An urgent need for African spirometry reference equations: the Paediatric and Adult African Spirometry study

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SUMMARY

BACKGROUND: The GLI2012 (Global Lung Initiative 2012) has provided the largest data set to date for multi-ethnic spirometry reference equations; however, data on African populations are limited. In pulmonary function testing, diagnosis of lung disorder is based on comparing the individual’s lung function to a reference appropriate for sex and ethnicity.

METHODS: We conducted a systematic review of studies reporting spirometry results in healthy children and adults in Africa. Data from these studies were collated for $Z$-scores of forced expiratory volume in 1 sec ($zFEV_1$), forced vital capacity ($zFVC$) and $zFEV_1/FVC$ compared to GLI reference equations.

RESULTS: Nine studies, covering a total of 4750 individuals from North, South, East, West and Central Africa (52% were female), were reviewed. Marked differences were noted between individuals from North Africa and sub-Saharan Africa. The Southern cohort had an excellent fit with the GLI-African American. The West African showed a poor fit to all reference equations. The North African group showed the best fit for the GLI Caucasian $zFEV_1$ ($0.12 \pm 0.98$), $zFVC$ ($-0.15 \pm 0.98$) and $zFEV_1/FVC$ ($0.05 \pm 0.89$), Central $zFEV_1$ ($-0.16 \pm 0.79$), $zFVC$ ($-0.09 \pm 0.83$) and $zFEV_1/FVC$ ($-0.17 \pm 0.71$) and East African $zFEV_1$ ($0.10 \pm 0.88$), $zFVC$ ($0.16 \pm 0.85$) and $zFEV_1/FVC$ ($-0.10 \pm 0.95$) cohorts had an excellent fit with the GLI-African American. The $zFEV_1/FVC$ ratios were stable across all the populations.

CONCLUSION: Current evidence seems to support the use of GLI2012 reference values in North African and sub-Saharan African populations after taking into account ethnic correction factors.

KEY WORDS: global lung initiative; lung function; healthy; population; Africa

LOW- AND MIDDLE-INCOME countries (LMICs), including African countries, have a disproportionately high burden of infectious respiratory diseases, coupled with an increasing burden of non-communicable respiratory diseases such as chronic obstructive pulmonary disease (COPD), emphysema, bronchiectasis and asthma. The management of these colliding epidemics requires accurate diagnosis and care to reduce morbidity and mortality in these resource-scarce settings.

Pulmonary function testing is the most widely used tool for the diagnosis, severity assessment, management, risk factor categorisation and follow-up of patients with chronic lung diseases, provided ‘normal’ values for healthy individuals can be determined. These vary according to age, sex, height and ethnicity of the relevant population. Reference data should also take into account the normal trajectory of lung growth in childhood, and subsequent physiological decline associated with the aging process.

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It is well recognised that comparing an individual’s results to values from an ethnically inappropriate population may lead to the under- or over-diagnosis of lung diseases, incorrect treatment and increased costs for the individual, the family and the healthcare system.\(^5\)\(^\text{-}^7\) A number of reference equations have been published in the literature, but the largest data set produced were the 2012 Global Lung Initiative multi-ethnic reference equations (GLI\(_{2012}\)), which included individuals aged 3 to 95 years.\(^8\) The GLI\(_{2012}\) included data pooled from four ethnic groups: Caucasians (Caucasians of European descent, as well as South Americans and North Africans), Blacks (African Americans), South-East Asians and North East Asians. The GLI\(_{2012}\) was innovative in that it allowed for the smooth transitioning of data from childhood to adulthood using sophisticated statistical modeling.

Of the large number of data sets collected in GLI\(_{2012}\), data from the African continent were lacking, with only 4.8% of the study sample being from two North African populations; who were included in the Caucasian population dataset.\(^8\),\(^9\) It has previously been described that Caucasians have larger static and dynamic lung volumes and forced expiratory flow rates than other ethnicities.\(^10\)

The aim of the present study was to collate previously published African spirometric data to determine the fit of African populations to GLI\(_{2012}\) spirometry equations.

**METHODOLOGY**

**Study design**
A systematic review of the literature was completed using the following main search terms (MeSH) in combination: Reference ranges, African, Spirometry OR Lung function, Healthy OR Normal, Adult, Paediatric; and using the following variations and synonyms: Prediction equations, Lung function, Normal, Asymptomatic, Paediatric, Women/men. The databases searched included PubMed Central, EMBASE, Medline and Google Scholar. Studies from January 1970 to November 2018 were included. The references of selected studies and relevant review articles were also scanned for further eligible studies.

**Inclusion criteria**
Studies were considered eligible for inclusion if they involved African adults or children of any age, included ≥100 healthy non-smoking subjects, used standardised equipment and testing, documented calibration and quality control, recorded essential clinical information (sex, height, age and ethnic group) and if the contributing investigator had obtained ethical approval from their statutory authority to contribute data to the Paediatric and Adult African Spirometry project. Identified studies were screened for eligibility and the corresponding authors were contacted. Those authors willing to participate signed a data sharing agreement. The data were collected by a central study administrator, collated and stored in a custom password protected data repository. Each contributing site provided information regarding the equipment, methodology and quality control procedures used for data collection. Each site’s information and data were checked for eligibility by assuring 1) that compliance with international standards was met, 2) that the relevant clinical data were available, and 3) that the data outcomes were appropriate.

**Exclusion criteria**
Any outcomes of >5 or ≤5 Z-scores from the FEV\(_1\) of the specific population mean (forced expiratory volume in 1 sec) FVC (forced vital capacity) <0.5 were excluded from the data set before the data were collated.\(^11\) Any multiple testing was excluded and any participants with known chronic lung disease, known smokers or where smoking status was not recorded were excluded.

**Data analyses**
Statistical analyses were performed using STATA v13 for Windows (STATA Corporation, College Station, TX, USA). Spirometric values FEV\(_1\), FVC and FEV\(_1\)/FVC were converted to Z-scores using the GLI\(_{2012}\) software (https://www.ers-education.org/guidelines/global-lung-function-initiative/tools). Z-scores were represented as means and standard deviations (SD) and comparisons were shown graphically. Cohort mean ± SD Z-scores for FEV\(_1\) and FVC were compared using the GLI Caucasian, African American and ‘Other’ equations. ‘Goodness of fit’ was considered for a Z-score difference of <0.5, which was considered a good fit for no physiological or clinical impact.

Ethical approval was granted from the Institutional Review Boards of the University of Pretoria (HREC: 8/2014) Pretoria, South Africa, and University of Cape Town (HREC: 765/2013) Rondebosch, South Africa.

**RESULTS**
Of 49 articles identified, 39 met the inclusion criteria (Figure). One study included unpublished data from a South African birth cohort.\(^12\) Of these, 21 investigators were contactable and agreed to participate, of whom four withdrew consent and four agreed to participate but did not submit the data. The analysis included data submitted from 11 studies, totalling 33 864 participants\(^9\),\(^12\)\(^\text{-}^24\) (Table 1 and Supplementary Table S1). Of these, 29 122 participants from four studies were excluded, two of which had no record of smoking status\(^21\),\(^22\) and for the other two, the data
did not match the sourced publication.\textsuperscript{17,18} Eight further individual study participants were excluded due to missing data; the FEV\textsubscript{1} and FVC results were missing for four individuals in Benin and in South Africa, respectively. The outlying data (\(\geq 5\) or \(\leq 5\) \(Z\)-scores) were excluded as follows: 77 using the ‘Other’ GLI equation, 70 using the African-American equation and 64 using the Caucasian equation.

A total of 4750 (52\% female) participants aged 5–85 years were included in the final analysis. The demographic characteristics and the fit of the lung function to the GLI references are shown in Table 2A and 2B. The studies included were conducted in urban or peri-urban settings.

The GLI ‘Other’ reference was the best fit for the collated data set. However, there was marked heterogeneity between regions. For Tunisian and Algerian (North African) subjects the GLI Caucasian reference was the best fit; while the Benin (West African) data had a poor fit to all GLI references. The South African (Southern), Angola (Southern), Madagascar (East) and Democratic Republic (DR) Congo (Central) African data had an excellent fit to GLI African-American.

A comparison of lung function \(Z\)-scores between the equipment used across the studies was undertaken (Tables 3 and 4). The Tunisian studies showed statistically significant differences between the equipment used. For the Tunisian cohort, consisting of two paediatric studies\textsuperscript{14,20} \((n = 1041)\), one study\textsuperscript{15} of adults aged 19–90 years \((n = 581)\) and another study\textsuperscript{16} of adults aged \(> 40\) years \((n = 108)\), there were statistically significant differences across the studies for mean \(\pm\) SD \(Z\)-scores for FEV\textsubscript{1} \(-0.99\pm 1.34\) vs. \(1.19\pm 1.61\) and \(0.47\pm 1.28\); all \(P < 0.005\).

**DISCUSSION**

In this collated dataset of healthy adults and children from across the African continent, we found marked differences in the fit of spirometry data to the GLI spirometry reference equations between North and sub-Saharan African populations. North African (Tunisia and Algeria) data displayed the best fit with GLI Caucasian data. For the Southern African (South Africa and Angola), East African (Madagascar), Central African (DR Congo) data the best fit was for GLI African American equation. The West African paediatric and adolescent data (Benin) showed sub-
stantially reduced lung volumes overall, with a poor fit to all the GLI references. The FEV1/FVC ratios were preserved for all the datasets except for the West African individuals.

There were differences in calculated spirometry Z-scores within countries that could be attributable to the equipment utilised across the studies. We would conclude that the application of the GLI2012 FEV and FVC equations in African populations should therefore be applied with ethnic and regional consideration, but that as reported previously, the FEV1/FVC ratio is independent of ethnicity and therefore can be used to diagnose obstructive lung diseases (FEV1/FVC < LLN or FEV1/FVC Z-score ≤ 1.64) with reasonable confidence. The unexpected finding of the West African cohort of school-going children contradicts previously reported data. This may reflect technical challenges in obtaining good quality spirometry from young children and requires further exploration to assess whether these differences are truly due to ethnic variation or other unknown factors, e.g., socio-economic status, nutrition and exposure to indoor and outdoor pollution. A study in Tanzanian men and boys aged 13 to 29 years also showed similar differences in fit to both GLI 2012 and the Third National Health and Nutrition Examination Survey (NHANES III) references.

Although the GLI network has successfully collated spirometry to develop robust, all age international reference equations, in this study of retrospectively collated data, the heterogeneity across the African regions suggests a need to utilise different ethnic correction factors in North African and sub-Saharan populations. This heterogeneity could be explained by ethnic differences between geographically remote parts of the African continent, although other factors, such as differences in measurement techniques or equipment used, could also account for these differences. In addition, poor quality data cannot be excluded as a contributing factor, as suggested by the variable age-dependence of lung function data. Moreover, it is likely that socio-economic and environmental factors play an important role in lung function at the population level. We were unable to account for these differences in this study.

The reason for the poor fit of the West African children to the African-American reference is unclear. The Bight of Benin was part of the slave trade route to the USA and the Beninese were also part of the original Bantu who populated most of Western and Southern Africa. The sub-Saharan cohort has a good fit to the GLI African-American reference equation, which should be similar to that of the Beninese. With the similar genetic background, the finding of such significant differences is therefore surprising. Other factors, such as poverty, low birth weight and exposure to high levels of pollution, may contribute to these differences, although the impact of these

<table>
<thead>
<tr>
<th>Variable</th>
<th>North Africa</th>
<th>West Africa</th>
<th>East Africa</th>
<th>Central Africa</th>
<th>Southern Africa</th>
<th>Total</th>
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<td>Algeria</td>
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<td>2362 (49.7)</td>
<td>484 (10.2)</td>
<td>399 (8.4)</td>
<td>377 (7.9)</td>
<td>4750</td>
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<tr>
<td>Tunisia</td>
<td>245 (49.9)</td>
<td>1226 (51.9)</td>
<td>154 (31.8)</td>
<td>197 (49.4)</td>
<td>170 (45.1)</td>
<td>2476</td>
</tr>
<tr>
<td>Benin</td>
<td>326 (6.4)</td>
<td>153 (5.0)</td>
<td>133 (5.0)</td>
<td>130 (3.2)</td>
<td>130 (3.2)</td>
<td>526</td>
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<tr>
<td>Madagascar</td>
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<td>153 (5.0)</td>
<td>133 (5.0)</td>
<td>130 (3.2)</td>
<td>130 (3.2)</td>
<td>526</td>
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<tr>
<td>South Africa</td>
<td>245 (5.0)</td>
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<td>2476</td>
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</table>

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Table 2A  Lung function data by country of origin using GLI African-American, Caucasian and other equations to calculate Z-scores

<table>
<thead>
<tr>
<th>Variable</th>
<th>Algeria mean ± SD</th>
<th>Tunisia mean ± SD</th>
<th>Benin mean ± SD</th>
<th>Madagascar mean ± SD</th>
<th>DRC mean ± SD</th>
<th>Angola mean ± SD</th>
<th>South Africa mean ± SD</th>
<th>Total mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV₁, I</td>
<td>3.2 ± 0.9</td>
<td>2.8 ± 0.9</td>
<td>1.9 ± 0.6</td>
<td>1.3 ± 0.3</td>
<td>1.6 ± 0.4</td>
<td>1.6 ± 0.4</td>
<td>2.7 ± 0.5</td>
<td>2.4 ± 1.0</td>
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<tr>
<td>FVC, I</td>
<td>4.0 ± 1.1</td>
<td>3.2 ± 1.1</td>
<td>2.4 ± 0.7</td>
<td>1.5 ± 0.3</td>
<td>1.9 ± 0.4</td>
<td>1.7 ± 0.4</td>
<td>3.1 ± 0.5</td>
<td>2.9 ± 1.2</td>
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<tr>
<td>FEV₁/FVC</td>
<td>0.8 ± 0.1</td>
<td>0.9 ± 0.1</td>
<td>0.8 ± 0.2</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.0</td>
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</table>

GLI African-American
FEV₁ Z-score 1.07 ± 0.95 0.98 ± 1.43 −2.25 ± 1.16 0.10 ± 0.88 −0.16 ± 0.79 −0.32 ± 0.75 0.07 ± 1.13 0.35 ± 1.57
FVC Z-score 1.37 ± 0.94 0.81 ± 1.44 −1.79 ± 1.24 0.16 ± 0.85 −0.09 ± 0.83 −0.38 ± 0.80 0.07 ± 1.08 0.35 ± 1.50
FEV₁/FVC Z-score −0.50 ± 0.75 0.30 ± 1.14 −1.07 ± 1.56 −0.10 ± 0.95 −0.17 ± 0.71 0.10 ± 0.78 −0.00 ± 0.97 −0.03 ± 1.17

GLI Caucasian
FEV₁ Z-score −0.07 ± 0.90 −0.13 ± 1.44 −3.18 ± 1.00 −1.10 ± 0.82 −1.36 ± 0.74 −1.50 ± 0.70 −1.08 ± 1.02 −0.75 ± 1.52
FVC Z-score 0.17 ± 0.88 −0.35 ± 1.42 −2.83 ± 1.11 −1.10 ± 0.79 −1.36 ± 0.78 −1.63 ± 0.76 −1.10 ± 1.01 −0.82 ± 1.45
FEV₁/FVC Z-score −0.41 ± 0.73 0.39 ± 1.13 −0.96 ± 1.49 0.01 ± 0.94 −0.06 ± 0.70 0.21 ± 0.78 0.09 ± 0.94 0.09 ± 1.13

GLI Other
FEV₁ Z-score 0.48 ± 0.96 0.39 ± 1.48 −2.83 ± 1.09 −0.56 ± 0.88 −0.83 ± 0.79 −0.99 ± 0.75 −0.54 ± 1.10 −0.25 ± 1.58
FVC Z-score 0.86 ± 0.99 0.26 ± 1.56 −2.49 ± 1.27 −0.49 ± 0.89 −0.78 ± 0.88 −1.05 ± 0.85 −0.51 ± 1.14 −0.23 ± 1.60
FEV₁/FVC Z-score −0.58 ± 0.78 0.26 ± 1.19 −1.09 ± 1.59 −0.17 ± 0.99 −0.24 ± 0.74 0.04 ± 0.81 −0.07 ± 0.99 −0.08 ± 1.20

Table 2B  Lung function data by region of origin using GLI African-American, Caucasian and other equations to calculate Z-scores

<table>
<thead>
<tr>
<th>Variable</th>
<th>North Africa mean ± SD</th>
<th>West Africa mean ± SD</th>
<th>East Africa mean ± SD</th>
<th>Central Africa mean ± SD</th>
<th>Southern Africa mean ± SD</th>
<th>Total mean ± SD</th>
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<tr>
<td>FEV₁, I</td>
<td>2.8 ± 0.9</td>
<td>1.9 ± 0.6</td>
<td>1.3 ± 0.3</td>
<td>1.6 ± 0.4</td>
<td>2.2 ± 0.7</td>
<td>2.4 ± 1.0</td>
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<td>FVC, I</td>
<td>3.4 ± 1.2</td>
<td>2.4 ± 0.7</td>
<td>1.5 ± 0.3</td>
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<td>2.5 ± 0.8</td>
<td>2.9 ± 1.2</td>
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<tr>
<td>FEV₁/FVC</td>
<td>0.8 ± 0.1</td>
<td>0.8 ± 0.2</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.0</td>
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GLI African-American
FEV₁ Z-score 0.99 ± 1.36 −2.25 ± 1.16 0.10 ± 0.88 −0.16 ± 0.79 −0.12 ± 0.98 0.35 ± 1.57
FVC Z-score 0.91 ± 1.38 −1.79 ± 1.24 0.16 ± 0.85 −0.09 ± 0.83 −0.15 ± 0.98 0.35 ± 1.50
FEV₁/FVC Z-score 0.16 ± 1.12 −1.07 ± 1.56 −0.10 ± 0.95 −0.17 ± 0.71 0.05 ± 0.89 −0.03 ± 1.17

GLI Caucasian
FEV₁ Z-score −0.12 ± 1.37 −3.18 ± 1.00 −1.10 ± 0.82 −1.36 ± 0.74 −1.28 ± 0.91 −0.75 ± 1.52
FVC Z-score −0.26 ± 1.36 −2.83 ± 1.11 −1.10 ± 0.79 −1.36 ± 0.78 −1.35 ± 0.94 −0.82 ± 1.46
FEV₁/FVC Z-score 0.25 ± 1.11 −0.86 ± 1.49 0.01 ± 0.94 −0.06 ± 0.70 0.14 ± 0.87 0.09 ± 1.13

GLI Other
FEV₁ Z-score 0.40 ± 1.40 −2.83 ± 1.09 −0.56 ± 0.88 −0.83 ± 0.79 −0.76 ± 0.97 −0.25 ± 1.58
FVC Z-score 0.37 ± 1.49 −2.49 ± 1.27 −0.49 ± 0.89 −0.78 ± 0.88 −0.78 ± 1.05 −0.23 ± 1.60
FEV₁/FVC Z-score 0.11 ± 1.18 −1.09 ± 1.59 −0.17 ± 0.99 −0.24 ± 0.74 −0.02 ± 0.91 −0.08 ± 1.20

GLI = Global Lung Initiative; SD = standard deviation; DRC = Democratic Republic of Congo; FEV₁ = Forced expiratory flow in 1 sec; FVC = forced vital capacity.

Table 3  Lung function equipment by country and study population

<table>
<thead>
<tr>
<th>Variable</th>
<th>Algeria</th>
<th>Tunisia</th>
<th>Benin</th>
<th>Madagascar</th>
<th>DRC</th>
<th>Angola</th>
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DRC = Democratic Republic of Congo.
factors is controversial in determining ‘normality’ of lung function based on deprivation status. A study of children in Nigeria in both rural and urban settings, did not find any significant differences between Nigerian and African-American children.\textsuperscript{25} Interestingly, a more recent study of Nigerian children aged 18–65 years showed an increase, although not statistically significant, in FEV\textsubscript{1}, FVC and PEF compared to a previous study determining Nigerian references, but found that GLI African-American also over-estimated the references in the local population.\textsuperscript{27} Although the children in the sub-Saharan countries were much poorer in comparison to their African-American counterparts, the exclusion of underweight children with body mass index Z-scores below −2 may have adjusted for these differences, suggesting a strong genetic contribution to lung function rather than socioeconomics. This is similar to findings comparing UK-Indian children with urban and rural children in the Indian sub-continent.\textsuperscript{28}

The strength of the current study is that it attempted to collate data sets from various regions on the African continent using methodology previously utilised by the GLI and gives some credence to the fact that there are indeed differences in the fit of African regional, i.e., North and sub-Saharan populations to the GLI\textsubscript{2012} equations, which have diverse genetic backgrounds. This study is limited by the fact that the data collected were retrospective. Not all of the available data could be included due to lack of access to data or lack of consent from authors. We also had to exclude a large number of participants from previous studies due to a lack of information on smoking status.

This study highlights the urgent need for high quality prospectively collected lung function data in healthy African populations for the determination of new local GLI coefficients that are specific to the various regions of Africa. In conclusion, GLI\textsubscript{2012} is the most robust and physiologically sound reference equation for most populations. The current evidence is still limited but seems to support the use of GLI\textsubscript{2012} reference values in North and sub-Saharan African populations, taking into account the use of different ethnic correction factors. Prospective spirometry data collection is required as the GLI\textsubscript{2012} reference values have still to be validated in several African countries.

Acknowledgements

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Conflicts of interest: none declared.

References


Table 4 Differences in lung function Z-scores according to different equipment in Tunisia using GLI Other

<table>
<thead>
<tr>
<th>Tunisia</th>
<th>PAL MINATO, hot-wire anometer</th>
<th>Spida 5, hot-wire anometer</th>
<th>Pneumotach, ZAN 500 plethysmograph</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV\textsubscript{1}, Z-score, mean ± SD</td>
<td>Median [IQR]</td>
<td>1.08 [−0.00 to 2.35]</td>
<td>0.35 [−0.31 to 1.24]</td>
<td>0.000</td>
</tr>
<tr>
<td>FVC Z-score, mean ± SD</td>
<td>Median [IQR]</td>
<td>0.67 [−0.37 to 1.77]</td>
<td>0.62 [−0.28 to 1.71]</td>
<td>0.000</td>
</tr>
<tr>
<td>FEV\textsubscript{1}/FVC Z-score, mean ± SD</td>
<td>Median [IQR]</td>
<td>0.86 [1.50 to 1.57]</td>
<td>−0.49 [−1.25 to 0.34]</td>
<td>0.000</td>
</tr>
</tbody>
</table>

GLI = Global Lung Initiative; FEV\textsubscript{1} = forced expiratory volume in 1 sec; SD = standard deviation; IQR = interquartile range; FVC = forced vital capacity.


**CONTEXTE** : GLI2012 a fourni la plus vaste base de données relative aux équations de référence multiethniques, mais les données émanant d’Afrique sont limitées. Les tests de diagnostic de la fonction pulmonaire sont basés sur la comparaison entre la fonction pulmonaire des individus testés et une référence appropriée en termes de genre et d’ethnité.

**MÉTHODE** : Une revue systématique des études rapportant des spirométries chez des enfants et des adultes en bonne santé en Afrique. Les données des études ont été compilées pour le score $Z$ du volume expiratoire maximal par seconde (VEMS$_1$), la capacité vitale forcée (CVF) et le rapport VEMS$_1$/CVF comparés aux équations de référence de GLI.

**RÉSULTATS** : Neuf études comprenant 4750 individus, dont 52% de femmes venant de l’Afrique du Nord, du Sud, de l’Est, de l’Ouest et du Centre. Des différences marquées ont été notées entre les populations d’Afrique du Nord et d’Afrique sub-saharienne. Le zVEMS$_1$ ($-0,12 \pm 0,98$), la zCVF ($-0,15 \pm 0,98$) et le zVEMS$_1$/FVC ($0,05 \pm 0,89$) d’Afrique du Sud, le zVEMS$_1$ ($-0,16 \pm 0,79$), la zCVF ($-0,09 \pm 0,83$) et le zVEMS$_1$/FVC ($-0,17 \pm 0,71$) d’Afrique Centrale et le zVEMS$_1$ ($0,10 \pm 0,88$), la zCVF ($0,16 \pm 0,85$) et le zVEMS$_1$/FVC ($-0,10 \pm 0,95$) d’Afrique de l’Est concordaient très bien avec le GLI-Africain Américain. Les résultats d’Afrique de l’Ouest ont montré une concordance médiocre avec toutes les équations de référence. Le groupe d’Afrique du Nord a montré la meilleure concordance avec le GLI-Caucasien zVEMS$_1$ ($-0,12 \pm 1,37$), la zCVF ($-0,26 \pm 1,36$) et le zVEMS$_1$/FVC ($0,25 \pm 1,11$). Les rapports zVEMS$_1$/FVC ont été stables dans toutes les populations.


**RESUMEN**

**MARCO DE REFERENCIA**: La Iniciativa Global de la Función Pulmonar del 2012 (GLI2012, por Global Lung Initiative) ofrece el conjunto de datos más exhaustivo de ecuaciones multiéticas de referencia de la espirometría, pero los datos de África son escasos. En el contexto de las pruebas de función pulmonar, el diagnóstico de normal o patológico se basa en la comparación de la espirometría de la persona, con una referencia adecuada con respecto al sexo y la etnia.

**MÉTODOS**: Se llevó a cabo una revisión sistemática de los estudios que comunicaban sobre la espirometría en niños y adultos sanos en África. Los datos de los estudios se recogieron y se expresaron como puntuación $Z$ del volumen espiratorio forzado en el primer segundo (zVEF$_1$), la capacidad vital forzada (zCVF) y el cociente zVEF$_1$/CVF y se compararon con las ecuaciones de referencia de la GLI.

**RESULTADOS**: Se incluyeron nueve estudios con 4750 participantes, el 52% era de sexo femenino y procedía de África del norte, del sur, del este y África central. Se observaron diferencias considerables entre las personas de África del norte y de África subsahariana. Las cohortes de zVEF$_1$ ($-0,12 \pm 0,98$), zCVF ($-0,15 \pm 0,98$) y zVEF$_1$/CVF ($0,05 \pm 0,89$) del sur; de zVEF$_1$ ($-0,16 \pm 0,79$), zCVF ($-0,09 \pm 0,83$) y zVEF$_1$/CVF ($-0,17 \pm 0,71$) del centro; y de zVEF$_1$ ($0,10 \pm 0,88$), zCVF ($0,16 \pm 0,85$) y zVEF$_1$/CVF ($0,10 \pm 0,95$) del este de África exhibieron un ajuste excelente con las referencias afroamericanas del GLI. En los datos provenientes de África occidental el ajuste fue deficiente con todas las ecuaciones de referencia. El grupo de África del norte presentó el mejor ajuste con las referencias caucásicas del GLI: zVEF$_1$ ($-0,12 \pm 1,37$), zCVF ($-0,26 \pm 1,36$) y zVEF$_1$/CVF ($0,25 \pm 1,11$). Los cocientes zVEF$_1$/CVF fueron estables en todas las poblaciones.

**CONCLUSIÓN**: La evidencia de la presente revisión sistemática parece respaldar la utilización de los valores de referencia de la GLI2012 en las poblaciones de África del norte y África subsahariana, teniendo en cuenta la necesidad de aplicar diferentes factores étnicos de corrección.