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Short Communication

Maximum Heart Rate Influencing Factors for Cardiac Patients

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Cardiac epidemiology aims to derive heart rate changes determinants, which are primarily important to heart specialists. Many factors are associated with the heart rate functions to go slow down, or speed up, or vary inexplicably, which are known as heart rate change determinants. The basal, maximum and peak heart rate measurement values are practically used in physiology and clinical medicine [1-3]. Commonly, the percentage of peak, or maximum, or basal, or a fixed heart rate is accepted to ascertain the medicine, or exercise intensity in both the rehabilitation programs and the disease prohibition [4,5]. The following queries are investigated in the current article.

- What are the determinants of the maximum heart rate achieved for the cardiac patients?
- What are the effects of the determinants on maximum heart rate achieved?

These queries are investigated herein with a real data set of 303 cardiac patients involving 14 study variable which is displayed in UCI machine learning repository. Readers can find the data set, and the patient population in UCI machine learning repository, which is not reported herein. The 14 study variables are as follow.

- Age (in years),
- Sex (1=male; 0=female),
- Resting blood pressure (RBP) (in mm Hg on admission to the hospital),
- Chest pain (CP) (1=typical angina; 2=atypical angina, 3= non-anginal pain or asymptomatic),
- Fasting blood sugar (Fbs)((Fbs> 120 mg/dl) (1 = true; 0 = false)),
- Serum cholestoral (Chol) (in mg/dl),
- Maximum heart rate achieved (Thalach),
- Resting electrocardiographic (Restecg) (resting electrocardiographic results -- value 0= normal; 1= having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV)),
- Slope (the slope of the peak exercise ST segment- value 1= up sloping, 2= flat, 3= down sloping),
- ST depression induced by exercise relative to rest (Oldpeak),
- Exercise induced angina (Exang) (1 = yes; 0 = no),
- Thal (3 = normal; 6 = fixed defect; 7 = reversable defect),
- Ca (number of major vessels (0-3) colored by flourosopy),
- Target (num: diagnosis of heart disease (angiographic disease status) value 0: <50% diameter narrowing; 1:> 50% diameter narrowing (in any major vessel: attributes 59 through 68 are vessels)).

The above data set contains only 04 continuous variables such as age, serum cholestoral, resting blood pressure and maximum heart rate achieved, and the rest 10 are attribute characters. The above queries can be examined based on probabilistic modeling of the response maximum heart rate achieved on the remaining factors and variables.

Let us examine the maximum heart rate achieved modeling on the remaining variables/ factors. Note that the response maximum heart rate is continuous positive non-constant variance, and non-normally distributed random variable, which should be modeled applying Joint Generalized Linear Models (JGLMs) adopting both the Log-normal & Gamma distributions [6-8]. Gamma JGLMs fit of maximum heart rate achieved is better than the Log-normal, which is displayed in Table 1, and its fit diagnostic check is displayed in Figure 1. Figure 1(a) displays the absolute residuals plot against the predicted maximum heart rate achieved values, which is nearly a flat straight line, interpreting that variance is constant with the running means. Figure 1(b) reveals the normal probability plot of maximum heart rate achieved values for mean Gamma fitted model in Table 1. Fitting discrepancy is not shown in anyone of the plots. So, Gamma fitted maximum heart rate model (Table 1) is nearly closer to its true model. Maximum heart rate mean & dispersion models are as follows.

Gamma fitted Maximum heart rate mean ($\hat{\mu}$) model (from Table 1) is

$\hat{\mu}$ = exp. (5.0286 + 0.0490 Chest pain2 - 0.0060 Age + 0.0330 Chest pain3 + 0.0002 Cholestoral + 0.0010 Resting BP -0.0585 Exercise induced angina + 0.0628 Target + 0.0919 Thal2 + 0.0852 Thal3),

and the Gamma fitted Maximum heart rate variance ($\hat{\sigma}^2$) model is

$\hat{\sigma}^2$ = exp. (-4.0324 -0.6820 Chest pain2 - 0.3818 Chest pain3 + 0.0320 Age - 0.0054 Cholestoral - 0.6336 Target).

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Table 1: Maximum heart rate JGLMs results from Gamma and Log-Normal fit.

Model	Covariate	Gamma model				Log-normal model			
		Estimate	s.e	t-value	P-value	Estimate	s.e	t-value	P-value
Mean model	**Constant**	5.02861	0.070722	71.1033	<0.0001	5.00712	0.07166	69.872	<0.0001
	Age	-0.006	0.000773	-7.7842	<0.0001	-0.0062	0.00078	-7.9592	<0.0001
	Chest pain2	0.04901	0.019802	2.4742	0.0139	0.05301	0.02001	2.6492	0.0085
	Chest pain3	0.03302	0.018073	1.8252	0.069	0.03582	0.01831	1.9521	0.0519
	Resting BP	0.00101	0.000413	2.3141	0.0213	0.00102	0.00042	2.4121	0.0165
	Cholestoral	0.00022	0.000113	2.1491	0.0325	0.00032	0.00011	2.3652	0.0187
	Exr. indu. Angina	-0.0585	0.018171	-3.2191	0.0014	-0.0576	0.01842	-3.1281	0.0019
	Thal2	0.09191	0.032691	2.8121	0.0053	0.09803	0.03318	2.9532	0.0034
	Thal3	0.08522	0.033462	2.5472	0.0114	0.09183	0.03399	2.7013	0.0073
	Target	0.06281	0.019602	3.2022	0.0015	0.06823	0.01991	3.4273	0.0007
Disper-sion model	**Constant**	-4.0324	0.72113	-5.5922	<0.0001	-4.0468	0.7288	-5.553	<0.0001
	Age	0.03201	0.00993	3.2361	0.0013	0.03362	0.01	3.3713	0.0008
	Chest pain2	-0.682	0.25913	-2.6322	0.0089	-0.6962	0.259	-2.688	0.0076
	Chest pain3	-0.3818	0.21052	-1.8141	0.0707	-0.3833	0.2103	-1.823	0.0693
	Cholestoral	-0.0054	0.00193	-2.7791	0.0058	-0.0055	0.0019	-2.842	0.0048
	Target	-0.6336	0.19791	-3.2013	0.0015	-0.6438	0.1982	-3.249	0.0013
AIC		**2602.685**				**2611**			

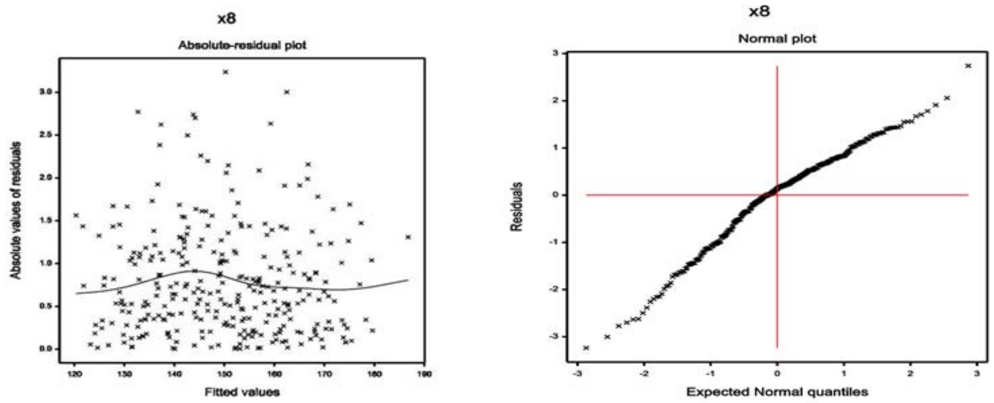

Figure 1(a) **Figure 1(b)**

Figure 1: For the joint Gamma fitted models of MHR (Table 1), the (a) absolute residuals plot against the fitted MHR values, and (b) the normal probability plot for the mean MHR model.

From the above mean & dispersion models and Table 1, the following determinants of maximum heart rate achieved and its associations with them can be intimated.

- Maximum Heart Rate (MHR) is inversely associated with age (P<0.0001), concluding that it is higher for younger cardiac patients than older.

- MHR is directly associated with chest pain at level 2 (P=0.0139) and level 3 (P=0.0690), interpreting that it is higher for the cardiac patients with atypical angina, or non-anginal pain, or asymptomatic than patients with typical angina.

- MHR is directly associated with Resting Blood Pressure (RBP) (P=0.0213), indicating that it increases as RBP increases.

- MHR is directly associated with cholestoral (P=0.0325), implying that it increases as cholestoral level increases.

- MHR is inversely associated with exercise induced angina (P=0.0014), concluding that it is higher for the cardiac patients having no exercise induced angina than the others.

- MHR is directly associated with Thal at level 6 (P=0.0053) and level 7 (P=0.0114), interpreting that it is higher for the patients with fixed defect and reversal defect than normal.

- MHR is directly associated with Target (P=0.0015), indicating that it is higher for the patients with angiographic disease status with >50% diameter narrowing than others.

- Variance of MHR is directly associated with age (P=0.0013), implying that MHR variance is higher at older cardiac patients than younger.

- Variance of MHR is inversely associated with chest pain, indicating that it is higher for the cardiac patients with typical angina than patients with atypical angina (P=0.0089) and non-anginal pain or asymptomatic (P=0.0707).

- Variance of MHR is inversely associated with cholestoral level (P=0.0058), concluding that it rises as cholestoral level decreases.

- Variance of MHR is inversely associated with Target (P=0.0015), concluding that it is greater for the cardiac patients with angiographic disease status with <50% diameter narrowing than others.

The determinants of maximum heart rate achieved, and their association with it are focused herein. It is shown that mean maximum heart rate determinants are age, chest pain, resting blood pressure, cholestoral level, exercise induced angina, Thal, Target, while the variance maximum heart rate determinants are age, chest pain, cholestoral level and Target. The report shows that there are many determinants of MHR, and they have significantly associations with it. Therefore, variations of maximum heart rate are regulated by many factors as stated above. Heart specialists, researchers and cardiac patients will be benefitted from the report. Maximum heart rate should be cared at older ages along with chest pain status, cholestoral level and resting blood pressure.

Conflict of Interest

The authors confirm that this article content has no conflict of interest.

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