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LUNG FUNCTION IN A COLD ENVIRONMENT: A CURRENT PERSPECTIVE

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Some previous authors, particularly Beaudry (1) and Schaefer (2), have noted a relatively poor lung function in the people of arctic communities. Low lung volumes have been associated with enlargement of the pulmonary arteries and a high incidence of electrocardiographic abnormalities which have been ascribed to cold-induced pulmonary damage. Our own research has suggested that "Eskimo lung" is a rarity (3). If there is indeed a cold-induced deterioration of lung function, however, it should now be diminishing since one consequence of acculturation has been a progressive reduction in cold exposure among the indigenous populations. Accordingly, we have carried out cross-sectional and longitudinal determinations of the aging of lung function in the Canadian Inuit community of Igloolik.

METHODS

All measurements of lung function were made by the same observer during the winters of 1970-71 and 1980-81, using a modern 13.5-liter low resistance Stead-Wells spirometer. At the time of the initial survey, many of the population were still making long and frequent hunting trips, but by 1980-81 the majority of the settlement had adopted a more sedentary lifestyle. The proportion of self-reported cigarette smokers among those over the age of 14 years had also increased from 64% of males and 85% of females in 1970-71 to 81% of males and 93% of females in 1980-81. Moreover, the average daily cigarette consumption by the smokers had risen from 11.8 in the men and 7.4 in the women to 20.2 in the men and 12.0 in the women.

On both occasions we tested all of the Igloolik population over the age of 9 years who were willing to complete the tests. We were successful in recruiting a high percentage of those living in the settlement, about 75% of the men and 60% of the women. Medical records allowed us to distinguish those with a prior history of respiratory disease from those with healthy lungs. Only 2 men in the village showed minor right ventricular bundle branch block, and there were no recorded cases of "Eskimo lung". However, about 10% of the adults had a history of chronic respiratory disease (usually primary or secondary tuberculosis).

RESULTS

Looking at the data first in cross-sectional fashion, we fitted the standard type of age and height regression equations to our data, using multiple regression techniques. Figures for men (Table 1) showed a substantial increase in the partial coefficient for aging from 8.3 ml/yr in 1970-71 to 31.4 ml/yr in 1980-81; this change led to an increase in typical predicted lung volumes for the young adult, but a marked decrease in typical predicted volumes for the 60 year old. Results for females show a similar general trend. This pattern of aging seems due entirely to the presence of a diseased cohort within the Igloolik community, and when the equations were recalculated excluding diseased sub-

Table 1. Equations for the prediction of FVC in Canadian Inuit men as calculated by multiple regression analysis, with typical values for male, height 165 cm.

	Typical values	
	Age 20	Age 60
<u>All men</u>		
1970 = -7.90 - 0.0083A + 0.0788H	4.93	4.60
1980 = -6.19 - 0.0314A + 0.0738H	5.36	4.11
<u>Healthy men</u>		
1970 = -4.57 - 0.0204A + 0.0617H	5.20	4.39
1980 = -4.78 - 0.0224A + 0.0643H	5.38	4.49
<u>Men with a history of respiratory disease</u>		
1980 = -9.69 - 0.0311A + 0.0940H	5.20	3.95

Table 2. Equations for the prediction of $FEV_{1.0}$ in Canadian Inuit men as calculated by multiple regression analysis, with typical volumes for male, height 165 cm.

	Typical values Age 20	Age 60
All men		
1970 = -5.28 - 0.0193A + 0.0584H	3.97	3.20
1980 = -4.28 - 0.0353A + 0.0566H	4.35	2.94
Healthy men		
1970 = -2.88 - 0.0240A + 0.0455H	4.15	3.19
1980 = -4.14 - 0.0269A + 0.0549H	4.38	3.13
Men with a history of respiratory disease		
1980 = -4.95 - 0.0367A + 0.0599H	4.20	2.73

jects, no significant differences of aging coefficients were found between the 1970-71 and 1980-81 surveys.

The same type of picture emerges for cross-sectional analyses of forced expiratory volume ($FEV_{1.0}$) (Table 2). If all members of the community are included in the multiple regression equations, the predicted lung function of the typical 60 year old male shows a decrease from 1970-71 to 1980-81. If diseased subjects are excluded, however, a small improvement in lung function can be seen in the 20 year old subjects, with no deterioration of FEV1.0 in the 60 year old individuals.

When the data are examined in a true longitudinal fashion (Table 3), there is a plainly accelerating curve of aging from those subjects who were initially aged 20 to 29 through those initially aged 30 to 39 to those initially aged 40 to 49 years, this being true of both forced vital capacity (FVC) and $FEV_{1.0}$, and also of both men and women. Such a pattern is at variance with the normal course of aging of lung function through the middle adult years, but is again readily explicable in terms of the passage through the Igloolik community of a cohort who developed tuberculosis in the 1950s who were subsequently successfully treated, but who still have some residual impairment of lung function.

The lung function of the people of Igloolik continues to develop until the early twenties. Accordingly, it is appropriate to include all young people aged 9 to 19 years in logarithmic equations describing growth of lung function in the community (Table 4). Other factors being equal, one might expect lung volumes to increase as the third power of height (4) although southern communities do not always reach this standard, particularly for girls, because of limited fitness and weakness of the chest muscles. When the Igloolik population was tested in 1970-71, the boys exceeded the theoretical exponent of 3.0 for both FVC and $FEV_{1.0}$, the girls reached an exponent of 3.01 for vital capacity, but had an exponent of only 2.50

Table 3. Longitudinal data showing loss of lung function (L,BTPS) in Inuit men and women over 10 years (1970-71 to 1980-81).

Initial age	FVC Men	FVC Women	$FEV_{1.0}$ Men	$FEV_{1.0}$ Women
20-29	-0.13	-0.11	-0.23*	-0.03
30-39	-0.47***	-0.23**	-0.42***	-0.29***
40-49	-0.70***	-0.38**	-0.54***	-0.36***

*** $P < 0.01$
** $P < 0.025$
* $P < 0.05$

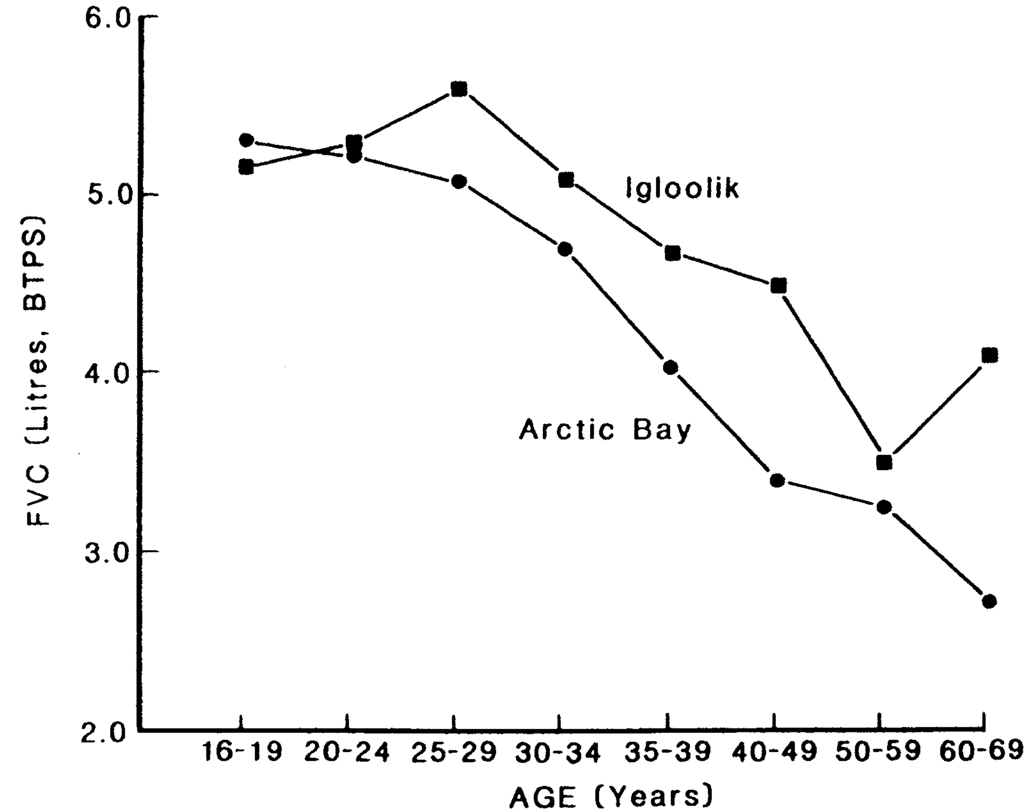

Figure 1. Cross-sectional comparison of FVC in Inuit men from Igloolik (squares) and Arctic Bay (circles). (At body temperature, pressure, saturated with water vapor, BTPS).

Table 4. Cross-sectional comparison of logarithmic equations describing growth of lung function in Inuit children aged 9 to 19 years.

Boys	Girls
Forced expiratory volume	
1970 = $1.76 \times 10^{-7} \times H^{3.31}$	1970 = $1.07 \times 10^{-7} \times H^{2.50}$
1980 = $2.16 \times 10^{-7} \times H^{3.29}$	1980 = $5.20 \times 10^{-7} \times H^{3.11}$
Forced vital capacity	
1970 = $2.55 \times 10^{-7} \times H^{3.28}$	1970 = $9.72 \times 10^{-7} \times H^{3.01}$
1980 = $1.30 \times 10^{-7} \times H^{3.43}$	1980 = $1.36 \times 10^{-7} \times H^{3.41}$

for the more effort-dependent $FEV_{1.0}$ measurement. Repetition of the tests in 1980-81 confirmed the impression already mentioned that young adults had a better lung function than in 1970-71. In particular, the exponents and thus predicted volumes were increased for both boys and girls.

DISCUSSION

Schaefer published cross-sectional data for pulmonary volumes measured on male Inuit living in the smaller community of Arctic Bay in 1980 (5). In young men, his findings agree closely with our data, but his cross-sectional curves suggest a faster rate of aging of function than we observed in Igloolik. We illustrate in Figure 1 the FVC data for Igloolik and Arctic Bay: curves for $FEV_{1.0}$ and maximum mid-expiratory flow rate follow a similar general pattern. There are a few miners in Arctic Bay, but we do not believe that either the proportion of miners or the extent of pneumoconiosis among present miners is sufficient to explain this difference of lung function results between the two communities. Arctic Bay is about 400 km north of Igloolik, but both settlements have equally harsh climates. There is thus no intrinsic reason to anticipate greater risk of freezing of the lung in the Arctic Bay region, although caribou hunters at Arctic Bay must travel somewhat farther than their Igloolik counterparts in search of game. Nor is there reason to anticipate a faster development of cigarette smoking at Arctic Bay than at Igloolik. Our data have already shown the marked impact of a diseased cohort upon the apparent aging of lung function, and it is logical to anticipate (as we have previously demonstrated in Igloolik) that a medical team will attract a higher proportion of volunteers with healed lung disease. The important lesson to draw from comparison of results for the two communities is that when examining aging curves for any population, southern or Inuit, subjects with healed respiratory disease must be excluded from the sample if the aging curve is not to be distorted.

A further practical point in the setting of standards for the Inuit population is that our longitudinal data have shown a rapid decrease of adult stature with age (some 2 cm per decade). We are still exploring reasons for this, and we need to consider further whether shortening of the spinal column leads to a parallel restriction of lung function.

Finally, looking ahead to the next decade, it is disturbing to note the ever increasing consumption of cigarettes, particularly by adolescents and young adults. This has not yet apparently had any marked effect upon standard spirometric test scores, but the effects of tobacco smoke are necessarily slow and insidious. A major impact of this adverse lifestyle must thus be anticipated over the next 10 to 20 years.

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