The impact of sedentary behaviour interspersed with intermittent physical activity on blood pressure and heart rate in healthy individuals

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Abstract

Sedentary lifestyle characterized by insufficient physical activity (PA) has been implicated as a risk factor for cardiovascular disease. The study assessed the effect of sedentary behaviour interspersed with intermittent PA on blood pressure (BP) in healthy female students at the University of Uyo. BP was measured by digital sphygmomanometer, and data were analysed using ANOVA at $p<0.05$. Twenty subjects were randomly selected for the study, which were divided into two groups (control and test groups). The control group (CG) was allowed to observe a 2-hour sitting without engaging in any PA, while the test group (TG) was allowed to observe a 10-minute walk after every 20-minute sitting for the 2-hour duration. BP and heart rate were measured in the two groups at intervals of 0, 20, 30, 50, 60, 80, 90, 110, and 120 minutes. The result showed a significant increase in systolic BP, mean arterial pressure, and heart rate at 30, 60, and 90 minutes in TG compared to CG. The diastolic BP significantly increased at 60 minutes in TG compared to CG. The study showed that PA resulted in an increase in blood pressure, which was restored to a normal level after 20-minute sitting in healthy female students.

Keyword: Sedentary behaviour; Physical activity; Blood pressure; Heart rate

1. Introduction

The prevalence of sedentary lifestyle continues to increase worldwide with the advancement of technology, which brought about mobile phones with all the basic necessities such as the Internet, social media, video games, video applications, software applications, and so on. Sedentary lifestyle is a major challenge to health, as there is overwhelming evidence associating sedentary lifestyle with increased mortality and morbidity [1]. The World Health Organization [1] characterized a sedentary lifestyle as having less than 100–150 minutes of light muscular activity or less than sixty minutes of intense muscular activity per week. A sedentary lifestyle increases mortality and the risks of developing cardiovascular diseases, diabetes mellitus, hypertension, and cancer [2]. Sedentary lifestyle has been reported to be the fourth most prominent risk factor for global mortality, responsible for about 6% of global deaths [2].

Sedentary behavior has been implicated as a risk factor for cardiovascular disease [3]. The mediator of sedentary behavior's effects on the cardiovascular system is suggested to be venous pooling within the lower extremities as a result of decreased muscular activity and consequently decreased action of the limbs' musculovenous pump [4]. The venous pooling at the low extremities reduces venous return to the heart, which in turn reduces cardiac output [5]. The decrease in cardiac output as a result of increased hydrostatic pressure at the lower extremities and increased arterial tortuousness brings about an uncommon hemodynamic condition that may increase the burden on the cardiovascular system [6]. Studies have reported that acute sitting sessions can result in impaired vascular function at the lower extremities [7], elevate the blood pressure at the peripherals [8], and increase the stiffness of the central and peripheral arteries [9]. Furthermore, Loh and coworkers [10] reported that acute exposure to sitting sessions may result in glucose metabolism impairment through the downregulation of skeletal muscle contraction-initiated glucose uptake. Triglyceride metabolism is also affected by the downregulation of lipoprotein lipase activities. They suggested that the downregulation of these metabolic pathways may result in increased systemic inflammation, which may enhance vascular function impairment and thus add to the burden on the cardiovascular system. The long-term impacts of the above-reported effects on cardiovascular functions are not known; however, it can be deduced that the repeated exposure to these physiological assaults mentioned above may over time contribute to the observed relationship between sedentary lifestyle and the risk of cardiovascular disease [10].

Physical activity is known globally as beneficial to human health, and engaging in moderate muscular activity has been encouraged worldwide. Physical activity is described as the movement of the skeletal muscles that leads to the expenditure of energy [11]. The health benefits of physical activity have been reported, specifically with regard to the prevention and treatment of chronic illnesses like type 2 diabetes, cardiovascular disease, and cancer [12,13,14,15]. There is evidence that muscular activity reduces the chance of developing metabolic syndrome. Routine muscular activities can enhance the prevention and management of cardiovascular disease, hyperglycemia, hyperlipidemia, and obesity [16,17,18,19,20]. Physical activity is a beneficial treatment technique to improve the prognosis for individuals with cardiovascular disease and prevent both the onset and development of the condition. Increased mitochondrial function, improved vasculature, and the release of myokines from skeletal muscle that support or increase cardiovascular function have been documented as some of the beneficial effects of physical activity [21]. Light exercise has been reported to cause changes in cardiovascular function in the elderly with a beneficial effect on prevention and restoration in severe cardiovascular disease [22].

Numerous studies have indicated that an increased level of muscular activity significantly enhances the function of the circulatory system by increasing cardiac output, stroke volume, and oxygen delivered to active tissues with reduced myocardial strain [23,24,25]. Physical activity causes the skeletal muscles to contract, which causes the release of histamine. Histamine has been documented to be essential for persistent post-exercise vasodilation [26,27,28]. Angiogenesis has also been reported as one of the mediators through which physical activity influences blood pressure; physical activity causes morphological changes in the vascular tree to increase blood flow [29,30]. Exercise reduces inflammation, proliferation, and fibrosis, and as a result, it enhances vascular remodeling across the layers of the artery wall land consequently reduces peripheral vascular resistance [31]. Furthermore, muscular activity has a sensitizing effect on insulin, which has been shown to be related to the degree of physical activity [24,32]. Insulin resistance develops as a result of abnormalities in insulin signaling transduction, which in turn increases the risk of cardiovascular disease. Consistent muscular activity has been shown to improve the action of insulin in people with insulin insensitivity [33,34,35].

Sedentary behavior is a phrase used to describe actions that involve little or no energy expenditure. Sedentary activities include watching television, playing video games, using a computer or phone, sitting at work or school, and commuting. Compounded sedentary behavior leads to a sedentary lifestyle. Numerous factors contribute to the physical well-being of an individual, and one of the most important ones is lifestyle. A sedentary lifestyle has been documented to increase the risk of cardiovascular diseases, diabetes mellitus, and other ailments. Most research has focused on the effects of sedentary lifestyles on the elderly and working-class adults. However, there is a paucity of data on the effects of sedentary behaviour on young adults in Nigeria. This study was therefore designed to evaluate the effect of sedentary behaviour interspersed with intermittent physical activity on blood pressure and heart rate in healthy subjects studying at the University of Uyo, Akwa-Ibom State.

2. MATERIALS AND METHOD

2.1 Subject selection/subject selection criteria

The female volunteers were selected at random from the University of Uyo. The volunteers had an age range of 18 to 23 years, a weight range of 45 to 70 kg, and a height range of 1.50 m to 1.75 m. 40 female participants were recruited for the study, and they were all duly informed about the protocol of the study. The study was approved by the Ministry of Health, Uyo, Akwa-Ibom State and written consent was obtained from all volunteers before screening.

The criteria given below were used to screen the volunteers for the study:
i. Do not have any history of cardiovascular disorders such as hypertension, cardiac failure, or cardiac arrest.
ii. Is not on any special medication
iii. Is medically fit
iv. To be readily available and cooperate adequately during the period of the experiment, the duration and procedures of the experiment were properly explained to the subjects.
iv. The volunteers were instructed to maintain their composure throughout the study.
After the prior examination, 20 volunteers were certified fit to participate in the study.

2.2 Study design

The experiment was carried out at the Medical Physiology Lab of the University of Uyo, Annex Campus, Uyo, Akwa-Ibom State. The 20 certified volunteers were randomly divided into two groups (groups A and B). Group A was the control group, while Group B was the test group. Each group was made up of 10 subjects. The control group was allowed to sit throughout the 2-hour duration of the experiment, while the test group was allowed to go for a 10-minute walk after every 20 minutes of sitting, making up four intervals consisting of 20 minutes of sitting and 10 minutes of walking. After the random selection, the subjects were allowed to rest for 15 minutes before the baseline blood pressure and heart rate were measured with the subjects comfortably seated. After baseline measurement, blood pressure and heart rate were measured in the two groups at intervals of 20 minutes, 30 minutes, 50 minutes, 60 minutes, 80 minutes, 90 minutes, 110 minutes, and 120 minutes with the subjects comfortably seated.

2.3 Measurement of blood pressure and heart rate

The blood pressure and heart rate measurements were taken using a digital sphygmomanometer with a cuff size of 12 x 26 cm. The handcuff of the digital sphygmomanometer was wrapped around the left arm of the subject, one inch (2–3 cm) away from their cubital fossa, and the arm was heard close to the heart. The subjects were asked to remain calm and composed and not move their arms or talk during the measuring process so as not to alter the readings. The switch of the digital sphygmomanometer was pressed, and in about 1–2 minutes, the cuff was inflated and deflated automatically, displaying the blood pressure and heart rate simultaneously on the screen of the sphygmomanometer. The blood pressure and heart rate were measured three consecutive times at a 1-minute interval between measurements, and the average was recorded. Mean arterial pressure was calculated using the formula: MAP = DBP + 1/3(SBP-DBP).

2.4 Statistical analysis

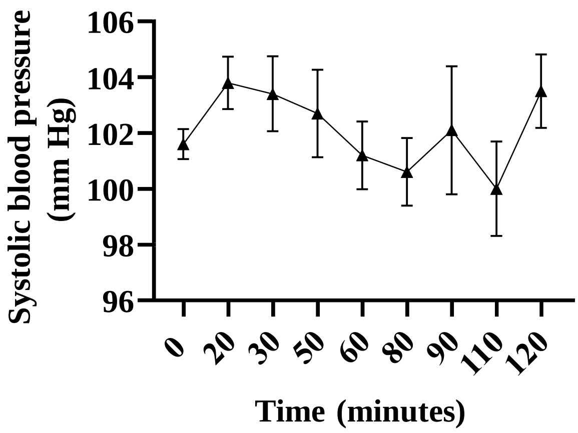
The data were presented as mean ± SEM. Analysis of variance (ANOVA) was used to analyse the data using Graphpad Prism 7.01 (Graphpad Software, Inc., USA). Turkey's tests was used to perform the post-hoc comparison following the ANOVA analysis. The level of significance for all the results was $P < 0.05$.

3. Results

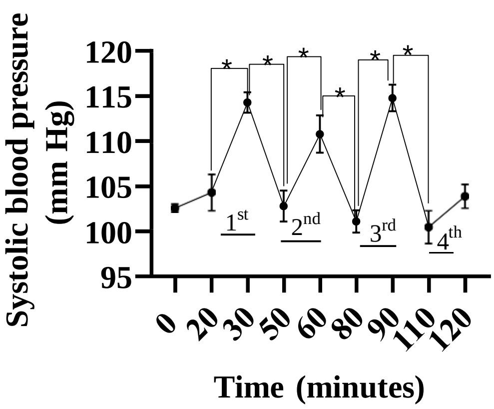
Change in systolic blood pressure (SBP)

The study recorded no significant change in systolic blood pressure in the control group throughout the duration of the experiment (figure 1a). In the test group a significant increase was observed at first, second, and third intervals after 10 minutes of walking compared to the SBP of sitting ($P<0.05$), however, at fourth interval of the study, no significant change in SBP was observed after 10 minutes of walking compared to sitting SBP (Figure 1b). When the SBP of the test group was compared to that of the control group, a significant increase was observed in test group at 30 minutes, 60 minutes, and 90 minutes of the study ($p<0.05$) (Figure 1c).

(a)



(b)



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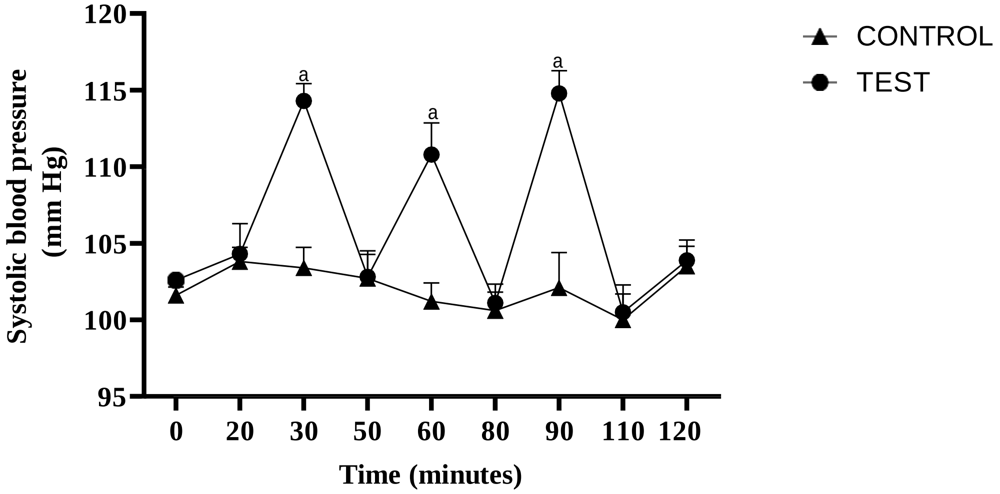


Figure 1: Systolic blood pressure (SBP)
The subjects were allowed to sit for 2 hours in the control group, while in the test group the subjects were allowed to go for a 10-minute walk after every 20 minutes of sitting. The blood pressure of all the subjects was measured at every 20 minutes of sitting and 10 minutes after the 20-minute sitting. (a) progressive changes in SBP in the control group, (b) progressive changes in SBP in the test group, and (c) the comparison between the control group and test group. * =$p<0.05$, a =$p<0.05$ compared to control group.

Change in diastolic blood pressure (DBP)

Figure 2 showed the changes in DBP. The study observed no significant change in DBP in the control group and test group throughout the duration of the experiment (Figure 2a & b). However, when the DBP of the test group was compared to that of the control group, a significant increase was observed in test group at 60 minutes of the study ($p<0.05$) (Figure 2c).

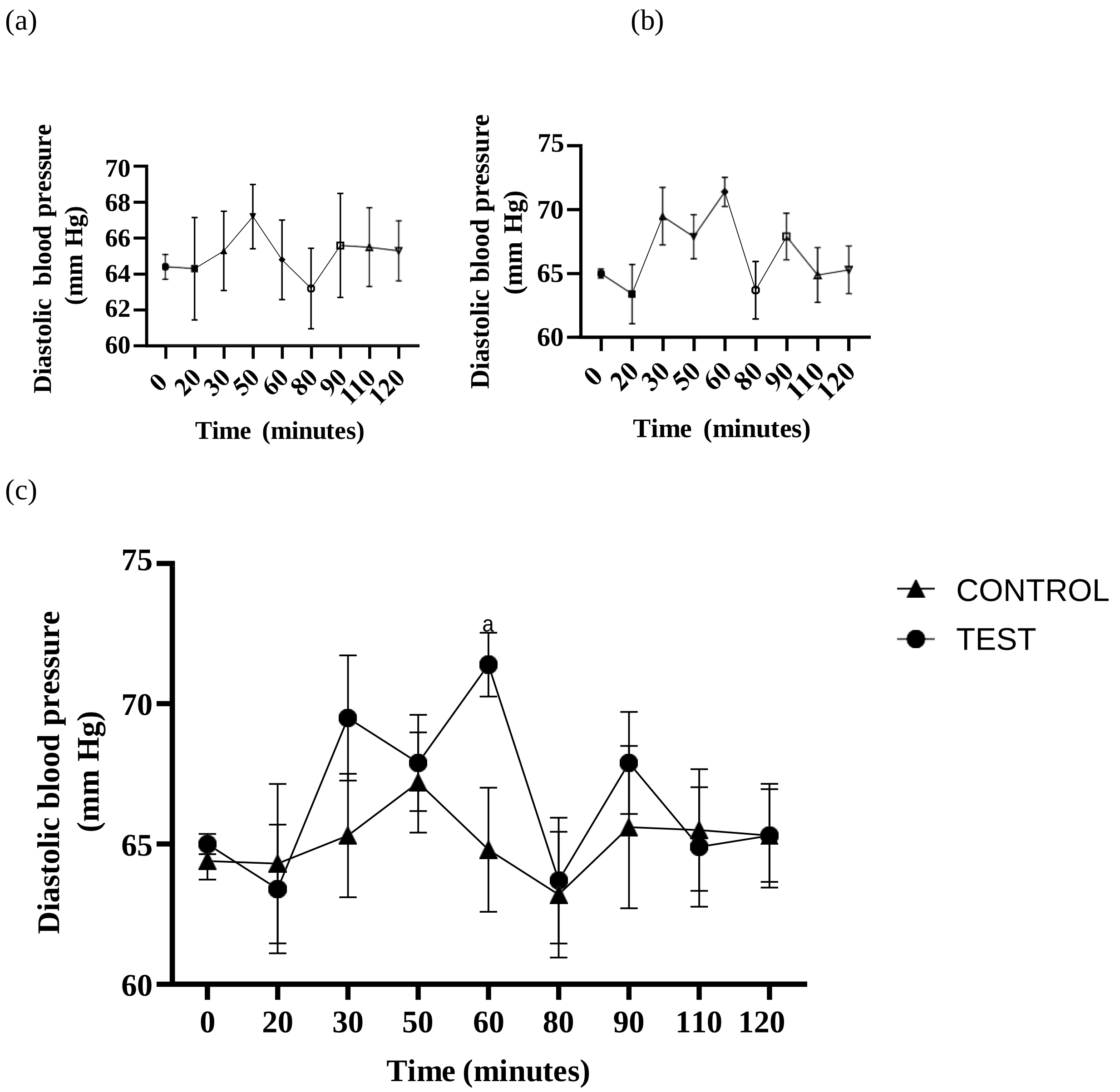


Figure 2: Diastolic blood pressure (DBP)
The subjects were allowed to sit for 2 hours in the control group, while in the test group the subjects were allowed to go for a 10-minute walk after every 20 minutes of sitting. The blood pressure of all the subjects was measured at every 20 minutes of sitting and 10 minutes after the 20-minute sitting. (a) progressive changes in DBP in the control group, (b) progressive changes in DBP in the test group, and (c) the comparison between the control group and test group. a =p<0.05 compared to control.

Change in mean arterial pressure (MAP)

Figure 3 showed the changes in MAP. The study observed no significant change in MAP in the control group throughout the duration of the experiment (Figure 3a). In the test group, a significant increase was observed in MAP at 30 minutes compared to 20 minutes, at 60 minutes compared to 80 minutes, and at 80 minutes compared to 90 minutes (p<0.05) (Figure 3b). The statistical comparison of the test group with the control group showed a significant increase in MAP at 30 minutes, 60 minutes, and 90 minutes in test group (p<0.05) (Figure 3c).

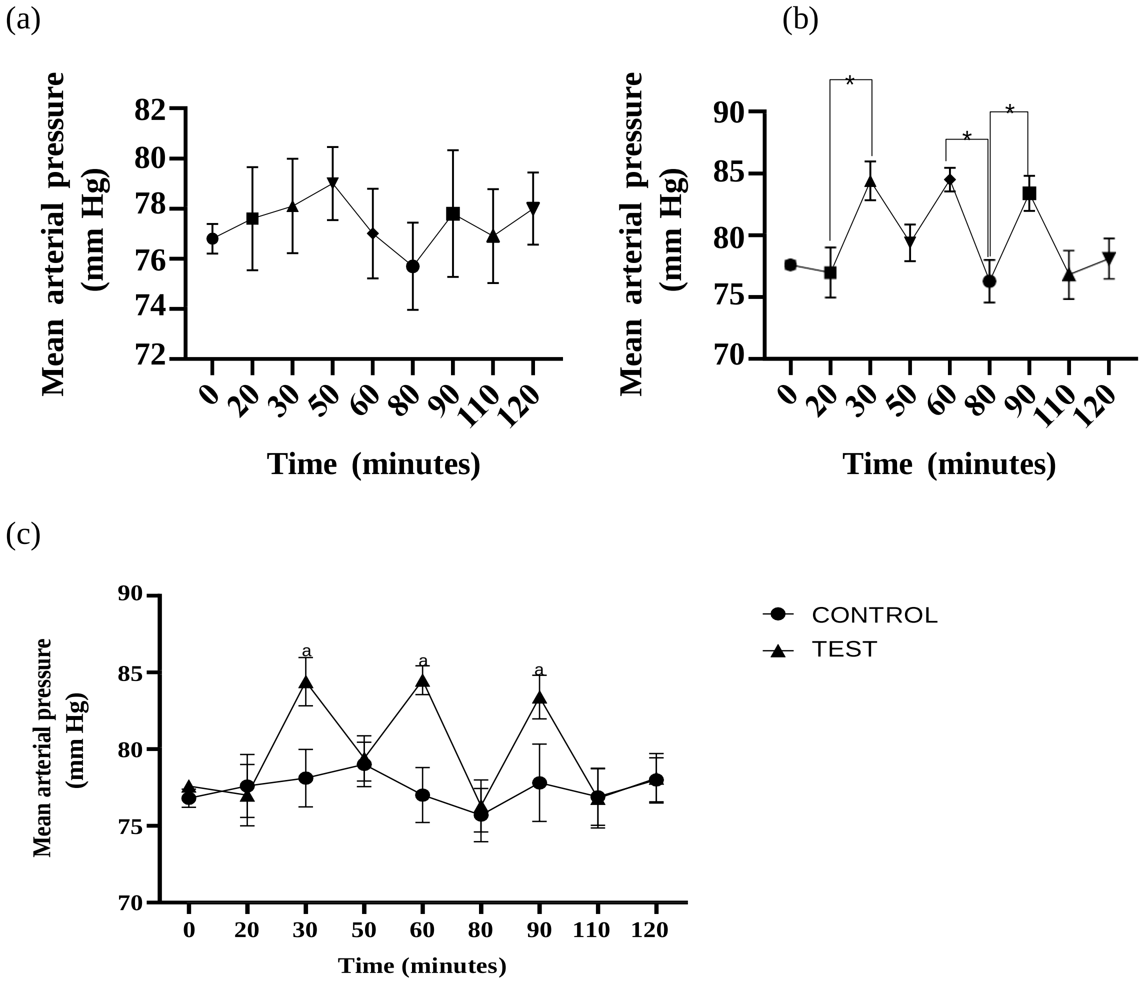


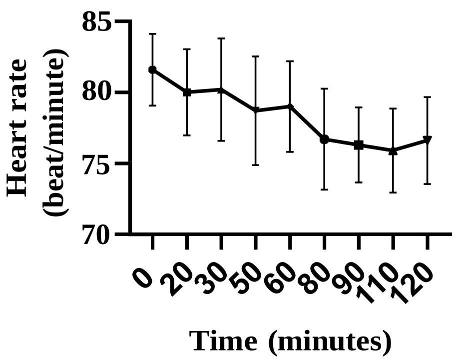
Figure 3: Mean arterial pressure (MAP)

The subjects were allowed to sit for 2 hours in the control group, while in the test group the subjects were allowed to go for a 10-minute walk after every 20 minutes of sitting. The blood pressure of all the subjects was measured at every 20 minutes of sitting and 10 minutes after the 20-minute sitting. (a) progressive changes in MAP in the control group, (b) progressive changes in MAP in the test group, and (c) the comparison between the control group and test group. * =p<0.05, a =p<0.05 compared to control group.

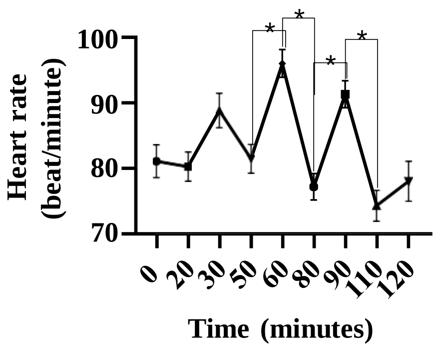
Change in heart rate (HR)

Figure 4 showed the changes in HR. The result showed no significant change in HR in the control group throughout the duration of the experiment (Figure 4a). In the test group, there was a significant increase from 50 minutes to 60 minutes, a significant decrease from 60 minutes to 80 minutes, a significant increase from 80 to 90 minutes, and a significant decrease from 90 to 110 minutes (p<0.05) (Figure 4b). The statistical comparison of the test group with the control group showed a significant increase in HR at 30 minutes, 60 minutes, and 90 minutes in test group (p<0.05) (Figure 4c).

(a)



(b)



(c)

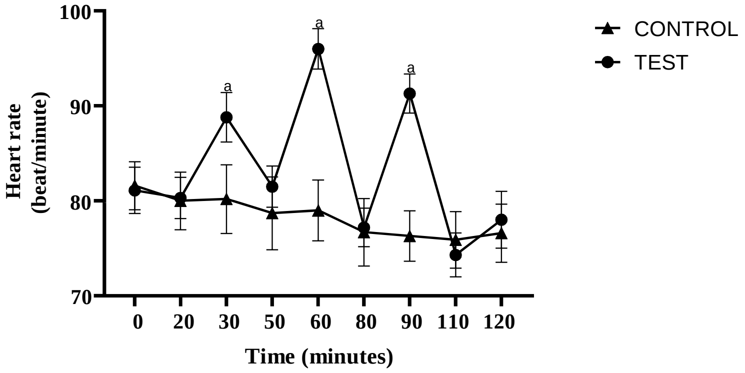


Figure 4: Heart rate (HR)

The subjects were allowed to sit for 2 hours in the control group, while in the test group the subjects were allowed to go for a 10-minute walk after every 20 minutes of sitting. The blood pressure of all the subjects was measured at every 20 minutes of sitting and 10 minutes after the 20-minute sitting. (a) progressive changes in HR in the control group, (b) progressive changes in HR in the test group, and (c) the comparison between the control group and test group. * =p<0.05, a =p<0.05 compared to control group

4. Discussion

Sedentary lifestyle poses a serious threat to health, and a wealth of research links it to higher rates of illness and mortality [1]. Sedentary lifestyle is defined by the World Health Organisation [1] as having less than 100–150 minutes of light muscular activity or less than 60 minutes of vigorous muscular activity per week. On the contrary, the health benefits of physical activity are well known across the world, and moderate muscular activity has been promoted globally. Physical activity is defined as the movement of the skeletal muscles that leads to the expenditure of energy [11]. Modern technology has highly encouraged the practice of sedentary behaviour worldwide. This study assessed the effect of sedentary behaviour interspersed with intermittent physical activity on blood pressure and heart rate among female students studying at the University of Uyo, Akwa Ibom State. Twenty (20) participants were randomly selected for this study, which was divided into two groups (control and test groups). The control group sat all through the 2-hour duration of the experiment, while the test group went for a 10-minute walk after every 20-minute sitting.

The study showed no significant change in SBP in the control group throughout the course of the experiment. In the test group, the 10-minute walk resulted in a significant increase in SBP at the first three intervals of the experiment, but no significant increase was recorded at the fourth interval after the 10-minute walk. Comparing the test group to the control group, the 10-minute walk brought about a significant increase in SBP at 30 minutes, 60 minutes, and 90 minutes. A different picture was observed in DBP. The DBP of the control and test groups showed no significant changes; however, when the test group was compared to the control group, a significant increase was observed at 60 minutes of the study. The result of the MAP was almost similar to that of the SBP except that there was no significant change from 30 to 50 minutes, 50 to 60 minutes, and 90 to 110 minutes. The heart rate result showed no significant change in the control group, but showed a significant increase from 50 to 60 minutes, 60 to 80 minutes, 80 to 90 minutes, and 90 to 110 minutes in the test group. The study also recorded a significant increase in heart rate in the test group at 30 minutes, 60 minutes, and 90 minutes compared to the control group.

In contrast to the results of this study, Gerage and coworkers [36] reported in their cross-sectional study involving 87 hypertensive patients that decreased sedentary activity time and increased moderate physical activity time are linked to a reduction in blood pressure. Similar to their report, another cross-sectional study reported a strong link between sedentary behaviour and increased systolic blood pressure among osteoarthritis Initiative participants, and the observed increase was independent of the time they spent engaging in light to intense physical activity. The study suggested that a reduction in daily sedentary time might be beneficial for blood pressure management [37]. The discrepancy in our observations might be due to different methodologies. The above are cross-sectional studies involving hypertensive patients and osteoarthritis participants, respectively. A systematic review and meta-analysis conducted by Teixeira et al., [38] documented that intermittent light to intense exercise training has the potential to bring about a decrease in blood pressure, particularly in hypertensive individuals, but they concluded that the certainty of the evidence was low. A study design similar to ours reported no significant changes in systolic and diastolic blood pressure after interrupting eight-hour sitting with 20 sessions of 2-minute light-vigorous physical activity breaks [39]. The discrepancy in our results might be due to the time allotted to the physical activity break (2 minutes). In our study, the physical activity break was 10 minutes. The authors submitted that sedentary behaviour might be linked to hypertension, and that a single bout of eight-hour sitting might not be sufficient to produce hypertensive effects in healthy children. We totally agree with their submissions. A session of 2-hour sitting might not be effective enough to induce the reported hypertensive effect associated with sedentary lifestyle.

The increase observed in systolic blood pressure and heart rate is because they were measured at the 10-minute mark to observe the immediate effect of the walk on blood pressure and heart rate. It is normal for the systolic blood pressure to increase in response to exercise as a result of increased cardiovascular demand and oxygen consumption by the active muscles [40]. In response to exercise, the body activates the sympathetic nervous system, and the increased sympathetic activity causes an increase in heart rate in order to increase cardiac output. The increase in cardiac output brings about an increase in systolic blood pressure [41]. In general, the blood pressure returns to a normal level within minutes or hours after the physical activity; this recovery time depends on the intensity and duration of the exercise [42]. In line with the above, the results showed that the blood pressure of the test group returned to a normal level after a 20-minute sitting. Furthermore, the heart adapts to exercise and becomes more efficient at pumping blood without an increase in heart rate over time, and as a result of this adaptation, the blood pressure reduces [43]. This explanation might be the reason the systolic blood pressure and heart rate did not significantly increase at 120 minutes.

5. Conclusion

Sedentary lifestyle has been implicated as a risk factor for various disease conditions, such as high blood pressure, while physical activity has been reported to have positive effects on health. However, from the results of this study, it was observed that physical activity resulted in an increase in blood pressure, which was restored to a normal level after 20-minute sitting in healthy young female adults.

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