Original Article

Influence of lifestyle choices on metabolic risk has distinct gender and age differences

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Abstract

Background and Aim: We aimed to determine the incidence of metabolic syndrome risk factors in young and older university campus population. The influence of life-style choices on the physiological risk profile was also assessed.

Methods: For this cross-sectional study, 335 volunteers were recruited from the main campus of Stellenbosch University in the Western Cape, South Africa. Complete data sets were available for 200 subjects (older males *n* = 35; older females *n* = 53; young males *n* = 27 and young females *n* = 85). Venous blood samples were collected and analyzed for fasting levels of glucose, triglycerides (TG) and total cholesterol. In addition, height, body mass, waist and hip circumferences as well as resting pulse rate and blood pressure (BP), were determined and body mass index was calculated. Subjects also completed a questionnaire on life-style choices.

Results: Central obesity and high BP was the major risk factors contributing to metabolic risk in the older population, while increased fasting TG level was the most common risk factor in young females. Gender differences in the young population included relatively higher cholesterol in females and higher BP in males. Although younger males consumed fast food more often than older males, the older population consumed significantly more alcohol and exercised significantly less.

Conclusion: We conclude that different generations and gender difference may have different etiologies for metabolic risk. Therefore, the preventative education on metabolic risk and monitoring of disease progression should be optimized for individual groups and revised regularly in order to accommodate these differences.

Key words: Age, gender, inactivity, metabolic syndrome, nutrition, obesity, South Africa, stress, triglycerides

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INTRODUCTION

The metabolic syndrome is defined as a cluster of risk factors, which if not properly managed can lead to cardiovascular disease (CVD) and type 2 diabetes mellitus. These chronic diseases annually cause ≈50% of deaths world-wide.[1] The CVD is projected by the World Health Organization as among the leading cause of death by 2020.[2] Urbanization is held responsible for increase in the occurrence of CVD, at least in the black South African population.[3] A recent study has reported that in the black South African population, there is 78% incidence of more than one cardiovascular risk factor, such as elevated blood pressure (BP) or central obesity.[3] It is known that abdominal adipose tissue releases non-esterified fatty acids into circulation, which inhibits insulin-stimulated glucose uptake and may prompt pro-inflammatory cytokine secretion.[4] This, along with the accumulation of inflammatory macrophages in adipose tissue is associated with increased low-grade chronic inflammation, a major contributor for development of diabetes and CVD.[5,6]

The burden of the metabolic syndrome has become global and the condition is manifesting more in younger populations, which has huge health and economic implications. We have recently reported that in a South African student population the diagnostic risk criteria for the metabolic syndrome as defined by the International Diabetes Federation (IDF),[7,8] are present in an alarmingly high percentage in younger generations.[9] Earlier awareness of these problems can possibly help to reduce the incidence of life-style-associated diseases. This can

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be achieved by introducing and promoting awareness of the metabolic syndrome to the society.

In a developing country like South Africa, education of the lay community can be one of the most powerful tools to prevent the undesired effects of technological and economic advancement. However, such education initiatives should be based on sound knowledge of the etiology of disease so that preventative action may be accurately aimed. Although generally accepted as a major etiological factor, obesity is not the only role player to be considered in the fight against metabolic syndrome. In this context and considering urbanization as a cause, several other contributing factors may be identified, such as an increase in office-bound job opportunities (thus less manual labor and a sedentary life-style), more competition for executive positions and employment in general leading to higher stress levels, and a faster-paced life often resulting in poorer nutritional choices. We investigated the etiological role of these effects of life-style on metabolic syndrome risk factor incidence in a university campus population, considering also differences between age and gender groups, in order to inform the ways in which to approach education of the lay public.

MATERIALS AND METHODS

Subject recruitment

A total of 335 volunteers, 120 males and 215 females were recruited from the Stellenbosch University campus. All subjects were verbally informed about the study and then entered into the study after signing of informed consent forms. The study was approved by the Committee for Human Research at Stellenbosch University (ref # N08/03/060) and it was conducted jointly by the Cardio-Metabolic Research Group and the Multidisciplinary Stress Biology Group, in the Department of Physiological Sciences at Stellenbosch University, according to the ethical guidelines and principles of the International Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council Ethical Guidelines for Research.

Data collection

Basic anthropometry measurements taken included height, weight and hip and waist circumferences, using a Rosscraft measuring tape. From these, body mass index (BMI = kg/m^2) and waist-to-hip ratio an indicator of central obesity was calculated. Secondly, resting pulse rate and BP were determined twice in a sitting position, after a rest in this specific position of at least 3 min and a total sedentary period of approximately 30 min. The measurements were taken with an automated sphygmomanometer (ALPK2, Pharmex Healthcare, Japan). Thirdly, 3 drops of whole blood was collected from fasted volunteers by finger-prick method, for immediate assessment of plasma concentrations of triglycerides (TGs) (mmol/l), glucose (mmol/l) and total cholesterol (mmol/l). For the latter, a concentration of more than 5.5 mmol/l was used as risk criteria to replace decreased high density lipoprotein (HDL) cholesterol, which was not assessed due to logistic considerations. All blood samples were immediately processed using portable, validated, accutrend automated analyzers (Accutrend GCT systems, Roche, Switzerland), which allow for spectrophotometric analysis of whole blood without prior processing. In addition, self-administered questionnaires were used to assess individual life-style choices and psychological stress status. For assessment of life-style choice, an in-house purpose-designed questionnaire commonly employed by our group[9] was used. For assessment of stress status, well-known validated questionnaires were used, including the perceived stress scale, profile of mood states (POMS), state and trait anxiety indices and the hardiness scale.[10]

Data analysis

Individuals were grouped into four metabolic risk groups according to their fulfillment of the IDF criteria, fulfilling either 0 (no risk), 1 (low risk), 2 (moderate risk) or 3 or more (high risk) risk factors (since metabolic syndrome is defined as the presence of 3 IDF risk factors, individuals with 3 or more factors were grouped together). Since the IDF criteria was required for categorization of individuals into risk categories, only individuals with complete data sets for all risk criteria assessed, was used for statistical analysis (n = 200, 62 males and 138 females). Subjects were categorized for age, with subjects below 30 years of age assigned to the "young" population and all subjects older than 30 years of age assigned to the "older" population. Ethnical distribution was not considered a confounder and was not corrected for, since it was similar in all subject categories (≈75% Caucasian, ≈20% Colored and ≈5% Black). Descriptive analysis was performed using Excel spreadsheets (MS Office). After determining that data was normally distributed, age and gender differences were assessed by factorial ANOVA and Bonferroni *post hoc* tests, while associations were assessed by calculation of the Pearson correlation coefficient (Statistica v. 9, StatSoft Southern Africa, Johannesburg, South Africa). For data that were not normally distributed (habitual exercise), differences were assessed using a Kruskal-Wallis non-parametric ANOVA by ranks and multiple comparisons tests (also by using Statistica). Data are presented as means and standard deviations, unless otherwise stated. P value of 0.05 was set as level of significance.

RESULTS

In terms of metabolic risk factor incidence [Figure 1], the older population displayed higher incidence than the younger population. An alarming 54% of older men displayed a cluster (3 or more) of risk factors, diagnosing them with the metabolic syndrome, while a slightly lower incidence was displayed in older females (34%). Less than 20% of the older population displayed no risk factors, while ≈40% of the younger population showed no risk. Younger males had a 4% incidence of metabolic syndrome when compared with 2% in their female counterparts. Despite this higher incidence of metabolic syndrome in younger males, this population seemed relatively healthy, with 74% displaying no or low risk. In contrast, 49% of young females displayed high risk (2 risk factors present) or metabolic syndrome.

Central obesity was present in 15% and 14% of young males and females respectively. However, this figure is relatively low when compared to the 63% and 65% central obesity reported in older populations, making it the most common risk factor in the older group, followed closely by elevated BP [Figure 2]. Systolic BP, but not central obesity, was positively correlated to the number of risk factors displayed (r = 0.43 and 0.76 for older females and males respectively, both $P < 0.05$). Although fasting TG levels did not seem to be influenced significantly by either age (tendency, $P = 0.07$) or gender, this parameter was the most prevalent risk factor in young females [Figure 2]. Younger males displayed similar incidence of various risk factors – 26%, 26% and 22% for fasting glucose, BP and TG respectively and did not seem to be at risk for suffering from any one particular metabolic abnormality.

Basic anthropometry and metabolic risk factor assessment results are illustrated in Table 1. Both central obesity and increased BMI, as well as increased BP (both systolic and diastolic) and total cholesterol, were more evident in older populations (all $P < 0.0001$). Of concern is the finding of increased systolic BP in young males when compared to young females (127 ± 10 vs. 117 ± 11; $P < 0.01$). In contrast, young females had much higher total cholesterol levels than the younger males ($P < 0.05$).

When considering life-style factors which may influence metabolic risk profile, females seemed to maintain their activity levels [on average 3.6 ± 2.8 and 3.4 ± 4.5 h/week, Figure 3 for more detailed analysis], while young males exercised much more than their older counterparts (on average 5.3 ± 3.8 vs. 2.4 ± 3.3 h/week; $P < 0.01$). In young females, increased habitual activity was negatively

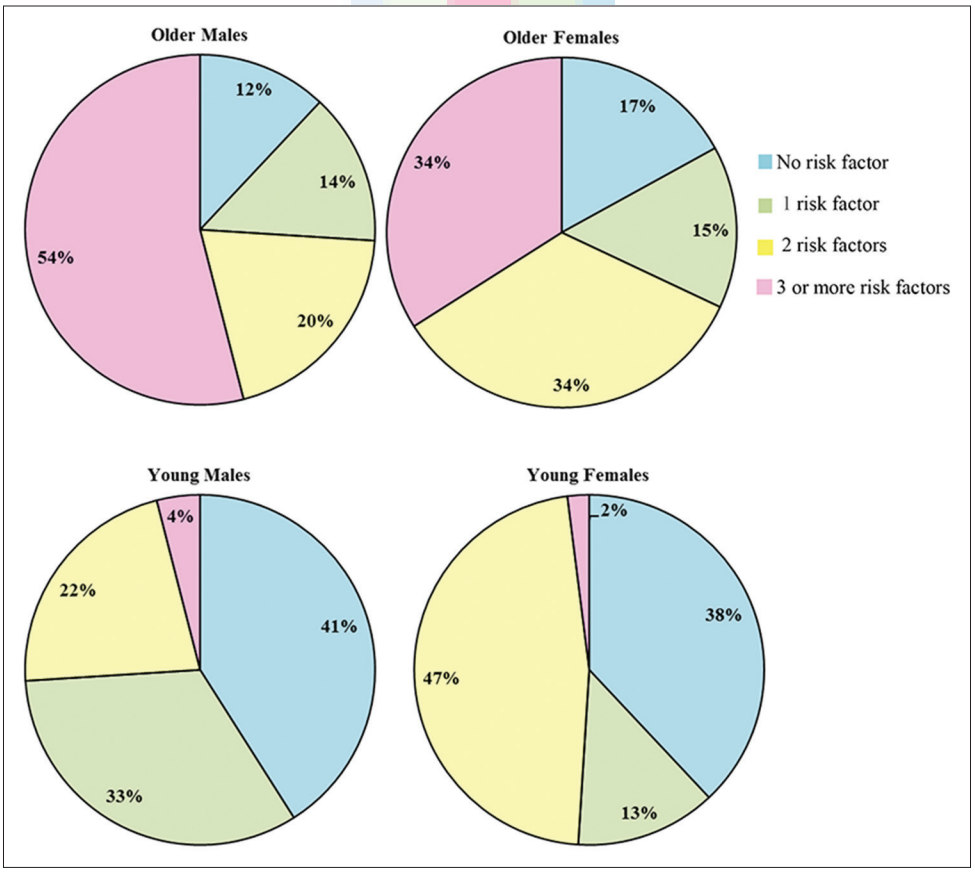

Figure 1: Incidence of metabolic risk factors in a university campus population categorised for age and gender

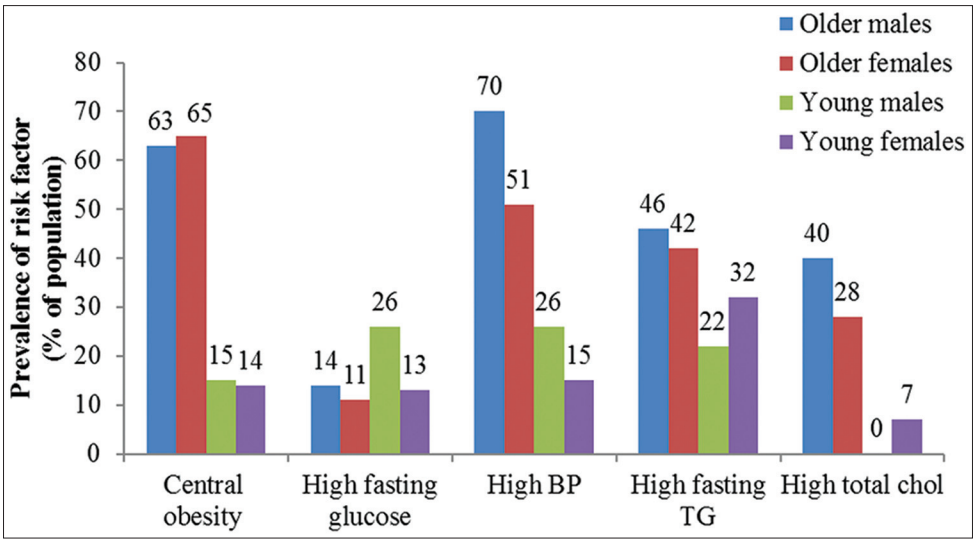

Figure 2: Relative contribution to metabolic risk by different international diabetes federation criteria. Note that high density lipoprotein cholesterol was replaced by fasting total cholesterol exceeding 5.5 mmol/l. BP: Blood pressure; TG: Triglycerides; chol: Cholesterol

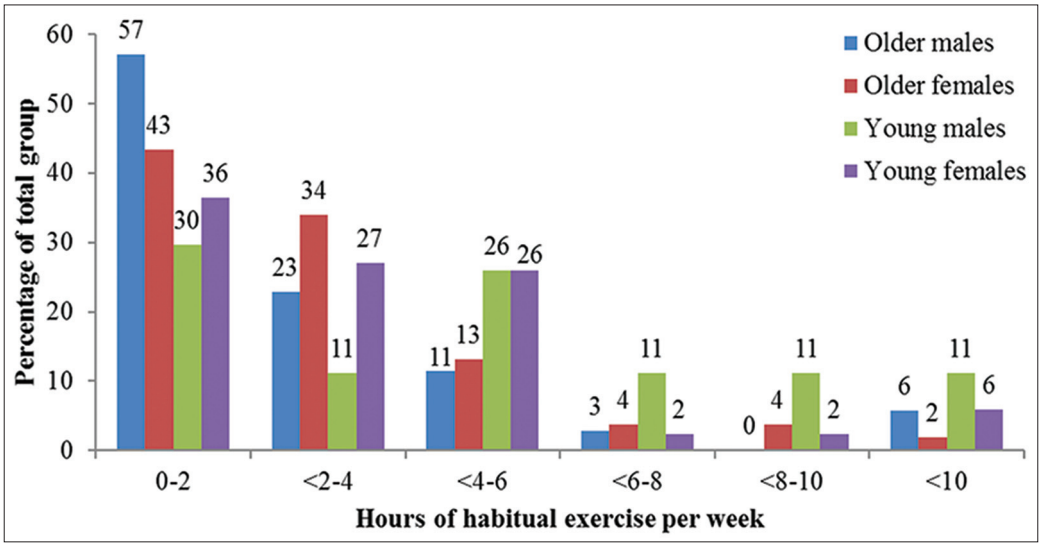

Figure 3: Illustration of habitual exercise per week in a university campus population

correlated with both systolic and diastolic BP ($r = -0.28$; $P < 0.01$ and $r = -0.25$, $P < 0.05$ respectively). Although fast food intake was higher in young males when compared with all other groups, this difference was not significant. However, the intake of fast food reported by young males was almost double that reported by older males (3.2 ± 5.9 vs. 1.9 ± 2.3 times/week), which may be of clinical importance. Although not statistically significant, self-reported habitual alcohol intake was about twice as high in men when compared to females of the same age and more than twice as high in older males when compared to younger males (on average 3.4 ± 4.2 vs. 1.3 ± 3.1 units/week). In young males, habitual alcohol intake was positively correlated with body mass, BMI, waist circumference and number of risk factors present ($r = 0.69$, 0.55, 0.66 and 0. 60 respectively, all $P < 0.05$).

Analysis of stress-related questionnaires revealed significantly higher POMS vigour scores and lower perceived stress scores in older females when compared to the younger group ($P < 0.001$ and $P < 0.05$ respectively). Although all groups scored similarly for Trate anxiety, younger females had higher scores for State anxiety index ($P < 0.01$) when compared to older females. For clarity, only data for females are presented graphically [Figure 4].

DISCUSSION

Data presented here indicates radical differences between genders and age groups in terms of their life-style-related choices, as well as in the resultant physiological metabolic syndrome risk profile.

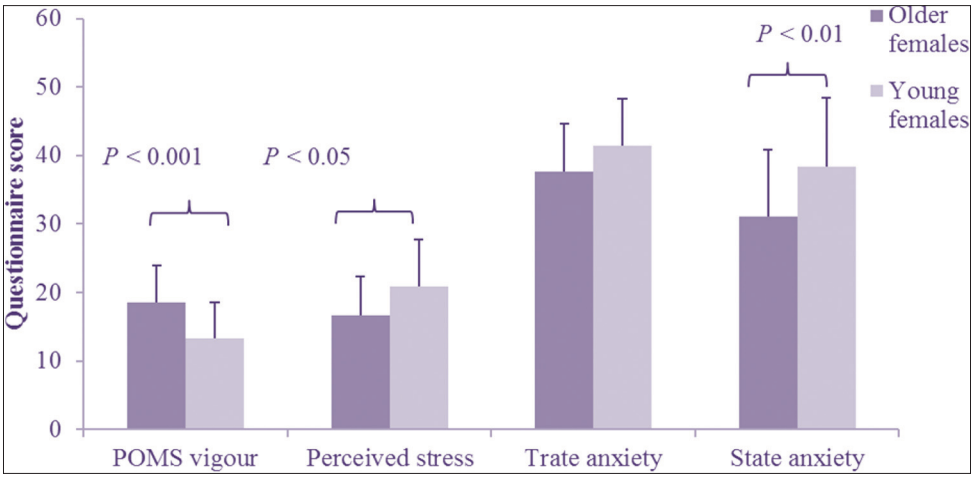

Figure 4: Differences in parameters indicative of stress status in young and older females in a campus population

Table 1: Anthropometry, BP and blood biochemistry results for a university campus population categorised in terms of gender and age

Parameters	Older		Young	
	Males *n*=35	Females *n*=53	Males *n*=27	Females *n* =85
Age (years)	47±7	48±7	22±3	21±1
Height (m)	1.77±0.06	1.63±0.06	1.76±0.08	1.67±0.06
Body mass (kg)	87.6±11.2	70.8±12.5	78.8±17.0	58.9±8.4
Body mass index (kg/m^2)	27.8±3.4	26.4±4.7	25.0±4.2[a]	21.1±2.5[a]
Waist circumference (cm)	97.1±8.6	84.9±11.5	84.6±10.2[a]	73.6±8.6[a]
Hip circumference (cm)	105.7±7.2	105.0±10.3	102.7±9.3	97.9±7.3
Waist: Hip ratio	0.92±0.06	0.81±0.06	0.81±0.17	0.74±0.05
Systolic BP (mmHg)	137±14	130±15	127±10[a,b]	117±11[a]
Diastolic BP (mmHg)	90±12	85±11	80±8[a]	76±8[a]
Resting pulse rate (beats/min)	67.7±8.9	70.4±9.3	64.3±13.4	73.1±13.4
Total cholesterol (mmol/L)	5.6±1.1	5.2±0.7	4.0±0.7[a,b]	4.5±0.9[a]
Glucose (mmol/L)	5.1±0.6	5.0±0.5	5.01±0.9	4.9±0.6
Triglycerides (mmol/L)	2.0±1.5	1.6±1.2	1.6±0.8	1.6±0.7

Data are expressed as Mean ± standard deviation. [a]Significant effect of age, independent of gender. [b]Significant effect of gender, age-dependent. BP: Blood pressure

Data obtained in volunteers aged between 38 and 58 years, indicated alarmingly high incidence of the metabolic syndrome (previously clinically undiagnosed in all cases), at more than 50% of males and a third of females displaying a cluster of risk factors. Only a few studies have been conducted on the prevalence of the metabolic syndrome in similar South African populations. A lower prevalence of only 31% was recently reported in a 98% male, corporate population of similar age,[11] but this result is probably conservative, since all volunteers with known diabetes, hypertension, or history of CVD were excluded from the particular study. Furthermore, more recently, the Adult Treatment Panel for Cholestrol guidelines ATPIII criteria, used in the above study, was shown to underestimate the prevalence by as much as 35% relative to the IDF criteria used in the current study.[12] Another paper by the later group,[13] using IDF criteria, reported a 30.4% incidence of metabolic syndrome in South African Caucasian women, which is similar to the current data for older females. Together, these data support the current data by showing elevated metabolic risk prevalence in relatively office-bound individuals.

In the current older population, the incidence of metabolic syndrome closely parallels the incidence of obesity, suggesting a potential major causal role for obesity in this population, where 80% of males and 59% of females were categorized as overweight and of these, 26% and 25% respectively as obese, according to their BMI. Although this is in agreement with literature citing obesity as a major risk factor of cardiometabolic syndrome,[4-6,14] this was not true for the younger population. Although the incidence of high metabolic risk (2 or more factors) was undesirably high, at 26% in males and 49% in females between the ages of 19 and 28 years, the younger female population, who showed substantially higher risk compared to their male counterparts, exhibited only 3.5% overweight and even 15.3% underweight phenotypes, when compared to 44% overweight and 11% obesity in the relatively more

healthy male group, raising a question on the role of obesity in the etiology of risk in this younger age group. This result is in agreement with a recent European study, which reported that higher occurrence of metabolic risk factors in children from different ethnic heritage was not as a result of increased adiposity.[15]

Next to obesity, a sedentary lifestyle is probably the next generally accepted contributor to metabolic syndrome or cardiovascular risk. Regular moderate exercise not only decreases the risk of being overweight, but also has proven anti-inflammatory effects.[16-19] When considering the study population as a whole, habitual activity levels are relatively low [Figure 1]. Recommendations for exercise are required specifically for the older population, where extremely high prevalence of obesity was measured. When comparing habitual activity levels between different groups, there are again discrepancies between gender and age groups. Females exhibited similar habitual exercise regimes independent of age. In contrast, while younger men exercised significantly more than females, older men were relatively sedentary in comparison to both younger men and females. The fact that alcohol consumption, although not excessive in any of the groups assessed, was highest in the older male group, indicates a tendency towards a more sedentary life-style and poorer health-related choices with age, in men specifically.

Chronic exercise is known to have BP lowering effects.[20] However, in the younger population, more habitual exercise does not seem to protect young males sufficiently from having significantly higher BP than young females. Unfortunately, more detailed analysis is required to more accurately pinpoint the exact reasons for increased BP in this group. Although chronic psychological stress is known to increase BP[21-23] by various mechanisms, such as modulation of the pattern of sympathetic activity[21] and induction of endothelial dysfunction,[22,24] sample size was too small in this group to draw definitive conclusions in this regard. It is therefore imperative that young males be advised to monitor their BP regularly, since this risk factor seems to be maintained with ageing and may even get worse, given the propensity for decreased physical activity in older males.

In the current study, detailed analysis of nutritional intake was not possible. However, in young males, who are reported to have the highest habitual fast food intake of the groups assessed, both fasting glucose and TG levels were elevated in more than 20% of individuals and alcohol intake was positively correlated with the number of risk factors present. These facts seem to indicate a relationship between unhealthy dietary intake and risk in young males. However, in young females, where very low incidence of overweight and seemingly healthier dietary intake was measured, incidences of elevated levels for both TGs and cholesterol were higher when compared to younger men. There could be more than one possible explanation for this gender-difference. Firstly, the fact that more young males took part in regular exercise, may have resulted in relatively lower TG and cholesterol levels in this group. TG levels in young females were correlated with resting pulse rate ($r = 0.34$, $P < 0.01$), supporting this possibility. Another role player, mentioned already as an etiological factor for lifestyle-related disease,[25] is psychological stress. Apart from outcomes of stress mentioned above, chronic stress may also result in chronic low-grade systemic inflammation,[26,27] which has been implicated as a contributor to atherosclerotic plaque formation[24,28] as well as insulin resistance and type II diabetes.[4,5] In the current study, older females showed lower perceived stress levels and anxiety and more vigor when compared to younger counterparts. Although no comparisons could be made relative to male population due to low statistical power, this data indicate that within the female gender, the younger generation suffers from relatively higher stress levels. The young generation is therefore also likely to exhibit more stress-related effects on metabolism in the long run. It is interesting to note that in apparently healthy, employed adults, the concern for personal safety and other measures of fear was reported to correlate with C-reactive protein levels in females.[29] This may suggest that the higher stress values in the young female population reported here, may not only be related to the fact that they are students, but also to a concern for personal safety, which may be of a more enduring nature in the South African context. High perceived stress levels has recently been linked to increased risk behavior, such as smoking, inactivity and drinking and increased risk of becoming overweight.[10] Therefore, in this group, health education should be focused on stress management, in order to successfully prevent the development of the metabolic syndrome and other chronic diseases with an inflammatory component.

Limitations of the study

Due to financial constraints and methods chosen, blood analysis, plasma insulin and direct estimation of HDL cholesterol were not assessed in the current study. Therefore, lipid-specific risk indicators such as the atherogenic index could not be calculated and also the incidence of insulin resistance is not known. Given the current results, it is vital to include these assessments in future studies, which would allow for more comprehensive interpretation of results. Furthermore, although the current data strongly suggests that high BP and central obesity has a role in the development of the metabolic syndrome, the relatively limited sample size, particular in the male cohort, did not allow for more detailed statistical analysis to precisely indicate direct cause and effect relationships. Future studies on this topic would therefore benefit from inclusion of sufficient volunteers to increase

statistical power and thus enable a multivariate regression analysis between BP or central obesity and the metabolic abnormalities measured.

CONCLUSION

Our data suggests that in the population assessed, males generally make unhealthy diet-related choices, but are partially protected from metabolic risk as long as they exercise sufficiently. However, on average, only the younger male populations engage in regular exercise. In contrast, females tend to make better choices for nutrition, but exercise less. In addition, younger generation females in the academic environment are subjected to much higher stress levels, which may have long-term adverse effects.

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