# CARDIOPULMONARY CAPACITIES OF MALAYSIAN FEMALES

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*ABSTRACT*

***Aerobic capacity ($VO_{2max}$) and lung capacities were measured in 66 healthy females ranging in age from 13 to 49 years. Forced vital capacity (FVC) and peak expiratory flow rate (PEFR) were measured using a dry spirometer and Wrights peak flow meter respectively. Cardiopulmonary parameters were obtained from a progressive ergocycle test to exhaustion. Mean FVC and PEFR obtained were 2.73±0.07 L and 412±8.5 L/min respectively. FVC correlated negatively with age in subjects from the 3rd to 5th decade of age (r= 0.38, p<0.05). Mean $VO_{2max}$ was 43.2±0.9 ml/kg/min in the 2nd decade compared to 30.3±0.7 ml/kg/min in the fifth decade. Regression analysis revealed an age related decline in $VO_{2max}$ of 0.45±0.8 ml/kg/min/year, which was found to be somewhat higher compared to other studies.***

*Keywords: aerobic capacity, cycle ergometer testing, lung capacity, Malaysian WOMEN, prediction equation*

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## INTRODUCTION

An awareness of the importance of exercise in fitness and health has of late been encouraged. Consequently, more and more people are getting actively involved in sports. The effect of this increased physical activity on the fitness of an average Malaysian female is still undetermined as little relevant information exist by which comparisons could be made to reflect this changing physical habits. There have been some isolated studies reporting aerobic capacity or fitness values for small specific Malaysian female groups[1,2]. The overall picture, however, is still incomplete. Very little information can be obtained from these studies to form the basis of a reliable reference standard for the Malaysian population or to establish a relationship between age and aerobic capacity ($VO_{2max}$) in the Malaysian women.

The present study therefore determines the cardiopulmonary fitness in healthy Malaysian females and attempts to develop a multiple regression equation for the prediction of $VO_{2max}$ in this group.

## MATERIALS AND METHODS

Sixty-six healthy females with ages ranging between 18 and 49 years participated in this study. They were divided into four age groups ranging from the second to fifth decade. None had a history of cardiovascular or respiratory ailments. Physical examination and electrocardiograms were found to be normal and their physical characteristics are given in Table I. All the subjects signed an informed consent form before participating in the study. Lung volume measurements were made using a dry rolling seal spirometer (Mijnhardt, Vicatest VCT). Forced vital capacity (FVC) was taken as the best of three readings. The volumes were corrected for body temperature and pressure saturated with water vapour (BTPS). Peak expiratory flow rates (PEFR) were measured using a Wrights peak flow meter. Graded physical exercise was performed on an electromagnetically braked cycle ergometer (Lode NV L-77). During the exercise electrocardiogram was continuously monitored (Kontron Medical Cardiac Monitor 151). All expired air was collected via a low resistance two-way non-rebreathing valve (Vacumed R2700B) and the volume determined by a precalibrated air flow meter (Singer DTM-151). It was then conveyed through a 10L mixing chamber containing a drying agent (Drierite, anhydrous $CaSO_4$) where the concentrations of oxygen and carbon dioxide in the dried air were measured using their respective analysers. The data was then fed into an IBM compatible computer and the rates of oxygen uptake (VO2 l/min or ml/kg/min, STPD) and oxygen pulse ($O_2P$, ml/beat STPD) were calculated according to a preestablished programme.

**Table I – Age, height and weight of Malaysian female subjects. Mean ± standard error of mean.**

| | Age Group | | | | |
|---|---|---|---|---|---|
| | A 13-19 (n=26) | B 20-29 (n=19) | C 30-39 (n=11) | D 40-49 (n=10) | Total (A-D) 13-49 (n=66) |
| Age (years) | 15.8±0.4 | 24.4±0.5 | 34.1±0.8 | 45.7±1.6 | 25.9±1.4 |
| Height (cm) | 156.5±1.1 | 158.7±1.1 | 156.9±1.9 | 156.6±2.4 | 157.2±0.7 |
| Weight (kg) | 47.8±1.4 | 50.5±1.0 | 52.3±1.5* | 54.3±3.6 | 50.3±0.9 |

Asterisk statistically significant difference when compared to Group A (*p<0.05)

All tests were conducted at least 2 hours after a light meal. Once the subject was seated comfortably on a cycle ergometer, a breathing valve was placed in the mouth and a nose clip applied. The subject was connected to an electrocardiograph and the heart rate was monitored throughout the procedure. After the expired gas concentrations and heart rates had reached a steady state, resting measurements were measured for 2 minutes. The exercise test involved pedalling the ergocycle at 60RPM until exhaustion. Initial work load was set at 50W which was then increased by 16W at the beginning of every subsequent minute until the subject reached exhaustion ie being unable to maintain a pedalling speed of 60RPM. The volumes and concentrations of oxygen and carbon dioxide in the expired air were recorded at the end of each minute during exercise and recovery phases. Heart rate (beats/min) was calculated from five to six recorded ventricular

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complexes over the last 10s of each minute. From these ventilation per minute (VE), oxygen uptake per minute ($VO_2$), carbon dioxide production per minute ($VCO_2$) and $O_2$ pulse were calculated. The highest rates of VE, $VO_2$ and $O_2$ pulse measured during maximal exercise were taken as $VE_{max}$, $VO_{2max}$ and $O_2P_{max}$ respectively.

Mean values with their standard error of means (SEM) were calculated. Statistical significance was tested by the students t-test and by analysis of variance (ANOVA). The conventional level of statistical significance of $p<0.05$ was used.

## RESULTS

The anthropometric data for the subjects is presented in Table I. Statistical analysis revealed no significant differences in height or body weight between the different age groups, although mean body weight was progressively higher with increasing age groups.

Pulmonary function as assessed by FVC and PEFR revealed small changes with age. However, only FVC had a significant negative correlation with age ($p<0.05$), with FVC in Group D being about 11% lower than that in Group A (Table II).

**Table II – Forced vital capacity (FVC) and peak expiratory flow rates (PEFR) of Malaysian female subjects. Mean ± standard error of mean.**

| | Age Group | | | | |
|---|---|---|---|---|---|
| | A 13-19 (n=26) | B 20-29 (n=19) | C 30-39 (n=11) | D 40-49 (n=10) | Total (A-D) 13-49 (n=66) |
| FVC (l) | 2.7± 0.1 | 2.9± 0.1 | 2.6± 0.2 | 2.4± 0.3 | 2.7±0.1 |
| PEFR (L/ min) | 408.8±14.7 | 435.4±10.7 | 402.6±18.7 | 407.0±32.8 | 411.5±8.6 |

Statistical analysis revealed no significant differences in work performance between the different age groups (Table III). Maximum oxygen uptake ($VO_{2max}$), which is often considered to indicate an individual's aerobic capacity, decreased with age, reaching statistical significance in Groups C ($p<0.01$) and D ($p<0.001$) Regression analysis of the data revealed a decline of 0.45 ml/kg/min/year ($r=-0.55$, $p<0.001$).

**Table III – Maximal work load attained (work $load_{max}$), maximal ventilation ($VE_{max}$), direct maximal aerobic capacity ($VO_{2max}$), maximal heart rate ($HR_{max}$) and maximal oxygen pulse ($O_2P_{max}$) in Malaysian female subjects. Mean ± standard error of mean**

| | Age Group | | | | |
|---|---|---|---|---|---|
| | A 13-19 (n=26) | B 20-29 (n=19) | C 30-39 (n=11) | D 40-49 (n=10) | Total (A-D) 13-49 (n=66) |
| Work $load_{max}$ (Watts) | 138.7±5.4 | 143.5±5.0 | 128.6±11.0 | 131.3±11.4 | 137.3±3.6 |
| $VE_{max}$ (l/min) | 52.7±2.3 | 51.2±2.4 | 48.7±3.6 | 41.9±4.9 | 50.0±1.5 |
| $VO_{2max}$ (l/min) | 2.1±0.1 | 2.1±0.1 | 1.8±0.2 | 1.6±0.1* | 2.0±0.1 |
| $VO_{2max}$ (ml/kg/min) | 43.2±1.4 | 41.5±2.0 | 34.3±2.6** | 30.3±1.7*** | 39.3±1.1 |
| $HR_{max}$ (beat/min) | 186.1±1.7 | 170.5±2.1*** | 175.4±3.8* | 172.7±2.6** | 178.1±1.4 |
| $O_2P_{max}$ (ml/beat) | 11.2±0.4 | 12.3±0.5 | 10.2±0.8 | 12.1±2.4 | 11.5±0.4 |

Asterisks indicate statistically significant differences when compared to Group A (*p<0.05; **p<0.01; ***p<0.001).

During exhaustive exercise, ventilation ($VE_{max}$) also decreased with age, but it was not statistically different between the age groups. As with the case of $VO_{2max}$ and $VE_{max}$, maximum heart rate ($HR_{max}$) was also lower in the older age groups (Table III) but this time the differences were statistically significant ($p<0.001$). Mean heart rate at peak exercise in Group D subjects was some 7% lower than that in Group A. Oxygen pulse ($O_2P$), which is a measure of the volume of oxygen consumed per heart beat, showed no significant differences between the different age groups.

Stepwise multiple regression was also used in determining the 'best' subset of three anthropometric variables for prediction of absolute and relative $VO_{2max}$ in healthy Malaysian females. This is an appealing method for determining the set of predictors in a linear model. By using the F-ratio test, this stepwise analysis includes or excludes a variable based upon the amount of its contribution. The regression equations with the coefficients for prediction of the absolute and relative $VO_{2max}$ are:-

$$VO2max\ (l/min) = 0.0226\ (Wt) + 0.0266\ (Ht) - 0.0203\ (Age) - 2.8382,$$

$(R^2 = 0.44, p<0.01)$ and

$$VO2max\ (ml/kg/min) = 51.0251 - 0.4543\ (Age),$$

$(R^2 = 0.31, p<0.01)$,

where Wt=weight is in kg, Ht=height in cm and age in years.

## DISCUSSION

The purpose of this study was to determine some physiological characteristics of a group of Malaysian females, from all the main races and covering a wide socioeconomic stratum of the country. Given the scarcity of information concerning lung parameters and directly determined $VO_{2max}$ in Malaysian females, this report presents lung parameters and cardiorespiratory responses of a sample of Malaysian females where measurements were made by direct determination during cycle ergometry.

Assessment of lung function shows that the mean forced vital capacity of 2.7±0.1L (Table II) is in good agreement with that observed in other Asian communities[3-5], but is somewhat lower than that observed in age-matched Europeans and American females[6-8]. The reason for this difference is uncertain, although it has been attributed to both genetic and environmental factors[9]. Anthropometric variations may explain some of these differences, as physical stature of Westerners on the average is somewhat larger than that of the Easterners. Peak expiratory flow rate, whilst being within the range observed in females from South India[10], was again lower than that from comparable Western subjects[6,11]. FVC correlated negatively with age, suggesting a progressive decline with advancing age. Age related decline in FVC has been reported by other investigators[12,13], and some of the age-related changes in the musculoskeletal components of the thoracic-abdominal compartments have been suggested to contribute to this decline. In this context, age-related decreases in maximal respiratory pressures have been reported[14]. Whilst the effects of regular exercise or training on the rate of this decline in lung function are uncertain, the decline however, can and may limit exercise performance.

As reported by others studies[15-19], maximum aerobic capacity, maximum ventilation and maximum heart rate responses to exercise were progressively lower in the older age groups (Table III). Mean maximal ventilatory responses to exercise were found to generally agree with observations of Sen Gupta[15], but seem considerably lower than corresponding Western data[18]. The exact reason for this is unknown although the smaller stature and lung volumes of Asians have, in part, been considered to contribute to this lower value[20,21].

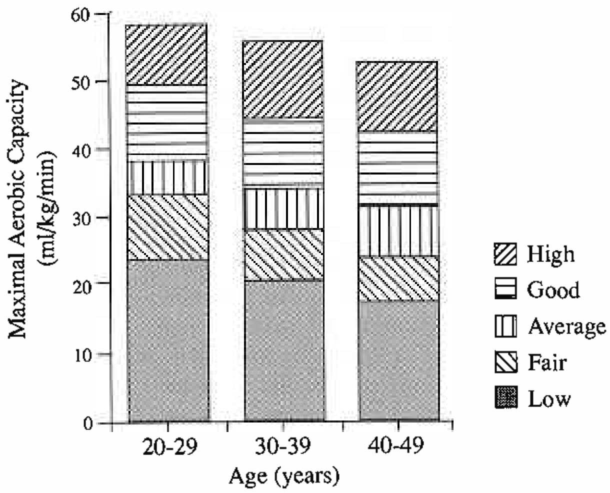
Mean maximum aerobic capacity ($VO_{2max}$) in all the subjects as a whole, was within the range of a clinically healthy and conditioned group[18,22], but was however, considerably lower in the older age group when compared by age category (Table III). This is true for both the absolute and relative $VO_{2max}$. $VO_{2max}$ in Group D was about 70% of that in Group A. The exact reason for the lower values in the older group is uncertain, but one possibility could be a decrease in maximal heart rate as a result of aging[18]. The $VO_{2max}$ (ml/kg/min) reaches its peak some time during the late teens or early twenties of an individual's life, after which it begins to decline[17,18]. A reduced level of physical activity has been considered to contribute partly to this decline. Aging, however, also results in reduction in function of almost every organ system. On the average, in the older adult, maximum heart rate, stroke volume and cardiac output, are decreased[23]. A decline in these cardiovascular parameters together with a number of other bodily functions could, in part, account for the lower $VO_{2max}$ in the older age groups.

Regression analysis revealed that the rate of decline of $VO_{2max}$ with age in our subjects was 0.45 ml/kg/min/year. This is about one and a half times of that reported in other cross-sectional studies[24,25]. This is an important observation particularly from the point of view of our physical work capacity and health status in general. It may also be reflective of our level of physical activity during the middle and later decades of our life as regular physical exercise helps reduce the rate of decline in an individual's aerobic capacity[26,27].

Inferences from this study are that not only are cardiopulmonary capacities of the Malaysian female lower but the rates of decline of these with age are also higher than females from the West. Admittedly, the number of subjects in this study, particularly in the older age groups, is small and may therefore not be completely representative of the actual cardiopulmonary capacity of these groups and further detailed and large-scale studies are needed. But should this observation be confirmed, then the need to investigate and identify the reason for this rapid decline with age is clearly indicated if we aspire to improve the health and fitness status of our population.

Further comparison of our aerobic capacity by age categories with the recommended standards of the American Heart Association Committee on Exercise (1972)[28], however, reveals a slightly more encouraging picture (Fig 1), with our subjects meeting their recommended good to average values. The rather higher rate of decline, nevertheless needs further study.

**Fig 1 – Aerobic capacity of Malaysian female subjects relative to American Heart Association recommendations (American Heart Association Committee on Exercise, 1972[28]). Arrow heads indicate present Malaysian mean values.**




It is not always possible to measure $VO_{2max}$ in a large population directly. Alternate indirect methods are therefore sought to predict an individual's aerobic capacity. One method used is to relate $VO_{2max}$ to different anthropometric values and studies to this effect have been published in the males[29,30]. We therefore thought it would be interesting to calculate a multiple regression equation to predict maximum oxygen uptake or aerobic capacity based on the present data. It must be emphasised that the calculated equation(s) were derived from a clinically healthy population aged from 13 to 49 years. The regression equations with the coefficients for prediction of the absolute and relative $VO_{2max}$ in the females are:-

$$VO_{2max}\ (l/min) = 0.0226\ (Wt) + 0.0266\ (Ht) - 0.0203\ (Age) - 2.8382;$$

($R^2 = 0.44$, $p<0.01$) and

$$VO_{2max}\ (ml/kg/min) = 51.0251 - 0.4543\ (Age);$$

($R^2 = 0.31$, $p<0.01$),

where Wt = weight is in kg, Ht = height in cm and age in years.

In conclusion, our results suggest that in terms of our chosen criterion of cardiorespiratory response, ie directly assessed aerobic capacity, the average Malaysian female is on average fit and meets the American Heart Association's Standards. The age-related decline in $VO_{2max}$ in the Malaysian female appears somewhat higher compared to that in the West. The reason for this is uncertain, but may have a basis on the level of physical activity.

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