PHYSICAL FITNESS OF CANADIAN PHYSICAL EDUCATION STUDENTS WITH A NOTE ON INTERNATIONAL DIFFERENCES

Roy J. SHEPHARD & Peter PIMM

Dept. of Environmental Health, School of Hygiene, University of Toronto

ABSTRACT

Measurements of physical fitness have been carried out on 161 University of Toronto physical and health education students, 78 men and 83 women; 144 of the students were non-smokers, and the remainder had a relatively light cigarette consumption, 10 men averaging 12.3 cigarettes/day and 7 women 8.7 cigarettes/day.

The more fit members of the group tended to volunteer for maximum testing, while less fit subjects elected sub-maximum test procedures. Allowing for this factor, the average $\dot{V}O_2$ (max) was 49.0 ml./kg. min in the male non-smokers, 37.7 ml./kg. min in the female non-smokers, 51.8 ml./kg. min for male smokers and 42.9 ml./kg. min for female smokers. Measurements of skinfold thicknesses (average readings for four groups 12.2, 13.3, 19.5 and 15.3 mm) with estimates of body fat (18.0, 28.5, 21.9 and 27.7%), muscle strength and lean mass support the view that although most students perceive themselves as fit, neither the men nor the women have an exceptional capacity for endurance work.

Despite a recent and fairly light cigarette habit, lung volumes are poorer in the smokers than in the non-smokers.

Even at the first laboratory visit, bicycle ergometer predictions of $\dot{V}O_2$ (max) over-estimate direct treadmill readings for this group, the discrepancy being 5-6% for the men and 8-9% for the women.

Results are compared with published information on physical education students from other nations. There seem national differences between endurance-oriented Scandinavian students and heavy, contact-sport oriented North Americans.

INTRODUCTION

The level of fitness attained by physical and health education students has practical interest for several reasons. Perhaps most importantly, if those who are destined to teach this subject are not themselves commited to the idea of maintaining personal fitness, then their likelihood of influencing others to become fit seems small. Physical education students also form a clearly identified stratum of University Society, with relatively homogeneous patterns of activity and it is thus arguable that international comparisons of fitness based on such populations might have more validity than comparisons of heterogeneous "laboratory normal" subjects. Lastly, Swedish physical education students provided the original material or a widely used method of predicting maximum oxygen intake (Åstrand, 1960); it is thus of interest to compare directly measured and predicted maximum oxygen intake readings for Canadian physical and health education students.

The world literature contains many reports based on small volunteer samples from physical education classes, but there is less information on the status of randomly selected students or entire classes. Relevant publications include studies from Belgium (Heiters, et. al., 1966; Bottin et. al., 1968a, b), Denmark (Asmussen and Mathiasen, 1962), South Africa (Sloan, 1963, 1966; Wyndham, 1972), Sweden (Åstrand, et. al., 1972), the United Kingdom (Sloan, 1963; Watson and Jennings-White, 1974) and the U.S. (Sloan, 1963). The present paper contributes data on 164 Canadian students, the entire third and fourth year classes at the University of Toronto, analysing separately the results for smokers and non-smokers.

METHODS

During their laboratory course in exercise physiology, physical and health education students at the University of Toronto carry out the I.B.P. measurements of physical fitness (Weiner and Lourie, 1969), groups of 4-5 students working from a very detailed laboratory manual under the close supervision of an instructor. The simpler anthropometric measurements are performed on the whole class, together with readings for grip strength, knee extension force and vital capacity. Depending on the enthusiasm of a particular class group, two of the 4-5 students usually perform a sub-maximal exercise text on the bicycle ergometer, and two students (usually the remaining members of the group) perform a direct measurement of maximum oxygen intake on the treadmill. Data is recorded on prepared laboratory record

sheets, and students are assigned a mark based on the adequacy of their work.

Despite these precautions, there were a few items students failed to record on their data sheets, and occasional aberrant results for entire groups of 5 students that indicated careless calibration of equipment or failure to follow instructions. The mean results shown exclude aberrant and missing readings.

Data have been divided into four basic populations — male non-smokers (n = 68), female non-smokers (n = 76), male smokers (n = 10) and female smokers (n = 7). The majority of smokers had a moderately high cigarette consumption for athletes (12.3 ± 8.0, 2-25/day in the men, 8.7 ± 2.6, 5-11/day in the women).

RESULTS

Physical characteristics.

A surprisingly large number of students (10 M, 13 F) did not record their age. Among the boys, some also missed height and weight, and carelessness must be suspected. However, this was not the case with the girls, and here deliberate modesty was presumably involved. The majority of students fell within quite a narrow age band, with the boys one year older than the girls (Table I), but there were occasional "mature" students up to the age of 32. There were no differences of height between male smokers and non-smokers but female smokers were 4.9 cm taller than non-smokers (t_{79} = 1.88, 0.1 > P > 0.05).*

Skinfold readings show that much of the extra weight of the male smokers was fat (Δ7.3 ± 2.0 mm, t_{76} = 3.63, P < 0.01). Percentages of body fat were calculated according to a modification of the equation of Durnin and Ramahan (1967).** Male smokers were 4.7 kg heavier than the non-smokers (respective excess weights relative to modified scale of Society of Actuaries [Shephard, 1974] 5.5 kg in non-smokers and 9.9 kg in smokers, t_{67} = 2.08, P < 0.05). Skinfold readings show that much of the extra weight of the male smokers was fat (Δ7.3 ± 2.0 mm, t_{76} = 3.63, P < 0.01). Percentages of body fat were calculated according to a modification of the equation of Durnin and Ramahan (1967)". When lean mass and body fat were expressed in units of kg per cm of standing height, the smokers were significantly fatter (P < 0.01) but not more muscular than the non-smokers.

Among the female students, the smokers were again heavier than the non-smokers, but this could be explained entirely by their difference in standing height (respective excess weights relative to modified scale of Society of Actuaries −1.1 kg in non-smokers and 1.8 kg in smokers). Although there was a suggestion of thicker skinfolds in the smokers (respective mean values 13.3 mm in non-smokers, 15.3 mm in the smokers) the difference was statistically insignificant, as were differences in body fat and lean mass per kg of standing height.

Lung Volumes

In all four groups of subjects, the vital capacity exceeded the age and height predicted values given by the equations of Anderson et al. (1968), the advantage being significant for the male non-smokers (4.70 ± 2.5%, 0.10 > P > 0.05), the female non-smokers (12.0 ± 2.4%, P < 0.001) and the female smokers (11.0 ± 5.5%, 0.1 > P > 0.05). Although average readings were a little lower in the smokers (1.5% in males, 1.0% in the females), these differences were not statistically significant.

Among the non-smokers, the one-second forced expiratory volume was slightly below normal in the men, but above predictions in the women (+10.6 ± 3.0%, P < 0.001). The average $F.E.V._{1.0}$ was 5.5% lower in male smokers, and 6.6% lower in female smokers; however, because of the small size of the group and the low and variable cigarette consumption, these differences from non-smokers were not statistically significant. The average $F.E.V._{1.0}/V.C.$ ratios for the non-smokers were a little less than predicted for normal sedentary subjects; the difference was statistically insignificant in the males, but was significant in the females (Δ2.5 ± 1.1%, P < 0.05). This finding reflects the large vital capacity rather than any impairment of one second flow. The average deficit was larger in the smokers (3.9%, n.s. in the men, 4.5 ± 1.6%, P < 0.05 in the women).

Aerobic power and muscle strength

A little over a half of our sample reached a plateau of oxygen intake < 0.15 ℓ/min during direct measurements of maximum oxygen intake (Table III). The absence of a clear plateau in some subjects seems an almost inevitable problem when but a single test is performed, with no guidance as to the aerobic power of the subject other than his or her response to the warm-up exercise. Nevertheless, all subjects continued to exercise to exhaustion, and a comparison of heart rates, respiratory gas ex-

* The significance of differences between means of unequally sized groups has been calculated according to the formula

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_p \sqrt{(1/N_1 + 1/N_2)}}$$

where $S_p^2 = \frac{N_1 (S_1^2) + N_2 (S_2^2)}{N_1 + N_2}$ (Dixon & Massey, 1969)

** Average skinfold readings have been calculated as Σ2 (triceps) + subscapular + suprailiac folds.

Table I

Physical characteristics of students from physical education classes (mean ± S.D., n, range), classified by sex and smoking habits. Data for Toronto normals: Shephard and Brown, (1968), Rode, (1970) provided for comparison.

Variable	Non-smokers		Smokers		Toronto Normals	
	Male	Female	Male	Female	Male*	Female†
Age (yr)	22.9 ± 2.5 (58) (20–32)	21.6 ± 2.2 (63) (19–32)	22.9 ± 1.3 (10) (21–25)	21.6 ± 1.1 (7) (20–23)	23	26
Height (cm)	177.3 ± 6.1 (65) (166.0–190.5)	163.4 ± 6.5 (74) (141.9–180.0)	177.5 ± 5.5 (9) (168.9–183.5)	168.3 ± 6.9 (7) (160.0–176.5)	173.5 ± 8.8 (64)	161.7 ± 7.9 (23)
Wt. (kg)	76.5 ± 9.0 (63) (60.5–95.2)	57.6 ± 7.4 (75) (41.9–75.9)	81.2 ± 7.8 (9) (70.5–91.0)	61.1 ± 5.9 (7) (53.9–69.0)	68.9 ± 10.0 (64)	57.0 ± 7.2 (23)
Excess Weight (kg)	5.5 ± 5.8 (60) (−6.4–20.7)	−1.1 ± 5.9 (72) (−12.6–20.1)	9.9 ± 7.6 (9) (−0.6–22.1)	1.8 ± 5.2 (7) (−6.4–8.5)	0.6 ± 8.3 (64)	1.4 ± 6.9 (23)
Skinfold Thicknesses						
Triceps (mm)	9.8 ± 4.9 (68) (2.0–25.6)	15.7 ± 4.4 (76) (7.0–30.0)	13.9 ± 4.9 (10) (7.6–23.0)	16.0 ± 6.4 (7) (6.0–27.0)		
Subscapular (mm)	12.1 ± 3.9 (68) (5.0–22.0)	12.4 ± 3.9 (76) (6.5–22.5)	14.7 ± 5.6 (10) (9.0–28.0)	16.0 ± 8.1 (7) (10.0–34.0)	11.0 (64)	18.6 (23)
Suprailiac (mm)	14.6 ± 6.5 (68) (3.0–34.7)	11.8 ± 5.8 (75) (2.0–28.0)	18.8 ± 6.4 (10) (10.0–28.3)	14.0 ± 11.1 (7) (3.0–38.0)		
Average of 3 folds (mm)	12.2 ± 4.2 (68) (5.0–25.4)	13.3 ± 4.0 (75) (6.7–21.4)	19.5 ± 13.6 (10) (9.9–55.3)	15.3 ± 8.1 (7) (8.3–33.0)		
Estimated % Body Fat	18.0 ± 4.5 (68) (6.9–29.2)	28.5 ± 4.0 (74) (17.0–36.3)	21.9 ± 3.9 (10) (16.2–29.2)	27.7 ± 3.0 (6) (23.6–30.2)	17.6 (64)	33.4 (23)
Lean Mass (kg/cm)	0.34 ± 0.03 (62) (0.24–0.42)	0.25 ± 0.03 (71) (0.15–0.31)	0.35 ± 0.03 (9) (0.30–0.39)	0.25 ± 0.02 (6) (0.23–0.29)	0.3280	0.2350
Body Fat (kg/cm)	0.07 ± 0.02 (62) (0.02–0.12)	0.10 ± 0.02 (71) (0.04–0.15)	0.10 ± 0.02 (9) (0.07–0.14)	0.09 ± 0.01 (6) (0.07–0.11)	0.0691	0.1175

* Men attending a Provincial Trade School – about 50% were smokers.
† Women attending smoking withdrawal clinic.

change ratios, and differences between directly measured and predicted $\dot{V}O_2$ (max) readings suggest that both "plateau" and "non-plateau" subjects realised their maximum oxygen intake.

In the majority of subjects from both "plateau" and "non-plateau" groups, the directly measured maximum oxygen intake exceeded the figure predicted by the Åstrand nomogram. Comparison of the treadmill maxima with bicycle ergometer predictions were made on only 7 students (3 men and 4 women). The bicycle prediction was higher in 6 of the 7 students, the discrepancy averaging 3.7 ml./kg. min (5.5%) in the men, and 3.1 ml./kg. min (8.2%) in the women. On the other hand, direct treadmill maxima were generally higher than the indirect bicycle ergometer predictions for other students. One may thus surmise that the more fit members of each laboratory group elected to perform the maximal treadmill run. On this basis, and correcting the bicycle ergometer predictions for over-estimation, the class average $\dot{V}O_2$ (max) for the male non-smokers would be 49.0 ml./kg. min, for the female non-smokers 37.7 ml./kg. min, for the male smokers 51.8 ml./kg. min, and for the female smokers 42.9 ml./kg. min. There was no significant difference or aerobic power between the male smokers and non-smokers, but as in our previous studies (Shephard and Rode, 1971) there was a suggestion that the female smokers had a greater aerobic power than their non-smoking counterparts.

There were no significant differences of muscle strength between smokers and non-smokers. The hand-grip force was a reasonably precise measurement (coefficient of variation 13.0% in the men, 15.7% in the women). Trunk flexion and knee extension force were much more variable; some of this variation may represent the influence of participation in various sports upon the strength of the back and leg muscles, but from our observation of the students, we suspect that much of it arises from difficulty in applying efficient counter-pressure on the Clark tensiometer table.

DISCUSSION

1. Physical Fitness of Students

Since the majority of the group were non-smokers, the physical fitness of this group will be discussed first, and then differences observed in the smokers will be analysed.

(a) *Body build.* The University students, both male and female, were taller than reference populations of young normal subjects studied in Toronto over the past ten years. This could reflect the continued economic privilege of the general University population, or the selection of physical education as a career by taller students. The former hypothesis seems the more likely, since in Belgium, women physical education students were 5 cm *shorter* than those enrolled in other faculties (Bottin et al., 1968), while in South Africa the male physical education students were 0.2 cm shorter and the women 2.2 cm taller than those from other disciplines (Sloan, 1966).

The male physical education students in Toronto were no leaner than reference populations of the same age; skinfold readings, and the corresponding estimates of body fat were indeed slightly higher than in a group attending a Provincial Trade School. On the other hand, a group of women attending a smoking withdrawal clinic (Rode, 1970) were a little heavier and fatter than the female physical education students (expressed in kg/cm, the smoking withdrawal patients had 7% more body weight than female physical education students who were also smokers).

When expressed per cm of standing height, all physical education groups carried more lean mass than the Toronto reference populations; among the non-smokers, the additional lean tissue amounted to 5.0% in the men and 6.3% in the women, while among the smokers the corresponding figures were 6.6% and 7.4%.

There seem surprisingly large differences of body build between physical education students in different countries and different socio-economic groups (Table V). Thus, within South Africa, the male "coloured" students are 12 cm shorter than the "whites", while the female "coloured" students are 7 cm shorter; both male and female "white" South African students carry some excess weight, but the coloured students are lighter than actuarial predictions. In Sweden, where aerobic training tends to be emphasized, the men weigh less than predicted, but in the U.S. (where samples presumably include contact sportsmen) there is an excess weight of 12 kg. The Canadian men are rather above the average height for 198 physical education students drawn from different parts of the world (advantage 2.3 cm), but the women are a little below the average height (discrepancy 0.9 cm); in both sexes, the excess weight relative to height seems intermediate between that noted for the U.S. (substantial excess in men, deficit in women) and that seen in many other countries.

(b) *Lung Volumes* We have noted already that the lung volumes of physical education students exceed the age and height related norms for a sedentary reference population (Anderson et al., 1968). The absolute vital capacity (Table VI) is very similar in the Danish (Asmussen and Mathiasen, 1962), Swedish (Åstrand et al., 1972) and Canadian samples, although in terms of volume per cm of standing height, the Scandinavian results are 2-3% larger than the data from this laboratory.

Table II

Lung volumes of students from physical education classes (mean ± S.D., n, range) classified by sex and smoking habits

Variable	Non-smokers		Smokers	
	Male	Female	Male	Female
Vital Capacity (ℓ BTPS)	5.59 ± 0.74 (61) (3.81–7.30)	3.94 ± 0.53 (67) (2.70–5.40)	5.71 ± 0.86 (10) (4.56–7.20)	4.22 ± 0.38 (7) (3.76–4.70)
% Predicted Vital Capacity*	104.7 ± 11.3 (52) (79.6–124.1)	112.0 ± 14.7 (55) (83.6–154.4)	103.2 ± 13.4 (9) (87.9–122.4)	111.0 ± 12.5 (7) (93.4–137.5)
One second forced expiratory volume (ℓ.BTPS)	4.62 ± 0.63 (57) (2.96–5.95)	3.37 ± 0.47 (56) (2.37–4.40)	4.46 ± 0.74 (7) (3.44–5.60)	3.41 ± 0.29 (4) (3.04–3.66)
% Predicted $F.E.V._{1.0}$**	98.5 ± 18.4 (47) (70.5–129.8)	110.6 ± 16.0 (45) (69.3–153.0)	93.0 ± 12.1 (6) (72.6–104.9)	104.0 ± 10.9 (4) (88.9–114.1)
$F.E.V._{1.0}$/V.C. (%)	82.8 ± 5.6 (55) (70.0–93.6)	85.1 ± 7.9 (53) (67.8–96.8)	80.3 ± 8.8 (6) (66.7–91.1)	8.31 ± 4.5 (4) (78.9–88.6)
Predicted $F.E.V._{1.0}$ /V.C. (%)	84.0 ± 1.6 (54) (80.5–87.2)	87.6 ± 0.6 (63) (84.9–88.2)	84.2 ± 1.2 (9) (83.0–86.6)	87.6 ± 0.3 (7) (87.2–88.0)

* Vital capacity predicted according to equations of Anderson et al. (1968).
** Predicted according to equations of Anderson et al. (1968)

Table III

A comparison of maximum oxygen intake data between subjects reaching a formal plateau (augmentation of $\dot{V}O_2 < 0.15$ ℓ/min) and those failing to do so. (Mean ± S.D. range)

	Plateau		No Plateau	
	Men (n = 14)	Women (n = 11)	Men (n = 15)	Women (n = 5)
$\dot{V}O_2$ (max) ℓ./min STPD	4.04 ± 0.44 (3.33–5.09)	2.34 ± 0.36 (1.78–2.75)	4.01 ± 0.53 (2.85–5.07)	2.80 ± 0.49 (2.40–3.62)
ml./kg. min STPD	54.7 ± 5.8 (4.50–66.3)	39.1 ± 4.6 (30.0–44.3)	53.6 ± 4.9 (44.5–58.8)	46.3 ± 4.83 (39.6–52.7)
Δ Åstrand prediction	+0.67 ± 0.57 (−0.344 to +1.58)	+0.25 ± 0.31 (−0.18 to +0.97)	+0.44 ± 0.49 (−0.20 to +1.79)	+0.44 ± 0.43 (0.03 to +1.05)
f_h (max)	201 ± 9 (183–215)	199 ± 9 (190–220)	200 ± 12 (180–227)	201 ± 11 (190–218)
R	1.03 ± 0.07 (0.92–1.13)	1.02 ± 0.05 (0.95–1.14)	1.04 ± 0.07 (0.89–1.15)	1.14 ± 0.25 (0.83–1.42)

Table IV

Aerobic power and muscle strength of physical education students (mean ± S.D., n, range) classified by sex, and smoking habits

Variable	Non Smokers		Smokers	
	Male	Female	Male	Female
Directly measured $\dot{V}O_2$ (max)				
ℓ./min STPD	4.04 ± 0.51 (25) (2.85–5.09)	2.46 ± 0.49 (17) (1.64–3.62)	3.89 ± 0.31 (4) (3.48–4.20)	2.45 (1)
ml./kg. min STPD	55.0 ± 5.1 (21) (44.5–66.3)	40.7 ± 5.7 (17) (30.0–52.7)	50.2 ± 4.7 (4) (45.0–55.3)	44.3 (1)
Predicted $\dot{V}O_2$ (max)*				
ℓ./min STPD	3.80 ± 0.85 (29) (2.11–5.72)	2.18 ± 0.39 (28) (1.58–3.18)	4.35 (1)	2.65 ± 0.54 (3) (2.29–3.27)
ml./kg. min STPD	48.1 ± 10.9 (27) (29.3–70.0)	39.0 ± 6.2 (28) (29.5–52.1)	61.8 (1)	45.5 ± 6.2 (3) (41.4–52.6)
Handgrip force, dominant hand (kg)	58.2 ± 7.8 (66) (38–74)	36.0 ± 5.7 (75) (25–52)	61.1 ± 6.2 (8) (52–70)	38.7 ± 5.7 (7) (33–48)
Trunk Flexion force (kg)	52.0 ± 17.3 (62) (22–103)	29.7 ± 15.4 (73) (7–96)	43.2 ± 11.6 (8) (28–58)	24.9 ± 6.9 (7) (17–38)
Knee extension force (kg)	93.6 ± 33.2 (61) (28–160)	57.8 ± 17.3 (73) (20–108)	79.5 ± 31.9 (9)	59.2 ± 10.1 (6) (17–73)
Heart rate in maximal effort	201 ± 11 (25) (180–220)	199 ± 10 (16) (190–220)	1.99 ± 10 (4) (192–210)	202 (1)
Respiratory gas exchange ratio in maximal effort	1.04 ± 0.07 (25) (0.89–1.15)	1.07 ± 0.15 (16) (0.83–1.42)	1.03 ± 0.06 (4) (0.94–1.07)	0.98 (1)
Number reaching plateau of $\dot{V}O_2$ <0.15 ℓ./min	11	10	3	1

* Mainly different subjects from direct measurements.

Table V

Physical characteristics of Physical Education students in other countries

Country	N and Sex (yr)	Age (yr)	Height (cm)	Weight (kg)	Excess Weight (kg)	Author
Belgium	12F	20.7	161.4 ± 4.6	56.0 ± 4.5	−0.9	Bottin et al. (1968a)
	17M	20.1	175.4	71.2	+1.7	Heiters et al. (1966)
	20F	19.8	163.6	57.1	−1.6	
Denmark	25M	24	175.0	70.0	+0.8	Asmussen & Mathiasen
	11F	23	164.0	61.0	+1.9	(1962)
South Africa						
"White"	38M	17-26	178.8 ± 7.6	75.4 ± 9.0	+3.2	Sloan (1966)
	34F	17-26	166.2 ± 3.8	62.8 ± 5.8	+2.1	
"Coloured"	38M	17-26	166.6 ± 3.4	62.6 ± 5.6	−0.4	
	34F	17-26	158.9 ± 4.4	54.3 ± 6.6	−0.9	
"White"	15M	18-25	175.6 ± 6.6	74.7 ± 9.1	+5.1	Sloan (1963)
	14F	18–25	166.0 ± 6.8	61.9 ± 10.5	+1.3	
	16F	–	–	58.8		Wyndham (1972)
Sweden	31M	25.9	176.6 ± 1.1	69.9 ± 1.1	−0.5	Åstrand et al. (1972)
	35F	21.9	165.6 ± 0.9	59.8 ± 1.0	−0.5	
United Kingdom	18M	18–25	173.0 ± 4.1	73.2 ± 5.3	+5.4	Sloan (1963)
	21F	18–25	165.0 ± 6.3	60.0 ± 6.5	−0.0	
	27F	19.7	167.5 ± 6.3	64.5 ± 8.6	+2.9	Watson & Jennings–White (1974)
United States	16M	18–25	182.0 ± 8.0	86.7 ± 11.0	+12.0	Sloan (1963)
	15F	18–25	164.0 ± 5.1	57.1 ± 6.4	−2.0	
Weighted average	M 198		174.8	71.7	+2.45	
	F 223		164.3	59.6	+0.30	

Table VI

Lung volumes of Scandinavian and Canadian physical education students

Variable	Men	Women	Author
Vital Capacity (ml/cm BTPS)	32.8	25.2	Andersen (1959)
Vital Capacity (ℓ.BTPS)	5.62 (25)	4.08 (11)	Asmussen &
(ml/cm BTPS)	32.1	24.9	Mathiasen (1962)
(ℓ.BTPS)	5.65 (31)	4.22 (35)	Åstrand et al.
(ml/cm BTPS)	32.0	25.5	(1972)
Vital Capacity (%)	80.0	79.9	Åstrand et al. (1972)
Vital Capacity (ℓ.BTPS)	5.55 (67)	3.94 (67)	Present study
(ml/cm BTPS)	31.3	24.1	

(c) *Aerobic power and muscle strength* As noted in the results, it is possible (i) that the more fit subjects of our population volunteered for maximum testing and (ii) that the Åstrand nomogram over-estimated the aerobic power of those performing the sub-maximum test; after correction for both of these possible sources of error, the aerobic power of the physical education students was very comparable with published data for the Toronto population of the same age (Shephard, 1969).

Data from other countries is summarized in Table VII; reported values for male physical education students range from 39.0 – 58.7 ml./kg. min, depending on the criteria of maximum effort, the type of ergometer used, the degree of training of the subjects and selection factors. It seems doubtful if the subjects of Heiters et al. (1966) reached a true maximum oxygen intake, since the average heart rate in their experiments was only 180/min, compared with 194-196/min in the series of Åstrand et al. (1972). If the true maximum heart rate of the Belgians was as in the Scandinavian series, then the Belgian students were only tested to 89% of maximum oxygen intake, and their true maximum would have been 43.3 ml./kg. min STPD. The Danish male PE students had an aerobic power very comparable with that found in Toronto. The Swedish PE students were substantially fitter on a per kilo basis, but in absolute terms their maximum oxygen intake was no greater than that observed for those of the Toronto group who elected to perform a maximal test. Von Döbeln (1956) measured the body fat of the Swedish group; the average was only 10.6% in 35 male students and 20.3% in 35 females; it thus seems likely that their better showing was not due simply to a selection of fitter subjects for maximum testing, but also reflected emphasis on endurance training and diminution of body fat.

Among the women PE students aerobic power ranged from 37.5 ml./kg. min in South Africa (where results may have been biassed downwards by the test altitude) to 47.6 ml./kg. min in Sweden. The Toronto sample was substantially less fit than Scandinavian students, whether data were expressed in absolute or in relative terms.

Two groups of male medical students from Belgium and France respectively had aerobic powers that compared well with those of PE students. However, in view of the vast medical classes at the universities in question, this may merely represent a sampling of the fittest students. The 9 female medical students examined by Wyndham (1972) were much less fit than South African PE students.

The values for handgrip force among our male physical education students were some 8% higher than for the reference population in Toronto; however, the values for our female students seemed no higher than our limited unpublished data for other young Toronto women. The only foreign PE students available for comparison are those of Asmussen and Mathiasen (1962). Their handgrip forces of 54.3 kg (M) and 36.7 kg (F) seem in keeping with our previous suggestion that male PE students in North American – either through selection or training – have a somewhat greater lean mass than their European counterparts.

Should the physical education student be striving for a higher level of personal fitness? The fact that neither the estimated percentage of body fat nor the aerobic power differ greatly from figures found in the average working class young Torontonian suggests that the physical education students should be undertaking more endurance-type activity. Well-trained male athletes can with advantage reduce their fat stores below 10% of body weight, and part of the failure of the present group to meet "ideal" weights could be corrected by a reduction of stored fat. In view of large constitutional differences in potential aerobic power, it is difficult to state categorically how much improvement of maximum oxygen intake might be attained by a more vigorous training programme; however, we do know that a number of University athletic teams that have undergone vigorous endurance training have realised a substantially higher aerobic power; thus, distance competitors in the men's swimming team have shown an average maximum oxygen intake of 4.89 l./min, 65.4 ml./kg. min STPD (Shephard et al., 1973[b]).

From the viewpoint of their ultimate health-teaching mission, perhaps the most alarming aspect of the present results is that neither the male nor the female students perceived a personal need for greater endurance activity, although a number of the boys commented that the girls' programme was inadequate in this respect. The boys mainly work quite hard in the gymnasium, but perhaps give too much emphasis to the development of strength. Among the girls, reluctance to undertake endurance work seemed related to fears of becoming too muscular "when I started jogging, my boy friend complained my calves were becoming too large" was a typical comment.

2. The effects of cigarette smoking

It is somewhat difficult to separate constitutional factors from responses to the cigarette habit. However, in agreement with our previous observations on the general population (Shephard and Rode, 1971; Rode, Ross and Shephard, 1972), the male cigarette smoker is in some respects less fit than his non-smoking counterpart. In the present series of data, this trend is reflected in a substantially higher percentage of body fat, although aerobic power is about the same for the two groups (both in absolute units and when expressed per kilogram of body weight). In contrast, the female smoker tends to be more fit than her non-smoking partner; among the

Table VII

Aerobic power of student populations in other countries (P.E. = Physical Education, M = Medicine)

Country	Faculty	Age (yr)	Sex n	Aerobic power ℓ./min STPD	ml./kg.min STPD	Author
Denmark	PE	24	25M	3.61	51.6	Asmussen & Mathiasen (1962)
		23	11F	2.79	45.7	(1962)
Sweden	PE	25.9	31M	4.08	58.7	Åstrand et al. (1972)
		21.9	35F	2.83	47.6	
Belgium	PE	20.1	17M	2.71	39.0	Heiters et al. (1966)
	PE	20.7	12F	2.28	41.1	Bottin et al. (1968[b])
	M	21.4	37M	3.83	56.7	Bottin et al. (1968[a])
South Africa	PE	–	16F	2.20	37.5	Wyndham (1972)
	M	–	9F	1.73	31.1	
France	M	17-23	73M	3.07	46.6	Flandrois & LaCour (1966)

present series of PE students there is no advantage in terms of body fat, but the aerobic power is substantially higher in the smokers.

An apparent deterioration of one second forced expiratory volume is shown rather equally in male and female smokers. Since the smokers are neither weaker nor smaller than non-smokers, we may assume the loss of $F.E.V._{1.0}$ is a reflection of the cigarette habit rather than associated constitutional factors. It is striking that a change of this magnitude can be demonstrated after only a few years of what might be regarded as relatively mild cigarette usage.

In terms of effectiveness in health education, it is encouraging to find that only 17 of the 161 students were smoking, and that in the majority of these 17 cigarette consumption was lower than in the general population of the same age.

3. Åstrand nomogram

Previous comparisons between bicycle ergometer predictions and directly measured treadmill maxima (Shephard et al., 1968) have suggested that in young and moderately active Canadians, a first submaximal test over-estimates the true maximum by 8.4%. The present sample is rather small for generalization, but it would appear that in Canadian physical education students also the true maximum is over-estimated, by an average of 5-6% in the men and 8-9% in the women. This reflects the absence of anxiety among the physical education students; for the most part, they enjoyed their laboratory classes in a good humored if not boisterous manner.

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