The Association between Cardiovascular Disease and Type-A Behavior

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Abstract

An analysis of data from a South African study yielded an association between Type-A behavior and the development of cardiovascular disease. The study, carried out in the first half of 1979, consisted of individuals from communities with a noted higher incidence in cardiovascular disease. Adding Type-A behavior as a risk predictor to a model predicting the development of cardiovascular disease resulted in an increase in the accuracy of the model. The known relationship between Type-A behavior and common traits of the personality type such as higher stress levels and lack of social interaction, could explain its association with cardiovascular disease and its contribution to an increase in the accuracy of a predictive model. Future work should be done to investigate Type-A behavior and its relationship with the intersection between biological and psychological functions, and determine whether it would be impactful enough to include as a risk factor for cardiovascular disease in clinical offices and medical examinations.

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1 Introduction

Cardiovascular diseases, namely diseases that affect the heart or its surrounding blood vessels, are a prevalent issue in the modern world. They account for roughly a third of global deaths [Org21], and methods to improve treatment and understand risk factors are a primary focus of research in the medical field. For instance, the Framingham Study, which has been running for over 70 years, has collected data over generations to further understand the relation between risk factors, clinical values, and cardiovascular disease risk [AC19]. Although cardiovascular disease is certainly influenced by many physical risk factors, analysis of personality is less common. It must be noted that the Framingham Study has conducted analyses on personality related risk factors in the past [HS80], but these are relatively scarce.

Lifestyles are influenced by everyday choices, which include but are not limited to: dieting, budgeting, and social activity. These choices are heavily dependent on general behavior, and it has been proven that aspects of personality traits affect decision making and in turn physical health, portraying a bridge between psychological and physical decisions [HI17]. Personalities can be organized into many different systems and categories, inclusive of the "16 personalities", along with typed behaviors, such as Type-A, Type-B, Type-C, and Type-D behavior [TL20]. Each of these behaviors have type-specific traits that distinguish them from their counterparts [PM12]. Type-A behavior is accepted as an indicator of competitiveness, instilling obligations of high achievement into oneself, along with impatience, a quick temper, and other attributes generally suggestive of extreme mood changes and constant comparison with peers [TS90] [IJ88]. Research into Type-A behavior and its relationship with cardiovascular disease risk is especially important due to a lack of current studies in this intersection, along with raising awareness for psychological health and assistance, which could expand beyond cardiology. Type-A behavior was found to lead to an increase in the prevalence of obesity — a risk factor of cardiovascular disease — in a study conducted on a population of Japanese men [SO18]. Furthermore, it was found that Type-A behavior is associated with aggression, self-confidence, nervousness, depression, and metabolic syndrome and sedentary behavior [SO18]. The potential impact of Type-A behavior on cardiovascular disease risk has been noted since the 1960s, and the analysis that has been done on the subject has produced ambivalent results [EG16]. There have been studies that have found an association between Type-A behavior and cardiovascular disease risk [SO18], while other studies that have shown there to be no relationship present [Typ] Notably, there have been attempts to combat the assumed influence of Type-A behavior on cardiovascular disease risk through psychological treatment, which have found success, however further research into such treatment is required to confirm results [NE].

To measure Type-A behavior, a variety of strategies may be employed, but the most common forms of measurement are through self-report questionnaires. Each of the questionnaires' items generally have two phrases which describe behavior completely indicative of Type-A behavior and describe behavior from which Type-A behavior is completely absent. The results are then compiled and calculated to determine the magnitude of Type-A behavior in that individual, based upon the extent to which the individual indicated their agreement for either side of the spectrum provided [RJ83] [EJ90] [RW69]. As research in the intersection between Type-A behavior and cardiovascular disease is quite limited, with most studies focusing on more somatic risk factors, this paper aims to present the psychological and quantitative relationship between Type-

A behavior and the risk predictors of cardiovascular disease. Along with a quantitative analysis showcasing the correspondence between Type-A behavior and the risk factors of cardiovascular disease complemented with the risk of cardiovascular disease itself, this paper hopes to discuss the psychological impact of a Type-A personality on heart disease risk, and understand the relationship maintained by the traits of Type-A behavior and heart disease.

2 Methods

2.1 Data Source: The SAHeart Study

In order to conduct the analyses present in this paper, the SAHeart dataset was used [RJ83] This dataset was gathered from a retrospective study conducted during the first half of 1979. The data used in this paper is a subsample of this dataset, due to a restriction of access to the full dataset. The population was gathered from three South African towns located in the southwestern Cape province, which were all generally similar culturally and socioeconomically. The sample used in this paper consists of 462 individuals, with measured values of age (in years), tobacco use (in kilograms), alcohol consumption (units unclear), obesity (BMI), adiposity (scaled with BMI), Type-A behavior (Bortner Short Rating Scale), systolic blood pressure (mmHg), high density lipoprotein (mmol/l), documentation of cardiovascular disease in the individual's family history, and whether the individual had developed cardiovascular disease themselves [RJ83].

2.1.1 Measurement of Variables

All information regarding the method of measurement for each variable is present in the study's paper [RJ83]. The Bortner Rating Scale is a standard method of measuring Type-A behavior through a questionnaire. Developed in 1969, the scale was created using data from 76 male insurance and business executives. The scale used 14 items, with each item placing one phrase at one end and another phrase at the other end. The individuals would mark a vertical line through the 1.5-inch line that was connecting the two phrases to communicate their magnitude of agreement or disagreement with either side [EJ90] [RW69]. The scale has been revised several times to fit the purpose of numerous studies, including converting the scale to a numerical system, with the magnitudes of numbers indicating strength of agreement with either phrase. Each item may also be weighted to produce an encompassing final result, which could then be compared to the minimum and maximum possible values to section the extent of Type-A behavior into ranges [RJ83]. The study administered a modified version of the Bortner Rating Scale as initially described to the individuals in the study to measure their Type-A behavior extent numerically. This scale had 12 bipolar items, each worth 7 points. Using the magnitude of agreement or disagreement the individual indicated for each item, a value out of 7 points was calculated, with 1 point indicating a complete absence of Type-A behavior characteristics and 7 points being indicative of absolute presence of Type-A behavior characteristics. This paper assumes a high score correlates to a greater extent of Type-A behavior. To calculate BMI, the units for obesity and adiposity measurements, the height (to the nearest half centimeter) and weight of the individual were measured through the usage of an anthropometer and beam balance respectively, with the individual wearing light clothing and no shoes. Systolic blood pressure, measured in mmHg, was measured through standard means described by the American Heart Association [RJ83], allowing for all individuals to rest for 5 minutes before measurement to maintain consistency and eliminate potential error from activities the individual was involved in prior to the gathering of data. The values were recorded 3 times, and the lowest of the

3 values was taken as the absolute measurement. To measure the magnitude of tobacco consumption, the number of cigarettes smoked per day by each individual was recorded through a self-report questionnaire, and using the standard composition of cigarettes, the total amount of tobacco in kilograms consumed for each individual was calculated. Whether the individual had cardiovascular disease present in their family history was also measured through the self-report questionnaires. To determine whether the individual had developed cardiovascular disease, electrocardiographs were taken in combination with information from the questionnaires. Development of ischaemic heart disease (IHD) was determined through information given in the questionnaire regarding chest pain, along with an analysis of the waves in the electrocardiographs. The study identified male individuals with IHD through the presence of large and medium Q waves (Minnesota codes 1.1 and 1.2), large and medium ST-segment depressions (4.1 and 4.2), large and medium T-wave inversions (5.1 and 5.2), and left and right bundle-branch blocks (7.1 and 7.2), all of which could be observed through the electrocardiographs. For females, IHD was identified through similar waves, though medium ST depressions and bundle-branch blocks were not considered suggestive of IHD.

2.1.2 Analysis of Relationship between Type-A Behavior, CVD Risk Factors and CVD

We used linear regression to understand the association between a combination of risk factors of cardiovascular disease and Type-A Behavior: obesity, adiposity, and systolic blood pressure. The formulas for the linear regression models followed the basis of: $y = \beta_0 + \beta_1 \mathrm{x}_1 + ... + \beta_\mathrm{n} \mathrm{x}_\mathrm{n} + \epsilon$, with each x corresponding to each risk predictor used, y being the outcome or value to predict, along with the intercept β_0, the regression coefficients $\beta_1, .., \beta_\mathrm{n}$, and ϵ being the error of the model. To calculate the 95% confidence intervals of the regression coefficients and intercept, the following formula was used: Sample Mean ± 1.96xSE. We derived 2 logistic regression models predicting CVD status using obesity, systolic blood pressure, and tobacco consumption as risk predictors for the first model, and adding Type-A behavior as a risk predictor for the second model. Logistic regression was implemented to determine the effect adding Type-A behavior as a risk predictor would have on the model. The equation for each of these logistic regression models was of the form log(odds of y) $= \beta_0 + \beta_1 x_1 + ... + \beta_n x_n + \epsilon$, with y being the outcome, $x_1..x_n$ being the risk predictors of the model, and ϵ being the error of the model. To derive and validate the models, the dataset was split into a training and a testing set, with the training set consisting of 75% of the values of the overall dataset and the testing set comprising the remaining 25%. The seed functionality of the R language was used to create random but reproducible training and testing sets for easier accessibility. Both models were then trained using the same training set and were validated through the same testing set as a means of comparing model performance. If the probability of having heart disease predicted by the model was greater than 0.5, it was deemed that the model predicted cardiovascular disease as present, and absent otherwise. This predicted outcome was then compared to the true outcomes in the testing set, and the accuracy, sensitivity, and specificity were all calculated to compare the models. A p-value under 0.05 defined statistical significance. All analysis was conducted in R 4.2.0.

3 Results

3.1 Distribution of Data

Continuous	Mean	Standard Deviation
Systolic Blood Pressure (mmHg)	138.33	20.49
Tobacco Consumption (kg)	3.64	4.59
Adiposity (scaled with BMI)	25.41	7.78
Type-A Behavior (BSRS)	53.10	9.82
Obesity (BMI)	26.04	4.21
Age (years)	42.82	14.61

Table 1: Mean, Standard Deviation, and Units for each Continuous Variable

Binary	Frequency of Presence	Percentage of Total Sample
Development of CVD	160	34.63%
Presence of CVD in Family History	192	41.56%

Table 2: Frequency of "Present" Outcome and Percentage of Population with "Present"

The distribution of the data displays that all individuals had systolic blood pressure levels generally on the high end of the normal range [OB11]. BMI values were generally higher than the standard range by a small margin. It is likely that there is an enrichment of individuals with cardiovascular disease as per the proportion shown in Table 2.

3.2 Assessing Association Between Individual Risk Factors and Type-A behavior

Conducting linear regression on the individual risk predictors and Type-A behavior portrayed no clear relationship between any one individual predictor and Type-A behavior. The 95% confidence intervals of the coefficients of obesity (Value: -0.05, 95% CI: -0.17, 0.06), adiposity (Value: 0.17, 95%CI: -0.04, 0.39), and systolic blood pressure (Value: -0.03, 95% CI: -0.07, 0.02) crossed 1. The association between the predictors and Type-A behavior was not statistically significant. as evidenced by the p-values, which were all above 0.05.

	Coefficient	**95% Confidence Interval**	**P-Value**
Obesity	-0.05	(-0.17, 0.06)	0.36
Adiposity	0.17	(-0.04, 0.39)	0.11
Systolic blood pressure	-0.03	(-0.07, 0.02)	0.22

Table 3: Linear Regression Models for Individual Risk Predictors against Type-A Behavior

3.3 Relationship between Type-A Behavior and Combination of CVD Risk Predictors

Despite the above finding, multivariate linear regression showed that a combination of risk predictors resulted in a marginal increase in the R^2 value. In this multivariate model, obesity and adiposity had statistically significant associations to Type-A behavior with p-values less than 0.05, while the association between systolic blood pressure and Type-A behavior was not statistically significant, having a p-value greater than 0.05.

	Coefficient	95% Confidence Interval	P-Value
Obesity	0.49	(0.19, 0.80)	0.001
Adiposity	-0.23	(-0.39, -0.06)	0.009
Systolic blood pressure	-0.02	(-0.07, 0.03)	0.37
Intercept	48.82	(40.91, 56.74)	2e-16

Table 4: Multivariate Regression Models for Combination of Risk Predictors against Type-A Behavior

3.4 Relationship between Type-A Behavior, Cardiovascular Disease, and Cardiovascular Disease in Family History

Logistic regression with Type-A behavior as a risk predictor and cardiovascular disease as an outcome yielded a statistically significant association between the two. The regression coefficient for Type-A behavior in the model had a value of 0.02 ± 0.02 and a p-value of 0.03, indicating a statistically significant association. However, logistic regression conducted on Type-A behavior as a risk predictor and the presence of cardiovascular disease in an individual's family history did not present a statistically significant association. The regression coefficient for Type-A behavior in this model had a value of 0.0093 ± 0.019 and a p-value of 0.34, indicating a statistically insignificant association.

	Coefficient	95% Confidence Interval	P-Value
Type-A Behavior	0.02	(0.003, 0.04)	0.03

Table 5: Logistic Regression Model with Type-A Behavior Risk Predictor Against Outcome of CVD

	Coefficient	95% Confidence Interval	P-Value
Type-A Behavior	0.009	(-0.009, 0.03)	0.34

Table 6: Logistic Regression Model with Type-A Behavior Risk Predictor Against Outcome of CVD Present in Family History

We derived two logistic regression models. The first one utilized obesity, systolic blood pressure, and tobacco consumption as risk predictors and development of cardiovascular disease as the outcome. This model portrayed a strong association between systolic blood pressure and the outcome, along with tobacco consumption and the outcome. This was indicated by the low p-values of 0.00878 and 9.49e-09 for each predictor coefficient respectively. The second logistic regression model, which added Type-A behavior as a risk predictor, had similar results, with systolic blood pressure and tobacco consumption maintaining their statistically significant association with the outcome. Type-A behavior also showed a statistically significant association with the outcome, with a p-value of 0.00973.

Risk Predictors	Coefficient	95% Confidence Interval	P-Value
Obesity	0.04	(-0.02, 0.09)	0.24
SBP	0.02	(0.004, 0.03)	0.009
Tobacco	0.19	(0.13, 0.26)	9.49e-09

Table 7: Multivariate Logistic Regression Model with Obesity, Tobacco Consumption, and Systolic Blood Pressure as Risk Predictors for Outcome of CVD

Risk Predictors	Value	95% Confidence Interval	P-Value
Obesity	0.03	(-0.03, 0.09)	0.33
SBP	0.02	(0.005, 0.03)	0.007
Tobacco	0.19	(0.13, 0.26)	1.02e-08
Type-A behavior	0.03	(0.008, 0.06)	0.009

Table 8: Multivariate Logistic Regression Model with Type-A Behavior as an added Risk Predictor to the model in Table 5 for Outcome of CVD

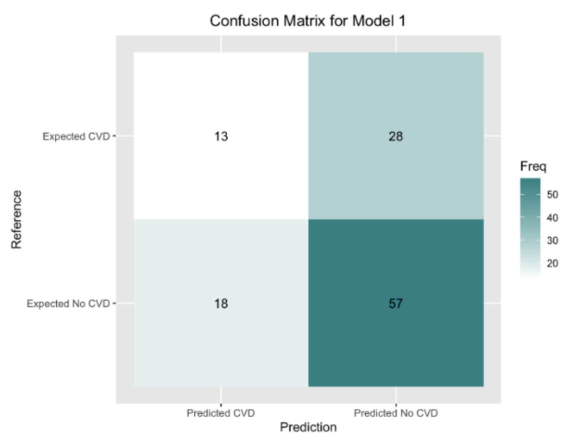

Figure 1: Confusion Matrix for Multivariate Logistic Regression Model 1 (Without Type-A behavior as risk predictor)

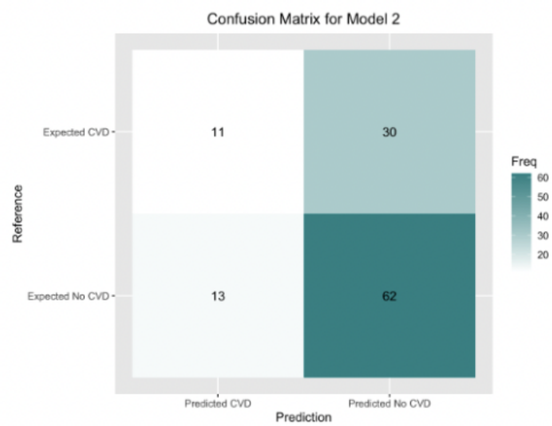

Figure 2: Confusion Matrix for Multivariate Logistic Regression Model 2 (With Type-A behavior as risk predictor)

As shown by Figure 1, Model 1 best predicted individuals who did not develop cardiovascular disease, but was not as successful in predicting individuals with cardiovascular disease, as it predicted over 50% of individuals who had developed cardiovascular disease as false negatives, or not having cardiovascular disease. As shown by Figure 2, Model 2 performed slightly better in predicting individuals who did not develop cardiovascular disease, but predicted more false negatives than Model 1. Overall, the models performed relatively similarly, with Model 2 being more accurate in terms of predicting negative cases, while Model 1 was more accurate in predicting positive ones, by a very slim margin.

3.5 Impact of Type-A Behavior on Predictive Model Performance

Adding Type-A behavior to the model as a risk predictor resulted in an increase in accuracy, from 60.3% to 64%. Additionally, from Model 1 to Model 2, the sensitivity increased from 76% to 82.67%, while the specificity of the model decreased from 31.7% to 26.8%.

Predicting CVD	**Accuracy**	**Sensitivity**	**Specificity**
Model 1 (Without Type-A)	60.3%	76%	31.7%
Model 2 (With Type-A)	64%	83%	26.8%

Table 9: Accuracy, Sensitivity, Specificity, Values for Multivariate Logistic Regression Models

4 Discussion

4.1 Summary of Results

We found that there is no clear association between an individual's BSRS score and the individual risk factors of cardiovascular disease, however there is a statistically significant association between Type-A behavior and cardiovascular disease itself. There was no statistically significant association between Type-A behavior and the presence of cardiovascular disease in an individual's family history. Along with this, it was found that adding Type-A behavior as a risk predictor to a cardiovascular disease predictive model resulted in an increase in the accuracy of the model.

4.2 Relation of Results to Other Studies

Previous studies have similarly found that Type-A behavior does not show a clear association with risk predictors of cardiovascular disease, other studies have found statistically significant associations between Type-A behavior and these risk predictors [YK87] [KD85]. Results are likely to be variable, as Type-A behavior is influenced by a variety of situational factors, including familial relations, environmental and societal structure, and socioeconomic status [HJ76] [WW93] [RF84]. As indicated by the SAHeart paper, the population that the data was gathered from was chosen for its unusually high incidence of cardiovascular disease. This may have influenced the frequency of individuals with high BSRS scores, as well as the distribution of risk predictors such as BMI and systolic blood pressure values.

Type-A behavior may influence cardiovascular disease risk for a variety of reasons. Aside from cardiovascular disease, Type-A behavior has been associated with increased plasma cortisol concentrations in workplace and testing environments. It has also been observed that in high stress situations, people with Type-A behavior experience a relatively high magnitude of stress-induced changes [LW86]. Stress has been shown to impact long term cardiovascular disease risk, and coronary conditions specifically related to stress — such as stress cardiomyopathy — have been identified [SA12]. The natures of individuals with more extreme Type-A behavior traits tend towards competitiveness which pushes them to be above their fellow students or workers [LW86]. Studies have found that those with a more competitive nature are perceived to be more distant, based on observations from people interacting with them. This distant nature compels observants to distance themselves from such competitors [TL14]. This places competitors in a more isolated environment, which leads to lack of social interaction and support, something that has also been found to show an association to heightened cardiovascular disease risk [SA12].

However, although personality, including Type-A behavior, is normally individually developed, there are circumstances where situational factors such as socioeconomic status and familial relations may impact the extent of Type-A behavior present in an individual. Studies have found that Type-A students experience more parental pressure, generally come from higher socioeconomic status families, and are more aware of the expectations placed on them than Type-B students, as Type-B represents traits that are essentially the opposite of Type-A behavior [OC81]. Higher expectations from parental figures show that certain characteristics of Type-A behavior may be developed or made more extreme based on childhood influences.

4.3 Advantages and Disadvantages of the Study

Due to the nature of the data, taken as a sample from a larger dataset, results could be due to selection bias. Furthermore, the size of the sample used was quite small. In consideration of the size needed for a better performing machine learning model, the models may not have presented the true association between Type-A behavior and the various outcomes and risk predictors analyzed. This sample is likely to be enriched in individuals who have developed cardiovascular disease, which could be due to an increase in the incidence of cardiovascular disease in South Africa. This feature of the sample is disadvantageous, as it is not representative of the general population, and the reasoning behind this enrichment is unknown. The study derives data from 3 societies in the same general geographic location, with similar socioeconomic status distributions and overall lifestyles. The main risk predictor analyzed in this paper, namely Type-A behavior, is partially dependent on situational factors [HJ76] [WW93] [RF84]. Thus, the lack of variety in the backgrounds of individuals in the study could contribute to a loss in the applicability of the results to other populations, where the factors determining the extent of Type-A behavior are not the same as those in this study. However, the SAHeart study made use of the Bortner Shorting Rating scale to measure Type-A behavior, which is a widely recognized method and thus is comparable with many other studies that use similar scales.

4.4 Clinical Implications

The results of this paper suggest that adding Type-A behavior as a risk predictor to current models could increase the models' performance and provide better understanding for patients in regards to the risk for cardiovascular disease. Furthermore, Type-A behavior could be measured at clinical offices using self-report questionnaires, allowing for personality to become a more important factor in determining a patient's health. Analysis of personality could improve cardiovascular risk predictions, along with the prediction of other diseases' risks. Furthermore, as noted previously, Type-A behavior has been shown to be influenced by situational factors [HJ76] [WW93] [RF84], so it may be useful for clinical offices to look further into the socioeconomic backgrounds of individuals, along with their parental relations and overall lifestyle. This could reveal more about factors that may influence their behavioral characteristics and health problems relating to anxiety, stress, and depression due to pressure or lack of mental support.

4.5 Future Work

The analysis in this study could be improved and yield more representative results upon access to a larger dataset. Along with this, future work could determine how certain biological functions correspond to social and psychological actions. Studies have begun exploring this relationship [PWT22], but it could be useful to analyze this correspondence in a more broad sense, by pinpointing attributes of personality and how they relate to these biological and psychological actions. Furthermore, some studies have found that more social individuals make better health choices [FE00], so it could be useful to study the association between Type-A behavior and social activity.

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