Defence Life Science Journal, Vol. 8, No. 1, January 2023, pp. 3-9, DOI : 10.14429/dlsj.7.18003


# Fatness Predicts Cardiovascular Disease Risk Factor Profile Better than Fitness in Healthy Men: A Discriminant Analysis Approach

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**ABSTRACT**

Fitness is healthy and can help to reduce, but not eliminate, the negative effects of obesity. As a result, identifying variables for categorizing individuals into high-risk or low-risk groups is critical.The study's goalwas to determine the relationship between fitness, fatness, and cardiovascular disease risk factors as well as to construct a discriminant model for categorizing individuals as high-risk or low-risk. A total of 120 in-service healthy armed forces personnel aged 25 to 49 years were randomly selected as subjects for this study and were measured for the selected fitness and fatness variables, namely cardio respiratory endurance, muscular endurance, muscular leg and back strength, flexibility, weight, waist circumference, hip circumference, waist-hip ratio, body mass index, waist to height ratio, and fat percentage. The findings revealed that fitness variables contribute little to CVD risk factors than specific fatness characteristics, which appear to play a larger role.Based on selected fitness and fatness indicators, a discriminant model was developed to classify subjects into high and low cardiovascular disease risk groups. The group centroid was found to be 0.829. The model validity was determined to be 80.6 per cent based on the classification matrix. Finally, the findings of the study suggest that age and waist circumference play an important role in distinguishing individuals with high and low CVD risk.

**Keywords:** Middle Aged; Cardiovascular Diseases; Discriminant Analysis; Body Weight; Muscle Strength; Risk Factors

## 1. INTRODUCTION

Cardiovascular diseases (CVDs)have emerged as an important health problem and the leading cause of death and disability globally. In 2019, 17.9 million people died worldwide from CVDs, which is 32 % of all mortalities. Heart attacks or strokes were counted for 85 % of these deaths[1]. In developing countries, the burden of non-communicable diseases (NCDs) is increasing, resulting in increased morbidity and early mortality.[2,3,4] In India, "CVDs were responsible for 28.1 % of total deaths and 14.1 % of total disability-adjusted life years (DALYs) in 2016, compared to 152 % and 69 %, respectively, in 1990".[5] India has one of the highest rates of cardiovascular disease (CVD) in the world, with a death rate of 272 per 100,000 people compared to the global average of 235. CVDs affect Indians a decade before the rest of the world and are responsible for one-fifth of all deaths worldwide.[6] The rising incidence of cardiovascular risk factors, including hypertension, dyslipidemia, diabetes, obesity, physical inactivity, and tobacco, is contributing to the increased burden of CVDs.[1]

Received : 25 March 2022, Revised : 21 November 2022
Accepted : 23 January 2023, Online published : 3 April 2023

It is assumed that armed forces members are apparently healthier than the general population because they live a healthy lifestyle that includes frequent physical activity, decent nutrition, and easy access to preventive healthcare. On the other hand, military service is fundamentally connected with long hours of work, strict disciplinary mechanisms, the stress of being apart from family, inhospitable weather and terrain conditions, and the threat of enemy action, all of which contribute to an increased risk of CVDs.[7]

Many studies show that regular physical activity, whether for work or pleasure, improves health and reduces the risk of various ailments, including stroke, diabetes, osteoporosis, heart disease, high blood pressure, colon cancer, and obesity.[8] According to research published online in Heart, obesity, regardless of other biological or social risk factors commonly associated with coronary heart disease, is a killer in and of itself. A higher incidence of established CVD risk factors such as hypertension, cholesterol, and diabetes has been associated with weight gain. Moreover, it is thought that they are also responsible for the higher risk of heart disease.[9,10] Obesity is commonly measured using the body composition and body mass index (BMI). Body composition is one element of Health-Related Physical Fitness (HRPF). In addition to body composition, other elements include cardio respiratory endurance, muscular strength, muscular endurance, and flexibility. HRPF measures the body's ability to exercise and its ability to lower disease risk. As a result, HRPF testing could have significant consequences in preventing chronic diseases. HRPF has been proven in previous studies to predict several CVD risk variables.[11-15]

"The relative and combined contributions of fitness and fatness to health are debatable[16], given the various combinations of fitness and fatness in adult populations.[17] According to several researches, exercise can balance the adverse effects of obesity,[13,18] implying that fit obese people have fewer health problems. Others claim that increasing fitness or physical activity is beneficial and helps to minimize, but does not eradicate, the negative effects of obesity".[19] Various studies on the relationship between HRPF and CVD in the general population have been conducted, but mostly on mortality outcomes based on a literature review. As a result, a cross-sectional study has been done to find out the relationship between HRPF, fatness, and CVD risk factors as well as to construct a discriminant model for categorising individuals as high-risk or low-risk in defence service personnel.

## 2. METHODOLOGY

### 2.1 Sample

A total of 150 healthy in-service armed forces personnel aged 25 to 49 years from an operational area were chosen at random as study subjects. Only 120 of the 150 defence personnel were eventually considered subjects because they completed all the test items. Those who could not complete all the tests were thus eliminated. Following the appropriate testing procedure, data on fitness, i.e., HRPF, selected fatness variables and clustered CVD risk factors, were collected.

All of the subjects were living in the regiment and had food arrangements. Before administering tests, the researcher met with the authorities and subjects to explain the requirements of the testing procedures in full so that there would be no confusion about the effort expected of them. All of the participants voluntarily agreed to take part in the study, understood the requirements, and signed a consent form acknowledging their understanding of the procedures.

Subjects were instructed to fast overnight before testing as well as refrain from exercise, caffeine, and smoking. Before testing, the administration of equipment was thoroughly explained and demonstrated. Fatness, HRPF and CVD risk factors were measured in the morning from 05:30 to 08:00 am before breakfast to establish uniform testing circumstances. A NABL-accredited laboratory pathologist analysed blood samples for the majority of CVD risk factors using a semi-automatic analyser. The research was approved by the Research Development & Advanced Studies of LNIPE, Gwalior (Letter No. Acad/Ph.D./ R/11/277/335) and it was carried out as per the Helsinki Declaration.

### 2.2 Measurement

Before the start of the investigation, all of the instruments that would be utilised in the study were calibrated. An anthropometric scale was used to measure height in centimeters, and a weighing machine was used to determine the weight in kilograms. With the use of a gullick tape, the waist and hip circumference were measured in centimeters. The Waist Hip Ratio (WHR) was obtained by dividing the waist and hip measurements to the closest 0.1 centimeters. The Waist Height ratio (W HT R) was obtained by dividing the waist circumference by the height to the closest 0.1 centimeters.[20] Cooper's 12-minute run/walk test on a hundred-meter ground was administered to measure cardiovascular endurance (CE). Subjects were asked to stand just behind the starting line and with the command "set, go", they started running/walking and it continued for up to 12 min. One lap scorer was assigned for each subject to record the distance covered to the nearest one meter.

A dynamometer test was used to determine maximum muscular strength of leg and back (LST & BST). The subjects bent their knees to lift the handle, and then straightened their legs by exerting pulling force on the handle. The reading on the leg strength was recorded in kg from the dial down the dynamometer.[21] Flexed arm hang test was used to measure the muscular endurance (ME) of the subjects. Subjects were instructed to flex both elbows by raising their chin above the bar and were allowed to hold the position for as long as possible. A stopwatch was started and stopped when the subject's chin dropped below the bar. The subjects' flexibility was examined using the Sit and Reach Test. The subjects maintain their stance until the researcher placed a marker at the tips of their fingertips as they gradually moved forward in response to the signal.[22]

Systolic Blood pressure (SBP) and Diastolic Blood pressure (DBP), Fasting Blood Glucose (FBG), and each component of the lipid profile viz., High-Density Lipoprotein Cholesterol (HDL), Low-Density Lipoprotein Cholesterol (LDL), Triglycerides (TRIG), and Total Cholesterol (TC) were examined by a doctor, blood drained by an expert phlebotomist and analyzed by a professional pathologist on the same day at the pathology laboratory of Gajra Raja Medical College, Gwalior (MP). The blood samples were collected early in the morning before breakfast and a semi-automatic analyzer was used for analysing all the biochemical variables.

Body density of subjects was determined by using the formula: Dry Wt.-Wet Wt. /Water Density - Residual Volume (RV). RV was calculated by multiplying vital capacity (VC) by 0.24 (Shaver, 1982) and using the resulting body density value, the Siri equation was used to determine the fat%. The equipment used in this study was properly calibrated.[23]

### 2.3 Clustering of CVD Risk Factors

The following variables were used to cluster CVD risk factors: FBG, SBP, DBP, HDL, LDL, triglycerides, and total cholesterol. The given formula was used to standardise each of these variables:

(Value-Mean) / Standard Deviation = Z Value

50 + 10 x Z = Standardized Value

The metabolic risk score was calculated by multiplying the HDL-cholesterol standardised value by -1 and assigning a higher risk with increasing value. The mean of the seven standardised scores was used to construct the CVD risk score. Subjects with a score below the 25$^{th}$ percentile (P25) were considered to have low CVD risk, whereas those with a score beyond the 75$^{th}$ percentile (P75) were considered high risk.

### 2.4 Statistical Analysis

All variables were examined for normality using the Kolmogorov-Smirnov test. Themeanand standard deviation were used to describe the subject characteristics in different categories and understand the fitness and fatness factors contributing to cardiovascular disease. To determine the relationship between the variables, the pearson product-moment correlation was used. Using a discriminant function, a discriminant analysis was used to classify the subjects into high-risk and low-risk groups. The assumption of statistical significance was made if the p-value<0.05.

## 3. RESULTS

The mean and standard deviation of selected fitness and fatness variables in the high and low-risk groups are depicted in Table 1. The subjects were categorized into two groups based on the 25$^{th}$ and 75$^{th}$ percentiles of the clustered CVD risk factors. Thirty-one subjects were divided into two groups: those at high risk and those at low risk.

Table 2 shows that the FLEX was significantly related to the FBS, whereas the other CVD risk variables had no significant relationship. CE had a significant relationship with SBP and TRIG, while none of the other CVD risk variables had a meaningful relationship. ME had a significant relationship with SBP and DBP, while none of the other CVD risk variables had a significant relationship. Strength in the legs and back did not correlate with CVD risk factors. As a result, fitness variables were found to have a lower contribution to CVD risk factors, and some fitness variables had no significant relationship to any CVD risk factor.

However, WT has no significant relationship with LDL and TC, although there is a substantial relationship with other risk variables. BMI was found to have a substantial connection with LDL, TRIG, and TC, but not with the other risk variables. WHR did not significantly correlate with LDL and TC, but it did have a substantial relationship with other risk variables. There was no significant relationship between WC and LDL, while there was a significant relationship between other risk variables. Although other risk variables had significant relationships, FBS, LDL, TRIG, and TC had no significant relationship with HC. While FBS, HDL, TRIG, and TC were not shown to have a significant relationship with fat percent, other risk variables did. WHTR did not have a significant relationship with LDL or TC, but it did have a significant relationship with other risk variables. As a result, these specific fatness characteristics appear to have a more significant role in CVD risk factors.

**Table 1. Descriptive statistics (Means ± SD) for data on selected fitness and fatness variables**

| Variables | High Risk | Low Risk |
|---|---|---|
| Age (yrs) | 33.51±6.58 | 34.07±5.46 |
| Height (cm) | 175.12±4.98 | 174.54±5.53 |
| Weight (kg) | 76.14±10.16 | 67.49±6.28 |
| Body Mass Index ($kg/m^2$) | 24.78±2.64 | 22.21±2.51 |
| Waist Circumference (cm) | 85.70±6.83 | 75.77±6.42 |
| Hip Circumference (cm) | 94.60±4.42 | 88.70±4.49 |
| Waist Hip Ratio (cm) | 0.90±0.04 | 0.86±0.04 |
| Waist Height Ratio (cm) | 0.49±0.04 | 0.43±0.04 |
| Flexibility(in) | 1.47±4.78 | 3.86±3.53 |
| Leg Strength (kg) | 113.51±23.66 | 115.64±18.56 |
| Back Strength (kg) | 109.32±21.04 | 115.59±15.36 |
| Cardiorespiratory Endurance (mt) | 1669.68±509.73 | 1888.07±448.70 |
| Muscular Endurance (sec) | 24.39±14.19 | 36.51±19.24 |
| Fat Percentage | 16.00±6.99 | 15.44±5.92 |

**Note: Sample in High and Low-Risk Category (N) = 31**

Table 3 evealed that the value of canonical correlation was 0.644. Because the square of the correlation explains the variance, the independent variables in the developed model can depict 41.48 % (= 0.6442) of the variation in the high and low-risk groups. Wilks' lambda indicates the discriminant function's significance (p-value<0.00);it can be assumed that the discriminant function created in the model was significant.

Table 4 reports the discriminant function built using the unstandardised discriminant coefficient. Due to their high discrimination power, only two variables were kept in the model i.e., age and waist circumference.

As a result, the discriminant function 'Z' was created by utilising these two variables' constant values and coefficients, as given in table.

$$Z = -10.540 + (-0.076)x\ 1 + (0.162)x2$$

Z = Discriminate Function, -10.540 (Constant), X1 = Age, X2 = Waist Circumference.

The goal of the discriminant analysis was to create a decision model for categorizing subjects into one of two risk groups: high or low. As shown in Figure 1, the new group-1 mean (low risk) was -0.829, while the new group-2 mean (high risk) was 0.829.

**Table 2. Correlation (r)between CVD Risk Factors, Fitness and Fatness Variables**

| | SBP | DBP | F B S | HDL | LDL | TRIG | TC |
|---|---|---|---|---|---|---|---|
| **FLEX** | -0.120 | -0.125 | **-0.378**$^{*}$ | 0.106 | -0.083 | -0.111 | -0.128 |
| **C E** | **-0.240**$^{*}$ | -0.173 | -0.114 | -0.015 | 0.062 | **-0.287**$^{*}$ | -0.033 |
| **LST** | 0.124 | 0.043 | 0.078 | -0.037 | 0.024 | 0.002 | 0.057 |
| **B ST** | -0.042 | -0.153 | -0.146 | 0.003 | -0.010 | 0.083 | 0.020 |
| **M E** | **-0.342**$^{*}$ | **-0.312**$^{*}$ | -0.131 | 0.058 | 0.035 | -0.113 | -0.032 |
| **WT** | **0.526**$^{**}$ | **0.563**$^{**}$ | **0.215**$^{*}$ | **-0.238**$^{**}$ | 0.079 | **0.196**$^{*}$ | 0.157 |
| **B M I** | **0.496**$^{*}$ | **0.509**$^{*}$ | **0.213**$^{*}$ | **-0.202**$^{*}$ | 0.063 | 0.161 | 0.130 |
| **W H R** | **0.481**$^{*}$ | **0.460**$^{*}$ | **0.277**$^{*}$ | **-0.195**$^{*}$ | -0.002 | **0.361**$^{*}$ | 0.160 |
| **W C** | **0.608**$^{*}$ | **0.615**$^{*}$ | **0.292**$^{*}$ | **-0.268**$^{*}$ | 0.097 | **0.232**$^{*}$ | **0.198**$^{*}$ |
| **H C** | **0.509**$^{*}$ | **0.548**$^{*}$ | 0.172 | **-0.229**$^{*}$ | 0.149 | 0.050 | 0.163 |
| **FAT%** | **0.240**$^{*}$ | **0.285**$^{*}$ | 0.109 | 0.039 | **-0.212**$^{*}$ | 0.102 | -0.112 |
| **W HT R** | **0.563**$^{*}$ | **0.539**$^{*}$ | **0.300**$^{*}$ | **-0.224**$^{*}$ | 0.059 | **0.204**$^{*}$ | 0.159 |

***significant as p< 0.05 level; *Chahar, 2013*[11]**

The group centroids for categorising individuals into one of two groups are depicted in Figure 1. Low-risk individuals had discriminant scores that were to the left of the centre (Z = 0) and high-risk ones that were closer to the right (Z = 1).

Table 5 shows that the model accurately classified 25 of the 31 participants in the low-risk group, whereas it correctly classified 25 of the 31 subjects in the high-risk group. As a result, the model correctly identified 80.6 per cent of the 62 cases, which is a relatively high rate. Hence the model can be considered valid.

**Table 3. Canonical Correlation and Wilks' Lambda**

| Function | Eigenvalue | Canonical Correlation | Wilks' Lambda | Sig. |
|---|---|---|---|---|
| 1 | 0.0710 | 0.644 | 0.585 | 0.000 |

**Table 4. Canonical Discriminant Function Coefficients (Unstandardised Coefficients)**

| Variables in Equation | Function |
|---|---|
| Age ($X_1$) | -0.076 |
| Waist Circumference ($X_2$) | 0.162 |
| (Constant) | -10.540 |

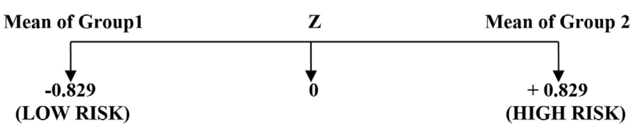


**Figure 1. Means of the transformed group centroids.**

## 4. DISCUSSION

The current study looked at the associations between HRPF, fatness, and CVD risk factors in defence personnel. The main finding of the study was that both fatness and HRPF were linked to CVD risk factors, but that body fatness (WC, HC, FAT %, WHR, WT, WHTR) had a stronger relationship with CVD risk factors than HRPF (FLEX and CE), as all of these variables were correlated to CVD risk factors in healthy defence personnel. The study's findings partially agreed with those of Andersen[24], *et al.*, who discovered that physical activity, fitness, skin fold, and waist circumference were all independently connected to CVD risk clustering.

Similarly, our study results revealed that FLEX was negatively related to FBS. Disc degeneration could explain the link between flexibility and blood glucose. Hyperglycemia impairs disc cell survival, resulting in disc degeneration and decreased lumbar flexibility.[25,26]According to Gregorio[27], *et al.*, "flexibility not only in the waist but also in the upper body is linked to cardio-metabolic risk factors". More research is required in the future to understand the association.

Our analysis of the relationship between ME and BP (SBP and DBP) showed that ME was negatively associated with BP. Previous research by Vaara[28], *et al.*, found that muscular endurance was inversely related to blood pressure regardless of fitness. Similarly, CE was found to be inversely related to TRIG, which was supported by Church[29], *et al.*, who discovered that cardio respiratory fitness was inversely related to blood triglycerides.

Furthermore, the correlation between fatness and CVD risk factors revealed that the majority of the fatness variables were positively related to SBP, DBP, FBS, and TRIG, and negatively related to HDL. Previous research has also demonstrated that high muscle mass AND body fatput a load on the circulatory system, enhancing CVD risk[30, 31], implying that weight loss and body composition change are essential factors in reducing CVD risk. This finding is similar to the research done by Goh[32], *et al.*, who concluded that measures of central obesity predict CVD risk better than measures of general obesity. It

**Table 5. Classification Results**

| | | Different Risk Groups | Predicted Group Membership | | Total |
|---|---|---|---|---|---|
| | | | Low Risk | HIgh Risk | |
| **Original** | **Count** | Low Risk | 25 | 6 | 31 |
| | | High Risk | 6 | 25 | 31 |
| | % | Low Risk | 80.6 | 19.4 | 100.0 |
| | | High Risk | 19.4 | 80.6 | 100.0 |
| 80.6 % of Original Grouped Cases were Correctly Classified | | | | | |

is also critical to maintaining a healthy weight while also preventing central obesity, and Chang[33], *et al.* also found that visceral fat and waist circumference were more strongly relatedto high CVD risk than BMI among Taiwanese middle-aged and elderly people.

Another goal of this study was to construct a discriminant model to classify individuals into high and low-risk categories to identify CVD risk. Subjects were divided into two groups based on criterion variables (clustered CVD risk factors); if a subject lies at or above the 75$^{th}$ percentile (P75), it was assumed as a high-risk group, and if a subject lies at or below the 25$^{th}$ percentile (P25),it was assumed as a low-risk group. Further discriminant analysis reveals age and waist circumference discriminate against high-risk individuals from low-risk individuals.

$$Z = -10.540 + (-0.076)x\ 1 + (0.162)x2$$

Z = discriminated function, -10.540 (constant),
X1 = age, X2 = waist circumference.

Hence, this discriminant model correctly classified 80.6 % of high and low-risk individuals. Hence, this discriminant model can be used to identify and give a verdict onan individual's CVD risk. The findings of the study aligned with the studies done by Goh[32], *et al.* and Chang[33], *et al.*

Within the study's constraints, the findings also revealed that only waist circumference had the highest discriminating power among the fitness and fatness variables tested. The model created in this study to distinguish between high and low cardiovascular disease risks was adequate, with 80.6 per cent of cases correctly classified. As a result, to lower the CVD risk, one should focus more on these variables. The findings of this study showed that maintaining or enhancing fitness while avoiding fat gain, is beneficial in lowering the CVD risk variables in healthy people. These results are partially consonant with the study undertaken by Lee[34], *et al.* and came to the same conclusion about maintaining or improving fitness, as well as limiting fat gain, is vital for lowering the chance of developing CVD risk factors in healthy persons. Fatness and gaining more weight could be identified as the essential components in increasing the risk of CVD. Therefore, individuals must take the necessary care to maintain weight and fat to avoid CVD. Healthy body composition is critical for maximising health and reducing the risk of many chronic diseases and disorders.

The risk of CVDs is higher in the Indian population, which is linked to body fat distribution with increased visceral body fat. The significant prevalence of pre-obesity among healthy armed forces members demonstrates the need to re-examine the criteria, as the Indian government has already adopted the BMI levels recommended for Asians in defining obesity. If not diagnosed early, the high number of pre-obese people will provide a significant challenge to our healthcare system, as would the enormous burden of CVD risk. Though there is a healthy lifestyle program in place in the armed forces, the significant "burden of CVD risk factors calls for a priority-based public health approach", as evidenced by our study. Most of these disorders go undetected until a catastrophic event occurs, such as an acute coronary crisis or a stroke. The massive burden of CVD risk necessitates frequent public health surveillance of CVD risk variables rather than opportunistic screening.

"One of the advantages of the present study was that we first looked into the relationship between HRPF, fatness, and CVD risk factors in defence personnel", and a new model was provided for CVD prevention strategies. Secondly, the fatness and HRPF variables studied were simple to measure and obtain. As a result, doing HRPF self-assessments is convenient for individuals. However, there are certain limitations to this research. Firstly, because respondents were hesitant to provide information about their family history, smoking habits, or alcohol consumption, the study did not include these factors. Secondly, this study was done on a small sample size, which restricts the generalise ability and leads to adopting a high alpha level. Thirdly, this study was delimited to only defence personnel and in a specific location. As a result, additional research is required to cross-validate the current study's findings with a broader and more diverse sample.

## 5. CONCLUSION

Among defence personnel, reduced flexibility was linked to fasting blood sugar, while reduced muscular strength was linked to blood pressure, and reduced cardiorespiratory endurance was linked to triglycerides. Furthermore, body mass index, waist-hip ratio, waist circumference, and waisth eight ratio were all positively linked to systolic blood pressure, diastolic blood pressure, fasting blood sugar, and triglyceride levels and negatively linked to HDL cholesterol level. According to the findings of this study, flexibility, body composition, cardiorespiratory endurance, and muscular strength may be useful nonmedical markers for determining CVD risk. Furthermore, based on the study's findings, it is possible to conclude that age and waist circumference plays a significant role in distinguishing between high and low CVD risk. The most important thing to remember is that when it comes to cardio vascular disease prevention, one must start at an early age to live a healthier life in the future.

## ACKNOWLEDGMENT

The authors acknowledge the Indian Army for allowing the administration of the tests required for the study, all the defence personnel for being a part of the study, and the Institution of Eminence (IoE), Banaras Hindu University, Varanasi (UP)-221005, India for support.

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