3.74	3.73	3.72	3.70	3.68	3.66	3.63	3.60	3.58	3.55	3.51	3.48	3.44	3.40	3.36	3.32	3.27	3.22	3.17	3.12	3.07	3.01	2.95	2.89	2.83
69.0	3.89	3.88	3.86	3.85	3.84	3.82	3.80	3.78	3.75	3.72	3.70	3.67	3.63	3.60	3.56	3.52	3.48	3.44	3.39	3.34	3.29	3.24	3.19	3.13	3.07	3.01	2.95
70.0	4.01	4.00	3.99	3.97	3.96	3.94	3.92	3.90	3.87	3.85	3.82	3.79	3.76	3.72	3.68	3.64	3.60	3.56	3.51	3.47	3.42	3.36	3.31	3.25	3.20	3.14	3.07
71.0	4.13	4.12	4.11	4.10	4.08	4.06	4.04	4.02	4.00	3.97	3.94	3.91	3.88	3.84	3.81	3.77	3.73	3.68	3.64	3.59	3.54	3.49	3.43	3.38	3.32	3.26	3.20
72.0	4.26	4.25	4.24	4.22	4.21	4.19	4.17	4.15	4.12	4.10	4.07	4.04	4.00	3.97	3.93	3.89	3.85	3.81	3.76	3.72	3.67	3.61	3.56	3.50	3.45	3.39	3.32

Table D–18. LLN for FVC (L)–African-American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	1.68	1.68	1.66	1.65	1.63	1.62	1.60	1.57	1.55	1.52	1.50	1.46	1.43	1.40	1.36	1.32	1.28	1.24	1.19	1.14	1.09	1.04	0.99	0.93	0.87	0.81	0.75
54.0	1.76	1.75	1.74	1.73	1.71	1.69	1.67	1.65	1.63	1.60	1.57	1.54	1.51	1.47	1.44	1.40	1.36	1.31	1.27	1.22	1.17	1.12	1.06	1.01	0.95	0.89	0.83
55.0	1.84	1.83	1.82	1.80	1.79	1.77	1.75	1.73	1.70	1.68	1.65	1.62	1.58	1.55	1.51	1.47	1.43	1.39	1.34	1.30	1.25	1.19	1.14	1.08	1.03	0.97	0.90
56.0	1.92	1.91	1.89	1.88	1.86	1.85	1.83	1.80	1.78	1.75	1.73	1.70	1.66	1.63	1.59	1.55	1.51	1.47	1.42	1.37	1.32	1.27	1.22	1.16	1.10	1.04	0.98
57.0	1.99	1.99	1.97	1.96	1.94	1.93	1.91	1.88	1.86	1.83	1.81	1.77	1.74	1.71	1.67	1.63	1.59	1.55	1.50	1.45	1.40	1.35	1.30	1.24	1.18	1.12	1.06
58.0	2.08	2.07	2.05	2.04	2.03	2.01	1.99	1.97	1.94	1.91	1.89	1.86	1.82	1.79	1.75	1.71	1.67	1.63	1.58	1.53	1.48	1.43	1.38	1.32	1.26	1.20	1.14
59.0	2.16	2.15	2.14	2.12	2.11	2.09	2.07	2.05	2.02	2.00	1.97	1.94	1.91	1.87	1.83	1.79	1.75	1.71	1.66	1.62	1.57	1.52	1.46	1.41	1.35	1.29	1.22
60.0	2.24	2.23	2.22	2.21	2.19	2.17	2.15	2.13	2.11	2.08	2.05	2.02	1.99	1.95	1.92	1.88	1.84	1.79	1.75	1.70	1.65	1.60	1.55	1.49	1.43	1.37	1.31
61.0	2.33	2.32	2.31	2.29	2.28	2.26	2.24	2.22	2.19	2.17	2.14	2.11	2.07	2.04	2.00	1.96	1.92	1.88	1.83	1.79	1.74	1.68	1.63	1.57	1.52	1.46	1.39
62.0	2.41	2.40	2.39	2.38	2.36	2.35	2.33	2.30	2.28	2.25	2.22	2.19	2.16	2.13	2.09	2.05	2.01	1.97	1.92	1.87	1.82	1.77	1.72	1.66	1.60	1.54	1.48
63.0	2.50	2.49	2.48	2.47	2.45	2.43	2.41	2.39	2.37	2.34	2.31	2.28	2.25	2.21	2.18	2.14	2.10	2.05	2.01	1.96	1.91	1.86	1.80	1.75	1.69	1.63	1.57
64.0	2.59	2.58	2.57	2.56	2.54	2.52	2.50	2.48	2.46	2.43	2.40	2.37	2.34	2.30	2.27	2.23	2.19	2.14	2.10	2.05	2.00	1.95	1.89	1.84	1.78	1.72	1.66
65.0	2.68	2.67	2.66	2.65	2.63	2.61	2.59	2.57	2.55	2.52	2.49	2.46	2.43	2.39	2.36	2.32	2.28	2.23	2.19	2.14	2.09	2.04	1.99	1.93	1.87	1.81	1.75
66.0	2.77	2.77	2.75	2.74	2.72	2.71	2.69	2.66	2.64	2.61	2.58	2.55	2.52	2.49	2.45	2.41	2.37	2.33	2.28	2.23	2.18	2.13	2.08	2.02	1.96	1.90	1.84
67.0	2.87	2.86	2.85	2.83	2.82	2.80	2.78	2.76	2.73	2.71	2.68	2.65	2.62	2.58	2.54	2.50	2.46	2.42	2.37	2.33	2.28	2.23	2.17	2.12	2.06	2.00	1.93
68.0	2.96	2.95	2.94	2.93	2.91	2.89	2.87	2.85	2.83	2.80	2.77	2.74	2.71	2.68	2.64	2.60	2.56	2.51	2.47	2.42	2.37	2.32	2.27	2.21	2.15	2.09	2.03
69.0	3.06	3.05	3.04	3.03	3.01	2.99	2.97	2.95	2.92	2.90	2.87	2.84	2.81	2.77	2.73	2.70	2.65	2.61	2.57	2.52	2.47	2.42	2.36	2.31	2.25	2.19	2.13
70.0	3.16	3.15	3.14	3.12	3.11	3.09	3.07	3.05	3.02	3.00	2.97	2.94	2.90	2.87	2.83	2.79	2.75	2.71	2.66	2.62	2.57	2.51	2.46	2.40	2.35	2.29	2.22
71.0	3.26	3.25	3.24	3.22	3.21	3.19	3.17	3.15	3.12	3.10	3.07	3.04	3.00	2.97	2.93	2.89	2.85	2.81	2.76	2.72	2.67	2.61	2.56	2.50	2.45	2.39	2.32
72.0	3.36	3.35	3.34	3.32	3.31	3.29	3.27	3.25	3.22	3.20	3.17	3.14	3.10	3.07	3.03	2.99	2.95	2.91	2.86	2.82	2.77	2.71	2.66	2.60	2.55	2.49	2.42

Table D–19. Predicted FEV_1 (L)–African-American females–NHANES III

Height (Inches)	Age																											
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.05	2.01	1.98	1.95	1.91	1.87	1.84	1.80	1.76	1.72	1.68	1.64	1.60	1.56	1.51	1.47	1.42	1.38	1.33	1.29	1.24	1.19	1.14	1.09	1.04	0.99	0.94
54.0	2.12	2.09	2.05	2.02	1.98	1.95	1.91	1.87	1.84	1.80	1.76	1.72	1.67	1.63	1.59	1.54	1.50	1.45	1.41	1.36	1.31	1.26	1.22	1.17	1.11	1.06	1.01
55.0	2.20	2.16	2.13	2.10	2.06	2.02	1.99	1.95	1.91	1.87	1.83	1.79	1.75	1.71	1.66	1.62	1.58	1.53	1.48	1.44	1.39	1.34	1.29	1.24	1.19	1.14	1.09
56.0	2.28	2.24	2.21	2.17	2.14	2.10	2.07	2.03	1.99	1.95	1.91	1.87	1.83	1.79	1.74	1.70	1.65	1.61	1.56	1.52	1.47	1.42	1.37	1.32	1.27	1.22	1.16
57.0	2.35	2.32	2.29	2.25	2.22	2.18	2.14	2.11	2.07	2.03	1.99	1.95	1.91	1.86	1.82	1.78	1.73	1.69	1.64	1.59	1.55	1.50	1.45	1.40	1.35	1.30	1.24
58.0	2.43	2.40	2.37	2.33	2.30	2.26	2.23	2.19	2.15	2.11	2.07	2.03	1.99	1.94	1.90	1.86	1.81	1.77	1.72	1.67	1.63	1.58	1.53	1.48	1.43	1.38	1.32
59.0	2.52	2.48	2.45	2.42	2.38	2.34	2.31	2.27	2.23	2.19	2.15	2.11	2.07	2.03	1.98	1.94	1.90	1.85	1.80	1.76	1.71	1.66	1.61	1.56	1.51	1.46	1.41
60.0	2.60	2.57	2.53	2.50	2.46	2.43	2.39	2.35	2.31	2.27	2.23	2.19	2.15	2.11	2.07	2.02	1.98	1.93	1.89	1.84	1.79	1.74	1.69	1.64	1.59	1.54	1.49
61.0	2.68	2.65	2.62	2.58	2.55	2.51	2.47	2.44	2.40	2.36	2.32	2.28	2.24	2.19	2.15	2.11	2.06	2.02	1.97	1.92	1.88	1.83	1.78	1.73	1.68	1.63	1.57
62.0	2.77	2.74	2.70	2.67	2.63	2.60	2.56	2.52	2.48	2.45	2.41	2.36	2.32	2.28	2.24	2.19	2.15	2.10	2.06	2.01	1.96	1.91	1.86	1.81	1.76	1.71	1.66
63.0	2.86	2.83	2.79	2.76	2.72	2.69	2.65	2.61	2.57	2.53	2.49	2.45	2.41	2.37	2.33	2.28	2.24	2.19	2.14	2.10	2.05	2.00	1.95	1.90	1.85	1.80	1.75
64.0	2.95	2.91	2.88	2.85	2.81	2.77	2.74	2.70	2.66	2.62	2.58	2.54	2.50	2.46	2.41	2.37	2.33	2.28	2.23	2.19	2.14	2.09	2.04	1.99	1.94	1.89	1.84
65.0	3.04	3.00	2.97	2.94	2.90	2.86	2.83	2.79	2.75	2.71	2.67	2.63	2.59	2.55	2.50	2.46	2.42	2.37	2.32	2.28	2.23	2.18	2.13	2.08	2.03	1.98	1.93
66.0	3.13	3.10	3.06	3.03	2.99	2.96	2.92	2.88	2.84	2.80	2.76	2.72	2.68	2.64	2.60	2.55	2.51	2.46	2.42	2.37	2.32	2.27	2.22	2.17	2.12	2.07	2.02
67.0	3.22	3.19	3.16	3.12	3.09	3.05	3.01	2.97	2.94	2.90	2.86	2.82	2.77	2.73	2.69	2.65	2.60	2.55	2.51	2.46	2.41	2.37	2.32	2.27	2.22	2.16	2.11
68.0	3.32	3.28	3.25	3.22	3.18	3.14	3.11	3.07	3.03	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.69	2.65	2.60	2.56	2.51	2.46	2.41	2.36	2.31	2.26	2.21
69.0	3.41	3.38	3.35	3.31	3.28	3.24	3.20	3.16	3.13	3.09	3.05	3.01	2.96	2.92	2.88	2.84	2.79	2.75	2.70	2.65	2.60	2.56	2.51	2.46	2.41	2.35	2.30
70.0	3.51	3.48	3.44	3.41	3.37	3.34	3.30	3.26	3.22	3.18	3.14	3.10	3.06	3.02	2.98	2.93	2.89	2.84	2.80	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40
71.0	3.61	3.58	3.54	3.51	3.47	3.44	3.40	3.36	3.32	3.28	3.24	3.20	3.16	3.12	3.08	3.03	2.99	2.94	2.90	2.85	2.80	2.75	2.70	2.65	2.60	2.55	2.50
72.0	3.71	3.68	3.64	3.61	3.57	3.54	3.50	3.46	3.42	3.38	3.34	3.30	3.26	3.22	3.18	3.13	3.09	3.04	3.00	2.95	2.90	2.85	2.80	2.75	2.70	2.65	2.60

Table D–20. LLN for FEV_1 (L)–African-American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	1.63	1.60	1.56	1.53	1.49	1.46	1.42	1.38	1.34	1.30	1.26	1.22	1.18	1.14	1.10	1.05	1.01	0.96	0.92	0.87	0.82	0.77	0.72	0.67	0.62	0.57	0.52
54.0	1.69	1.66	1.62	1.59	1.55	1.52	1.48	1.44	1.40	1.36	1.32	1.28	1.24	1.20	1.16	1.11	1.07	1.02	0.98	0.93	0.88	0.83	0.78	0.73	0.68	0.63	0.58
55.0	1.75	1.72	1.68	1.65	1.61	1.58	1.54	1.50	1.46	1.42	1.38	1.34	1.30	1.26	1.22	1.17	1.13	1.08	1.04	0.99	0.94	0.89	0.84	0.79	0.74	0.69	0.64
56.0	1.81	1.78	1.74	1.71	1.67	1.64	1.60	1.56	1.52	1.48	1.44	1.40	1.36	1.32	1.28	1.23	1.19	1.14	1.10	1.05	1.00	0.95	0.90	0.85	0.80	0.75	0.70
57.0	1.87	1.84	1.81	1.77	1.74	1.70	1.66	1.62	1.59	1.55	1.51	1.47	1.42	1.38	1.34	1.30	1.25	1.21	1.16	1.11	1.06	1.02	0.97	0.92	0.87	0.81	0.76
58.0	1.94	1.90	1.87	1.83	1.80	1.76	1.73	1.69	1.65	1.61	1.57	1.53	1.49	1.45	1.40	1.36	1.31	1.27	1.22	1.18	1.13	1.08	1.03	0.98	0.93	0.88	0.82
59.0	2.00	1.97	1.93	1.90	1.86	1.83	1.79	1.75	1.71	1.67	1.63	1.59	1.55	1.51	1.47	1.42	1.38	1.33	1.29	1.24	1.19	1.14	1.09	1.04	0.99	0.94	0.89
60.0	2.07	2.03	2.00	1.96	1.93	1.89	1.86	1.82	1.78	1.74	1.70	1.66	1.62	1.58	1.53	1.49	1.44	1.40	1.35	1.31	1.26	1.21	1.16	1.11	1.06	1.01	0.95
61.0	2.13	2.10	2.07	2.03	2.00	1.96	1.92	1.88	1.85	1.81	1.77	1.73	1.68	1.64	1.60	1.56	1.51	1.47	1.42	1.37	1.32	1.28	1.23	1.18	1.13	1.07	1.02
62.0	2.20	2.17	2.13	2.10	2.06	2.03	1.99	1.95	1.91	1.88	1.84	1.79	1.75	1.71	1.67	1.62	1.58	1.53	1.49	1.44	1.39	1.34	1.29	1.24	1.19	1.14	1.09
63.0	2.27	2.24	2.20	2.17	2.13	2.10	2.06	2.02	1.98	1.94	1.90	1.86	1.82	1.78	1.74	1.69	1.65	1.60	1.56	1.51	1.46	1.41	1.36	1.31	1.26	1.21	1.16
64.0	2.34	2.31	2.27	2.24	2.20	2.17	2.13	2.09	2.05	2.01	1.97	1.93	1.89	1.85	1.81	1.76	1.72	1.67	1.63	1.58	1.53	1.48	1.43	1.38	1.33	1.28	1.23
65.0	2.41	2.38	2.34	2.31	2.27	2.24	2.20	2.16	2.12	2.09	2.05	2.00	1.96	1.92	1.88	1.83	1.79	1.74	1.70	1.65	1.60	1.55	1.50	1.45	1.40	1.35	1.30
66.0	2.48	2.45	2.42	2.38	2.35	2.31	2.27	2.24	2.20	2.16	2.12	2.08	2.04	1.99	1.95	1.91	1.86	1.82	1.77	1.72	1.67	1.63	1.58	1.53	1.48	1.42	1.37
67.0	2.56	2.52	2.49	2.45	2.42	2.38	2.35	2.31	2.27	2.23	2.19	2.15	2.11	2.07	2.02	1.98	1.93	1.89	1.84	1.80	1.75	1.70	1.65	1.60	1.55	1.50	1.44
68.0	2.63	2.60	2.56	2.53	2.49	2.46	2.42	2.38	2.34	2.31	2.27	2.22	2.18	2.14	2.10	2.05	2.01	1.96	1.92	1.87	1.82	1.77	1.72	1.67	1.62	1.57	1.52
69.0	2.71	2.67	2.64	2.60	2.57	2.53	2.50	2.46	2.42	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.08	2.04	1.99	1.95	1.90	1.85	1.80	1.75	1.70	1.65	1.59
70.0	2.78	2.75	2.72	2.68	2.65	2.61	2.57	2.54	2.50	2.46	2.42	2.38	2.33	2.29	2.25	2.21	2.16	2.12	2.07	2.02	1.97	1.93	1.88	1.83	1.78	1.72	1.67
71.0	2.86	2.83	2.79	2.76	2.72	2.69	2.65	2.61	2.57	2.54	2.50	2.45	2.41	2.37	2.33	2.28	2.24	2.19	2.15	2.10	2.05	2.00	1.95	1.90	1.85	1.80	1.75
72.0	2.94	2.91	2.87	2.84	2.80	2.77	2.73	2.69	2.65	2.61	2.57	2.53	2.49	2.45	2.41	2.36	2.32	2.27	2.23	2.18	2.13	2.08	2.03	1.98	1.93	1.88	1.83

Table D–21. Predicted FVC (L)–Mexican American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.68	2.67	2.66	2.64	2.62	2.60	2.58	2.56	2.53	2.51	2.48	2.45	2.41	2.38	2.34	2.30	2.26	2.22	2.18	2.13	2.08	2.03	1.98	1.93	1.87	1.82	1.76
54.0	2.78	2.77	2.75	2.74	2.72	2.70	2.68	2.66	2.63	2.60	2.58	2.54	2.51	2.48	2.44	2.40	2.36	2.32	2.28	2.23	2.18	2.13	2.08	2.03	1.97	1.91	1.85
55.0	2.88	2.87	2.85	2.84	2.82	2.80	2.78	2.76	2.73	2.70	2.68	2.64	2.61	2.58	2.54	2.50	2.46	2.42	2.38	2.33	2.28	2.23	2.18	2.13	2.07	2.01	1.95
56.0	2.98	2.97	2.96	2.94	2.92	2.90	2.88	2.86	2.83	2.81	2.78	2.75	2.71	2.68	2.64	2.60	2.56	2.52	2.48	2.43	2.38	2.33	2.28	2.23	2.17	2.12	2.06
57.0	3.09	3.07	3.06	3.04	3.03	3.01	2.99	2.96	2.94	2.91	2.88	2.85	2.82	2.78	2.75	2.71	2.67	2.63	2.58	2.54	2.49	2.44	2.39	2.33	2.28	2.22	2.16
58.0	3.19	3.18	3.17	3.15	3.13	3.11	3.09	3.07	3.04	3.02	2.99	2.96	2.92	2.89	2.85	2.81	2.77	2.73	2.69	2.64	2.59	2.54	2.49	2.44	2.38	2.33	2.27
59.0	3.30	3.29	3.27	3.26	3.24	3.22	3.20	3.18	3.15	3.12	3.09	3.06	3.03	3.00	2.96	2.92	2.88	2.84	2.80	2.75	2.70	2.65	2.60	2.55	2.49	2.43	2.37
60.0	3.41	3.40	3.38	3.37	3.35	3.33	3.31	3.29	3.26	3.23	3.20	3.17	3.14	3.11	3.07	3.03	2.99	2.95	2.90	2.86	2.81	2.76	2.71	2.66	2.60	2.54	2.48
61.0	3.52	3.51	3.49	3.48	3.46	3.44	3.42	3.40	3.37	3.34	3.32	3.28	3.25	3.22	3.18	3.14	3.10	3.06	3.02	2.97	2.92	2.87	2.82	2.77	2.71	2.65	2.59
62.0	3.63	3.62	3.61	3.59	3.57	3.55	3.53	3.51	3.48	3.46	3.43	3.40	3.36	3.33	3.29	3.26	3.22	3.17	3.13	3.08	3.03	2.99	2.93	2.88	2.82	2.77	2.71
63.0	3.75	3.74	3.72	3.71	3.69	3.67	3.65	3.62	3.60	3.57	3.54	3.51	3.48	3.45	3.41	3.37	3.33	3.29	3.24	3.20	3.15	3.10	3.05	2.99	2.94	2.88	2.82
64.0	3.86	3.85	3.84	3.82	3.81	3.79	3.76	3.74	3.72	3.69	3.66	3.63	3.60	3.56	3.53	3.49	3.45	3.40	3.36	3.31	3.27	3.22	3.16	3.11	3.06	3.00	2.94
65.0	3.98	3.97	3.96	3.94	3.92	3.90	3.88	3.86	3.83	3.81	3.78	3.75	3.72	3.68	3.64	3.61	3.57	3.52	3.48	3.43	3.38	3.34	3.28	3.23	3.17	3.12	3.06
66.0	4.10	4.09	4.08	4.06	4.04	4.02	4.00	3.98	3.95	3.93	3.90	3.87	3.84	3.80	3.76	3.73	3.69	3.64	3.60	3.55	3.51	3.46	3.40	3.35	3.29	3.24	3.18
67.0	4.23	4.21	4.20	4.18	4.17	4.15	4.13	4.10	4.08	4.05	4.02	3.99	3.96	3.92	3.89	3.85	3.81	3.77	3.72	3.68	3.63	3.58	3.53	3.47	3.42	3.36	3.30
68.0	4.35	4.34	4.32	4.31	4.29	4.27	4.25	4.23	4.20	4.17	4.15	4.11	4.08	4.05	4.01	3.97	3.93	3.89	3.85	3.80	3.75	3.70	3.65	3.60	3.54	3.48	3.42
69.0	4.48	4.46	4.45	4.43	4.42	4.40	4.38	4.35	4.33	4.30	4.27	4.24	4.21	4.17	4.14	4.10	4.06	4.02	3.97	3.93	3.88	3.83	3.78	3.72	3.67	3.61	3.55

Table D–22. LLN for FVC (L)–Mexican American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.20	2.18	2.17	2.15	2.14	2.12	2.10	2.07	2.05	2.02	1.99	1.96	1.93	1.89	1.86	1.82	1.78	1.74	1.69	1.65	1.60	1.55	1.50	1.44	1.39	1.33	1.27
54.0	2.28	2.26	2.25	2.23	2.22	2.20	2.18	2.15	2.13	2.10	2.07	2.04	2.01	1.97	1.94	1.90	1.86	1.82	1.77	1.73	1.68	1.63	1.58	1.52	1.47	1.41	1.35
55.0	2.36	2.35	2.33	2.32	2.30	2.28	2.26	2.23	2.21	2.18	2.15	2.12	2.09	2.06	2.02	1.98	1.94	1.90	1.85	1.81	1.76	1.71	1.66	1.60	1.55	1.49	1.43
56.0	2.44	2.43	2.41	2.40	2.38	2.36	2.34	2.32	2.29	2.27	2.24	2.21	2.17	2.14	2.10	2.06	2.02	1.98	1.94	1.89	1.84	1.79	1.74	1.69	1.63	1.57	1.52
57.0	2.52	2.51	2.50	2.48	2.47	2.45	2.43	2.40	2.38	2.35	2.32	2.29	2.26	2.22	2.19	2.15	2.11	2.07	2.02	1.97	1.93	1.88	1.83	1.77	1.72	1.66	1.60
58.0	2.61	2.60	2.58	2.57	2.55	2.53	2.51	2.49	2.46	2.44	2.41	2.38	2.34	2.31	2.27	2.23	2.19	2.15	2.11	2.06	2.01	1.96	1.91	1.86	1.80	1.74	1.69
59.0	2.70	2.69	2.67	2.66	2.64	2.62	2.60	2.57	2.55	2.52	2.49	2.46	2.43	2.40	2.36	2.32	2.28	2.24	2.19	2.15	2.10	2.05	2.00	1.95	1.89	1.83	1.77
60.0	2.79	2.77	2.76	2.75	2.73	2.71	2.69	2.66	2.64	2.61	2.58	2.55	2.52	2.48	2.45	2.41	2.37	2.33	2.28	2.24	2.19	2.14	2.09	2.03	1.98	1.92	1.86
61.0	2.88	2.87	2.85	2.84	2.82	2.80	2.78	2.75	2.73	2.70	2.67	2.64	2.61	2.57	2.54	2.50	2.46	2.42	2.37	2.33	2.28	2.23	2.18	2.12	2.07	2.01	1.95
62.0	2.97	2.96	2.94	2.93	2.91	2.89	2.87	2.85	2.82	2.79	2.76	2.73	2.70	2.67	2.63	2.59	2.55	2.51	2.47	2.42	2.37	2.32	2.27	2.22	2.16	2.10	2.04
63.0	3.06	3.05	3.04	3.02	3.00	2.98	2.96	2.94	2.91	2.89	2.86	2.83	2.79	2.76	2.72	2.68	2.64	2.60	2.56	2.51	2.46	2.41	2.36	2.31	2.25	2.20	2.14
64.0	3.16	3.15	3.13	3.12	3.10	3.08	3.06	3.03	3.01	2.98	2.95	2.92	2.89	2.85	2.82	2.78	2.74	2.70	2.65	2.61	2.56	2.51	2.46	2.40	2.35	2.29	2.23
65.0	3.25	3.24	3.23	3.21	3.19	3.17	3.15	3.13	3.11	3.08	3.05	3.02	2.99	2.95	2.91	2.88	2.84	2.79	2.75	2.70	2.66	2.61	2.55	2.50	2.44	2.39	2.33
66.0	3.35	3.34	3.33	3.31	3.29	3.27	3.25	3.23	3.20	3.18	3.15	3.12	3.08	3.05	3.01	2.97	2.93	2.89	2.85	2.80	2.75	2.70	2.65	2.60	2.54	2.49	2.43
67.0	3.45	3.44	3.42	3.41	3.39	3.37	3.35	3.33	3.30	3.28	3.25	3.22	3.18	3.15	3.11	3.07	3.03	2.99	2.95	2.90	2.85	2.80	2.75	2.70	2.64	2.58	2.53
68.0	3.55	3.54	3.53	3.51	3.49	3.47	3.45	3.43	3.40	3.38	3.35	3.32	3.28	3.25	3.21	3.17	3.13	3.09	3.05	3.00	2.95	2.90	2.85	2.80	2.74	2.69	2.63
69.0	3.65	3.64	3.63	3.61	3.59	3.58	3.55	3.53	3.51	3.48	3.45	3.42	3.39	3.35	3.31	3.28	3.24	3.19	3.15	3.10	3.06	3.01	2.95	2.90	2.85	2.79	2.73

Table D–23. Predicted FEV_1 (L)–Mexican American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.41	2.37	2.34	2.31	2.27	2.24	2.20	2.16	2.12	2.08	2.04	2.00	1.96	1.92	1.87	1.83	1.78	1.74	1.69	1.64	1.59	1.54	1.49	1.44	1.39	1.33	1.28
54.0	2.49	2.46	2.43	2.39	2.36	2.32	2.28	2.25	2.21	2.17	2.13	2.09	2.05	2.00	1.96	1.91	1.87	1.82	1.77	1.73	1.68	1.63	1.57	1.52	1.47	1.42	1.36
55.0	2.58	2.54	2.51	2.48	2.44	2.41	2.37	2.33	2.29	2.25	2.21	2.17	2.13	2.09	2.04	2.00	1.95	1.91	1.86	1.81	1.76	1.71	1.66	1.61	1.56	1.50	1.45
56.0	2.66	2.63	2.60	2.56	2.53	2.49	2.46	2.42	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.09	2.04	1.99	1.95	1.90	1.85	1.80	1.75	1.70	1.64	1.59	1.53
57.0	2.75	2.72	2.69	2.65	2.62	2.58	2.55	2.51	2.47	2.43	2.39	2.35	2.31	2.26	2.22	2.17	2.13	2.08	2.03	1.99	1.94	1.89	1.84	1.78	1.73	1.68	1.62
58.0	2.84	2.81	2.78	2.74	2.71	2.67	2.64	2.60	2.56	2.52	2.48	2.44	2.40	2.35	2.31	2.26	2.22	2.17	2.13	2.08	2.03	1.98	1.93	1.87	1.82	1.77	1.71
59.0	2.93	2.90	2.87	2.83	2.80	2.76	2.73	2.69	2.65	2.61	2.57	2.53	2.49	2.45	2.40	2.36	2.31	2.26	2.22	2.17	2.12	2.07	2.02	1.97	1.91	1.86	1.80
60.0	3.03	2.99	2.96	2.93	2.89	2.86	2.82	2.78	2.74	2.71	2.66	2.62	2.58	2.54	2.49	2.45	2.40	2.36	2.31	2.26	2.21	2.16	2.11	2.06	2.01	1.95	1.90
61.0	3.12	3.09	3.06	3.02	2.99	2.95	2.92	2.88	2.84	2.80	2.76	2.72	2.68	2.63	2.59	2.54	2.50	2.45	2.41	2.36	2.31	2.26	2.21	2.15	2.10	2.05	1.99
62.0	3.22	3.19	3.15	3.12	3.08	3.05	3.01	2.97	2.94	2.90	2.86	2.82	2.77	2.73	2.69	2.64	2.60	2.55	2.50	2.45	2.40	2.35	2.30	2.25	2.20	2.14	2.09
63.0	3.32	3.28	3.25	3.22	3.18	3.15	3.11	3.07	3.03	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.69	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	2.24	2.19
64.0	3.42	3.38	3.35	3.32	3.28	3.25	3.21	3.17	3.13	3.09	3.05	3.01	2.97	2.93	2.88	2.84	2.79	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.39	2.34	2.29
65.0	3.52	3.49	3.45	3.42	3.38	3.35	3.31	3.27	3.23	3.20	3.16	3.11	3.07	3.03	2.98	2.94	2.89	2.85	2.80	2.75	2.70	2.65	2.60	2.55	2.50	2.44	2.39
66.0	3.62	3.59	3.55	3.52	3.49	3.45	3.41	3.38	3.34	3.30	3.26	3.22	3.17	3.13	3.09	3.04	3.00	2.95	2.90	2.85	2.81	2.75	2.70	2.65	2.60	2.55	2.49
67.0	3.72	3.69	3.66	3.63	3.59	3.55	3.52	3.48	3.44	3.40	3.36	3.32	3.28	3.24	3.19	3.15	3.10	3.05	3.01	2.96	2.91	2.86	2.81	2.76	2.70	2.65	2.59
68.0	3.83	3.80	3.76	3.73	3.70	3.66	3.62	3.59	3.55	3.51	3.47	3.43	3.38	3.34	3.30	3.25	3.21	3.16	3.11	3.06	3.02	2.97	2.91	2.86	2.81	2.76	2.70
69.0	3.94	3.91	3.87	3.84	3.80	3.77	3.73	3.69	3.65	3.62	3.58	3.53	3.49	3.45	3.41	3.36	3.31	3.27	3.22	3.17	3.12	3.07	3.02	2.97	2.92	2.86	2.81

Table D–24. LLN for FEV_1 (L)–Mexican-American females–NHANES III

Height (Inches)	Age																										
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
53.0	2.00	1.96	1.93	1.90	1.86	1.83	1.79	1.75	1.71	1.67	1.63	1.59	1.55	1.51	1.46	1.42	1.37	1.33	1.28	1.23	1.18	1.13	1.08	1.03	0.98	0.92	0.87
54.0	2.06	2.03	2.00	1.97	1.93	1.90	1.86	1.82	1.78	1.74	1.70	1.66	1.62	1.58	1.53	1.49	1.44	1.40	1.35	1.30	1.25	1.20	1.15	1.10	1.04	0.99	0.94
55.0	2.13	2.10	2.07	2.04	2.00	1.96	1.93	1.89	1.85	1.81	1.77	1.73	1.69	1.65	1.60	1.56	1.51	1.46	1.42	1.37	1.32	1.27	1.22	1.17	1.11	1.06	1.00
56.0	2.21	2.17	2.14	2.11	2.07	2.04	2.00	1.96	1.92	1.88	1.84	1.80	1.76	1.72	1.67	1.63	1.58	1.54	1.49	1.44	1.39	1.34	1.29	1.24	1.18	1.13	1.08
57.0	2.28	2.25	2.21	2.18	2.14	2.11	2.07	2.03	1.99	1.96	1.92	1.87	1.83	1.79	1.74	1.70	1.65	1.61	1.56	1.51	1.46	1.41	1.36	1.31	1.26	1.20	1.15
58.0	2.35	2.32	2.29	2.25	2.22	2.18	2.14	2.11	2.07	2.03	1.99	1.95	1.91	1.86	1.82	1.77	1.73	1.68	1.63	1.59	1.54	1.49	1.43	1.38	1.33	1.28	1.22
59.0	2.43	2.39	2.36	2.33	2.29	2.26	2.22	2.18	2.14	2.10	2.06	2.02	1.98	1.94	1.89	1.85	1.80	1.76	1.71	1.66	1.61	1.56	1.51	1.46	1.40	1.35	1.30
60.0	2.50	2.47	2.44	2.40	2.37	2.33	2.29	2.26	2.22	2.18	2.14	2.10	2.06	2.01	1.97	1.92	1.88	1.83	1.78	1.74	1.69	1.64	1.59	1.53	1.48	1.43	1.37
61.0	2.58	2.55	2.51	2.48	2.44	2.41	2.37	2.33	2.30	2.26	2.22	2.18	2.13	2.09	2.05	2.00	1.96	1.91	1.86	1.81	1.76	1.71	1.66	1.61	1.56	1.50	1.45
62.0	2.66	2.62	2.59	2.56	2.52	2.49	2.45	2.41	2.37	2.34	2.29	2.25	2.21	2.17	2.12	2.08	2.03	1.99	1.94	1.89	1.84	1.79	1.74	1.69	1.64	1.58	1.53
63.0	2.74	2.70	2.67	2.64	2.60	2.57	2.53	2.49	2.45	2.41	2.37	2.33	2.29	2.25	2.20	2.16	2.11	2.07	2.02	1.97	1.92	1.87	1.82	1.77	1.72	1.66	1.61
64.0	2.82	2.79	2.75	2.72	2.68	2.65	2.61	2.57	2.54	2.50	2.46	2.41	2.37	2.33	2.29	2.24	2.19	2.15	2.10	2.05	2.00	1.95	1.90	1.85	1.80	1.74	1.69
65.0	2.90	2.87	2.83	2.80	2.77	2.73	2.69	2.66	2.62	2.58	2.54	2.50	2.45	2.41	2.37	2.32	2.28	2.23	2.18	2.13	2.09	2.04	1.98	1.93	1.88	1.83	1.77
66.0	2.98	2.95	2.92	2.88	2.85	2.81	2.78	2.74	2.70	2.66	2.62	2.58	2.54	2.50	2.45	2.41	2.36	2.31	2.27	2.22	2.17	2.12	2.07	2.02	1.96	1.91	1.85
67.0	3.07	3.04	3.00	2.97	2.93	2.90	2.86	2.82	2.79	2.75	2.71	2.67	2.62	2.58	2.54	2.49	2.45	2.40	2.35	2.30	2.25	2.20	2.15	2.10	2.05	1.99	1.94
68.0	3.15	3.12	3.09	3.06	3.02	2.98	2.95	2.91	2.87	2.83	2.79	2.75	2.71	2.67	2.62	2.58	2.53	2.49	2.44	2.39	2.34	2.29	2.24	2.19	2.13	2.08	2.03
69.0	3.24	3.21	3.18	3.14	3.11	3.07	3.04	3.00	2.96	2.92	2.88	2.84	2.80	2.75	2.71	2.66	2.62	2.57	2.53	2.48	2.43	2.38	2.33	2.27	2.22	2.17	2.11

APPENDIX E

RESPIRATORY USE TEST PROCEDURE EXAMPLE

E–1. Purpose.

a. This test is performed when there are questions or concerns regarding an individual's ability to perform required functions while wearing PPE. These questions or concerns may arise during a review of the OSHA Respirator Medical Evaluation Questionnaire, a physical exam, fit testing, or concerns raised by the employee or the supervisor. The test results can be used in support of Americans with Disabilities Act (ADA) concerns.

b. Individuals with significant cardiovascular history (exertional angina, history of tachy- or brady-dysrythmias, recent myocardial infarction or electrocardiogram (EKG) changes, age-indeterminant) may be most appropriately referred to a cardiologist for an exercise tolerance test (treadmill). Individuals with severe obstructive or restrictive defects on screening spirometry (that is, less than 60 percent predicted FVC, FEV_1, or FEV_1%), chronic bronchitis, claustrophobia, panic attacks, or a history of respirator intolerance may be candidates for a use test in which the individual's ability to perform his or her usual duties while wearing a respirator and/or other associated PPE is evaluated.

E–2. Indications and Scope. The intent of the use test is to simulate conditions the employee will experience during usual work conditions. For example, to test an employee's ability to tolerate the use of a powered air-purifying respirator under normal evacuation conditions, the employee is asked to walk, while wearing an escape respirator, to a specified location at the pace at which an evacuation would occur. If an employee is required to climb 6 flights of stairs carrying 50 pounds while wearing a mask, a test scenario will be developed that is an appropriate representation of the tasks the employee would be expected to perform under normal working conditions. When planning the test, consider extreme heat conditions. A use test may be indicated for, but not limited to, the following:

a. Claustrophobia.

b. Exertional dyspnea.

c. Return to work following short-term illnesses, such as pneumonia or acute asthma attacks.

d. History of seasonal rhinitis, hay fever, cold-induced bronchospasm, or other conditions for which the patient routinely requires inhaled bronchodilators or steroids.

e. Incidents where difficulty with respiratory PPE is observed.

f. Recurrent heat illnesses.

E–3. Procedure.

a. Develop a test scenario based on job description; discuss with supervisor and employee. Use DA 7761, Employee Monitoring Data Sheet, to record the data relevant to the test, as described in the paragraphs that follow.

b. Obtain resting vital signs, including blood pressure, heart rate, respiratory rate, and oxygen saturation percentage. Record the results in the pre-test data section of DA 7761.

c. Describe the specifics of the procedure to the employee: the work pace to be maintained, the distance covered, the approximate length of time to complete the test, the tasks to be completed, and the monitoring devices to be used.

d. Instruct the employee to report any symptoms that may develop during the physical and psychological stress of the procedure to the evaluator at the earliest recognition. Record any reported symptoms on DA 7761. Such symptoms include, but are not limited to—

(1) Chest pain.

(2) Moderate to severe chest tightness or pressure.

(3) Nausea.

(4) Extreme leg fatigue.

(5) Wheezing.

(6) Lightheadedness.

(7) Dizziness.

(8) Shortness of breath.

(9) Near-syncopal feeling.

(10) Heart irregularity.

(11) Panic feeling.

e. Calculate the 80 percent maximum heart rate (MHR) for the employee using the equation (220 − age) x 0.8 **or** 180 − age = MHR. Develop "stop test" criteria for oxygen saturation, blood pressure, heart rate, and respirator intolerance or distress. Recommendations would include an in-test blood pressure (BP) of 160/100 or a 10-percent decrement on oxygen saturation (SaO_2) levels. Testing is not recommended if the employee's BP is $\geq$ 140/90.

f. Apply the blood pressure cuff and the pulse oximeter, and leave them in place for continuous monitoring during the course of the test.

g. The employee dons the respirator, and the test begins. The evaluator accompanies the employee during the entire test. Even though the employee is instructed to alert the evaluator if any adverse symptoms develop, it is recommended that the evaluator ask the employee how he/she is doing every few minutes. The evaluator observes the employee for any signs that he/she is struggling to continue, such as a stumbling gait, labored breathing, confusion, agitation, or a look of anguish.

h. Observe the pulse oximeter for the employee's maximal heart rate on level surfaces as well as on inclines or stairs. Determine how quickly the heart rate drops when the employee reaches a level walking surface or stops. This will provide an approximate level of the employee's physical conditioning. In general, do not allow the employee to exceed 80 percent of his/her maximal heart rate for more than 10 minutes, even in the absence of adverse symptoms. Record the physiological monitoring data on DA 7761.

i. Terminate the test if the employee develops any adverse symptoms or if the employee's maximal heart rate remains at 80 percent or greater for 10 minutes.

j. It is generally advisable for the employee stop the exercise by slowing his/her pace to a leisurely stroll to prevent the occurrence of syncope/orthostatic episodes. This is especially true for employees aged 55 and older.

k. In the event a medical emergency should arise, initiate first responder care and summon an ambulance immediately.

l. When the test is complete, instruct the employee to walk slowly to prevent orthostasis. Measure the employee's vital signs, and document his/her subjective feeling of well-being.

m. An individual who performs well and develops no symptoms demonstrates a negative test. Stopping the test for medical considerations constitutes a positive test.

n. Discard the tubing after each patient, or disinfect the tubing with a 2-percent gluteraldehyde solution for 20-45 minutes.

E–4. Documentation.

a. All test records, including the Employee Monitoring Data Sheet (DA 7761) and a statement of clearance or restriction for the specific activity being tested (DA 7760, Medical Clinic Clearance for Respirator Use) will become a permanent part of the employee's medical record.

b. The employee's supervisor will be advised of the employee's test results.

GLOSSARY

Section I.
Acronyms and Abbreviations

ACGIH
American Conference of Governmental Industrial Hygienists

ACOEM
American College of Occupational and Environmental Medicine

AR
Army regulation

ATS
American Thoracic Society

BP
Blood pressure

CFR
Code of Federal Regulations

cm
centimeter

CPAC
Civilian Personnel Advisory Center

DA
Department of the Army

DOD
Department of Defense

DOEHRS–IH
Defense Occupational and Environmental Health Readiness System–Industrial Hygiene

ERS
European Respiratory Society

FEV_1
forced expiratory volume in 1 second

FVC
forced vital capacity

JOEM
Journal of Occupational and Environmental Medicine *(J Occup Environ Med)*

L
liter

LLN
lower limit of normality

L/m
liters per minute

MEDCEN
medical center

MEDCOM
U.S. Army Medical Command

MEDDAC
Medical Department Activity

MHR
maximum heart rate

mL
milliliter

mm
millimeter

MOS
military occupational specialty

MTF
medical treatment facility

NIOSH
National Institute of Occupational Safety and Health

obs
observed

OSHA
Occupational Safety and Health Administration

PEL
permissible exposure limit

ppm
parts per million

pred
predicted

REL
recommended exposure limit

SCBA
self-contained breathing apparatus

SEG
similar exposure group

SOP
standing operating procedure

THANES III
Third National Health and Nutrition Examination Survey

TLV
threshold limit value

VC
vital capacity

By Order of the Secretary of the Army:

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