INTERNATIONAL JOURNAL OF CIRCUMPOLAR HEALTH
2023, VOL. 82, 2151158
https://doi.org/10.1080/22423982.2022.2151158

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH ARTICLE

OPEN ACCESS Check for updates

How to account for Inuit ancestry in lung function prediction

Birgitte H Laustsen[a,b], Jakob H Bønløkke[c] and Martin R Miller[d]

[a]Department of Clinical Medicine, Danish Ramazzini Centre, Aalborg University, Aalborg, Denmark; [b]Institute of Nursing & Health Science, Ilisimatusarfik, University of Greenland, Nuuk, Greenland; [c]Department of Occupational and Environmental Medicine, Danish Ramazzini Centre, Aalborg University Hospital, Aalborg, Denmark; [d]Institute of Applied Birmingham Health Sciences, University of Birmingham, Birmingham, UK

ABSTRACT

Rigorous lung function prediction equations for the Inuit are lacking. We used spirometry from 351 Inuit and 29 people of other ancestry obtained during an occupational survey in Greenland to determine how to obtain valid lung function predictions for the Inuit using Global Lung Function Initiative (GLI) equations for Europeans. Standing height for the Inuit was used in the predictions as well as their height modified in line with the known differences in standing to sitting height ratio (SHR) for the Inuit. With recorded height in predicting lung function, mean±SD Inuit z-scores for FVC and FEV1 were significantly higher than predicted (0.81±1.20 and 0.53±1.36, respectively, $p<0.0001$) which was not true for the non-Inuit participants (-0.01±1.04 and 0.15 ±1.17, respectively). When using height modified for SHR the mean±SD Inuit z-scores for FVC and FEV1 were no longer significantly different from predicted (0.10±1.10 and -0.12±1.24, respectively). The mean±SD Inuit FEV1/FVC z-scores were not significantly different from the non-Inuit, being respectively -0.45±0.98 and -0.01±1.04. Modified height changed the mean±SD Inuit FEV1/FVC z-scores to -0.39±0.99. Representative lung function predictions from GLI equations can be made for Inuit by using standing height modified for the known differences in SHR between Inuit and those of European ancestry

ARTICLE HISTORY
Received 19 July 2022
Revised 16 November 2022
Accepted 17 November 2022

KEYWORDS
List ancestry; ethnicity; Inuit; lung function; lung function prediction equations; lung function reference values; Race

Introduction

The relationship between sex, age and height and the spirometric indices of forced expiratory volume in the first second of expiration (FEV1) and forced vital capacity (FVC) differs between peoples of different ancestral backgrounds. It has long been recognised that the FEV1 and FVC in people of African descent appear to be lower than those of people of similar age and height who are of European ancestry [1,2]. Hence, separate reference equations have been derived from American healthy non-smoking people of African ancestry [3] (African-Americans) so that patients with these characteristics can have their lung function compared against an appropriate reference population. For the Inuit, it has been shown that lung function prediction equations derived from people of European ancestry give predicted values that are too low [4,5]. The reason behind this difference in the relationship between lung function, age, sex and height for people of different ancestry is in part due to differences in the relation between standing height and thoracic size. Standing height is used in lung function reference equations to help take into account differences in thoracic size. Because the sitting height to standing height ratio (SHR = sitting height/standing height), also known as the Cormic index, varies between peoples of different ancestry [6–11] the relationship between standing height and lung function is not the same for people of different ancestry. People who have historically originated from close to the equator (e.g. Nigerians) have a smaller SHR (longer limbs in relation to height) [12,13] and those originating from colder climates such as at extremes of latitude (e.g. the Inuit) or altitude (e.g. the Quichuan people of Peru) have a high SHR (shorter limbs in relation to height) when compared to those of European descent [11,14]. This follows Allen's rule [15] that homeothermic species adapted to living near the equator have longer limbs and appendages in order to facilitate temperature regulation and those adapted to colder climates have the opposite with shorter limbs in relation to overall body size to help conserve heat.

We recently undertook a study on lung function in workers in the seafood industry in Greenland involving a high proportion of people of Inuit ancestry. We have used the spirometric data from this study to determine for the first time how accurately the Global Lung

CONTACT Martin R Miller martin@drmiller.uk Institute of Applied Birmingham Health Sciences, University of Birmingham, Birmingham UK

Initiative reference equations from people of European ancestry [16] predicted the lung function for the Inuit. We then determined if modifying the standing height in line with the known differences in SHR between the Inuit and Europeans could improve the lung function predictions.

Method

Study population

The data for this study arose from a project conducted from 2016 to 2018 on the west coast of Greenland investigating possible health effects from working in the seafood industry. The participants were workers who were either employed in factories in the major cities of Greenland or in small settlements, or on four factory trawlers. All employees were invited to participate in the study, and 382 employees (approximately 85% of the total) agreed to take part. The study was approved by The Regional Ethics Committee in Central Denmark Region (1–16-02-475-16) and The Ethics Committee for Medical Research in Greenland (2015–11,317). Written and oral informed consent was obtained from each participant.

Data collection

Data was collected in 2016–2018 at the workplace of the participants by a team of doctors specialised in occupational medicine. A modified version of the European Community Respiratory Health Survey (ECRHS) lung function questionnaire [17] was translated into Danish and Greenlandic. It included questions regarding ethnicity, work exposures, health, smoking and diet. Clinical interviews were performed with the aid of native medical students, who were fluent in Danish and Greenlandic language, if the participants were unable to fill in the questionnaires themselves. Standing height was measured using a stadiometer. Spirometry was performed using one of two types of spirometers (MIR Spirobank II spirometer and Easy-One® NDD Medical Technologies, Zurich, Switzerland). Lung function was registered as forced expiratory volume in the first second of expiration (FEV1) and forced vital capacity (FVC) as best values from any of at least three acceptable blows.

Global Lung Function Initiative (GLI) 2012 prediction equations based on data from Europeans were used as recommended by the American Thoracic Society and European Respiratory Society recent statements on lung function interpretation [18]. When obtaining a prediction of lung function height was first entered as the recorded standing height (rht). For the Inuit, the height was then secondly entered as the recorded height having been modified (mht) for the known sex-specific differences in SHR between Inuit (SHR = 0.534 and 0.539 for male and females respectively) [14] and Europeans (SHR = 0.513 and 0.526 for male and females respectively) [8]. Using standing height to predict lung function in the Inuit with prediction equations based on people of European ancestry gives predicted values for FEV1 and FVC that are too low, because the Inuit have shorter legs in relation to standing height than do Europeans, and so their lung function appears to be supra-normal [4]. We hypothesised that modifying their height by the ratio of (Inuit-SHR)/(European-SHR) as below might increase their height appropriately to get a more accurate lung function prediction.

Males: mht = rht x SHR-Inuit/SHR-European = rht x 0.534/0.513 = rht x 1.0409357

Females: mht = rht x SHR-Inuit/SHR-European = rht x 0.539/0.526 = rht x 1.0247148

The deviation from the predicted value for FEV1, FVC and FEV1/FVC were all expressed as z-scores in accordance with the recent ATS/ERS statement [18]. Z-scores are the number of population standard deviations a result is away from predicted with negative values being below predicted. A z-score of −1.645 approximates to the population 5^{th} percentile, often used as the lower limit of normal (LLN) [18], a z-score of zero approximates to the 50^{th} centile or median value and a z-score of +1.96 approximates to the 97.5^{th} percentile.

All the analysis was undertaken using Stata/SE 17.0 (StataCorp LLC, Texas, USA). Means were compared using t-test, with unequal variances where appropriate. Proportions were tested by the chi-squared test. A probability of 0.05 was considered as the level of significance.

Results

There were 380 of the 382 participants in the study with complete data of whom 351 were of Inuit descent (71.5% men) and 29 non-Inuit (79.3% men) comprising 17 from Denmark, 8 from the Faroe Islands, and one from the Middle East and three participants of other non-European ancestry. For the GLI equations, these three participants were coded as “other” and the rest coded as “white”. The demographic data for the study participants are shown in Table 1. The Inuit were significantly younger than those of European ancestry (mean ± SD 38.3 ± 13.5 years and 49.3 ± 11.1 years, respectively, $p < 0.0001$) and there were significantly more Inuit ever-smokers at 90.6% versus 56.8% for non-Inuit ($X^2 = 26.1$, $p < 0.001$). The proportion of men amongst Inuit and those of European ancestry were not significantly different at 72% and 79%, respectively ($X^2 = 0.81$, $p = 0.37$). The recorded heights for the Inuit were significantly shorter than for those of European ancestry (1.68 ± 0.08 m and 1.74 ± 0.10 m, respectively, $p < 0.01$) but there was no difference between the heights when the Inuit recorded height was modified for SHR (1.75 ± 0.09, $p = 0.92$). For BMI, the Inuit were not significantly different from those of European ancestry (26.2 ± 5.4 Kg·m^{-2} and 27.5 ± 3.9 Kg·m^{-2} respectively, $p = 0.10$) but when BMI was corrected for SHR the mean Inuit BMI was significantly lower than that for those of European ancestry (24.4 ± 5.1 Kg·m^{-2}, $p < 0.0005$). Physician recorded asthma was noted in 8.9% of the Inuit participants, which was not significantly different from the 7.1% found in the remaining participants ($p = 0.77$, X^2 test).

For lung function the z-score results are shown in Table 2. It can be seen that the mean FVC and FEV1 z-scores for the Inuit using GLI with recorded height were significantly above predicted (0.81 ± 1.20 and 0.53 ± 1.36, respectively, $p < 0.0001$), whereas for those of European ancestry this was not the case (0.12 ± 0.91 and 0.15 ± 1.17, respectively, $p = 0.5$). When using height modified for SHR, the mean change in Inuit FEV1 z-score was −0.65 (range −1.22 to −0.20) and the mean Inuit FEV1 z-score was then less than that of the non-Inuit but was not significantly different from zero (−0.12 ± 1.24, $p = 0.08$). The mean change in zFVC by modifying height was −0.71 (range −1.19 to −0.24) but the mean FVC z-score remained slightly, but not significantly, above predicted (0.10 ± 1.10, $p = 0.10$) matching that of the Europeans (0.12 ± 0.91). Figure 1 shows the histograms for FEV1 and FVC for GLI with and without the height modification. Using a modified height for deriving z-scores led to data that were closer to a Gaussian distribution with better centring on a mean of zero (panels C&D). The same histograms for FEV1/FVC are shown in Figure 2. Figure 3 shows for the Inuit that there was no correlation between age and FEV1 z-score using modified height ($r = 0.07$) which was also true for FVC z-score (not shown, $r = -0.04$).

The mean FEV1/FVC z-score for the Inuit was significantly lower than that for those who were not Inuit (−0.45 ± 0.96 and −0.01 ± 1.04, respectively, $p < 0.03$), which may reflect the higher proportion of smokers amongst the Inuit. Using modified height changed the mean FEV1/FVC z-score by only 0.06 (range 0.01 to 0.12) to −0.39 ± 0.99. The proportion of participants with FEV1/FVC below the lower limit of normal (LLN) using modified height was 10.0% for the Inuit (n = 35) and 3.5% (n = 1) for the non-Inuit participants, but this difference was not statistically significant due to small sample size ($p = 0.34$, Fisher's exact test). The mean z-scores for FEV1, FVC and FEV1/FVC for the 8.7% of the participants with physician diagnosed asthma are shown in Table 3 and were lower than that found for those without asthma, both with and without the height modification for predicting lung function, but the differences were not significant.

Discussion

We have confirmed that using GLI prediction equations and recorded height for our Inuit participants gave predicted values that were too low, making it appear as if the Inuit have supra-normal lung function [4,5]. We

Table 1. Demographic data for the Inuit and non-Inuit participants.

	Inuit n = 351			non-Inuit n = 29		
	Mean	SD	Range	Mean	SD	Range
Age years	38.3	13.5	16.0 to 65.6	49.3	11.1	20.0 to 68.1
Recorded Height m	1.68	0.08	1.44 to 1.90	1.74	0.10	1.55 to 1.92
Modified Height m	1.75	0.09	1.48 to 1.98	-	-	-
BMI Kg·m^{-2}	26.2	5.4	16.8 to 53.8	27.5	3.9	17.7 to 34.0
Modified BMI Kg·m^{-2}	24.4	5.1	15.6 to 49.7	-	-	-

Table 2. Table of z-score values for FEV1, FVC and FEV1/FVC for the 351 Inuit with recorded height and height modified for SHR and the 29 non-Inuit participants.

	Inuit n = 351				Inuit Modified Ht n = 351				non-Inuit n = 29			
	Median	Mean	SD	Range	Median	Mean	SD	Range	Median	Mean	SD	Range
zFEV1	0.56	0.53	1.36	−3.24 to 5.75	−0.07	−0.12	1.24	−3.45 to 4.53	0.35	0.15	1.17	−3.74 to 1.68
zFVC	0.77	0.81	1.20	−2.57 to 5.28	0.06	0.10	1.10	−2.96 to 4.12	−0.10	0.12	0.91	−1.97 to 1.87
zFEV1/FVC	−0.34	−0.45	0.98	−3.56 to 2.27	−0.29	−0.39	0.99	−3.53 to 2.36	0.21	−0.01	1.04	−4.57 to 1.35

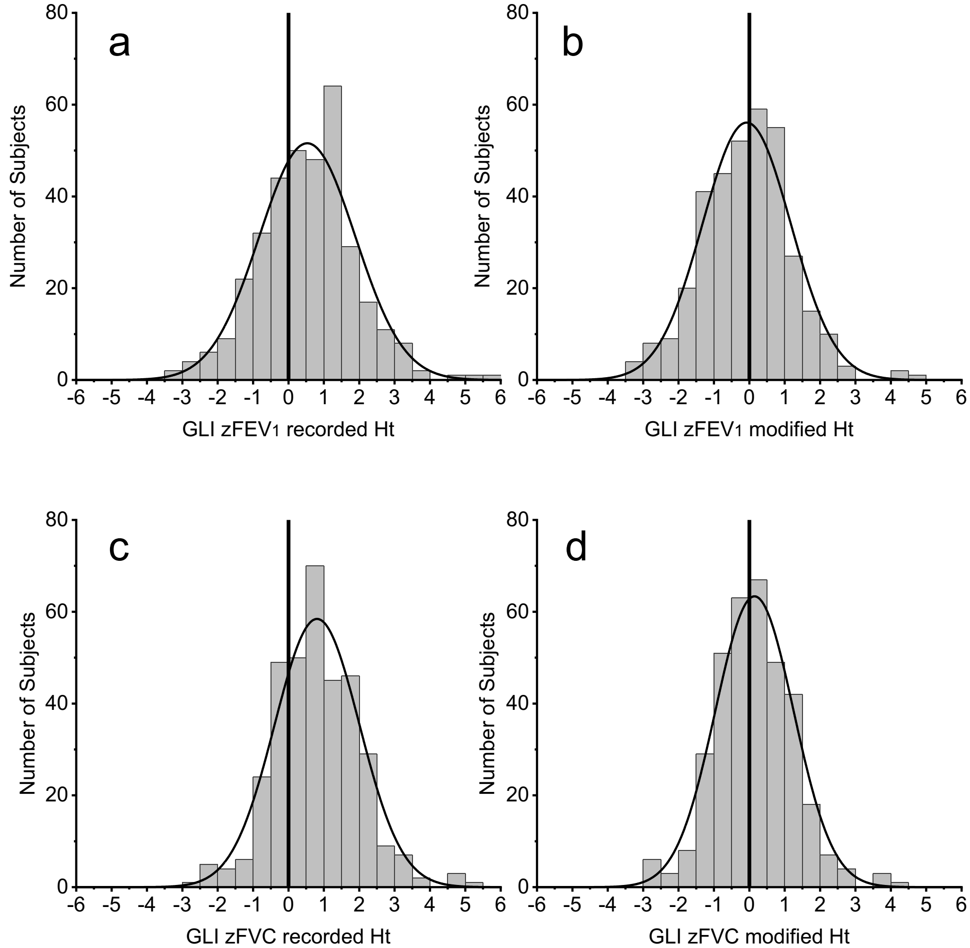

Figure 1. Histograms of the z-scores for FEV1 and FVC for the 351 people of Inuit descent calculated by GLI using recorded height (panels A & C) and with height modified for SHR (panels B & D).

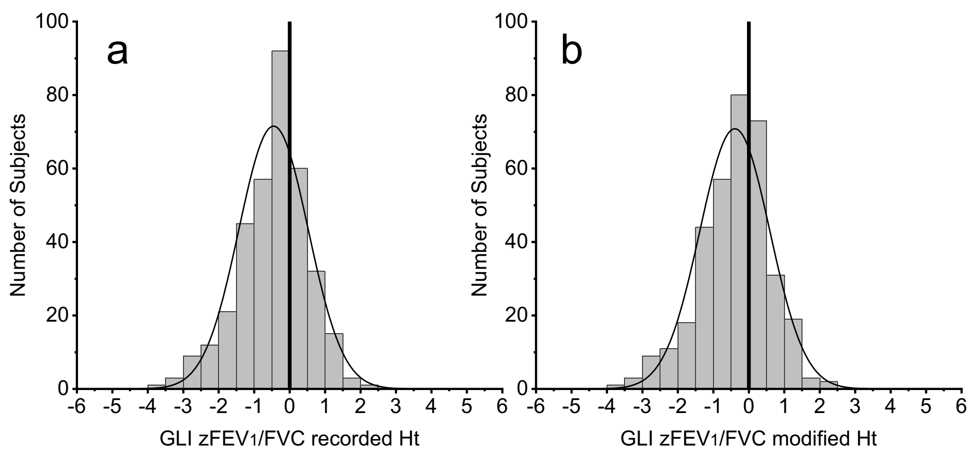

Figure 2. Histograms of the z-scores for FEV1/FVC for the 351 people of Inuit descent calculated by GLI using recorded height (panel A) and when using height modified for SHR (panel B).

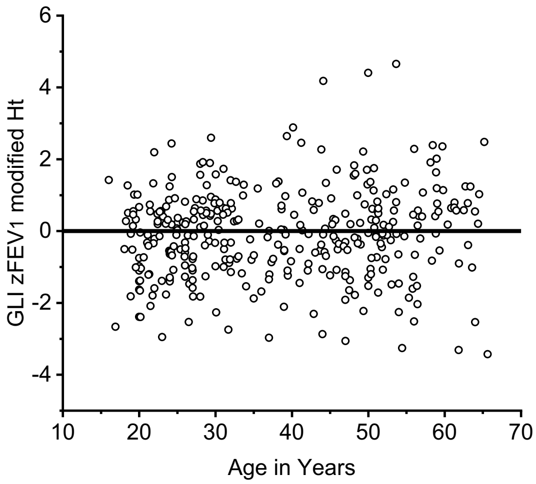

Figure 3. Plot of GLI FEV1 z-scores for the 351 Inuit participants using modified height against age.

have shown that by modifying the recorded height for the known differences in SHR between European and the Inuit this discrepancy is removed. Diagnosing or assessing the severity of pulmonary conditions in the Inuit would be compromised by using recorded height and GLI equations and our suggested height modification removes this problem. For our Inuit participants, the FEV1/FVC was significantly below predicted with and without the height modification, whereas the FEV1/FVC for those of European or other ancestry was not significantly different from predicted. This may be due to the much higher smoking rates among the Inuit in our study compared to those of European or other ancestry. The effect of height modification in FEV1/FVC z-score for the Inuit was very small and is in keeping with the findings of others that ancestry has a much lesser effect on FEV1/FVC compared to that for FEV1 and FVC [3].

There has been increased interest in questioning whether using ancestry-specific prediction equations is appropriate [19,20]. It has been shown that lower socio-economic status (SES), as reflected by poorer education and lower income, is associated with lower lung function [21] and the fact that African Americans appear to have lower spirometric lung function than those of European ancestry may be due in part to poorer SES. However, genetic factors have been shown to be the major reason behind the differences in lung function between African Americans and people of European ancestry [22]; the effect of poverty has been estimated at 2.5% to 7.5% of the difference, with education accounting for 2.0% to 4.7% and anthropomorphic differences accounting for about 35% of the discrepancy [23]. In Canada, the Inuit have low socio-economic circumstances compared to Canadians of European ancestry [24] and yet their lung function appears to be supra-normal, giving further support to the finding that genetic influences are more powerful than low SES in this respect. We do not have any information about the socio-economic circumstances in our study. However, as we excluded managers and office workers and included only participants who were employed in fishing and seafood processing, the differences in socio-economic status between participants may be limited.

Although SHR is a factor in explaining the differences in the relationship between lung function and height for both African-Americans and the Inuit it is not necessarily true for all Nations. In children of Asian origin living in the UK, sitting height did not account for the smaller lung function in children of Asian ancestry when compared to children of European ancestry [25]. It is known that the configuration of the thorax is different between men and women [26] and so it may be that there are also differences in this respect between people of different ancestry. To date, standing height has been used as the best size indicator so far for assessing lung function. However, it may be that using other anthropomorphic measurements, such as ulnar length, which are not affected by obesity in the way that sitting height can be affected will lead to a better prediction for lung function in the future.

Table 3. Mean (SD) z-scores for spirometric indices in the 33 participants with physician diagnosed asthma and the 347 non-asthmatics, together with the mean difference (95% confidence limits) between those with asthma and non-asthma.

		Asthma	Non-Asthma	Diff A-NonA
Recorded Ht:	zFEV1	0.07 (1.42)	0.54 (1.34)	−0.47 (−0.95 to 0.01)
	zFVC	0.50 (1.23)	0.78 (1.19)	−0.28 (−0.71 to 0.15)
	zFEV1/FVC	−0.67 (1.13)	−0.40 (0.97)	−0.28 (−0.69 to 0.14)
Modified Ht:	zFEV1	−0.48 (1.32)	−0.07 (1.23)	−0.41 (−0.85 to 0.03)
	zFVC	−0.12 (1.12)	0.12 (1.08)	−0.24 (−0.62 to 0.15)
	zFEV1/FVC	−0.62 (1.13)	−0.34 (0.98)	−0.28 (−0.70 to 0.13)

We conclude that modifying height according to differences in SHR may be a valid approach to obtain improved lung function prediction for peoples of non-European ancestry where there are no adequate ancestry-specific prediction equations.

Abbreviations

ECRHS: European Community Respiratory Health Survey; FEV1: Forced expiratory volume in the first second of expiration; FVC: Forced vital capacity; GLI: Global Lung Function Initiative; LLN: Lower limit of normal; SES: Socio-economic status; SHR: Sitting height divided by standing height ratio

Acknowledgments

We thank Kurt Rasmussen, Torben Sigsgaard, Niels Ebbehøj, Øyvind Omland, Ole Carstensen, Kirsten Østergaard and the medical students, who helped collect the data, for their diligence in obtaining the lung function data for this study.

Disclosure statement

Birgitte Laustsen, Jakob Bønløkke and Martin Miller individually declare that they have no relevant conflicts of interest in terms of relationships or finance in respect of this work.

Funding

This work was supported by the Danish Working Environment Research Fund [grant number 20165103740]; the Greenlandic Occupational Health Award (the work environment reward 2015); the Occupational Health Service in Greenland; the Greenlandic Workers' Union; Greenland Business Association; Royal Greenland; Polar Seafood and Bank of Greenland. The sponsors had no role in study design, data collection, analysis or interpretation of data, the writing of the report or the decision to submit the article for publication.

ORCID

Martin R Miller http://orcid.org/0000-0001-9971-5759

References

[1] Oscherwitz M, Edlavitch SA, Baker TR, et al. Differences in pulmonary functions in various racial groups. Am J Epidemiol. 1972;96(5):319–327.
[2] Rossiter CE, Weill H. Ethnic differences in lung function: evidence for proportional differences. Int J Epidemiol. 1974;3:55–61.
[3] 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.
[4] Rode A, Shephard RJ. Pulmonary function of Canadian Eskimos. Scand J Respir Dis. 1973;54:191–205.
[5] Krause TG, Pedersen BV, Thomsen SF, et al. Lung function in Greenlandic and Danish children and adolescents. Respir Med. 2005;99(3):363–371.
[6] Hawkes CP, Mostoufi-Moab S, McCormack SE, et al. Sitting height to standing height ratio reference charts for children in the USA. J Pediatrics. 2020;226:221–227.e15.
[7] Yap WS, Chan CC, Chan SP, et al. Ethnic differences in anthropometry among adult Singaporean Chinese, Malays and Indians, and their effects on lung volumes. Respir Med. 2001;95(4):297–304.
[8] Fredriks AM, Van Buuren S, Van Heel WJM, et al. Nationwide age references for sitting height, leg length, and sitting height/height ratio, and their diagnostic value for disproportionate growth disorders. Arch Dis Child. 2005;90(8):807–812.
[9] Chan Y, Salem RM, Hsu YHH, et al. Genome-wide analysis of body proportion classifies height-associated variants by mechanism of action and implicates genes important for skeletal development. Am J Hum Genet. 2015;96(5):695–708.
[10] Hamill PVV, Johnston FE, Lameshow S, Body weight, stature, and sitting height: white and Negro youths 12-17 years, USA. Vital. Heal. Stat. 1973. 11(126).
[11] Demirjian A. Anthropometry Report: height, weight and body dimensions. Ottawa Canada: Department of National Health and Welfare; 1980. p. 107–108.
[12] Ukwuma M. A study of the Cormic index in a Southeastern Nigerian Population. Internet. J. Biol. Anthropol. 2009;4(1):1–6.
[13] Pomeroy E, Stock JT, Wells JCK. Population history and ecology, in addition to climate, influence human stature and body proportions. Sci Rep. 2021;11(1):274.
[14] Galloway T, Chateau-Degat ML, Egeland GM, et al. Does sitting height ratio affect estimates of obesity prevalence among Canadian Inuit? Results from the 2007-2008 Inuit health survey. Am. J. Hum. Biol. 2011;23(5):655–663.
[15] Allen JA. The influence of physical conditions in the genesis of species. Radical. Rev. 1877;1:108–140.
[16] Quanjer PH, Stanojevic S, Cole TJ, et al. Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations. Eur Respir J. 2012;40(6):1324–1343.
[17] ECRHS questionnaire, (n.d.) [2020 Sept 30] .https://www.ecrhs.org/questionnaires-and-protocols
[18] Stanojevic S, Kaminsky DA, Miller M, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. Eur Respir J. 2022;60:2101499.
[19] Elmaleh-Sachs A, Balte P, Oelsner EC, et al. Race/Ethnicity, spirometry reference equations and prediction of incident clinical events: the multi-ethnic study of atherosclerosis (Mesa) lung study. Am J Respir Crit Care Med. 2021 Dec 16; 10.1164/rccm.202107-1612OC.
[20] McCormack MC, Balasubramanian A, Matsui EC, et al. Race, lung function and long-term mortality in the national health and examination survey III. Am J Respir Crit Care Med. 2021 Oct 1; Online ahead of print. DOI:10.1164/rccm.202104-0822LE .
[21] Prescott E, Lange P, Vestbo J. Socioeconomic status, lung function and admission to hospital for COPD: results from the Copenhagen City Heart Study. Eur Respir J. 1999;13(5):1109–1114.
[22] Menezes AMB, Wehrmeister FC, Hartwig FP, et al. African ancestry, lung function and the effect of genetics. Eur Respir J. 2015;45(6):1582–1589.

[23] Harik-Khan RI, Fleg JL, Muller DC, et al. The effect of anthropometric and socioeconomic factors on the racial difference in lung function. Am J Respir Crit Care Med. 2001;164:1647–1654.
[24] Duhaime G, Édouard R. Monetary poverty in Inuit Nunangat. Arctic. 2015;68:223–232.
[25] Whittaker AL, Sutton AJ, Beardsmore CS. Are ethnic differences in lung function explained by chest size? Arch Dis Child Fetal Neonatal Ed. 2005;90:423–429.
[26] Bellemare F, Jeanneret A, Couture J. Sex differences in thoracic dimensions and configuration. Am J Respir Crit Care Med. 2003;168(3):305–312.