

## **Cardiovascular health screening among South African students**

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### **Abstract**

Stress is an unavoidable part of everyday life due to the demands and stressors associated with modern lifestyle. Health risks provoked by this increasingly prevalent condition lead to cardiovascular disease, which ultimately results in a poor health status. Studies have confirmed that there is a correlation between a person's lifestyle and stress levels: sedentary lifestyles increase the risk of developing various cardiovascular conditions. Improved physical fitness is one of the lifestyle modifications proven to benefit heart health by reducing the effects of stress and its associated threats. The purpose of this study was to compare the heart health of subjects from two further education and training institutes. Institution 1 is a traditional tertiary institution that focuses on lectures, while Institution 2 provides an organised, daily physical training programme in addition to its academic programme. Subjects underwent a non-invasive Vipot<sup>TM</sup> test which measures the cardio stress index (CSI), heart rate (HR), and QRS duration. Additional variables measured included: age, gender, perceived stress level, systolic and diastolic blood pressure and body mass index. Results obtained from the study indicate that students from Institution 1 (n=158) had significantly higher readings (p<0.001) than those from Institution 2 (n=128) on CSI and HR, but significantly lower readings on blood pressure (systolic and diastolic). In theory, this finding may be attributed to the fact that individuals from Institution 1 (training population) follow a set daily physical routine which improves their heart health and decreases stress-related risk.

**Keywords:** Stress, Vipot test, cardio stress index, physical activity, heart rate variability.

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## **Introduction**

Cardiovascular disease is a chronic health problem and remains the leading cause of death in modern society (Kivimaki, Leino-Arjas, Luukkonen, Riihimaki, Vahtera & Kirjonen, 2002). Risk factors for the development of cardiovascular disease include advanced age, a history of high blood pressure, hypercholesterolemia and diabetes mellitus, as well as modifiable risk factors such as stress and physical inactivity (Ainsworth & Pettee Gabriel, 2009). Studies done by Brotman, Golden & Wittstein (2007) established the link between psychosocial distress and cardiovascular disease and identified this as an important public health issue. Studies also claim that people suffer an increased level of stress in the period before myocardial infarction (Greenwood, Muir, Packham & Madeley, 1996). This confirms the notion that chronic stress has a particularly precarious impact on the cardiovascular system and should be seen as one of the major risk factors contributing to the multifactor aetiology of cardiovascular disease (Greenwood *et al.*, 1996). Furthermore, accumulating evidence identifies physical inactivity as the most prevalent behavioural factor contributing to the cardiovascular disease epidemic facing modern civilization (Leon, 2009). An international case control study of risk factors for cardiovascular disease found that physical inactivity was one of the major contributors to heart disease, with data indicating that 12% of myocardial infarctions may be attributed to physical inactivity, second to hypertension (18%) and similar to type 2 diabetes mellitus (10%) (Ainsworth & Pettee-Gabriel, 2009). Epidemiological studies consistently identify a strong linear association between coronary heart disease and sedentary lifestyles (Leon, 2009).

The plausible benefits of increased physical activity stretch over a range of cardio protective mechanisms such as decreasing myocardial oxygen demands, increasing vascular supply and improving autonomic nervous control (Rudack, 2005; Leon, 2009). However, the degree of protection offered by physical activity is not clear. By investigating the various levels and types of physical activity that people engage in, while monitoring their cardiovascular health, researchers may be able to explain the role of physical activity in promoting heart health and provide simple guidelines for healthier lifestyles.

The present study was designed to compare the cardiovascular health of students from two tertiary institutions and to determine cardiac stress levels and possible health risks precipitated by the students' contrasting lifestyles. Institution 1 is a traditional tertiary institution focusing on teaching and learning, while Institution 2 provides an organised, daily physical training programme in addition to its academic programme.

Although literature refers to an ample number of studies on cardiovascular health, stress and physical activity, these topics are usually investigated either individually

or in association with one other factor, while little or no research deals with all three issues simultaneously. More importantly, the novelty of this study is attributed to the methodology and equipment used. The Viport is a relatively new medical device that provides direct CSI measurements which directly calculates an individual's stress levels and current cardiovascular state.

## **Methods and Material**

### Subjects

The study sample (n=286) comprised second-year students from the University of Pretoria (Institution 1: n=158) and training recruits from the South African Police Service (SAPS)(Institution 2: n=128). Men and women of various ethnic groups participated in the study, with ages ranging from 18-60 years.

The inclusion criterion for the study was a signed informed consent, whilst participants with cardiovascular and related chronic diseases were excluded from the study. The students from Institution 1 spend an average of eight hours a day in classes. None indicated participation in more than light physical activity. The students in Institution 2 spend at least one hour a day engaging in moderate (organised) physical activity and the rest of the day in classroom studies.

### Design

An observational, cross-sectional study design was used to compare the cardiovascular health of university students with the training sample. Variables included were: age, gender, PSI, systolic and diastolic blood pressure, BMI, and the variables obtained with Viport<sup>TM</sup> included:CSI, HR, heart rhythm and QRS duration.

### Ethical consideration

The study procedure was approved and clearance was obtained from the Research Ethics Committee of the Faculty of Health Sciences of the University of Pretoria, South Africa, in accordance with the principles of Helsinki Declaration (Protocol 46/2010).

### Equipment and procedures

Preceding the testing procedures, questionnaires were handed out to the participants to obtain biographical information and medical histories. The questionnaire included an emotional health section, adapted from Prentice's wellness assessment tool (Prentice, 1999). This section of the survey aimed to determine the perceived stress

index (PSI) of participants on a scale from 0-8. A lower score indicates a higher subjective stress level. All testing was carried out on the same day.

### *Cardiac Stress Index*

A non-invasive diagnostic method commonly used to assess heart functionality and current health status of the heart, is heart rate variability (HRV) analysis (Pumprla, Howorka, Groves, Chester & Nolan, 2002). This detailed analysis of heart rate fluctuation provides information on the modulation of the heart by the autonomic nervous system in response to a variety of dynamic circumstances (Dishman, Nakamura, Garcia, Thompson, Dunn & Blair, 2000; Pumprla *et al.*, 2002). As the human heart is constantly influenced by external and internal stimuli, it requires dynamic innervations by both the sympathetic and parasympathetic divisions in order to react appropriately to the constant change (Pumprla *et al.*, 2002). Alterations in the HRV pattern provide early and perceptive indications of compromised heart health (Dishman *et al.*, 2000; Pumprla *et al.*, 2002). This implies that a healthy individual with an adequately functioning autonomic control mechanism should have a high variability in heart rate (Pumprla *et al.*, 2002). Conversely, reduced HRV implies a possible underlying pathological condition that causes maladaptive responses of the autonomic nervous system to stimuli (Pumprla *et al.*, 2002). For instance, during times of psychosocial distress the heart undergoes adjustment reactions such as increased heart rate and reduction of the variation range of cardiac cycles, suggesting changes in the co-ordinated sympathovagal balance and implying a sympathetic dominant control mechanism (Pumprla *et al.*, 2002).

Innovative heart and stress screening technologies such as the Vipot<sup>TM</sup> allows for quick and efficient electrocardiograph (ECG)-based assessment of heart health. This portable device allows for various HRV variables to be transferred via algorithms into the cardiac stress index (CSI) which provides an indication of the current stress loading of the heart (Energy-Lab Technologies, 2005). High HRV translates into a low CSI percentage of between 0-25%, thus implying a low stress level and healthy variability (Energy-Lab Technologies, 2005). Alternatively, clinically significant lowered heart rate variation measurements transform into high CSI readings, ranging above 25%, indicating a high cardiac stress load and associated cardiovascular risk (Energy-Lab Technologies, 2005). The CSI is a sensitive indicator of stress, and is considered analogous to HRV (Rudack, 2005; Aghamohammadi, Eidy, Parfouthi, Hoseinzadeh, Sharabian & Golzari, 2010).

A battery operated Vipot<sup>TM</sup> device was used to determine the CSI (%) of the participants. The device also provides additional information about heart rhythm, heart rate (HR) and QRS duration. Prior to testing, subjects positioned themselves in a seated, relaxed manner. The three metal corners (electrodes) of the Vipot<sup>TM</sup> were moistened with conducting gel, after which the device was placed on the left side of

the chest. The correct measurement position was identified by placing the index finger on the left collarbone of the subject, and then affixing the Viport™ approximately three finger-widths below this position. Participants were instructed to breathe calmly and avoid talking and movement for the two-minute duration of the test. A CSI reading of 20% or less is indicative of high HRV, thus representing a normal cardiac stress load. A heart rate of between 60-80 beats per minute (bpm) is considered normal and QRS complex duration should lie between 60-110 milliseconds (ms).

### *Blood pressure*

While each participant remained in a seated position, auscultatory systolic and diastolic blood pressures were measured (left arm) at Korotcoff sounds I and IV, using the cuff manometry method (Beam & Adams, 2011).

### *Body composition measurement*

Body mass index (BMI) was determined from height and weight measurements (kg) and a Seca Leicester portable height measure to determine stature (m) of each student. Formula used for the calculation of BMI:  $(\text{Weight}/(\text{Height})^2)$  (Beam & Adams, 2011).

### Statistics

The descriptive statistical analysis was conducted by means of Number Cruncher Statistical System (NCSS 2007) statistical software. A within-group analysis was performed to determine the means and standard deviations for each variable and, concurrently, a within-group normality test for each of the variables was carried out by means of a Shapiro-Wilk test. Furthermore, a comparison of the relevant variables was compiled by way of an independent sample t-test. The level of significance was set at  $p \leq 0.05$ .

### Results

Descriptive statistics of the two participating groups are presented in Table 1.

Table 1: Selected characteristics (mean  $\pm$  SD) of participants ( $N=286$ )

Variable	Institution 1 ( $n=158$ )	Institution 2 ( $n=128$ )	p-value
Age (years)	20.4 $\pm$ 1.1	39.6 $\pm$ 8.8	$p=0.000$
Body Mass Index ( $\text{kg.m}^2$ )	23.3 $\pm$ 4.5	27.8 $\pm$ 7.3	$p=0.000$
Perceived stress Index	5.6 $\pm$ 1.6	7.1 $\pm$ 1.9	$p=0.012$
Heart rate (bpm)	83.1 $\pm$ 14.8	76.4 $\pm$ 13.3	$p=0.000$
Systolic blood pressure (mmHg)	119.9 $\pm$ 12.6	132 $\pm$ 16.9	$p=0.001$
Diastolic blood pressure (mmHg)	72.9 $\pm$ 9.9	86.1 $\pm$ 12.2	$p=0.017$

The t-test confirmed significant differences between the groups with regard to BMI, PSI, HR and blood pressure. Results of the gender-based and combined comparative analysis pertaining to mean CSI and average CSI risk of the participants are presented in Table 2 and Figure 1. The mean CSI of students from Institution 1 were found to be significantly higher than that of Institution 2. The overall risk percentage of Institution 1 was also found to be significantly higher. Interestingly, results indicate that females from Institution 1 had the highest CSI of all the participating groups.

Table 2: Gender and group comparisons of mean CSI and average CSI risk

Variable	Institution 1	Institution 2	p-values
Mean CSI Males	32.91	29.44	$p=0.261$
Mean CSI Females	37.24	24.38	$p=0.000$
Mean group CSI	36.09	27.26	$p=0.001$
Male CSI risk (%)*	46	40	$p=0.05$
Female CSI risk (%)*	60.32	33.93	$p=0.005$
Total CSI risk (%)*	57.23	37.50	$p=0.005$

\*CSI  $\geq 25\%$  indicates risk

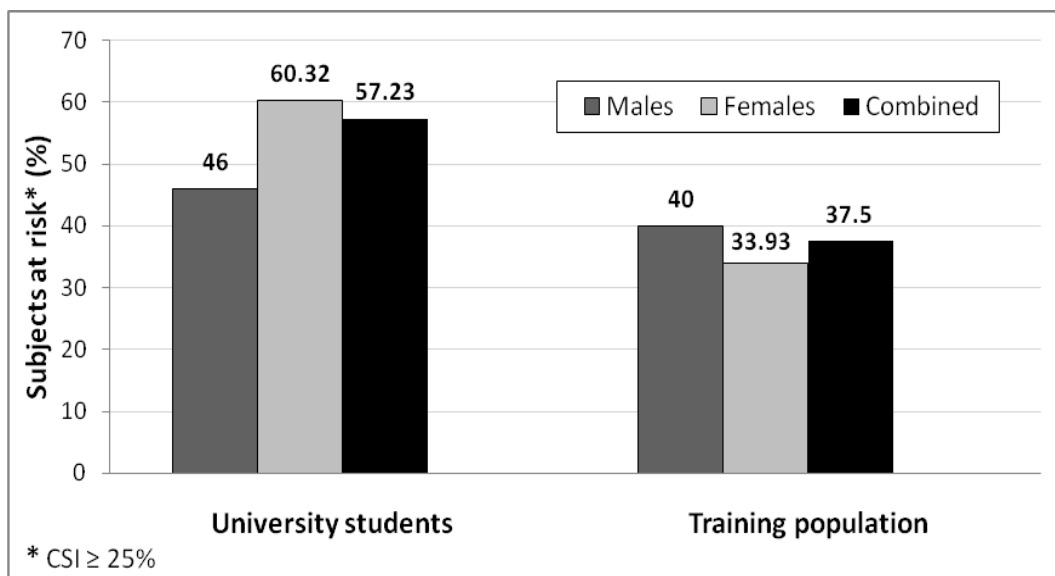


Figure 1: Percentage of subjects indicating CSI risk.

Figure 2 confirms the statistically significant differences ( $p < 0.05$ ) in mean CSI values between the two independent groups. More specifically, it verifies that the mean CSI of Institution 1 ( $36.09 \pm 24.1$ ) is significantly higher than that of Institution 2 ( $27.26 \pm 22$ ).

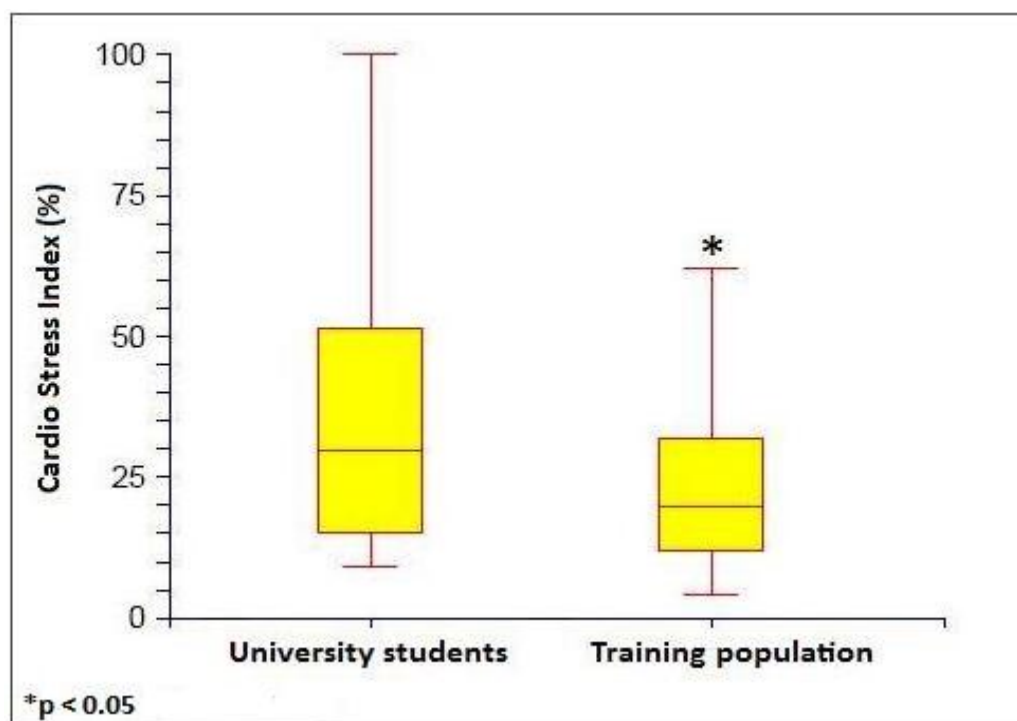


Figure 2: Box plot comparison of mean CSI

Comparisons based on mean CSI values in relation to age showed a significant difference ( $p = 0.005$ ) when results of the two institutions were compared. However, a within-group comparison of mean CSI for the four different age categories of Institution 2 showed no significant difference. Table 3 summarizes these findings.

Table 3: Comparison of mean CSI by age groups

Age group (years)	Institution 2		Institution 1	
	Number of subjects	Mean CSI (%)	Number of subjects	Mean CSI (%)
18 – 30	21	25.38*	158	36.09*
31 – 40	45	24.80	---	---
41 – 50	48	28.33	---	---
51 – 60	9	33.22	---	---

\* $p = 0.005$

## Discussion

Results of this study indicate that the CSI readings of both men and women from Institution 1 were significantly higher ( $p < 0.001$ ) than those of participants from

Institution 2. When comparing subgroups, females from Institution 1 appear to have the highest CSI (37.24%), whilst women participants from Institution 2 showed the lowest CSI (24.38%). The total percentage of students from Institution 1 who appear to be at risk amounts to an alarming 57.23%. Conversely, a total of 37.50% of subjects from Institution 2 indicated CSI readings above 25%.

Furthermore, when comparing mean PSI between the two groups, results indicate a significantly higher PSI for students from Institution 1. This could also be linked to the higher mean HR of the students, as stress levels result in increased HR (Jennings, 2007). Further analysis of the results (Table 1), clearly shows that there is a significantly higher mean BP amongst the individuals from Institution 2 in contrast to the students from Institution 1. This could be attributed to the notable age difference between the groups, as previous studies state that systemic vascular resistance increases with age, resulting in elevated BP (Oxeham & Sharpe, 2003).

In order to eliminate age as a confounding variable in the findings, the study compared the mean CSI of university students and a same-age subgroup of the training population, and also conducted a further within-group comparison of mean CSI between the different age categories of the training population. The results showed that there was still a significant difference in the mean CSI between university students and the training population, but no significant difference in the mean CSI results between the various age categories within the training population was found (Table 4). These results were unforeseen as previous studies generally indicated a decrease in HRV with advancing age, thus implying a parallel increase in CSI with age (Zhang, 2007). In theory, this finding could be attributed to the fact that these students are subjected to a set daily physical routine which improves their physical fitness and decreases stress-related risk.

Our findings are in accordance with those of previous studies which show that an increased level of physical activity is accompanied by a reduction in perceived stress (King, Taylor & Haskell, 1993). Research also reveals that aerobic exercise promotes health by reducing the intensity of the stress response and shortening the time it takes to recover from stress (Vuori, 2004). A study conducted by Knapen *et al* (2009) found that physical activity at a self-selected intensity is associated with a reduction in the level of anxiety and an improvement in subjective well-being. A few of the potential physiological mechanisms of exercise thought to be responsible for these results include: increased norepinephrine, serotonin and beta-endorphins, as well as increased parasympathetic activity (Knapen *et al.*, 2009). These findings implicate the potential of exercise therapy for anxiety disorders (Knapen *et al.*, 2009).

Furthermore, research has shown that regular moderate physical activity improves autonomic nervous system compliance and stability (Leon, 2009). This cardio protective mechanism has a positive impact on one's heart rate variability, allowing



an increased cardiovascular adaptability to internal and external stimuli and ultimately resulting in a reduced CSI (Rudack, 2005). Studies have found that regular moderate physical activity, such as light endurance training in the form of jogging three times a week, increases HRV (Rudack, 2005). Improved HRV values could be observed after only a few weeks of training (Rudack, 2005).

## **Conclusion**

Regular monitoring of physiological stress levels by means of CSI measurements may help individuals recognise premature risk factors, thus allowing an opportunity to respond accordingly by adopting healthy lifestyle modifications such as relaxation exercises and increased physical activity (Energy-Lab Technologies, 2005). Physical activities along with stress management are modifiable lifestyle behaviours (Scott, 2005). Lifestyle behaviours represent the single most controllable influence over health prospects and are the most important determinants of well-being (Robbins, Powers & Burgess, 2008).

The results of this study support the notion that increased physical activity promotes overall cardiovascular health and may serve as a powerful antidote to stress. Although it is generally accepted that high BMI values are indicative of overweight or sedentariness, it should be noted that BMI calculation does not compensate for the muscular component of individuals. This implies that well-built, muscular individuals may be wrongly labelled as overweight.

Future studies should include biochemical markers of stress (e.g. salivary cortisol) and heart health (e.g. triglycerides) that could be correlated with CSI results.

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