New Spirometry and Interpretation Practices

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Conflict of Interest

- Member of a working group (Chest, ATS, CTS, and AARC) that is developing a research statement based upon the evidence and gaps for the use of race/ethnicity in interpreting PFTs

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  - Professor, Cardiopulmonary Sciences
    - Rush University
    - Chicago, IL
LEARNING OBJECTIVES

After completion of this presentation, the learner will be able to:

01 Describe the recent changes to the 2019 ATS/ERS technical standards for conducting spirometry tests.

02 Interpret whether spirometry results are normal or if there is bronchodilator responsiveness according to the 2021 ERS/ATS technical standards.

03 Identify issues that result when race and ethnicity are used to predict normal values for lung function tests.

(Slow) Vital Capacity (VC)

Forced Vital Capacity (FVC)
Assesses: Airflow limitation (obstructive pattern)
- $\text{FEV}_1/\text{VC} < \text{LLN}$
ATS/ERJ Acceptability Criteria

Must have BEV \leq 5\% of FVC or 0.100 L, whichever is greater
Must have no evidence of a faulty zero-flow setting
Must have no cough in the first second of expiration*
Must have no glottic closure in the first second of expiration*
Must have no glottic closure after 1 s of expiration
Must achieve one of these three EOFE indicators:
1. Expiratory plateau (\leq 0.025 L in the last 1 s of expiration)
2. Expiratory time \geq 15 s
3. FVC is within the repeatability tolerance of or is greater than
   the largest prior observed FVC
Must have no evidence of obstructed mouthpiece or spirometer
Must have no evidence of a leak
If the maximal inspiration after EOFE is greater than FVC, then
   FIVC - FVC must be \leq 0.100 L or 5\% of FVC, whichever is
greater


Examples BEV

BEV \leq 5\% of the FVC or 0.100 L
• Whichever is greater

Absence of Glottic Closure

FVC = 3.20 L  \[\rightarrow\]  FVC = 3.69 L

Glottic closure

Normal

End of Forced Exhalation Criteria (EOFE)

Must achieve one of these three EOFE indicators:
1. Expiratory plateau ($\leq 0.025$ L in the last 1 s of expiration)
2. Expiratory time $\geq 15$ s
3. FVC is within the repeatability tolerance of or is greater than the largest prior observed FVC†

Blocked Mouthpiece

Leak

If the maximal inspiration after EOFE is greater than FVC, then FIVC – FVC must be \( \leq 0.100 \) L or 5% of FVC, whichever is greater.

FIVC = 3.49 L
FVC = 3.32 L
5% of 3.32 L = 0.17 L

Interpretation Bronchodilator Responsiveness

\[
\text{Bronchodilator Response} = \left( \frac{\text{Post–bronchodilator value (L)} - \text{Pre–bronchodilator value (L)}}{\text{Predicted value (L)}} \right) \times 100
\]

A change of >10% is considered a significant BDR response.

#Predicted value should be determined using the appropriate GLI spirometry equation.

FVC Assessment: \( \frac{(3.35 - 2.90) \times 100}{3.12} = 14.4\% \)

FEV\textsubscript{1} Assessment: \( \frac{(2.52 - 1.72) \times 100}{2.46} = 32.5\% \)

Use LLN for Accurate Measure of Predicted Normal

If you use 80% predicted for older populations:
• Exclude values in the 95% CI (normal) that fall below 80% predicted
  • Incorrectly diagnose patients with obstruction

Younger population
• More measures
• Less variability

Older population
• Fewer measures
• More variability

What is Normal?

• 80-120% of predicted normal value
  • Less accurate
  • Strongly discouraged

• 95% confidence intervals are more accurate
  • Lower limit of normal (LLN)
    • 5th percentile
  • Upper limit of normal (ULN)
    • 95th percentile

Clearly document LLN on PFT report
When results are close to the LLN, consider the person’s:
• Medical history
• Physical findings
• Pre-test probability of disease

Stanojevic 2021, ERS/ATS Technical Standard on Interpretive Strategies for Routine Lung Function Tests, *Eur Respir J.*
**Z – Scores**

\[ z = \frac{x - \mu}{\sigma} \]

*Z* = standardized score (z-score)

\( x \) = patient's value

\( \mu \) = mean of the sample

\( \sigma \) = standard deviation of the sample

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**Practice Interpreting Z-scores**

<table>
<thead>
<tr>
<th>SPIROMETRY</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best</td>
<td>LLN</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>3.90</td>
<td>3.70</td>
</tr>
<tr>
<td>FEV₁ (L)</td>
<td>2.02</td>
<td>2.91</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>0.52</td>
<td>0.68</td>
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<tr>
<td>FET (s)</td>
<td>10.3</td>
<td></td>
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</tbody>
</table>

Reference values: GLI 2012 Test quality; Pre: FEV₁ - A, FVC - A; Post: FEV₁ - A, FVC - B

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What Influences Variation?

Spirometry Factors

- Age
- Sex (birth)
- Height/Arm span
- Race or ethnic origin
- Weight
  
  *Not used in prediction equation, but does affect variation*

Differ for each pulmonary function test
Are the findings based upon robust evidence and statistical analyses?

### Spirometry Differences between African Americans and Whites

<table>
<thead>
<tr>
<th>Citation</th>
<th>Age Group</th>
<th>Sample Size</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hankinson et al., 2010, CHEST</td>
<td>45-84 y</td>
<td>1068</td>
<td>Adjustment for African Americans:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• NHANES III = 0.85</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• MESA – Lung Study = .81</td>
</tr>
<tr>
<td>Burney &amp; Hooper, 2012, Int J Epidemiol</td>
<td>45-64 y</td>
<td>7489</td>
<td>Sex</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
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<td>Female</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Female</td>
</tr>
<tr>
<td>Quanjer et al, 2012, Eur Respir J</td>
<td>2.5 – 95 y</td>
<td>2545 (AA)</td>
<td>Adjustment for African Americans compared to White:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FVC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FEV₁</td>
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</table>
Validity and Reliability

Race is a socially constructed term
- May mask modifiable risk factors
- Nutrition and premature birth\(^6,8,9\)
- Pollution and environment\(^6,8-12\)
- Socioeconomic\(^6-9, 13\)
  - Education\(^6,9,12\)
  - Poverty\(^6, 9, 11\)
  - Inequalities in access to medical care\(^11, 13\)

Accuracy of measurement
- No established relationship between race and biology\(^14\)
- Race is a broad and less precise term
  - Genetic testing for ancestry is more precise\(^15\)
  - “Island” categorization of race\(^14\)
- Race/ethnicity is not fixed/unchangeable identity\(^16\)
  - Affiliate with multiple categories
  - Personal identities evolve over time
- Self-report vs. measured ancestry
  - An individual may have a complex genetic ancestry
  - Self-report is a poor predictor of genetic ancestry\(^17\)
- Multicultural or multiracial backgrounds
- 3965 MESA participants who underwent genetic analysis\(^18\)
- Computed reference equations (sex, age, and height)
  - Race specific
  - Full sample
    - Lose precision with race-specific equations
    - Had 1/3 higher confidence intervals
- Immigrants and acculturation


Race in the Spirometry Literature

Study characteristics
- Definition of race/ethnicity
  - Across entire sample, 39 (17.3%) had definitions
  - Beginning in 2000, 70% of studies with parallel controls had definitions
- Only 6.1% examined socioeconomic status
- Reasons for nonwhites to have lower volumes
  - 29.4% anthropometric differences
  - 23.1% environmental differences
  - 21.8% inherent differences
  - 24.3% no explanation
- 59.3% of studies had sample sizes 100-999

Reporting Race
- Provide rationale for using race
  - Self-identify/chart review
  - No consensus on categories
  - Open-ended question/fixed categories\(^16\)
  - Aggregating data

Historical Explanations
- Implied inferiority

Currently
- Unexplained\(^6\)
- Consider all relevant factors\(^16\)

- Systematic review comparing race (white to others)
  - \(N = 226\) articles
  - Published between 1922-2008
Value #2

Consider if race-adjustment would relieve or exacerbate health inequities

Clinical Decisions

**Diagnosis**
Consider the clinical picture in addition to diagnostic testing results
- The ratio (FEV₁/FVC) is not affected\(^6, 19\)
- An important concern in restrictive conditions\(^8\)
  - *Make the diagnosis on other variables*\(^20\)
  - Issues more prominent when values are near threshold\(^9\)

**Prognosis (mortality)**
Do **not** race-adjust FVC\(^20\)
- Consider the functional role of VC
  - The absolute value of VC is critical for survival

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\(^6\) Vyas et al, 2020, *Hidden in Plain Sight – Reconsidering the Use of Race Correction in Clinical Algorithms, NEJM*

\(^13\) Vyas et al, 2020, *Hidden in Plain Sight – Reconsidering the Use of Race Correction in Clinical Algorithms, NEJM*

\(^8\) Borrell et al, 2021, *NEJM*

Underestimate impairment
- Reduce probability of treatment/compensation

Overestimate impairment
- Unnecessary testing
- Higher life-insurance premiums
- Ineligible for certain professions
- Withhold certain treatments
- Anxiety
- Inclusion in clinical trials
Occupational Health: 1978 Cotton Dust Standards

The standard specifies that the predicted FEV₁ and FVC for blacks should be multiplied by 0.85 to adjust for ethnic differences. Comparative studies in general show the vital capacity of black workers to be about 15 percent less than that of white workers (Ex. 1, pp. 131–3). In the proposal, OSHA requested information on formulas which should be used for evaluating results of pulmonary function among ethnic groups in order to provide proper interpretation of spirometry measurements for blacks without inadvertently fostering discrimination in hiring practices. NIOSH ad-


Value #3

Evaluate plausible causal mechanisms

Vyas et al, 2020, Hidden in Plain Sight – Reconsidering the Use of Race Correction in Clinical Algorithms, NEJM
Epidemiology Research on Disparities

**Target Needs**
Explore how social and physical environments influence lung function\(^9,10\)

**Collect Race Data**
Ignoring race counterproductive\(^15\)
- Promotes inequity
- Limits opportunities for societal interventions

**Interpretation**
Do not use race-adjusted values\(^20\)
- Masks potential social and environmental disadvantage\(^20,21\)
- Interpret racial disparities as injustices to solve vs. simple facts

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**Differential Approach to Race**
- Epidemiologic analysis vs. clinical guidelines

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**Next Steps**

**Reference Values**
- Consider when and if race/ethnicity adjustment is warranted
- Clinical outcome
- Occupational health
- Epidemiology
- Consider using composite race/ethnicity equations

**Evaluate Use of Race on Outcomes**\(^9\)
- Do race/ethnicity adjustments in PFTs impact clinical outcomes?
- How do PFT results fit into clinical decisions/guidelines?
- What effectively reduces health disparities?

Mindfully consider how we measure, use, and report "race"

*Kaplan & Bennett*. Use of Race and Ethnicity in Biomedical Publication. *JAMA* 2003;289:2709-2716.\(^{16}\)
References

Questions?

We’ll get to as many questions as we can!

Thank you for listening!
We appreciate you being here.

NEXT Webinar:
Long COVID-19: A Fresh Perspective on the Condition & Concerns

April 28, 2022
4:00 PM ET
Visit Allergy & Asthma Network at www.allergyasthanetwork.org

Please remain online for 2 – 3 minutes to complete an evaluation survey!

Thank you!