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# Normal Levels of Activity in Canadian City Dwellers

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SCANDINAVIAN workers[1] have suggested that a pulse rate of 140-150 per minute must be reached to induce cardiorespiratory training, while others[2, 3] have noted some increase in aerobic power following much more moderate exercise. One possible explanation of these divergent findings is that the response to a training regimen depends not only upon the intensity of the exercise undertaken, but also upon the initial fitness of the individuals concerned.[3] Whereas among some Scandinavian populations the pulse rate not infrequently exceeds 140-150 per minute for significant periods during the day, in the more sedentary communities of urban Canada, a pulse rate of 120 per minute may be unusual.

Even in Scandinavia, sedentary groups exist. Andersen[4] obtained telemetric recordings of pulse rates from three office workers, and found few values greater than 110 per minute during a normal working day. The present report describes the pulse rate experience of some typical city dwellers in Canada.

## Methods

Readings were obtained by means of a small portable electrocardiograph amplifier and tape recorder.[5] An accelerated playback device with digital counter and printing mechanism provided a permanent record of the pulse rate for alternate minutes of a 24-hour day. This information was correlated with a detailed diary and responses to a more general "activity recall" questionnaire. Approximate figures for energy expenditure were also calculated, using personal graphs of pulse rate versus oxygen consumption established in the laboratory.

*Subjects.* Repeated studies were made on eight members of the laboratory staff over the course of a year, 24-hour records being obtained for several working days and at least one weekend day on each subject. Ages and physical data for the laboratory subjects are shown in Table II. Additional 24-hour records were obtained on eight students at the Provincial Institute of Trades: seven aged 16 to 19 years and one aged 60 (mean height 176.3 cm., range 161.3 to 186.7 cm. and mean weight 70.8 kg., range 56.7 to 81.2 kg.).

*Pulse rate recording technique.*—The electrocardiogram was recorded from parasternal leads, using the Holter[5] miniature amplifier and tape recorder (Avionics Corporation, Los Angeles, California). This apparatus was portable (weight 1.6 kg., volume 1470 c.c.). During the daytime it was strapped to the waist or slung from the shoulder in a leather carrying case; at night, extension leads were fitted to allow the recorder to rest on a chair at the bedside.

The manufacturers claimed the recording speed to have a precision of $\pm 0.2\%$. In practice, this was not achieved. When first received, and operated under ideal conditions on the laboratory bench, errors of $\sim 0.8\%$ occurred when the batteries were well charged (voltage $\sim$ 8.5), and these errors increased to $\sim 1.2\%$ after the batteries had been used for 10 hours (voltage $\sim$ 7.6).* Somewhat greater errors were encountered in ambulatory subjects, momentary slowing of the motor occurring when the recorder was subjected to vigorous movements. The total "loss" of time over a 10-hour tape was usually $\sim$ 10 minutes; however, it was possible to adjust the time base and the pulse rates for this loss by

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*The voltage applied to the motor is stabilized by a Zener diode.

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TABLE I.—EXAMPLE OF METABOLIC ANALYSIS OF TYPICAL DAY (SEDENTARY MEMBER OF LABORATORY STAFF)

| *Activity* | *Duration of activity per day (min.)* | *Average pulse rate (per min.)* | *Equivalent gross energy expenditure (Kcal./min.)* | *Total work per day* | |
|---|---|---|---|---|---|
| | | | | *(From pulse rate)* | *(From activity recall)* |
| Sitting | 522 | 82.5 | 1.6 | 835 | 956 |
| Standing | 40 | 86.0 | 2.2 | 88 | 72 |
| Odd jobs in laboratory | 20 | 95.2 | 3.7 | 74 | 72 |
| Walking | 28 | 111.6 | 6.3 | 176 | 78 |
| Driving | 72 | 80.0 | 1.5 | 108 | 210 |
| Eating | 82 | 89.2 | 2.7 | 221 | 164 |
| Drinking coffee | 4 | 88.8 | 2.6 | 10 | — |
| Stairs up* | 5 x 2 | 105.8 | 5.4 | 54 | 27 |
| Stairs down* | 5 x 2 | 91.3 | 3.1 | 31 | — |
| Washing and dressing | 56 | 97.7 | 4.1 | 230 | 210 |
| Lying in bed | 51 | 78.0 | 1.5 | 77 | 105 |
| Asleep | 520 | 66.6 | 1.25 | 650 | 653 |
| Other items | 25 | 97.6 | 4.1 | 100 | 144 |
| Other | 1440 | | | 2654 | 2711 |

*The observed pulse rate is averaged for the two-minute interval following ascent or descent.

picking out the more vigorous activities recorded in the subject's diary.

The tapes were replayed at 60 times the speed of recording, using an "electrocardioscanner" (Avionics Corporation). The trigger signal from this device was fed to a digital counter and printing mechanism (Hewlett Packard); pulse rates were counted over alternate seconds (corresponding to alternate minutes of "real" time in the original record).

*Interpretation of pulse records.*—Subjects performed a progressive step test,[6] climbing a double nine-inch step at a progressively increasing rate (10, 15, 20, 25 ascents per minute). Pulse rates during the test were recorded by standard electrocardiogram, and expired gas was collected for the measurement of oxygen consumption during the final minute at each rate of ascent. A personal oxygen consumption/pulse rate curve was plotted for each subject, and was used to estimate metabolic activity assuming a standard conversion factor of 1 l. oxygen ≡ 5 Kcal. energy expenditure. The same data were applied to the Astrand nomogram[7] for the estimation of the maximum oxygen intake of the subjects.

*Activity records.*—Subjects were required to keep a minute-by-minute diary of their activities while wearing the tape recorder. An activity recall questionnaire (Shephard—to be published) was also completed, and an approximate figure for the subject's daily energy expenditure was calculated from the known energy cost[8,10] of the various activities specified.

## RESULTS

### 1. *Typical Patterns of Metabolic Activity*

The type of metabolic pattern seen during a typical day in the life of a sedentary member of the laboratory staff is illustrated in Table I. In this example, the highest pulse rate recorded was during a 28-minute period of brisk walking (average pulse 111.6 per minute). The energy expenditures estimated from the pulse data were in fair general agreement with estimates based on the activity recall questionnaire, the total discrepancy for the 24-hour period being 57 Kcal.

From the standpoint of training, it is convenient to classify all recorded pulse rates into four categories (Table II): < 100 per minute (corresponding to the sedentary, light, and

TABLE II.—CUMULATIVE PERIODS AT SPECIFIED PULSE RATES. LABORATORY STAFF, AVERAGE FIGURES FOR THREE TO FIVE WEEK-DAYS AND ONE OR TWO WEEKEND DAYS

| | | *Age (yr.)* | *Height (cm.)* | *Weight (kg.)* | *Period at stated pulse rate (minutes)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *<100/min.* | *100 to 120/min.* | *120 to 140/min.* | *140 to 170/min.* | *> 170/min.* | *Maximum oxygen intake (ml. STPD†/kg. min.)* |
| Sedentary subjects | | | | | | | | | | |
| | B | 39 | 170 | 67.2 | 1340 | 100 | 0 | 0 | 0 | 33.1 |
| | Ho | 65 | 174 | 70.0 | 1155 | 269 | 16 | 0 | 0 | 27.1* |
| | Hu | 30 | 185 | 92.5 | 1402 | 29 | 9 | 0 | 0 | 28.6** |
| | R | 25 | 168 | 57.6 | 1318 | 122 | 0 | 0 | 0 | 33.3 |
| | S | 37 | 182 | 75.0 | 1411 | 4 | 25 | 0 | 0 | 38.0 |
| Subjects taking voluntary sport | | | | | | | | | | |
| | N | 26 | 172 | 75.0 | 1323 | 87 | 20 | 10 | 0 | 48.1 |
| | S | 29 | 174 | 81.7 | 1404 | 23 | 7 | 6 | 0 | 48.3 |
| | W | 23 | 173 | 69.9 | 1292 | 94 | 54 | 0 | 0 | 58.1 |

*Subject had lung decortication some 15 years ago; he now has no symptoms apart from dyspnea on vigorous effort.
**Subject very obese.
†STPD.: Standard temperature and pressure, dry gas.

TABLE III.—PULSE RATE OF ACTIVE SUBJECT DURING SPECIFIED ACTIVITIES ON SIX DIFFERENT DAYS FROM A TWO-MONTH PERIOD; RESULTS EXPRESSED AS DISCREPANCIES FROM AVERAGE PULSE RATE FOR A GIVEN ACTIVITY

| *Activity* | *Average pulse rate* | *Discrepancy on individual days* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Day 1* | *Day 2* | *Day 3* | *Day 4* | *Day 5* | *Day 6* |
| Sitting at work | 78.5 | +1.8 | −1.5 | — | +0.9 | −1.2 | +0.1 |
| Standing at work | 83.7 | −5.3 | +1.9 | +1.5 | — | −0.5 | +2.5 |
| Climbing stairs | 108.8 | −3.3 | +7.2 | −1.7 | +0.4 | +2.5 | −4.0 |
| Sitting at home | 69.4 | +2.3 | — | +2.2 | −3.0 | −0.1 | −1.2 |
| Cooking | 84.6 | +1.3 | — | −6.7 | — | +2.6 | +2.9 |
| Eating | 79.8 | +2.0 | −0.1 | −1.7 | −5.5 | +5.5 | −0.1 |
| Washing and dressing | 87.3 | +6.2 | — | −5.7 | −0.8 | — | — |
| Sleeping | 59.3 | +2.3 | +3.6 | −1.6 | −3.0 | +1.8 | −3.1 |
| Walking | 99.6 | −8.5 | — | — | −6.8 | +4.4 | +10.8 |
| Running | 142.7 | −5.8 | — | — | — | +0.1 | +5.8 |
| Weight lifting | 118.6 | −2.8 | — | — | — | +6.2 | −3.5 |
| Systematic discrepancy for a given day.. | | −0.9 | +2.3 | −1.9 | −2.5 | +2.1 | +1.0 |

moderate work scales of Brown and Crowden[11]), 100-120 per minute (lower part of "heavy" work scale, unlikely to produce training), 120-140 minute (upper part of "heavy" work scale, possibly giving some training), 140-170 ("very heavy" work, certain to produce training) and > 170 per minute (near maximum effort).

None of the laboratory staff who were not participating in voluntary sport reached a pulse rate > 140 per minute in their normal daily activities. Even pulse rates > 120 per minute were uncommon. As in the example of Table I, the main sources of exercise were walking and stair climbing. Different subjects walked from 18 to 75 minutes per day at pulse rates ranging from 100 to 127 per minute (mean: 111 per minute). In the first minute following stair climbing, the pulse rate of different subjects ranged from 105 to 129 per minute (mean: 111 per minute); the majority worked on the third floor, and in consequence climbed from 6 to 28 flights of stairs per day. A further source of exercise reported by three of the eight subjects was the carrying of a heavy load; the pulse rate recorded ranged from 115 per minute while shopping to 130 per minute while carrying 30 pounds (subject 'Ho'). The voluntary exercise which accounted for the pulse rates > 140 per minute in two of the three more active members of the staff was distance running. There was a general correlation between the pulse rates recorded in Table II and the maximum oxygen intake of the subjects; the largest intakes were found in the subjects reaching pulse rates of 140-170 per minute through voluntary exercise, and the poorest intakes were found in those whose recorded pulse rate never exceeded 120 per minute.

The students at the Provincial Institute of Trades showed pulse rates that were comparable with those of the sedentary staff. None were participating in regular sport, and in none was a pulse rate > 140 per minute recorded during either work or leisure. Two of the eight men reached a pulse > 120 per minute in the first minute after climbing stairs. In most of the others, the only vigorous activity was walking (5 to 75 minutes per day, with an average pulse rate of 107 per minute). One of the eight men "ran" for 20 minutes (pulse rate 116 per minute), and one reached an average rate of 107 per minute while working in the welding shop.

### 2. *Consistency of pulse response to a given activity*

The average pulse rate recorded during an individual's performance of any given activity varied relatively little from day to day (Table III). Further, much of the variation that was observed probably reflected true differences of metabolic activity (for instance, an increased pace of walking). Systematic departures from the individual's mean relationship between pulse rate and activity amounted to one to three beats per minute when averaged over the entire day. However, larger discrepancies occurred for several hours following intense activity; such discrepancies were particularly obvious when the subjects were asleep. In sedentary subjects, the sleeping pulse rate declined to an average of 61 to 73 per minute; thereafter it showed occasional peaks 5 to 15 beats per minute above this average (presumably associated with dreams), and smaller changes presumably related to variations in the depth of sleep. The more active subjects had a lower average sleeping pulse rate (57-59 per minute), and showed a different pulse pattern on nights when vigorous exercise was undertaken shortly before going to bed. On such nights (Fig. 1), an increase of sleeping pulse rate persisted into the small hours of the morning; presumably an increase of resting metabolism may make some contribution to this phenomenon, but it seems mainly a reflec-

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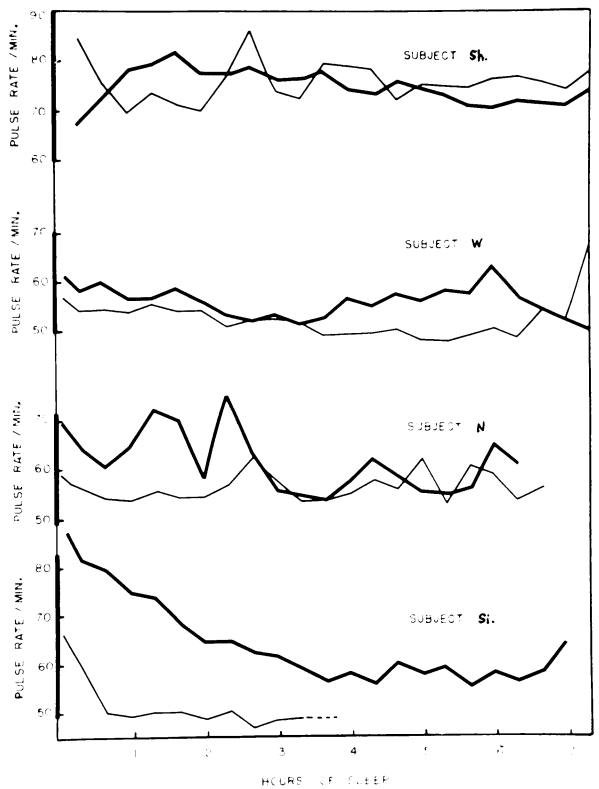


Fig. 1.—Influence of previous activity on pulse rate during sleep. The nights represented by the thick lines followed evenings of activity—for N and Si, running three miles one hour before sleep, for W an hour of calisthenics and swimming three hours before sleep, and for Sh a day redecorating the basement, concluded three hours before sleep.

tion of a decrease of stroke volume secondary to intra- and extra-vascular pooling during exercise.

The pulse rate may also be increased by mental concentration and emotional stress. An average change of 10 beats per minute (range: -8 to +26 per minute) was observed when 13 subjects were compared while sitting relaxed (reading a newspaper or light fiction), and while studying or carrying out calculations. While driving in downtown Toronto, the pulse rate of eight subjects ranged from 84 to 103 per minute (mean: 94 per minute); the lowest of these figures is in keeping with the anticipated energy expenditure, and the additional 10 to 20 beats per minute in some subjects is an expression of the combined effects of concentration and anxiety. The pulse rate was substantially higher (110 to 120 per minute) in the passengers than in the drivers of our group.

### 3. *Discrepancy between diary records and responses to activity recall questionnaire*

Results are summarized in Table IV. The information obtained from the activity recall questionnaire was relatively crude; in general subjects overestimated the time spent in active pursuits (walking and sports), and underestimated the time spent driving, sitting at home, and sleeping. Somewhat surprisingly, the number of flights of stairs climbed per day was underestimated. The overall effect of these discrepancies was an overestimate of the energy expenditure; however, in view of the brevity of active periods, the total error over 24 hours was quite small (60 to 70 Kcal.).

## DISCUSSION

### 1. *Activity in a Canadian city*

The present observations suggest that a pulse rate of 120 per minute is relatively uncommon in a Canadian city dweller. The two main sources of energy expenditure for the subjects studied were walking and the climbing of stairs; the walking was probably above average, as several of the subjects did not own or have ready access to a car. The place in which most of the subjects were employed (the third floor of an older building, with rather slowly moving elevators) also favoured the use of stairs; a substantial part of the urban population work either in sprawling single-storey factories, or in tall office blocks where use of a high-speed elevator is essential. Study of a larger sample might thus reveal an even lower average level of activity.

TABLE IV.—DISCREPANCIES BETWEEN DIARY RECORDS AND RESPONSES TO ACTIVITY RECALL QUESTIONNAIRE. LABORATORY STAFF, AVERAGE FIGURES FOR THREE TO FIVE WEEK-DAYS AND ONE OR TWO WEEKEND DAYS

| | *Error in recall assessment relative to diary records* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Activity* | *Results for individual subjects* | | | | | | | | *Average all subjects* |
| Sitting at work (min.) | +50 | −115 | +135 | − 6 | +80 | +43 | −48 | −11 | +16 |
| Standing at work (min.) | −15 | +23 | −17 | − 6 | − 9 | +44 | −35 | − 4 | − 2 |
| Climbing stairs (flights) | − 9 | 0 | − 4 | − 7 | + 6 | −13 | −12 | −10 | − 6 |
| Sitting home, incl. eating (min.) | −32 | +130 | −72 | −42 | −90 | −149 | +100 | + 9 | −18 |
| Washing and dressing (min.) | −15 | − 5 | +60 | +16 | + 5 | − 1 | + 7 | − 6 | + 8 |
| Sleeping (min.) | −21 | −60 | −71 | −57 | −15 | −51 | +57 | +14 | −26 |
| Walking (min.) | − 3 | +61 | +38 | +126 | −13 | + 8 | −22 | −42 | +19 |
| Driving (min.) | +15 | −17 | −12 | −10 | −45 | — | — | — | −14 |
| Participation in sports (min.) | +31 | 0 | − 6 | +18 | 0 | −32 | +17 | +45 | + 9 |

TABLE V.—CLASSIFICATION OF LEVELS OF INDUSTRIAL ACTIVITY AFTER BROWN AND CROWDEN[10] WITH EQUIVALENT PULSE RATES

| *Level of industrial activity* | *Energy cost (Kcal./min.)* | *Oxygen consumption (l./min. STPD*)* | *Approximate percentage of max. $O_2$ intake* | *Equivalent steady state pulse rate (per min.)* |
|---|---|---|---|---|
| Sedentary | 1.2 - 2.1 | 0.24 - 0.42 | 8 - 14 | |
| Light | 2.1 - 3.3 | 0.42 - 0.66 | 14 - 22 | |
| Moderate | 3.3 - 5.4 | 0.66 - 1.08 | 22 - 36 | <104 |
| Heavy | 5.4 - 9.0 | 1.08 - 1.80 | 36 - 60 | 104 - 138 |
| Very heavy | >9.0 | >1.80 | >60 | >138 |

*Standard temperature and pressure, dry gas.

The employment of the laboratory staff would be considered as light work, and none of the students studied at the Provincial Institute of Trades were carrying out heavier tasks than welding. Would different findings be obtained on "heavy" workers? Recent work in Australia[12] has shown little relationship between "heavy" work and physical fitness as assessed from the predicted maximum oxygen intake. This reflects in part the decreasing work demands of traditional heavy industries. However, it can be questioned how large a contribution industrial work has ever made to personal fitness. Of the five primary categories of industrial activity proposed by Brown and Crowden,[11] the first three seem unlikely to develop cardiorespiratory fitness, the contribution of the fourth is at best intermittent, and only during very heavy work is there a regular and substantial training stimulus (Table V).

If the average city dweller receives no significant cardiorespiratory training from work or normal leisure pursuits, voluntary participation in vigorous sports is vital to the development and maintenance of an adequate maximum oxygen intake. One author has recently suggested that the lowest desirable maximum oxygen intake is 40 ml./kg./min.[13] A substantial percentage of adult males in Canada fail to meet this standard,[14] including all of the present sample, except the three undertaking regular exercise.

### 2. *Unspecified Activities*

The opinion is sometimes expressed that sexual activity is the one remaining vigorous pursuit of city life. No attempt was made to collect pulse rate or diary information relating to sexual activity, as this was considered an unwarranted invasion of personal privacy. However, occasional pulse recordings have been obtained by others during sexual intercourse.[15, 16] Neither the participants nor the circumstances of the act may be typical of the general urban population, but such studies suggest a heart rate of 140 to 150 per minute is reached during orgasm, with values of ~ 120 per minute for 20 minutes or so before and after intercourse.

These high pulse rates do not necessarily reflect corresponding metabolic effort; they are partly an emotional response, and partly a reaction to isometric contraction of the erector muscles. Neither emotional tachycardia nor isometric work has much influence upon cardiorespiratory fitness, and the frequency and intensity of sexual activity is thus unlikely to be an important factor in cardiorespiratory training.

### 3. *Relation of Pulse Rate to Metabolic Activity*

Training seems to result from an increase of pulse rate only when there is a corresponding increase in metabolic activity. Possible factors distorting the relationship between pulse rate and oxygen consumption have been reviewed elsewhere.[17] An increase of pulse rate with emotional stress and excitement can cause problems during certain sedentary activities (where the total energy expenditure is small) and in exciting sports. The average increase of pulse rate (~ 10 per minute) seen during both mental concentration and the "stress" of city driving causes the equivalent oxygen consumption to be over-estimated, almost doubling the apparent metabolic activity. The influence of emotional stress on pulse rate seems relatively greater in passive than in active participants. In the present series, the car passengers were affected more than the drivers, and in earlier unpublished work the spectators at an ice-hockey game were influenced more than the players.

The oxygen consumption corresponding to a given pulse rate is substantially lower if arm rather than leg work is performed. This is a particularly important source of error in the estimation of oxygen consumption if the task involves isometric work (as in the carrying of heavy loads, subject 'Ho'). The pulse/oxygen consumption relationship is also altered for some hours following vigorous isotonic exercise (as in the elevated sleeping pulse rate shown in Fig. 1).

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### 4. *Use of Recall Questionnaires*

The limited validity of recall questionnaires[18] has been confirmed. The amount of vigorous activity undertaken was generally overestimated. Most subjects have a tendency to exaggerate, and long periods of activity are more readily recalled than shorter periods. Further, the time involved in travel, changing, preparing equipment, and general conversation tends to be regarded as time spent at a given activity. In a recent time and motion study of some required student programs, as little as 25% of the allocated time was actually spent in active sport (Shephard and Pelzer, unpublished data).

### 5. *Practical Implications*

The importance of voluntary participation in vigorous activity for the development of cardiorespiratory fitness is well documented. The present study shows that walking, as normally practised, is not an adequate substitute. The usefulness of the office staircase deserves comment. Most subjects walked upstairs quite slowly, and by running up two floors 10 or more times a day, they could have induced a significant amount of training. The busy executive may claim he has no time for sport, but he could save five minutes per day by using the staircase in place of the elevator. At present, the staircase in many buildings is difficult to find, poorly decorated and generally unattractive. Its architectural status should be improved. However, this alone will not cause a lazy person to use the stairs. Consideration should also be given to designing an elevator that will not transport healthy office staff less than three floors without the use of a special key.

***Summary*** Miniature tape recorders have been used to obtain continuous 24-hour records of pulse rate from 16 men living in Toronto. The pulse rate of the majority rarely exceeded 120 per minute, and values greater than 140 per minute were not recorded except from two men who engaged in vigorous running during their spare time. The main sources of exercise in the subjects studied were walking and climbing stairs. Neither was sufficiently vigorous to induce cardiorespiratory training, and this was reflected in the low maximum oxygen intake of most subjects. The average pulse rate while driving was 94 beats per minute, about 10 beats per minute higher than anticipated from the normal pulse/oxygen consumption relationship. The pulse rate was also increased relative to metabolic demands during mental concentration, and for some hours following heavy exercise. The responses of the subjects to a recall questionnaire exaggerated periods of activity relative to tape and diary records.

***Résumé*** Des magnétophones miniatures ont été employés pour obtenir, pendant 24 heures, l'enregistrement continu du pouls de 16 hommes habitant Toronto. Le pouls, chez la majorité des sujets, n'excédait que rarement 120 pulsations par minute et des valeurs de plus de 140 pulsations par minute n'ont pas été observées, sauf chez deux hommes qui pratiquaient la course à pied durant leur temps libre. Les sources principales d'exercice chez les sujets étudiés étaient la marche et l'ascension d'escaliers. Aucune de ces deux activités n'était suffisamment vigoureuse pour produire un entraînement cardio-respiratoire, comme en témoignait la faible consommation maximum d'oxygène de la plupart des sujets. La vitesse moyenne du pouls, au volant d'une automobile, était de 94 pulsations par minute, environ 10 pulsations par minute de plus qu'on aurait pu escompter d'après le rapport normal pouls sur la consommation d'oxygène. L'auteur a également noté une augmentation de la vitesse du pouls en rapport avec les besoins métaboliques au cours de la concentration mentale et pendant les quelques heures qui suivaient un exercice violent. Les réponses des sujets à un questionnaire exagéraient les périodes d'activité par rapport aux renseignements fournis par la bande magnétique et les notes écrites.

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