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Effects of a Physical Activity Program on Cardiac Cycle Events in Sedentary Individuals

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Abstract

Physical activities – walking, fitness and ballroom dancing - were offered over a six month period (April-September 2007). Sixty-minute classes were offered three times a week, in the morning, at the Physical Activities Stand, in a program called *Mexa-se* (Move your Body). Each class was divided into three stages: warm-up (10 minutes); the class itself (45 minutes); and stretching and relaxation exercises performed to background music, in the last phase (05 minutes). Twenty-five sedentary individuals took part in this study: n=09 men (ages 34 to 50) and n=16 women (ages 31 to 51). This study aims to verify the effects of the program on the following cardiac cycle events: Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and heart rate (HR). The Naughton Protocol was applied and the individuals were evaluated and re-evaluated according to the aforesaid methodology. Heart rate, Systolic Blood Pressure and Diastolic Blood Pressure at rest and during post-exercise recovery were statistically analyzed t-test, with $p>0.05$ significance level. At rest: in both sexes, there was no significant difference between evaluation and re-evaluation heart rate; regarding SBP and DBP, only the men showed a significant difference between evaluation and re-evaluation values. At recovery: there was no difference between evaluation and re-evaluation heart rate in either group (men and women); SBP was different between evaluation and re-evaluation in both groups from the first minute up to the sixth minute; regarding DBP, there was no difference in the first minute, but from the second minute onward, both groups showed a difference between evaluation and re-evaluation values. It should also be noted that at evaluation, both groups completed the Protocol to the 4th stage, and at re-evaluation, 37.5% of females and 33.3% of males completed the Protocol to the 5th and 6th stages. For statistical analysis, we only included up to the 4th stage in the re-evaluation, which showed a significant difference for the male group but not for the female group. Through these results, we observed that the offered physical activity program was an efficient means to a cardiac cycle events.

Keywords: Physical activities; Cardiac cycle; Sedentary individuals

Introduction

Well-structured, well-supervised physical activity can help one to achieve and maintain an adequate body weight, and also contributes positively to the mitigation of other risk factors for coronary disease, such as lipid profile, insulin resistance and hypertension. Physical activity contributes not only to body weight management, but also to the control of diabetes, high blood cholesterol and arterial hypertension [1-3].

Barbosa & Bankoff [4] analyzed the level of physical activity among Unicamp employees and verified that 70.6% of employees showed improvements to health, quality of life, work performance and job relationships with physical activity.

Salve & Bankoff [5] reported that physical activity is one of the fundamental elements in achieving and maintaining good quality of life. Exercise should be practiced during leisure hours, as well as at work through specific programs. This contributes significantly to the establishment of physical and mental equilibrium.

Barbosa [4] highlights that recent studies have shown that gaining the health benefits of physical activity does not require hours of exercise. It is enough to perform thirty minutes per day of moderate intensity physical activity, either continuously or cumulatively.

Ghorayeb & Barros [6] also mention the value of physical activity when it comes to psychological factors, i.e., exercise can generate emotional wellbeing and relieve stress. Endorphins have a relevant role in the sensation of wellbeing, and there is a direct correlation between plasma endorphin concentration and the practice of physical activities. Despite the current controversies regarding an association between endorphin immunoreactivity - especially beta-endorphin - and the practice of isotonic exercises, the acute beneficial effects of physical activity on human mood and wellbeing seems clear.

Other relevant factors in the emotional benefits brought by exercise are better self-esteem due to an improvement of body image and better autonomy due to the greater physical mobility made possible by physical activity.

Allsen et al. [7] highlight other benefits brought by regular physical activity, including:

- Increased aerobic fitness when performing specific tasks;
- Improved functional capacity of the circulatory and respiratory systems;
- Greater muscle and joint strength and flexibility;
- Reduced risk of lower-back injuries;
- Improved bone strength;

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- Weight control and reduced body fat;
- Positive effect on the internal organs;
- Slower physiological aging;
- Development of physical capacities;
- Reduced energy expenditure and, consequently, less fatigue while performing specific tasks;
- Stress relief;
- Stimulated mental activity; and
- Lower risk of noncommunicable chronic diseases.

According to Maris [8], Theobald & Diettrich [9], the benefits that physical activity can bring are countless, with such direct effects on physical health: reduction of body weight and body fat percentage; reduction of resting blood pressure; improvement of diabetes; reduction of total cholesterol; and improvement of aerobic and anaerobic capacity. Other benefits include improvements to cardio-respiratory capacity, muscle strength, muscle tone, flexibility, bone and joint strength, and calorie expenditure, in addition to beneficial effects on the psychomotor development of children.

Systolic and diastolic arterial blood pressure

Blood pressure (BP) is the force or pressure exerted by the blood on the arteries. The higher number (systolic blood pressure) reflects the pressure on the arteries during ventricular systole, when contraction of the myocardium forces a large volume of blood into the arteries. Pressure on the arteries then lowers during the diastole stage of the cardiac cycle, when the heart fills with blood. Resting systolic BP normally ranges from 110 to 140 mmHg, whereas diastolic BP usually ranges from 60 to 80 mmHg [10].

In Brazil, some population studies estimated the prevalence of hypertension at 20.0%-30.0% [11,12]. A study conducted in the urban region of Porto Alegre in the Brazilian state of Rio Grande do Sul, to assess the prevalence of hypertension and its association with biological, socio-economic and environmental exposure factors, found a prevalence of 19.2% using a threshold value of 160/95 mmHg, including those individuals that used antihypertensive medications. When the threshold was lowered to 140/90 mmHg, prevalence rose to 29.8% [13]. Another study performed on Governador Island, in the state of Rio de Janeiro, revealed a prevalence of 24.9% using the 160/95 mmHg threshold value [14].

The currently acknowledged risks or causes of inceased blood pressure include constitutional factors (age, gender, race, obesity); environmental factors (salt, calcium, potassium, alcohol and fat intake, smoking); work-related environmental factors (stress, physical and chemical agents); and factors related to an individual's social status [15,16].

Therefore, for the treatment of hypertension, health professionals recommend the adoption of practices that can minimize the aforementioned risk factors, in addition to prescribed medication. Accordingly, in order to prevent the complications of high blood pressure, hypertensive individuals must not only take medication, but also endeavor to change old habits or adopt new ones [17,18].

Researchers acknowledge the importance of combining knowledge, attitudes and practices in order to plan and prepare educational initiatives that can be applied to bearers of cardiovascular disease. However, those same professionals consider the associations between these variables to be complex, as they involve social, environmental and emotional factors [8,19,20].

Heart rate

Resting heart rate variability (HRV) has been studied as a non-invasive way to assess the autonomic regulation of heart rate, whose debilitation is associated with higher cardiovascular risk. Better documentation is still required, however, regarding the behavior of such regulation during exercise, when important neural alterations take place. We studied the behavior of heart rate (HR) and its variability during the different metabolic phases of physical exercise [21].

Studies have shown that for sedentary individuals Yamamoto et al. [1,22], trained individuals Rimoldi et al. [23], Shin et al. [24], and bearers of heart conditions Arai [25], Bernardi [2], progressive physical exercise suppresses the parasympathetic nervous system and stimulates the sympathetic nervous system, which both control HR. However, several of these studies Yamamoto et al. [1], Nakamura [26], Shin et al. [24], applied a continuous work rate increment protocol (ramp protocol), which does not permit HR stabilization at each stage of the activity - a necessary condition for adequate HRV assessment [6]. The behavior of HRV and its associations with the different intensities and metabolic phases of progressive physical exercise, such as the intensification of anaerobic metabolism [anaerobic threshold (AT)] and metabolic acidosis decompensation [respiratory compensation point (RCP)], also require further documentation [21].

Sedentary lifestyle

In Brazil, the greatest public health problems are sedentary lifestyle, obesity, hypertension, smoking, diabetes and high cholesterol. Lifestyle factors account for 54% of the risk of death by myocardial infarction and 50% of the risk of death by stroke, which are currently the leading causes of death in the country [27,28].

The high prevalence of sedentary habits in current society is a problem which appeared in modern civilization only recently and is one of the main challenges faced by public health. Evidence of this fact is the current predominance of very mild physical effort in most human activities, demanding an energy expenditure of less than 500 kcal per day. In other words, 15 times less than our ancestors of 100 thousand years ago, whose nomadic, hunter-gatherer habits required an expenditure of roughly eight thousand kcal per day in order to survive. At least 60% of the world's population does not fulfill the minimum recommended amount of 30 minutes moderate exercise per day, and it is also estimated that 31% to 51% of individuals do exercise, but insufficiently - less than two and a half hours of moderate intensity exercise per week [23,29].

The literature report that 80% of adults in Brazil are sedentary, 52% are overweight, and 11% are obese, which explains the increase in morbidity and mortality given that obesity is a risk factor in several noncommunicable chronic diseases. The highest rates of overweight and obesity are concentrated in the South region of Brazil, affecting 89.6% and 25.2% of the population, respectively [17,18,30].

Regarding this issue, Bankoff & Zamai [31], Bankoff et al. [28,32] comment that considerable changes have been taking place regarding posture, diet and lifestyle, for people are spending many hours on passive activities such as watching television, using the computer, and performing desk work at their respective jobs; not to mention the manner of locomotion in major urban centers which requires minimal

energy expenditure, in contraposition to the average daily food intake of a modern individual.

On one hand, technological progress has lengthened the human life span through advances in the treatment and prevention of communicable diseases, which comprised the main cause of morbidity and mortality prior to the 1930s.

According to Bankoff et al. [28,30], sedentary lifestyle is one of the leading health risk factors. The conditions associated with it include obesity, hypertension, and chronic degenerative diseases. In this study, the authors evaluated the performance of sedentary university employees and verified that among the analyzed subjects, 12.5% reached only the 2nd stage of the Naughton Protocol, 75% reached the 4th stage, and 12.5% reached the 5th stage. Regarding the body fat percentages of our research subjects, 50% were above the standard value and 37.5% were very high.

Thus, the advance of technology has created a life of relative comfort for modern society. Elevators, escalators and motor vehicles have diminished our need to walk. Everything is becoming increasingly easy in terms of required physical effort and energy expenditure Sharkey [33].

Zamai et al. [20,34], highlight that sedentary habits do not create merely a personal risk of infirmities, but also have a high financial cost to individuals, their families and the public coffers.

Sedentariness is an undesirable condition and comprises a health risk. Several studies have already reported that a more active lifestyle lowers probability of death and improves quality of life [35]. The health problems associated with sedentariness and obesity are constant in modern society and their prevalence has been advancing at alarming rates [36,37].

A review of the literature published over the past 50 years led to the conclusion that sedentary habits cause a countless number of problems which later lead to premature death, in what are known as Sedentary Death Syndrome (SeDS). The aforesaid review revealed that:

- SeDS will be responsible for the deaths of 2.5 million Americans in the coming decade;
- Medical care will cost the United States 2.3 trillion dollars over the coming decade due to SeDS.

Physical inactivity has increased the prevalence of chronic disease. In the United States, the number of Type 2 diabetes cases has increased nine times since 1958 and obesity has doubled since 1980. Heart disease is still the leading cause of death [26].

General Objective

The objective of this study was to investigate the effects of an exercise program on the events of the cardiac cycle (systolic blood pressure (SBP) and diastolic (DBP) and heart rate (HR)) in sedentary subjects with the prospect of improving the levels.

Material and Method

Studied population

The subjects of this study were 25 sedentary employees of the State University of Campinas (Unicamp): n=09 men, ages 34 to 50; and n=16 women, ages 31 to 51. They were participants in the university's "Physical Activity and Socialization" program. The project was approved by the Ethics Committee of University of Campinas – number 482/2007

Methodological procedures

Physical activities were offered over a six-month period (April to September 2007), namely: walking, ballroom dancing and light resistance training. The 60-minute classes were offered at the Physical Activities stand set up for the *Mexa-se* (Move Your Body) Program, three times a week, in the morning. Each class was divided into three stages: warm-up (10 minutes); the class itself (45 minutes); and the final stage (05 minutes) were stretching and relaxation exercises were performed to background music. The study subjects underwent an "before and after" evaluation and re-evaluation.

Treadmill exercise protocol

To acquire the data applicable to the exercise protocol used in this study, we used an APEX TEB 2200 Integrated System, programmed for 7 stages and with an initial speed of 1.5 mph. The protocol used was the Naughton Model I, which is recommended for elderly patients or individuals with a heart condition. Due to the specific characteristics of the apparatus, it was necessary to adapt the first stage of the aforementioned Protocol, raising the speed variable from 1.0 Mph to 1.5 Mph. (Table 1)

A three-lead graphic configuration (MV5, D2M and V2M), which was perfectly suited to our purposes, was used in this study. The electrodes used were Carbo Cone®, 55 mm diameter, breathable fabric, activated with NaCl 10%, antiallergic, and radiotransparent - 3M.

Performance of treadmill protocol

The participating individuals were advised to:

a) Arrive at the location 15 minutes prior to commencement of the Protocol;

b) Have breakfast no later than two hours before commencement of the Protocol;

c) Avoid any type of physical activity on the day before the Protocol's application;

d) Bring appropriate clothing to perform the Protocol (shorts, two-piece bathing suit and sneakers);

e) Avoid eating or drinking in excess on the previous evening;

f) Get 6 to 8 hours of sleep on the night before the Protocol;

g) Avoid using sedatives and communicate any change in their health conditions in the preceding 24 hours.

Results

The following results refer to the Naughton exercise protocol evaluations and re-evaluations performed in April and September, respectively, before and after completing a physical activity program

Stages	Mph	% Incline	Min.
1st	1.5	0%	3
2nd	2.0	0%	3
3rd	2.0	3.5%	3
4th	2.0	7.0%	3
5th	2.0	10.5%	3
6th	2.0	14.0%	3
7th	2.0	17.5%	3

Table 1: Naughton Model I Protocol - Modified according to the specific characteristics of the APEX TEB 2200 Integrated System.

of heart rate monitored walking, ballroom dancing and light resistance training.

The results were obtained by Test t statistical analysis ($p > 0.05$ significance level) of the values obtained at evaluation and re-evaluation for heart rate, systolic blood pressure and diastolic blood pressure, in the following circumstances: at rest, at the 1st to 4th stages of the Naughton treadmill protocol, and during post-exercise recovery, as per Table 2.

After 06 months of aerobic physical activity for both groups (female and male) evaluated using the modified Naughton protocol on a treadmill before the start of physical activity and after the results in Table 2 shows that the heart rate showed no significant results through the Test t $p > 0.05$ for both groups in the variables analyzed after six months of aerobic physical activity practices.

Blood pressure Systolic and diastolic were the events that had more significant results through the test t $p > 0.05$, specifically for the male group. The levels of these events of the cardiac cycle decreased, with significant improvement after six months of practical aerobic physical activity.

We can see that the results shown in Table 3 for the female group, initial assessment and reassessment (after six months of aerobic physical activity) are values with minor differences when compared with the male group, however, we consider it a good gain when the subject can decrease the levels of systolic and diastolic blood pressure through the practice of aerobic physical activity

The results of Table 4, referring to this study's male subjects, shows that the men had a better response to the offered exercise program than our female subjects. We were able to verify that the men's HR and cardiac cycle events (SBP and DBP) at rest and during the 1st through 4th stages of Naughton's treadmill protocol were consistently lower at re-evaluation than at initial evaluation. At 1 minute and 2 minutes post-exercise recovery, the HR values were higher at re-evaluation.

Discussion

The benefits of physical exercise are not a new subject of research and discussion, considering the scientific publications, who reports that aerobic exercise (low intensity, long duration) is excellent to improve physical fitness and reduce body fat, thereby reducing the risk of cardiovascular disease [38]. Paffenbarger et al. [39], Skinner [40], Pollock and Wilmore [41], Guedes and Guedes [42], McArdle WD, Katch FI, Katch VL [43], and others have also described that low intensity, long duration physical activity increases cardiovascular fitness and reduces body fat in sedentary people, increasing their quality of life.

Through a physical activity program offered to the participants over a six-month period and using treadmill testing as the evaluation and re-evaluation parameter for both groups (males and females), we observed that specifically regarding heart rate, the women's group showed higher values at re-evaluation than those measured during the initial evaluation (at rest, 1st through 4th stages of the Naughton Protocol, and post-exercise recovery), after six months of regular physical activity. It should be noted that female re-evaluation heart rate was lower only for one measurement, namely at 1 minute recovery. At re-evaluation, female SBP and DBP were lower during the protocol stages and recovery, but not enough to reach the significance level.

We should remember that heart rate (HR) is mediated primarily by the direct activity of the autonomic nervous system (ANS), via the effects of the sympathetic and parasympathetic systems on sinus node autorhythmicity, with a predominant influence of vagal (parasympathetic) activity at rest and sympathetic activity during exercise [44]. According to Greenland et al. [11], a low resting heart rate tends to represent good health, whereas higher values are apparently related to a higher risk of mortality. Our female resting HR results fit the normal values, but after six months of regular, moderate physical activity, the female group's heart rate values at rest, during treadmill testing and at recovery were not reduced.

According to Guedes and Guedes [42], exercise heart rate should stay within a range of 135-174 bpm; in other words, physical exercise should be intense enough to raise HR above 135 bpm, but not to exceed 174 bpm. According to the consulted literature, both groups fit into the indicated limits. The men's resting heart rate at evaluation and re-evaluation fit the previously published normal ranges.

If we compare the values presented in Tables 2 (women) and 3 (men), the offered program produced a better response in the male group, although there was a slight difference in age range between the genders (34-50 for the men; 31-50 for the women). By observing those values, one concludes that further gender-based studies are required.

Cardiac Cycles	Evaluation, F	Re-evaluation, F	Evaluation, M	Re-evaluation, M
HR-resting	No difference	No difference	No difference	No difference
SBP-resting	No difference	No difference	Different *	Different *
DBP-resting	No difference	No difference	Different *	Different *
Final stage	No difference	No difference	Different *	Different *
HR-Rec-01min	No difference	No difference	No difference	No difference
HR-Rec-02min	No difference	No difference	No difference	No difference
HR-Rec-04min	No difference	No difference	No difference	No difference
HR-Rec-06min	No difference	No difference	No difference	No difference
SBP-Rec-01 min	No difference	No difference	Different *	No difference
SBP-Rec-02 min	No difference	No difference	No difference	Different *
SBP-Rec-04 min	No difference	No difference	Different *	Different *
SBP-Rec-06 min	Different *	No difference	Different *	Different *
DBP-Rec-01 min	No difference	No difference	No difference	No difference
DBP-Rec-02 min	Different *	Different *	Different *	Different *
DBP-Rec-04 min	No difference	No difference	Different *	Different *
DBP-Rec-06 min	Different *	No difference	Different *	Different *

Table 2: Results of Test t statistical analyses ($p > 0.05$ significance level) on cardiac cycle events of men and women, at evaluation (before initiating practice of regular physical activity) and re-evaluation (after six months of regular physical activity).

Women	EVALUATION			RE-EVALUATION		
	HR	SBP	DBP	HR	SBP	DBP
Resting	71.5	114.1	75.6	74.4	110	72.8
Stage 1	92.3	123.1	78.1	96.2	120.9	75
Stage 2	109.6	132.8	79.1	111.7	130.6	76.6
Stage 3	129.3	147.3	80.9	130	139.7	79.7
Stage 4	149.3	159.4	82.8	149	148.8	82.8
Mean	**120.1**	**140.7**	**80.2**	**121.7**	**135.0**	**78.5**
Std dev	**24.6**	**16.0**	**2.1**	**22.8**	**12.0**	**3.5**
Recovery, 1 min	127.5	153.3	80.6	109.6	144.1	79.1
Recovery, 2 min	109.6	144.1	79.1	110.9	143.9	78.4
Recovery, 4 min	101.7	131.6	78.1	101.5	130	74.7
Recovery, 6 min	102.6	122.2	76.1	105.3	120.6	73.4
Mean	**110.4**	**137.8**	**78.5**	**106.8**	**134.7**	**76.4**
Std dev	**12.0**	**13.7**	**1.9**	**4.3**	**11.5**	**2.8**

Table 3: General means (16 female subjects) of cardiac cycle events measured as per Naughton's treadmill Protocol, at evaluation and re-evaluation.

MEN	EVALUATION			RE-EVALUATION		
	HR	SBP	DBP	HR	SBP	DBP
Resting	71.1	146.1	94.4	63.2	121.7	81.1
Stage 1	103.3	171.7	106.1	91.8	142.2	87.2
Stage 2	119.8	188.9	101.7	100.8	146.7	86.1
Stage 3	134.3	198.9	101.3	114.9	163.3	88.3
Stage 4	147.3	201.9	101.9	132.3	177.2	92.2
Mean	**126.2**	**190.4**	**102.8**	**110.0**	**157.4**	**88.5**
Std dev	**18.9**	**13.6**	**2.2**	**17.7**	**16.0**	**2.7**
Recovery, 1 min	126.2	206.7	101.7	135.6	182.8	92.8
Recovery, 2 min	106.9	201.1	100	121.1	180.6	90.6
Recovery, 4 min	101.7	131.6	78.1	101.5	130	74.7
Recovery, 6 min	102.6	122.2	76.1	105.3	120.6	73.4
Mean	**109.4**	**165.4**	**89.0**	**115.9**	**153.5**	**82.9**
Std dev	**11.5**	**44.7**	**13.8**	**15.7**	**32.8**	**10.2**

Table 4: General means (09 male subjects) of cardiac cycle events measured as per Naughton's treadmill Protocol Model I, at evaluation and re-evaluation.

As refers to the protocol used in this study, the literature shows that the Naughton Protocol is one of the best-known exercise protocols, especially due to its applicability to elderly patients and bearers of heart disease. In this study, we chose to apply Naughton Model I because the studied individuals were sedentary and stated that they had never performed a treadmill test. On the other hand, the protocol we used may not have been adequate for our study subjects, as it is more highly recommended for elderly individuals and bearers of heart disease, conditions that did not apply to our male and female subjects, namely sedentary individuals with only some elevated cardiac cycle values.

A general analysis of the results reveals that the physical activity program offered over the six-month period elicited a greater response regarding SBP and DBP than HR.

It should also be noted that at evaluation, both groups completed the Protocol to the 4th stage, and at re-evaluation, 37.5% of the women and 33.3% of the men completed the Protocol to the 5th and 6th stages. For our statistical analyses, we considered the re-evaluation results only to the 4th stage, which revealed a significant difference in the male group, but not the female. Through these results, we observed that the offered physical activity program was an efficient means to affect cardiac cycle events.

Conclusions

- The cardiac cycle event values (SBP and DBP) of the female group at evaluation and re-evaluation were lower than those observed in the male group;
- The resting heart rates were within normal ranges, both at evaluation and re-evaluation;
- At the 1st through 4th stages of the Protocol, the measured heart rate values of the female group showed very little difference between evaluation and re-evaluation; in the male group, heart rate at re-evaluation was lower at the 1st through 4th stages of the Protocol as compared to the initial evaluation value, but higher at 02 minutes and 06 minutes post-exercise recovery;
- In the female group, SBP and DBP values at re-evaluation were lower than those measured at the initial evaluation. In the male group, the SBP and DBP values observed at re-evaluation were also lower when compared with the initial evaluation;
- The offered physical activities (HR-monitored walking, ballroom dancing and light resistance training) produced a greater response in terms of SBP and DBP than in terms of HR.
- The practices of physical activity contribute to specifically improve the levels of systolic and diastolic blood pressure for subjects of both sexes sedentary.

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