AGING AND GENDER EFFECTS ON RATE-PRESSURE PRODUCT: AN INDEX OF MYOCARDIAL OXYGEN CONSUMPTION

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Abstract

Background and Objectives: There are aging associated alterations in cardiac structure, metabolism and function. Evidence suggests alterations in myocardial metabolism contribute to the development and progression of heart failure. Hence it is essential to be aware of the impact of healthy aging on myocardial oxygen consumption. Rate-Pressure Product (RPP) is simple, non-invasive, easily measurable index of MVO_2. Seeking the effect of aging, we measured Rate -Pressure Product, in apparently healthy men and women of different age groups. To know the influence of gender we also compared the RPP in men and women in each age group.

Methods: A total of 152 healthy subjects (91 men, 61 women) were classified by age into four groups. Studies included recording of anthropometric parameters, physiological parameters, brachial systolic and diastolic blood pressure and ECG. Rate-Pressure Product calculated.

Results: Subjects of both genders showed an age related (18-65 years) decline of resting heart rate. Healthy men showed a gradual decline of rate pressure product from 18-65 years. Healthy young women between 20-35 years showed higher rate pressure product compared to men. Below 20 years RPP was lower in women compared to men. Between 35-54 years the gender differences in RPP diminished. Beyond 55 years RPP was higher in women compared to men.

Conclusion: Varying influence of aging on myocardial oxygen consumption observed in men and women. Healthy aging is associated with decline in myocardial oxygen consumption in men. In women no significant variation observed. In each age group gender differences in myocardial oxygen consumption observed.

Keywords: Myocardial Oxygen Consumption (MVO_2); Aging; Heart Rate; Rate-Pressure Product; Gender

1. Introduction:

Heart being a highly oxidative organ has relatively high oxygen consumption. Myocardial oxygen consumption is required for ATP regeneration that is used by membrane transport mechanisms and by cardiac muscle contraction and relaxation. Hence, the myocardial metabolism and function are closely related[1].

Aging is a physiological process. With aging there is a gradual decline of various bodily functions including cardiac functions. Hence there are aging associated alterations in cardiac structure, function and metabolism. These changes predispose to the development of various cardiovascular disorders particularly cardiac failure. The result is increased prevalence of cardiac failure in the elderly[2].

There is evidence that suggest alterations in myocardial metabolism contribute to the development and progression of heart failure[3]. Myocardial metabolism varies with aging[4]. Hence it is essential to study the impact of healthy aging on myocardial metabolism. The effect of aging on myocardial metabolism can be studied by determining the variations in myocardial oxygen consumption with advancing age[5]. Till date there are very few studies in this regard and have given conflicting results.

Also because of the sex hormones there are gender differences in myocardial metabolism. Gender related differences in myocardial metabolism may provide a clue to the observed differences in the prevalence and manifestations of a variety of cardiac disorders[6].

In humans, myocardial oxygen consumption can be determined by Fick's principle that requires catheterization of coronary sinus. This procedure is tedious and not suitable for general use. Rate pressure product, a product of heart rate and systolic blood pressure is an indirect measure of myocardial oxygen consumption (MVO_2). It is easily applicable, non-invasive predictor of myocardial oxygen consumption that can be easily used on a larger population[7].

Hence the aim of the present study is to evaluate the effect of aging on rate pressure

product which is surrogate of myocardial oxygen consumption and to assess the effect of gender on MVO_2.

2. Materials and Methods

We evaluated 152 (91 men and 61 women) healthy subjects of Indian origin randomly selected from among the staff and students of BLDEU's Shri B M Patil Medical college, Bijapur. The subjects were divided into four groups according to age [Group I (adolescents) - 18 -19 years, Group II (early adulthood) - 20-34 years, Group III (middle adulthood) - 35-54 years, Group IV (late adulthood) - 55-65 years].

The study was accepted by the ethics committee of our institution. Informed consent was obtained from all the participants.

Patients with cardio respiratory diseases, congenital anomalies, endocrine disorders, obesity, anemia, history of alcohol intake and tobacco consumption in any form, renal insufficiency, taking medications interfering with vascular reactivity (including any type of antihypertensive agents) were excluded from the study.

Each subject was studied at 3:00 PM in a controlled environment at room temperature. After 20 min of rest in a supine position, ECG was recorded using single channel student physiograph (Medicaid systems, Chandigarh, India) and brachial Systolic blood pressure; Diastolic blood pressure recorded using mercury sphygmomanometer (Diamond). Anthropometric parameters like height (cm), weight (Kg) were recorded. BSA, BMI were calculated.

The rate pressure product was calculated using the formula:

Rate Pressure Product (mm Hg/min) = Systolic Blood Pressure X Heart Rate[8]

3. Statistical Analysis: Statistical analysis was carried out using SPSS version 9.0. Results are expressed as Mean ± Standard Deviation. Differences between mean values of parameters between Group I, Group II, Group III and Group IV were evaluated by one way ANOVA. We compared mean values for men and women in each age group using the unpaired t- test. Correlation between rate pressure product and advancing age was done by Pearson's correlation. P-value <0.05 was taken as significant.

4. Results:

Table 1: Characteristics of Healthy Male Subjects of Group I, II, III, IV.

	Group I (18-19 yrs)	GroupII (20-34 yrs)	Group III (35-54 yrs)	Group IV (55-65 yrs)	P-value
Age (years)	18.44 ± 0.511	22.548 ± 3.139	40.54 ± 4.75	58.95 ± 3.63	0.000***
Height (cm)	171.88 ± 6.434	169.58 ± 5.875	162.136 ± 12.46	164.2 ± 6.65	0.000***
Weight (Kg)	65.88 ± 16.58	61.0 ± 9.23	58. 81 ± 9.86	61.7 ± 11.0	0.285
BMI (Kg/m^2)	22.30 ± 5.55	21.18 ± 2.79	21.71 ± 3.00	22.77 ± 3.26	0.451
BSA (Sq m)	1.77 ± 0.18	1.70 ± 0.129	1.63 ± 0.15	1.67 ± 0.16	0.054
Resting heart rate(beats/min)	90.11 ± 10.57	76.96 ± 10.13	80.55 ± 10.79	71.72 ± 7.48	0.000***
SBP (mm Hg)	124.11 ± 12.16	107.35 ± 10.83	115.36 ± 11.91	117.80 ± 13.90	0.000***
DBP(mm Hg)	80.55 ± 8.965	73.87 ± 8.70	79.90 ± 9.55	79.30 ± 10.03	0.037*
RPP (HR X SBP) mm Hg / min	11230.44± 1996.13	8242.58± 1267.70	9313.14± 1699.33	8412.90± 1086.52	0.000***

Data are presented as mean value ± SD. *p value<0.05, ** p value<0.01, *** p value<0.001
SBP = Systolic blood pressure; DBP = Diastolic blood pressure; RPP = Rate-pressure product

Table 2: Characteristics of Healthy Female Subjects of Group I, II, III, IV.

	Group I	Group II	Group III	Group IV	P-value
Age (years)	18.31 ± 0.47	24.33 ± 2.54	40.187 ± 5.192	56.52 ± 2.06	0.000***
Height (cm)	159.15 ± 3.80	155.77 ± 3.52	154.31 ± 4.23	152.0 ± 4.89	0.000***
Weight (Kg)	60.18 ± 9.03	50.66 ± 5.17	62.31 ± 13.36	56.11 ± 11.67	0.09
BMI (Kg/m^2)	23.79 ± 3.71	20. 90 ± 2.43	26.03 ± 4.73	24.21 ± 4.58	0.07
BSA (Sq m)	1.61 ± 0.11	1.48 ± 0.00	1.60 ± 0.17	1.51 ± 0.16	0.05*
Resting heart rate (beats/min)	89.36 ± 8.14	89.07 ± 8.04	80.66 ± 8.74	74.89 ± 12.38	0.000***
SBP (mm Hg)	110.31 ±12.29	114.66± 13.30	115.12 ± 12.54	125.17 ± 12.92	0.009**
DBP (mm Hg)	75.05 ± 7.84	74.66 ± 8.24	80.75 ± 9.32	82.11± 8.92	0.05*
RPP (HR X SBP) mm Hg / min	9840.42± 1271.80	10223.47± 1570.09	9253.0 ± 1170.41	9343.63± 1624.64	0.283

Data are presented as mean value ± SD.* p value<0.05, ** p value<0.01, *** p value<0.001
SBP = Systolic blood pressure; DBP = Diastolic blood pressure; RPP = Rate-pressure product

Mean age of subjects in Group I (M- 18.44 ± 0.51 years, F-18.31 ± 0.47 years), Group II (M-22.54 ± 3.13 years, F- 24.33 ± 2.54 years), Group III (M-40.54 ± 4.75 years, F-40.18 ± 5.19 years), Group IV (M- 58.95 ± 3.63 years, F-56.52 ± 2.06 years).

Body height decreased with age for both genders. No significant differences in weight, Body mass index with age in both genders. Resting heart rate decreased with age for both genders. Highly significant inverse correlation was observed between advancing age and resting heart rate in men (r = -0.371, P= 0.01) and women (r = -0.533, P= 0.000).

We observed highly significant gradual increase in SBP, DBP in men from group II to Group IV and in women from Group I to Group IV.

4.1 Rate- Pressure Product by age: We observed highly significant variation in rate pressure product in men from 18-65 years. Highly significant inverse correlation between advancing age and rate pressure product (r = -0.208, P= 0.05) observed in men.

No significant variation in RPP in women from 18-65 years. Insignificant inverse correlation between advancing age and Rate Pressure Product (r= -0.186, P=0.151) observed in women.

Figure 1: Correlation between advancing age and RPP in men

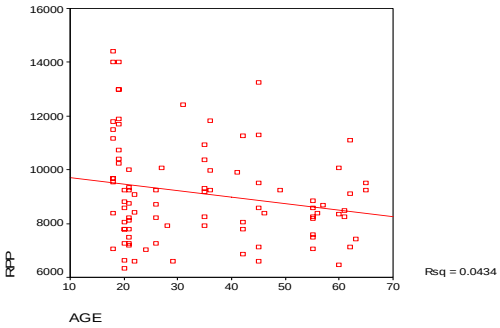
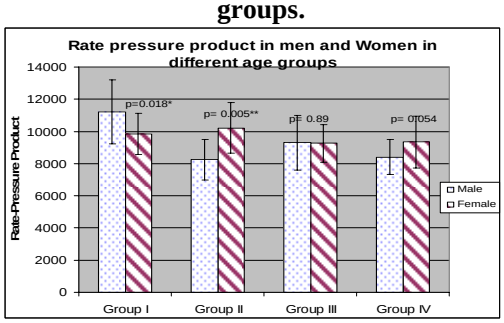


Table 3: Comparison of RPP between men and women of Groups I, II, III, IV.

	Males	Females	p-value
GroupI (18-19 years)	11230.44 ± 1996.13	9840.42+1271.80	0.018*
GroupII (20-34 years)	8242.58 ± 1267.70	10223.47+1570.09	0.005**
GroupIII (35-54 years)	9313.14 ± 1699.33	9253.0+1170.41	0.898
GroupIV (55-65 years	8412.90 ± 1086.52	9343.63+1624.64	0.054

Data are presented as mean ± SD. * p value<0.05, ** p value<0.01, *** p value<0.001

Figure 2: Mean ±SD of Rate Pressure Product in men and women in different age groups.



* p value<0.05, ** p value<0.01, *** p value<0.001

4.2 Rate -Pressure product by gender:

Rate pressure product was significantly lower in women below 20 years (Group I- 18-19 years) and significantly higher in women above 20 years (Group II - 20-34 years) compared to males. The gender difference diminished after 35 years of age. Beyond 55 years the rate pressure product is higher in women although it is not statistically significant.

5. Discussion:

5.1 Rate- Pressure Product by age: The results of our study demonstrate that in healthy men there is an age related decline in myocardial oxygen consumption. In healthy women an insignificant decline in myocardial oxygen consumption was observed with aging. This age related decline in myocardial oxygen consumption could be due to age related decline in the resting heart rate, as heart rate is one of the determinants of myocardial oxygen consumption[9]. The cause for this sex difference in the effect of aging on MVO_2 could be due to gender related differences in the left ventricular mass with ageing[10]. In contrast to our study, Andrew M Kates et al demonstrated significantly higher myocardial oxygen consumption in older group compared with the younger group, paralleling the higher

systolic and diastolic blood pressures in the older subjects[4].

5.2 Rate - Pressure Product by gender: The results of our study demonstrate gender differences in myocardial oxygen consumption with the hearts of young, healthy, non-obese women between 20-34 years of age using more oxygen than the hearts of age matched men at rest. The increased myocardial oxygen consumption observed in young women in group II (20-34 years) may be because of greater estrogen levels in women of this age group. Oestrogen increases myocardial oxygen consumption by up-regulation of uncoupling proteins[6]. Also could be the result of increased myocardial fatty acid oxidation seen in women as fatty acid oxidation is less oxygen efficient than glucose oxidation[6]. Peterson et al in their study on impact of gender on myocardial metabolic response to obesity observed higher plasma fatty acid level in women which may increase myocardial oxygen consumption via upregulation of uncoupling proteins[11].

In women under 20 years of age myocardial oxygen consumption was less compared to age matched men at rest. Between 35-55 years the gender differences in myocardial oxygen consumption diminished. This could be attributed to the fluctuations with age on serum estrogen levels. The estrogen levels start rising during second decade of life and reach a plateau during third decade. The levels start declining during the late fourth decade of life[10]. Beyond 55 years we observed higher myocardial oxygen consumption in women may be due to higher left ventricular mass in women which in turn increases the MVO_2[10, 12].

Conclusions:

We conclude from our study that 1. There are varying effects of aging on rate pressure product an index myocardial oxygen consumption in men and women. 2. There is gradual decline in rate pressure product in men from 18-65 years. 3. There is no significant variation in RPP in women from 18-65 years. 4. Significant Gender differences in RPP were observed between 18-19 years, and 20-34 years which diminished after 35 years.

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