The recent multi-ethnic global lung initiative 2012 (GLI_{2012}) reference values don’t reflect contemporary adult’s North African spirometry

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Received 25 July 2013; accepted 21 October 2013
Available online 30 October 2013

KEYWORDS
Spirometry;
Reference values;
North Africa;
Caucasian race;
Ethnic groups

Summary
Background: The applicability of the recent multi-ethnic reference equations derived by the ERS Global Lung Initiative (ERS/GLI) in interpreting spirometry data in North African adult subjects has not been studied.
Objective: To ascertain how well the recent ERS/GLI reference equations fit contemporary adult Tunisian spirometric data.
Population and methods: Spirometric data were recorded from 1192 consecutive spirometry procedures in adults aged 18–60 years. Reference values and lower limits of normality (LLN)
were calculated using the local and the ERS/GLI reference equations. **Applied definitions:** large airway obstructive ventilatory defect (LAOVD): FEV1/FVC < LLN. Tendency to a restrictive ventilatory defect (TRVD): FEV1 and FVC < LLN and FEV1/FVC > LLN. The spirometric profile, according to the two reference equations, was determined. Z-scores for spirometry from North African healthy subjects (n = 489) were calculated. If the average Z-score deviated by \( < \pm 0.5 \) from the overall mean, the ERS/GLI reference equations would be considered as reflective of contemporary Tunisian spirometry.

**Results:** Using Tunisian reference equations, 71.31%, 6.71% and 19.04% of spirometry records were interpreted as normal, and as having, LAOVD and TRVD, respectively. Using the ERS/GLI reference equations, these figures were respectively, 85.82%, 4.19% and 8.39%. The mean ± SD Z-scores for the contemporary healthy North African subject’s data were \(-0.55 \pm 0.87\) for FEV1, \(-0.62 \pm 0.86\) for FVC and 0.10 ± 0.73 for FEV1/FVC.

**Conclusion:** The present study don’t recommend the use of the recent ERS/GLI reference equations to interpret spirometry in North African adult population.

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**Abbreviations list**

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<th>Definition</th>
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<td>ATS</td>
<td>American Thoracic Society</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>ECSC</td>
<td>European Community for Steel and Coal</td>
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<tr>
<td>ERS</td>
<td>European Respiratory Society</td>
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<tr>
<td>FET</td>
<td>Forced Expiratory Time</td>
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<tr>
<td>FEV1</td>
<td>First second Forced Expiratory Volume</td>
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<tr>
<td>FVC</td>
<td>Forced Vital Capacity</td>
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<td>GLI</td>
<td>Global Lung Initiative</td>
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<tr>
<td>LAOVD</td>
<td>Large Airway Obstructive Ventilatory Defect</td>
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<tr>
<td>LLN</td>
<td>Lower-Limit-of-Normal</td>
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<td>LOA</td>
<td>Limits Of Agreement</td>
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<td>MVD</td>
<td>Mixed Ventilatory Defect</td>
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<td>NHANES III</td>
<td>National Health and Nutrition Examination Survey</td>
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<td>RVD</td>
<td>Restrictive Ventilatory Defect</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>TRVD</td>
<td>Tendency to Restrictive Ventilatory Defect</td>
</tr>
<tr>
<td>ULN</td>
<td>Upper-Limit-of-Normal</td>
</tr>
<tr>
<td>95%CI</td>
<td>95% Confidence Interval</td>
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</tbody>
</table>

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**Introduction**

Recently, the European Respiratory Society/Global Lung Initiative task force released spirometry reference equations (ERS/GLI2012) derived from data collected from 72031 healthy individuals aged 3–95 years [1]. These global all-age reference equations, encouraged by users and by many international respiratory societies are now implemented by manufacturers of spirometric devices and will be very soon commercialized in North Africa and will replace the local spirometric reference equations (eg, Tunisian (Tunisian1995) specific to subjects aged 18–70 years [2] or Algerian specific to subjects aged 19–77 years [3]). The ERS/GLI2012 equations provided age-, height-, sex-, and ethnic-specific reference equations and Lower-Limit-of-Normal (LLN) for spirometry. The spirometric values of 870 Tunisian older than 45 years [4,5] and 273 Algerian aged 19–73 years [3] were included in the Caucasian group (n = 55428). A major breakthrough was the application of a novel statistical technique (GAMLSS; www.lungfunction.org/files/GAMLSS-in-action.zip) [1]. The American Thoracic Society (ATS) and the ERS [1,6–8] both recommend the use of the fifth centile to define the LLN (i.e., \(-1.64\) Z-scores). Z-scores indicate how many Standard Deviations (SD) a measurement is from its predicted value, with only 5% of healthy subjects having a z-score of \(-1.6445\) or less (fifth percentile). Unlike percentage predicted, Z-scores are free from bias due to age, height, sex and ethnic group, and are therefore particularly useful in defining the LLN and Upper-Limit-of-Normal (ULN); they also simplify uniform interpretation of test results [1].

Studies validating the ERS/GLI2012 equations [1] for general use are important for acceptance. Recently some studies have shown that the ERS/GLI2012 [1] reference equations reflect contemporary Australasian adult’s spirometry [9], and are appropriate for use in children across a wide range of ethnicities [9–11]. In a recent study, limited to Caucasians in the 18–95-year age range; Quanjer et al. [12] have determined the diagnostic and interpretative consequences of adopting the ERS/GLI2012 [1] equations. Their conclusions were that the transition to ERS/GLI2012 equations will lead to limited changes in the predicted values of adults spirometric data and that adopting the ERS/GLI2012 [1] prediction equations will have small effects on the rates of detection of Large Airway Obstructive Ventilatory Defects (LAOVD).

As recommended by the ERS task force [1], more studies are required in non-Caucasians, particularly Arab population, since the ERS/GLI2012 reference equations [1] may not be suitable for use in Tunisian adults’ population. It is important that clinicians are made aware of the potential consequences of adopting these equations [1] for clinical decision making. The present study is designed to assess the impact of applying the ERS/GLI2012 equations for the interpretation of results of routine spirometry performed in Tunisian adults’ population and to ascertain, in a healthy group, how well they fit contemporary Tunisian spirometric data.
Population and methods

Study design

A cross sectional study was performed in the Functional Exploration Laboratory at the Occupational Medicine Group of Sousse (altitude < 100 m), Tunisia. For the present epidemiological study, approval from a hospital Ethics Committee wasn’t needed, because the spirometry was done as a routine exam.

Study population

The target population consisted of a group of subjects aged 18 years old and more, working in Sousse. Subjects were recruited from local workers visiting the Functional Exploration Laboratory. Only subjects aged 18–60 years having a complete record and with technically acceptable and reproducible spirometry maneuvers were included. Detailed information about study population appears in the Supplementary data.

From the workers’ total sample, a "healthy group" was retained according to international recommendations [7,13]. A healthy person was defined as one in whom there was (i) No presence of acute and no past chronic disease of the respiratory system, (ii) No heart disease which may influence the respiratory system, (iii) No more than incidental smoking experience or lifelong non-smokers and (iv) No LAOVD or Mixed Ventilatory Defect (MVD) according to local reference equations [2].

Data collection procedures

Medical data were collected using a simplified medical questionnaire detailed in the Supplementary data.

Two socioeconomic levels were defined according to occupational status: low (e.g. unskilled worker) and high (e.g. skilled worker, farmer and manager).

Cigarette and narghile use were evaluated [14–16]. The subject was qualified as a lifelong non-smoker when the cigarette or narghile use were < five packets-years or < five narghiles-years, respectively, or when the sum of cigarette and narghile use was lower than five [14–16].

The decimal age (accuracy to 0.10 years) was calculated from the date of measurement and the date of birth [17]. Standing height and weight were measured.

Depending on calculated Body Mass Index (BMI, kg m⁻²), subjects were classified as [18]: underweight (BMI < 18.5), normal weight (18.5 ≤ BMI < 25), overweight (25 ≤ BMI < 30) and obesity (BMI ≥ 30).

Spirometry was carried out in the sitting position, and a nose clip was applied. To avoid the problem of variability due to different technicians and devices [19], all tests were performed between 9.00 am and 1.00 pm by only one qualified person. All subjects performed spirometry on a modern equipment [uni-directional digital volume transducer (Micro Medical Limited. PO Box 6, Rochester. Kent ME1 2AZ England)]. The Spida 5 software was used. The flow sensor of the spirometer was calibrated daily with a 3-L syringe, to ensure performance. Spirometry was performed according to the international guidelines [19]. A minimum of three reproducible FVC measurements were obtained [19]. The following data were measured/calculated: Forced Vital Capacity (FVC, l), 1st second Forced Expiratory Volume (FEV1, l), FEV1/FVC ratio and Z-score (without unit).

Applied reference equations and definitions


Tunisian1995 equations [2] were generated from spirometry studies performed on 977 healthy non smoking Tunisian adults, aged 18–70 years. Additional information about Tunisian1995 equations appears in the Supplementary data.


Spirometric data were expressed in absolute values and as a percent of reference values (100 × measured value/reference value) according to Tunisian1995 (%Ref Tunisian1995) and to ERS/GLI2012 (%Ref ERS/GLI2012) equations [1,2]. For Tunisian1995 equations [2], spirometric data LLN were calculated using lower 95% confidence limits derived from the regression equation being used. For ERS/GLI2012 [1], a software calculated reference values, their LLN (5th centiles) and Z-scores for FEV1, FVC and FEV1/FVC and exported the results to a .csv file for manipulation in a spreadsheet.

The definitions used were based on the identification of a LLN for the spirometric parameter in question [6], LAOVD was defined as a "FEV1/FVC ratio < LLN" [6]. Although a true Restrictive Ventilatory Defect (RVD) can be diagnosed only on demonstration of a reduced total lung capacity, a Tendency to RVD (TRVD) was inferred from spirometry results for categorical comparison purposes only. A record with "FEV1 < LLN" and "FVC < LLN" and "FEV1/FVC ≥ LLN" was categorized as having a TRVD [6]. A MVD was defined as the association of a "FEV1/FVC ratio < LLN" and a "FVC < LLN" and a "FEV1 < LLN" [6].

Statistical analysis

The Kolmogorov–Smirnov test was used to analyze variables distribution [20]. When the distribution was normal and the variances were equal, the results were expressed by their means ± SDs and 95% Confidence Interval (95%CIs). If the distribution wasn’t normal, the results were expressed by their medians (1st–3rd quartiles).

The chi-2 test was used to compare percentages. The Student t-test was used to compare anthropometric and spirometric data from the total sample and healthy groups. A non parametric test (Wilcoxon matched pairs test) [20] was used to compare %Ref calculated according to the two reference equations [1,2].

Spirometry profiles (normal, LAOVD, TRVD, MVD) obtained using the two reference equations [1,2] were compared after construction of contingency tables. The proportion of subjects having different interpretations using the two reference equations [1,2] was calculated as a measure of discordance.

To assess how closely the LLNs obtained by the ERS/GLI2012 reference equations [1] matched those obtained by the Tunisian1995 equations [2], the difference between values estimated by the two reference equations was calculated. In order to assess if the values determined by the two reference equations [1,2] could be used...
interchangeably, the Limits Of Agreement (LOA) for each set of them was calculated using the Bland and Altman method [21]. LOA were used for comparison, with individual difference (measured value minus LLN reference value for FEV₁ or FVC) plotted against the corresponding mean value [21]. From these data, LOA were then calculated [mean difference between measured and LLN (FEV₁ or FVC) ± 1.96 SD].

Results

Descriptive data

Among the 3,010 explored subjects, only 1,192 (40%) were retained for analysis.

Fig. 1 exposes the distribution of the total sample according to sex, age and height ranges. Fewer subjects aged <25 years or ≥55 years were included, respectively, 5.9% and 5.4%. Fewer subjects (2.3%) having a height range of 1.43–1.55 cm were included.

Table 1 exposes the characteristics of the total sample and the healthy group. Compared to the healthy group, the total sample was significantly older and taller. The total sample group included a higher percentage of smokers. The two groups included significantly fewer females and obese subjects and higher percentages of subjects having low socioeconomic levels. Compared to the total sample, the healthy group had a significantly higher FEV₁ and FEV₁/FVC.

Analytical data

Comparison of measured spirometric data expressed as a %Ref from the two equations

Means ± SD (95%CI) of FEV₁ and FEV₁/FVC, expressed as %Ref ERS/GLI2012, were significantly higher than those expressed as a %Ref Tunisian1995 [respectively, 90 ± 12% (89–91) vs. 85 ± 12% (85–86) and 99 ± 8% (98–99) vs. 98 ± 8% (98–99)].

Comparisons of the percentages of subjects with spirometric data lower than the LLN range according to the two equations

The percentages of Tunisian subjects having measured spirometric data lower than the LLN ranges were significantly lower with the ERS/GLI2012 equations than those expressed as the %Ref Tunisian1995, respectively, 17% vs. 43% for FEV₁, 14% vs. 22% for FVC and 6% vs. 10% for FEV₁/FVC.

Table 2 exposes the mean bias and LOA for LLN, for FVC and FEV₁ on comparison of ERS/GLI2012 with Tunisian1995 equations: ERS/GLI2012 equations consistently over-predicted LLN for FVC and FEV₁ for males, females and the total sample.

Comparison of spirometry interpretation by the two equations (Table 3)

The main conclusions of Table 3 were:

i. Using Tunisian1995 equations, 71.31%, 6.71%, 19.04% and 2.94% of spirometry records were interpreted as being normal and as having, LAOVD, TRVD and MVD, respectively. Among the 80 LAOVD records and the 227 records according to Tunisian1995 equations, respectively, 33 (41.25%) and 134 (59.03%) records were classified as being normal using the ERS/GLI2012 equations.

ii. Using ERS/GLI2012 equations, 85.82%, 4.19%, 8.39% and 1.59% of spirometry records were interpreted as being normal, and as having, LAOVD, TRVD and MVD, respectively. Among the 1,023 normal records according to ERS/GLI2012 equations, 174 (17.01%) records were classified as being abnormal using the Tunisian1995 equations.

How well did the ERS/GLI2012 equations fit contemporary Tunisian spirometric data?

Mean ± SD Z-scores for the healthy Tunisian group data (n = 489) were −0.55 ± 0.87 (FEV₁), −0.62 ± 0.86 (FVC).
0.10 ± 0.73 (FEV₁/FVC). Only FEV₁/FVC was well within physiologically range considered to be irrelevant (<0.5).

The mean Z-score differences equate to absolute and percent predicted differences of −270 mL and 6.95% for FEV₁, −370 mL and 7.73% for FVC and a difference in FEV₁/FVC of 0.59%.

There were some meaningless weak significant associations between the spirometry Z-scores and age or height. The spirometry Z-scores were not related to sex.

Discussion

The main result of the present study conducted on 1192 adults was that the use of the recent multi-ethnic reference equations leads to misinterpretation of spirometry data in a significant proportion of subjects. The present study results don’t support the use of the ERS/GLI 2012 equations to interpret spirometry in Tunisian population and probably in North Africa population.

Methodology discussion

Study design

One of the main strong points of the present study is its prospective design. Hall et al. [9] study published in 2012, which had the same aims as ours, was a retrospective one, and all spirometry tests were performed in the year 2000 or later. Quanjer et al. [12] study was also a retrospective analysis of routinely obtained data which had been de-identified.

Although, no statistical methods have been used to choose subjects or to calculate their number, the fact that many private or government-owned firms in different areas of Sousse, Tunisia, were included gives a reasonable degree of confidence in the data. The large number (n = 1192) of spirometry records included for analysis ensured adequate representation of all categories of age and height (Fig. 1) allowing confident identification of even small differences without any bias.

One limit of the present study is the fewer number of females (8.7% of the total sample). In fact, the percentage of Tunisian active females is low at almost 27.9% [23].

Population source

The subjects studied herein represent a population that undergoes routine spirometry at a Functional Exploration Laboratory. The relatively higher proportion of normal spirometric records (71.31%) in the current study is explained by the fact that they were included as a record review of employment.

As recommended by some authors [24], though the results from this study can only be strictly applied to a similar population (Mediterranean or North African populations) tested with similar instruments and procedures, the conclusions can perhaps be generalized to other situations, as well, with minor differences.
Detailed discussion about the recruitment mode, the healthy subject definition and spirometry measurements and definitions appears in the Supplementary data.

**Statistical analysis**

The same statistical type of analysis applied in other studies [9,12,24] having the same aims as ours were applied.

**Results discussion**

The accuracy with which spirometry data are interpreted hinges on the appropriateness of the selected reference dataset [6,22]. Errors in interpretation, with respect both to overestimation and underestimation of lung function abnormalities, can occur if inappropriate reference equations are used [6,22].

Can the ERS/GLI 2012 equations be used interchangeably with the Tunisian 1995 equations?

The present study results, revealed large difference and wide confidence limits between ERS/GLI 2012 [1] and Tunisian1995 [2] equations, therefore indicating that the two cannot be used interchangeably. The following hypothesizes have been postulated as contributory factors [1,7,13,19,25–34]: various racial and ethnic groups; differences in body proportions, chest wall anatomy, thorax mechanical properties and parenchyma lung development. The contribution of ethnicity should be more studied, as from a sociological, historical and genealogical standpoint; the populations of Tunisia are made up of people of mainly Arab, Berber, and Turkish descent. It would be in this field interesting to get data from a homogenous Arabic community.

How well did the recent ERS/GLI 2012 equations fit contemporary Tunisian spirometric data?

The ERS/GLI task force has recently noted that data from some regions such as Africa and the Arab World are urgently required [1]. The present study results demonstrate that the recent ERS/GLI 2012 equations [1] aren’t well matched to spirometry outcomes obtained in a contemporary North-African population using modern equipment and in accordance with international spirometry guidelines [19].

As found by Hall et al. [9] (means ± SD Z-scores of FEV₁, FVC and FEV₁/FVC were respectively, 0.23 ± 1.00, 0.23 ± 1.00 and −0.03 ± 0.97), the differences in the mean Z-scores for all measured spirometric data were statistically significant, probably due to the large sample size of the ERS/GLI 2012 study [1]. But in contrast to the Hall et al. study data [9], where means Z-scores for all measured spirometric data were <0.5, in the present study, only FEV₁/FVC mean Z-scores (0.10 ± 0.73) was too small to be of any physiological relevance and is less than the within test variation accepted in spirometry testing. Furthermore, the observed variability (SD of the Z-score) of all of the outcomes was too far from one, indicating a bad overall fit. The present study dataset exhibited a statistically significant offset compared with the ERS/GLI2012 equations [1], which may have lead to an underestimation of the LLN. In fact, using FEV₁ as an example, the measured offset of −0.55 Z-scores equated to a mean difference of -270 mL or 6.95% predicted, which a clinically significant difference

### Table 2

<table>
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<th>Males</th>
<th>Females</th>
<th>Total sample</th>
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<tr>
<td>Tunisian1995</td>
<td></td>
<td></td>
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<tr>
<td>FVC (L)</td>
<td>0.43</td>
<td>0.56</td>
<td>0.46</td>
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<tr>
<td>FEV₁ (L)</td>
<td>0.06</td>
<td>0.43</td>
<td>0.33</td>
</tr>
<tr>
<td>ERS/GLI2012</td>
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<td></td>
<td></td>
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<tr>
<td>FVC (L)</td>
<td>0.56</td>
<td>0.45</td>
<td>0.51</td>
</tr>
<tr>
<td>FEV₁ (L)</td>
<td>0.06</td>
<td>0.43</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Data are mean difference (limits of agreement). Ventilatory variable mean difference (l) = measured value – lower limit of normal value. Limits of agreement = (mean difference - 1.96 SD to mean difference + 1.96 SD).

p < 0.05 (Wilcoxon matched pairs test): “Tunisia1995” vs. “ERS/GLI2012”.

For abbreviations, see Abbreviations’ list.
was. The \( FVC \) mean Z-score offsets is equally large and could also be considered as physiologically relevant. Z-scores indicate how many SDs a measurement is from its reference value [1]. Unlike %Ref, they are free from bias due to age, height, sex and ethnic group, and are therefore particularly useful in defining the LLN and ULN; they also simplify uniform interpretation of test results. In the present study there were some weak significant associations between the spirometry Z-scores and age for \( FEV_1/FVC, \) and height for \( FVC. \) The present study results didn’t support the use of the \( ERS/GLI\)2012 equations to interpret spirometry in the Tunisian population. Some other authors have tested this kind of association [9,22]. Hall et al. [9] found some weak, but statistically significant, associations between the spirometry Z-scores and age, height and sex. In the mutually adjusted multivariable models for height, weight, age and sex, Thompson et al. [22] observed statistically significant but small relationships for each of the spirometry Z-score outcomes (\( FEV_1 \) Z-scores declined with height and were lower in females, \( FVC \) Z-scores declined with height, \( FEV_1/ \) \( FVC \) Z-scores increased with age and were lower in females). Hall et al. [9] and Thompson et al. [22] considered that the magnitude of any differences related to such associations were small and of no physiological importance. Thompson et al. [22] advanced two possible mechanisms for the observed association: increased variability of spirometry variables with age [35] or that the all-age reference equations [35,36] didn’t have sufficient data in the older age range (i.e. \( >60 \) years) to accurately define the change in spirometry variable with age.

What is the impact of applying \( ERS/GLI\)2012 equations for the interpretation of results of routine spirometry performed in the Tunisian adult population?

The present study highlighted some important facts about using \( ERS/GLI\)2012 [1] in other populations, such as Mediterranean or North African populations. It is quite evident that they led to misinterpretation of spirometry data in a significant proportion of subjects or patients and which could result in inappropriate diagnosis and/or management (Table 3).

Quantification of agreement between reference values of different spirometric parameters using \( Tunisian_1995 \) [2], \( ERS/GLI\)2012 [1] equations was also attempted. This approach had definite advantages over merely reporting correlation or regression coefficients, as it provided a numerical estimate of how similar are values obtained from two distributions, and whether results from the two approaches could be used interchangeably [21]. Wide variations in the mean bias for all spirometric parameters studied were observed (Table 2). The LOA, which represented a numerical expression of range in which 95% of the bias values were likely to be situated, was also calculated. Findings of the present study suggested a rather poor agreement between \( ERS/GLI\)2012 and \( Tunisian_1995 \) equations [1,2].

The present study results are in contrast of these of Quanjer et al. [12] aiming to determine the diagnostic and interpretative consequences of adopting the \( ERS/GLI\)2012 equations. These authors have analyzed the spirometric records from 17572 Australian and Polonaise adults’ aged 18–85 years. As in the present study, these authors have calculated predicted \( FEV_1, \) \( FVC \) and \( FEV_1/ \) \( FVC, \) and \( LLN \) using three spirometric equations: European Community for Steel and Coal (\( ERS/ECSC \) ) [8], National Health and Nutrition Examination Survey (\( NHANES III \) ) [13] and \( ERS/GLI\)2012 equations [1]. Their main results were that: (i) \( ERS/GLI\)2012 [1] produce similar predicted values for \( FEV_1, \) and \( FVC \) compared with \( NHANES \) [13], but produce larger values than \( ERS/ECSC \) [8]; (ii) Differences in the \( LLN \) lead to an important increase in the prevalence rate of a low \( FVC \) compared to \( ERS/ECSC \) [8], and a significant decrease compared to \( NHANES \) [13]; (iii) Adopting \( ERS/GLI\)2012 [1] equations has small effects on the prevalence rate of airway obstruction; and (iv) \( ERS/GLI\)2012 [1] equations increase the prevalence of a ‘restrictive spirometric pattern’

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**Table 3  Comparison of spirometry interpretation by European Respiratory Society/Global Lung Initiative (ERS/GLI2012) and Tunisian1995 reference equations.**

<table>
<thead>
<tr>
<th>Tunisian1995</th>
<th>Normal (n = 850)</th>
<th>LAOVD (n = 80)</th>
<th>TRVD (n = 227)</th>
<th>MVD (n = 35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERS/GLI2012</td>
<td>849 (99.88)</td>
<td>33 (41.25)</td>
<td>134 (59.03)</td>
<td>7 (20.00)</td>
</tr>
<tr>
<td>LAOVD (n = 50)</td>
<td>0 (0.00)</td>
<td>45 (56.25)</td>
<td>0 (0.44)</td>
<td>4 (11.43)</td>
</tr>
<tr>
<td>TRVD (n = 100)</td>
<td>1 (0.12)</td>
<td>92 (40.53)</td>
<td>6 (17.14)</td>
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</tr>
<tr>
<td>MVD (n = 19)</td>
<td>0 (0.00)</td>
<td>1 (1.25)</td>
<td>0 (0.00)</td>
<td>18 (51.43)</td>
</tr>
</tbody>
</table>

For abbreviations, see Abbreviations’ list.
Data are number (%) of subjects.
Percentage is calculated as following: number of subjects/total of subjects for each spirometry interpretation.

*Tunisian1995 [2], ERS/GLI2012 [1].*
compared to ERS/ECSC [8] but decrease it compared to NHANES [13].

In conclusion, the transition from Tunisian1995 to ERS/ GLI2012 equations data will lead to considerable changes in the predicted values of spirometric data for Tunisian adults. In addition, adopting the ERS/GLI2012 equations will have big effects on the rates of detection of spirometric defects. Therefore, the results of the current study don’t support the use of the ERS/GLI2012 equations to interpret clinical and research results in contemporary Tunisian adults. As recommended by some authors [9,22], the analysis presented here is limited to a comparison of Tunisian or North African subjects and the conclusions should not be extended to different ethnic populations.

Recommendation

The ERS/GLI task force [1] is asked to consider North African population as an individual ethnic group and to create an appropriate coefficient (adjustment factor) for it. As the present study presents data from a large group of healthy adults (n = 489, larger than the threshold of 300 subjects recommended [38] to validate reference values to avoid spurious differences due to sampling error) and as data were collected using standardized protocols, it is possible to derive suitable ethnic coefficients for North African population, without recalculating the ERS/GLI2012 equations.

Authors’ contributions

BSH conceived of the study, and participated in its design, and performed the statistical analysis, and coordination and helped to draft the manuscript.  
MNE conceived of the study, and participated in its design and performed the spirometry tests.  
KHM conceived of the study, and participated in its design.  
ABA helped to draft the manuscript.  
AA helped to draft the manuscript.  
MB helped to draft the manuscript.  
KL helped to draft the manuscript.  
CM performed the spirometry tests.  
HB helped to draft the manuscript.  
AC helped to draft the manuscript.  
SR conceived of the study, and participated in its design, and performed the statistical analysis and coordination and helped to draft the manuscript.  
All authors read and approved the final manuscript.

Conflict of interest statement

No conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.rmed.2013.10.015.

References


