Impact of Physical Exercise on the Cardiovascular System in Elderly

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1 Introduction

The cardiovascular diseases are health problems faced by countries around the world. Research shows that the increased incidence of cardiovascular diseases is associated with different variables such as: body composition, diabetes mellitus, dyslipidemia, poor eating habits, historic family and physical inactivity. All these variables, over the years, to a greater or lesser extent, have contributed to an increase in the incidence of cardiovascular disease in elderly (Mosca, 2004; Bielemann et al., 2009; National Institute on Aging, 2011; Estruch et al., 2013).

Physical exercises are considered a potential support in the prevention, control and treatment of cardiovascular diseases (National Institute on Aging, 2011; Oliveira et al., 2012). While it is well known that physical inactivity is a major risk factor for cardiovascular disease, there is still a search for the mechanisms by which exercise exerts its positive effect. Skeletal muscle type fibre is affected to some extent by physical exercise. The different fibre types possess anti-inflammatory and glucometabolic properties that can decrease risk in this disease, because skeletal muscle fibre composition may be a mediator of the protective effects of exercise against cardiovascular disease (Andersen et al., 2013).

However, there is a need for a planning and control by a trained professional for appropriate exercise prescription according to patient assessments (Melo et al., 2006; Park et al., 2006).

In this respect, the cardiovascular system plays a fundamental role in facilitating these responses, including thermoregulation and delivery/removal of nutrients and waste products. Cardiac parasympathetic reactivation following a training session is highly individualized, that has function of a marker of cardiovascular recovery (Stanley et al., 2013).

With this, this chapter aims to present a study on the scientific bases for choice, evaluation and prescription of appropriate exercises, as well as the impacts of these exercises in individuals with cardiovascular diseases and this will be discussed in the following topics:

- Cardiovascular changes in elderly
- Effect of physical exercise on endothelial function
- Acute effect of aerobic and resistance exercise
- Chronic effect of aerobic exercise and resistance exercise
- Aerobic exercise and resistance training for hypertensive elderly

2 Cardiovascular Changes in Elderly

According to the considerations of the World Health Organization (WHO) the world population over 65 years old has rapidly increased in recent decades. For the next five years, the number of individuals aged 65 years old will surpass the number of children under 5 years of age (National Institute on Aging, 2011). This is occurring by rate reduction of births and the increase in life expectancy, due to improvements in health achieved in the 20th century, allowing the reduction of the number of infectious and parasitic diseases in the children, leading to lower rate mortality in this group and the consequent increase in the older population (National Institute on Aging, 2011).
The increase in life expectancy has also brought increased spending on noncommunicable diseases that ascend with age and directly affect economic growth (National Institute on Aging, 2011). According to the considerations of the National Health and Examination Survey, 67% of the U.S.A population with over age 60 was diagnosed with hypertension (Ostchega et al., 2007). Besides of the relationships with lifestyle, this high number is strongly associated with increased life expectancy of the population, which allows greater exposure of the individual to the natural changes that occur in the endothelium over the years, increasing blood pressure levels of population, especially, when associated with genetic predisposition and unhealthy lifestyle habits (Webb & Inscho, 2005; Montalti, 2012).

The endothelium is responsible for the maintenance vascular tonic, creating anticoagulant substances preserving the blood flow, besides maintaining the fluidity of the plasmatic membrane through a single layer of cells organized as a spindle. When the individual reaches the age of 30 years, these cells tend to die and be replaced by others who will not have the same ability to produce vasodilator substances (Bahia et al., 2006). With the passing of years, the endothelium gradually loses the capacity to elasticity as a result of changes in your components. Additionally, these changes cause increased BP, increases oxygen demand in the myocardium, reducing blood flow (Vaitkevicius et al., 1993; Mackey et al., 2002; Behringer et al., 2013; Alssar et al., 2013).

The aging process affects numerous diseases resulting of the physiological changes which may be potentiated by bad living habits. One of these is diabetes mellitus which also is related to hypertension. Over the years, carbohydrate metabolism is altered allowing subjects with genetic predisposition associated with inadequate habits of live can develop type 2 diabetes in the old age (Ferrannini et al., 1996, Muller et al., 1996). Another aspect is the gradual increase of inflammatory cytokines such as TNF and C-reactive protein over the years in patients with type 2 diabetes, which are also associated with the progression of this disease (Del Prato., 2009; Lechleitner et al., 2012).

Insulin resistance arises by genetic predisposition, but also is associated with cultural factors and bad habits of life, preceding type 2 diabetes and has strong contributions to the development of hypertension (Cheung & Li, 2012). These two co-morbidities have a similar pathophysiology, and as a result this, approximately half of all hypertensive patients are insulin resistant. In pathophysiological mechanism of these diseases the elevation of renin – angiotensin - aldosterone system (RAAS), the sympathetic nervous system (SNS), the oxidative stress and vascular dysfunctions are also observed (Cheung & Li, 2012). Figure 1 show the mechanism.

As previously stated, senility has as consequence the occurrence of numerous diseases by the body changes associated with aging. In France, estimates indicate that 8.2% to 14.0% of the population between 65 and 80 years of age are diabetics (Campagha et al., 2005). The Brazilian Society of Diabetes (BSD, 2011) indicates that 18% of elderly Brazilians suffer from this disease, and 50% by type II (BSD, 2011). According to the SBD (2011), the progressive loss of muscular mass with aging causes a decrease in availability of GLUT's (glucose transporters) responsible for the transport of blood glucose into the cells and in consequence, increases blood glucose levels in elderly compared to the young population.

This glycemic elevation and subsequent installation of type II diabetes is associated with endothelial dysfunction and the occurrence of atherosclerosis (Bahia et al. 2006). In the elderly, the metabolic syndrome has prevalence ranging from 11% to 43% around the world and is characterized by the presence of diseases such as: obesity, dyslipidemia, hypertension and diabetes, which increase possibilities of a cardiovascular event (Denys, 2009).

In addition, the rate of hypertensive patients with metabolic syndrome is a high number that reaches 85% (Duvnjak et al., 2008). That way, there is a high possibility of the individual developing associat-
ed diseases. For this reason, the realization of appropriate physical activity can help control these diseases, even when they are associated (blood pressure, blood glucose, dyslipidemia, etc.).

![Figure 1: Pathophysiological mechanism between the diabetes and hypertension. VSMC = vascular smooth muscle cell; SNN = sympathetic nervous system; RAAS = renin-angiotensin-aldosterone system (Mugo et al., 2007).](image)

For all above mentioned, the regular physical exercise serves either in preventing as treatment of metabolic syndrome its action affects the hormone levels, the muscular strength, bone metabolism and blood vessels. In the following topics will be presented studies that show acute and chronic effects of physical activity on the cardiovascular system, with emphasis on hypertension, because is a disease that affects millions of people worldwide and it increases with advancing age. We also discussed about the effects and care for prescription of exercise programs.

### 3 Effect of Physical Exercise on Endothelial Function

The vascular endothelium is represented by cells of the internal layer of all blood vessels and lymphatic system. It is just the small thickness of endothelium at the level of capillaries that allows active and passive molecules exchanges and ions between blood and lymph with the tissues (Cine et al., 1998; Galley & Webster, 2004; Gartner & Hiatt, 2013).

In relation to arterial and venous vessels after the endothelial layer, there are thickness variations of elastic fibers, of smooth musculature and of collagen fibers. The thickness variation of the smooth musculature is directly related to its constriction and dilation capacity by altering the volume, the pressure and flow velocity of blood through in the vessels (Cine et al., 1998; Galley & Webster, 2004; Gartner & Hiatt, 2013).
In physiological system, the vascular endothelium participates in the regulation of events related to blood coagulation, platelet and leukocyte action, besides regulation of vascular tone and inflammatory responses (Marsh & Coombes, 2005). During exercise practices, there is a greater blood pressure in the artery wall which causes the release of vasodilators which together with regulation the autonomic nervous play an important role in improving blood flow (Goto et al., 2003).

The presence of risk factors such as hypertension and dyslipidemia are directly related to the occurrence of endothelial dysfunction that result in the activation of inflammatory and pathological processes that can lead to vascular damage (Singh & Jialal, 2006). These pathological events can be minimized by performing exercises that reduce the occurrence of cardiovascular events (Abramson & Vaccarino, 2002), as will be discussed below.

Nitric Oxide (NO) is one of the endothelial agents most studied having vasodilator effect with important role in maintenance of the endothelial structure integrity. NO is synthesized by the enzyme Nitric Oxide Synthase (NOS) by L-arginine amino acid, yielding NO and L-citrulline. NOS have three isoforms: two constitutive isoforms (eNOS, endothelial, nNOS, neuronal) and one inducible isoform (iNOS), that are associated the cytotoxic inflammatory responses. The NO has variation both in the synthesis as in effects by means in exercises performance (Leung et al., 2008).

Studies have shown that regular physical exercise increases NO production, which increase coronary blood flow, thereby improving cardiac function (Rush et al. 2005; Goto et al., 2003). In addition, NO has inhibitory effects on platelet and leukocytes well as induces proliferation of arterial smooth fibers (Ford & Rush, 2007).

These characteristics on vascular tone and antithrombotic reinforce the important role of NO in the preservation of integrity of the blood flow in the individuals, in such a manner that the presence of Reactive Oxygen Species (ROS) can inactivate the NO, which potentializes the formation of atheromatous plaques (Antoniades et al., 2003; Beckman et al., 1990). At the same time, studies show that blockade of NO synthesis causes the promotion of autonomous activity sympathetic, with resulting increased in systemic arterial pressure (Togashi et al., 1992, Souza et al., 2001). Other studies show that performing aerobic exercise represents an antihypertensive therapy effective in minimizing cardiovascular risk factors (Maiorana et al., 2003; Goldsmith et al., 2000).

The increased NO synthesis appears to be associated with an increase in the bioavailability of its precursor, the amino acid arginine. Oral administration of L-arginine as a supplement increases the vasodilator effect of the lower limbs muscles of individuals that performed resistance exercises increasing the blood perfusion in these muscles as well as maximized the proteins synthesis involved in muscle contraction process (Schaefer et al., 2002). Thus, arginine also contributes to the synthesis of NO that seems to have role potentialized function in transition of the muscle fibers in resistance overloads (Smith et al., 2002).

Besides the NO, studies also show that aerobic exercises, practiced in childhood cause stimulation of some biological modulators that produce beneficial effects in decreasing the incidence of diabetes, hypertension and dyslipidemias also causing inhibition of other pro-inflammatory modulators (Barbeau et al., 2002; Cooper et al., 2004).

The antithrombotic effect of aerobic exercise has been identified by the reduction serum levels of important inflammatory modulators, such as C-Reactive Protein (CRP), Interleukin-6 (IL-6) and Tumor Necrosis Factor-α (TNF-α), which has been associated with the presence and progression of chronic diseases (Petersen & Pedersen, 2005; Greenberg & Obin, 2006; Visser et al., 2001; Barbeau et al., 2002; Brazil et al., 2007). One of the benefits of aerobic exercise on blood vessels is associated with the re-
response to post-exercise hypotension. Even though many components are involved in this response, the reduction in peripheral vascular resistance is certainly the one who has the most noticeable effects on the endothelium.

Once again NO have an important role vasodilator associated with a reduction in sympathetic autonomic response (Chen & Bonham, 2010). Added to this process, endothelial function tends to improve with regular exercise practice with induction angiogenic in the most active muscle groups of the exercises, increasing capillarity action and improving blood flow (Porter et al., 2002; Prior et al., 2003).

Another angiogenic effect caused by exercise is related to Endothelial Progenitor Cells (EPC) (Asahara et al., 1997). Studies show that exercise training increases the migration of EPC into the peripheral circulation and these cells secrete angiogenic modulators, such as: Endothelial Growth Factor (EGF) and granulocyte colony-stimulating factor (G-CSF) (Adams et al., 2008; Bonsignore et al., 2010). This migration of EPC can cause both neovascularization as vascular repair (Hill et al., 2003). In addition, the exercise at moderate intensities shows strong positive correlation between EPC and NO (Yang et al., 2007).

4 Acute Effect of Aerobic and Resistance Exercises

According to scientific literature, the controlled physical exercises has contributed for maintenance blood pressure because after executing the exercise, the blood pressure is reduced to values lower than those presented in the beginning of the exercise (Taylor-Tolbert et al., 2000; Melo et al., 2006; Park et al., 2006).

This acute effect is known as post exercise hypotension (PEH) and can last a few minutes or even a few hours, it is observed both in hypertensive individuals (Taylor-Tolbert et al., 2000; Hagberg et al., 1987; Melo et al., 2006), in borderline hypertensive individuals (Headley et al., 1998; Park et al., 2006) as well as in normotensive individuals (Forjaz et al., 2000; Wallace et al., 1999). Particularly for hypertensive patients PEH has significant clinical value.

The first report of PEH occurred in 1897 by Leonard Hill when he observed the process in an individual who ran 400 yards and 90 minutes after the proof revealed a PEH (Hill, 1897). Decades later (Schneider & Truesdell, 1922) also observed this same process in a test sit and rise from a chair five times every 15 seconds. However, investigations on the effects of PEH in the organism, the type of exercise, the population that this effect is more evident and the mechanism by which occurs, gained more evidence from the end of year 1970.

In this period, Fitzgerald (1981) after not present significant response to drugs, he decided to abandon the pharmacological treatment and began a running training allied to food reeducation. Between the years 1976 and 1979 he began to monitor your blood pressure three times / day, it went on to note that after the routine run approximately 25 min, their blood pressure reduced to levels lower than baseline.

PEH has been reported both in normotensive as in hypertensive individuals, in its turn, these latter have lower reduction of blood pressure when compared to normotensive groups (Forjaz et al., 2000; Oliveira et al., 2012). One possible explanation for this may be that in normotensive, the baroreflex mechanism prevents the occurrence of PEH as a form of not affect orthostatic tolerance (McDonald, 2002).
Already in the systemic form, two explanations can help understand the pressure reduction after exercise: the first is the cardiac output reduction caused by decreased systolic volume and second explanation by reducing peripheral vascular resistance (PVR) (Rezk et al., 2006; Rueckert et al., 1996).

Currently there are two types of physical exercises that are most studied by researchers to assess the PEH phenomenon, which are: aerobic and resistance exercises. Resistance exercise began to be discussed recently, having still controversial results due to the use of different training protocols involving: number of sets and sessions, number of repetitions, rest intervals, number of exercises and intensity of effort as well as level of fitness physical, age and profile pressure of the individual (Annunciation & Polito, 2011; Oliveira et al., 2012).

The effect mechanism PEH by resistance exercise realized in the intensity of 40% 1RM (one repetition maximum test) is promoted by reduced cardiac output and maintenance of PVR, while in intensity of 80% 1RM the cardiac output decreased continues, however, with the increase in PVR (peripheral vascular resistance). In this way, resistance exercise with lower intensity promotes PEH both Systolic Blood Pressure (SBP) as Diastolic Blood Pressure (DBP), in turn the highest intensity allows only reduction in SBP (Rezk et al., 2006).

In the aerobic exercise, Rueckert et al. (1996) observed the two hypotensive mechanisms at different times of the recovery after training, primarily by decreasing PVR and posterior decrease in cardiac output. Studies have shown the existence of acute hypotensive effect in hypertensive patients after the first training session with aerobic exercise (Taylor-Tolbert et al., 2000; Kokkinos & Papademetriou, 2000).

Behind all this, there is an adaptation of the autonomic nervous system to the new body physiological condition after physical activity, occurring inhibition of sympathetic nerve activity that favors the reduction in blood pressure as a consequence of the reduction in PVR (Floras et al., 1989; Halliwill et al., 1996).

In resistance exercise, the study of Melo et al. (2006) showed a greater reduction in blood pressure after low-intensity exercise in hypertensive women that used angiotensin-converting enzyme (ACE). In the same study PEH remained by 10pm below the levels shown in the pressure control session.

It is observed that both SBP and DBP remained at low levels (p <0.05), compared with the control session for up to 10h after the final of the resistance training session. The experimental session was performed with six exercises, three sets of 20 repetitions at an intensity of 40% 1RM (Melo et al., 2006).

The intensity used by Melo et al. (2006) corroborates the results encountered by Koltybn & Focht (1999) after verifying reductions in SBP and maintenance DBP in individuals who performed resistance exercise at 40% of 1RM, whereas increased SBP and DBP maintenance when performing training with 80% of 1 RM, suggesting that low-intensity resistance exercise has hypotensive effect greater than that realized at high intensity.

Recently, (Keese et al., 2011) investigated the hypotensive response in 4 different sessions: control, aerobic exercise, resistance exercise and concurrent exercise (aerobic and resistance exercises together in the same session). During the recovery period of this study, after 120 minutes the concurrent exercise session presented greater hypotensive effect compared to the other two exercise groups and the control session (Keese et al., 2011). It is noteworthy that studies using this methodology are recent and should be conducted in populations with different age groups as well as different pressure profiles.

The PEH through aerobic exercise was observed in cycle ergometer or treadmill ergometer at intensities ranging from 40% - 100% of heart rate reserve and VO2max or maximum predicted heart rate (Casonatto & Polito, 2009). But, there is still no consensus in the scientific literature of the ideal intensity
to obtain PEH (Polito & Casonatto, 2009) because both the low (Forjaz et al., 1998) as of high intensities (Macdonald et al., 2001) showed capacity to provoke PEH in hypertensive patients. However, studies with greater intensity are able to cause greater duration and magnitude (Piepoli et al., 1994; Forjaz et al., 2004).

Regarding the duration of exercise, numerous studies advocate the hypothesis when higher the realization of aerobic activity, the greater the effects on the duration and magnitude of PEH (March et al., 2005; Forjaz et al., 1998; Jones et al., 2007).

The study of March et al. (2005) submitting 9 volunteers pre-hypertensive at 4 sessions of aerobic exercise with the same intensity, around 75% of heart rate reserve and different durations of training, varying in 10, 20, 40 and 80 min. It was noted that the PEH had greatest magnitude and duration when applied for longer training protocol. Stanley et al. (2013) demonstrate that the time required for complete cardiac autonomic recovery after an aerobic training session is up to 24h following low-intensity exercise, 24–48 h following threshold-intensity exercise and at least 48h following high-intensity exercise.

The mechanism through which the PEH occurs after the realization of aerobic exercise still needs further study for effective prescription of training with greater hypotensive effect as well as population profile that best responds to exercise.

The responses to resistance exercise are similar to aerobic, reducing cardiac output and PVR. It is known that the reduction of PVR is associated with the release of vasodilator substances in the endothelium, such as NO, and adenosine prostaglandins. However, the PEH persist even with the blocking release of these substances. Another component that is directly involved in PVR is the reduction of sympathetic nerve activity, which also allows the occurrence of PEH (Annunciation & Polito, 2011).

In resistance exercise, the probably action hypotensive occurs through different pathways, that are depend on the intensity of the effort employed by the exercise. At low intensities with 40% of 1RM in resistance exercise hypotension is presented by reduction of CO and maintenance of PVR, since at high intensities as 80% of 1RM, the PEH is reduced by reduction of the CO, but with a slight increase in the PVR (Rezk et al., 2006).

The aerobic exercise mechanism PEH is associated only to the PVR, possibly due to vasodilation in smaller vessels as a result of arterial stiffness which also can be caused by increasing age (Hagberg, et al. 1987; Rueckert et al. 1996; Brandes et al. 2005).

The mechanism PEH after aerobic and resistance exercises, the training prescription that shows greater hypotensive effect and population profile that best responds to the type of exercise, are still poorly known. However, the studies identified in the scientific literature present different hypotheses to explain the phenomenon of PEH for resistance exercise and for the aerobic, but both have action with the two responsible for the mediation of blood pressure, which are: cardiac output (CO) and peripheral vascular resistance (PVR).

Finally, the blood pressure reduction was noted in the end of century XIX and gained visibility in the end of century XX. The experiments, with aerobic and resistance exercises presented positive effect even utilizing different protocols. However, although there are studies showing that resistance exercise performed at low intensity promotes hypotension for up to 10h, these should be viewed with caution because the study population was exclusively hypertensive individuals. For this reason, it is necessary to compare groups of different profile, as well as verification of the volume and intensity that fits best for patient profile evaluated.
Figure 2: Blood pressure assessment first and after resistance training program. Photography courtesy of Oliveira, M.C. Resistance Training program of the Laboratory of State University of Pará – Brazil.

5 Chronic Effect of Aerobic and Resistance Exercises

The regular practice of appropriate physical activity may represent a reduction of government public spending with pathologies associated to cardiovascular diseases, and in addition, heavily contribute to the improvement in the health and quality of life for people in all ages (Bielemann et al., 2009). The physical activity is associated with numerous systemic changes that result in adaptations of the organism seeking the homeostasis after performing a training session with physical exercise.

In this way, chronic exercise is associated with changes in body composition, in the lipid and glycemic index, muscle strength and blood pressure (Volakis et al., 2013). All these factors act directly or indirectly on the endothelium, consequently, the regular exercise is a potential agent to improve and maintain the integrity of the vascular tissue (Volakis et al., 2013).

These adaptations take place mainly at the molecular level, dividing into neurohumoral and autonomic effects which cause reduced sympathetic tone and increased of the sympathetic vascular changes due to increased vasodilation endothelial and NO synthesis, as well as cardiac adaptations as physiological hypertrophy, prevention of calcification, besides, non-cardiac adaptations musculoskeletal improvement, increased aerobic capacity and reduced blood viscosity. However, in certain areas such as in the venous system and microcirculation, studies are preliminary and warrant further attention by the scientific community (Gielen et al., 2010).

In the last decade, numerous studies have demonstrated that endothelial progenitor cells are stimulated with the realization of physical activity. These cells are produced by the bone marrow and are able to migrate to a region of lesioned endothelium, passing to differentiate into mature cells, and thus perform an important role in the regeneration process of the endothelium (Volakis et al., 2013). However, the changes brought about by physical exercise are not limited to the endothelium. It was found that blood pressure reductions in around 3 mmHg can mean reduced risk of suffering encephalic vascular accident in up to 14%, as well as 5-9% reduced risk in cardiovascular morbidity in trained individuals (Meka et al., 2008).

In a study of animal model for hypertension was observed decreased of sensitivity in the baroreceptors activity; however this situation is reversed with the low intensity training (Andersen & Yang,
In human’s low-intensity aerobic exercise also promoted chronic reducing of blood pressure, this being conducted among 40% to 60% VO$_{2\text{max}}$ with high volume weekly or related to the daily session (Alvez & Forjaz, 2007). For Whelton et al. (2002) in a meta-analysis that evaluated 54 controlled trials of aerobic training, it was found a mean reduction in systolic of 3.7 mmHg and 2.6 mmHg diastolic blood pressure.

In another meta-analysis study that investigated the chronic effects of resistance exercise on blood pressure, it was found reduced blood pressure between 3.2 and 3.5mmHg (Cornelissen & Fagard, 2005a). Even though seem little, as previously mentioned, the progressive reduction of the blood pressure through the physical activity significantly reduces the risk of death from cardiovascular disease (Meka et al., 2008). One factor for this are little work which aim to assess the chronic effects of resistance exercise in the cardiovascular system, another problem, as previously mentioned, is the profile and criteria for sample selection because trained volunteers, sedentary, normotensive, hypertensive users of antihypertensive medications, can present similar and/or different responses, but by different mechanisms which influence the results and consequently the conclusions. What can also be seen in meta-analysis study by Cornelissen & Fagard (2005b) evaluated 75 studies with healthy adults: normotensive and hypertensive patients for a minimum of four week intervention, this study observed reduction of - 6.9mmHg in hypertensive groups, while normotensive obtained - 2.4mmHg of reduction in blood pressure.

Given the above, one should consider the small number of investigations which aim to assess the characteristics of physical exercise in the process of chronic reduction in blood pressure. However, comparing resistance exercise with aerobic, there is a disparity in the number of studies in favor of aerobic exercise. Given this, there is a need for more studies to be verified a better way to prescribe resistance exercise with the objective of reducing chronic blood pressure. For Andersen et al. (2013) in an investigation in skeletal muscle morphology with risk of cardiovascular events in a sample of 466 71 years-old men without cardiovascular disease, of which 295 were physically active (strenuous physical activity at least 3 h / week) was concluded that higher skeletal muscle proportion of type-I fibres was associated with lower risk of cardiovascular events and a higher proportion of type-II fibres was associated with higher risk of cardiovascular events. These relations were only observed in physically active men. Skeletal muscle fibre composition may be a mediator of the protective effects of exercise against cardiovascular disease, which can justify the need for maintenance of resistance training at moderate and low intensities (aerobic and resistance exercises) for an appropriate hypotensive effect.

In turn, both exercises triggers physiological mechanisms endothelial that allow blood pressure control in the medium and long term, and the reduction of public spending on cardiovascular events coming from the hypertension can justify the use of training programs with these exercises for normotensive and hypertensive populations with greater professional care for hypertensive patients.

### 6 Aerobic and Resistance Exercises for Hypertensive Elderly

The American College of Sport Medicine (ACSM) recommends performing aerobic and resistance exercise to control blood pressure in hypertensive individuals, provided they are not suffering from cardiovascular or renal complications arising from these diseases (Pescatello et al., 2004). The physical exercise, especially aerobic should be associated to pharmacological treatment, as well as the change in lifestyle of hypertensive patients are, especially, recommended for the maintenance and control of blood pressure (Pescatello et al., 2004).
However, there is a major risk for hypertensive patients of increase in blood pressure while performing any physical activity. This increase occurs by activation of the sympathetic nervous system with the objective of optimize and redistribute blood flow in the recruited muscles during exercise, and for that reason can cause problems such as: cerebral aneurysm or myocardial ischemia (Vongpatanasin et al., 2011). But interestingly, as blood flow is directed to the left ventricle during cardiac diastole, the high elevation of diastolic pressure during exercise seems to cause a protective effect against cardiac ischemia, although it is the perilous increase of systolic pressure at this moment. This was observed by Vongpatanasin et al. (2011) with 469 elderly patients after exercise on a cycle ergometer.

The use pharmacologic therapy show also protective effect in the elevation process of blood pressure during exercise. Was what showed Gomides et al. (2010) submitting to a group of 10 hypertensive patients to a protocol with execution of a leg extension exercise to muscular failure in series of 100%, 80% and 40% of 1RM in two phases: initially with using the Atenolol (β-adrenergic blockade) and other group with placebo. The training series conducted with the drug therapy showed lower pressure values than those performed with placebo (Gomides et al., 2010).

For Haykowsky et al. (1996) The association of physical activity and increased blood pressure, especially when associated with the valsalva maneuver, cause pressure rises with higher values 480/350mmHg during exercise, which can lead to intracranial aneurysms. However, no study that shows caused death of individuals, but is prudent to consider this increase in blood pressure during exercise caused by maneuver valsalva (Haykowsky et al., 1996).

The valsalva maneuver is a hemodynamic process characterized by forced expiration against a closed glottis, increasing intrathoracic pressure and systemic circulation, leading the individual to dizziness, syncope and to brain injuries (Zhang et al., 2012). However, this is inevitable when the exercise intensity is equal or greater than 80% 1RM, and as a consequence can increase abruptly the pressure 58±28 mmHg. Already with higher loads, intrathoracic pressure exceeds 100 mmHg, which corresponds to increases about 60%, that is, more than the voluntary valsalva maneuver (Maccartney et al., 1999).

**Figure 3:** Resistance training for the treatment of hypertension patients. Photography courtesy of Oliveira, M.C. Resistance training program of the Laboratory of State University of Pará – Brazil.
Clinical trials have shown that aerobic exercise combining resistance exercise promotes the prevention and control of hypertension, and both when combined in the training program, provide best results for hypertension (Fletcher et al., 2001; Keese et al., 2011). The frequency of the training program should be 5 times / week, beginning with progressively lighter activity and subsequently moderate activity, for this, the intensity can be evaluated by a treadmill and strength tests in order to establish the maximum heart rate and also maximum strength (Brazilian Society of Hypertension, 2010; Sorace et al., 2012).

In the impossibility of realize the aerobic test, the calculation $HR_{\text{max}} = 220 - \text{age}$ can be used, except for individuals who use β-blockers and/or calcium inhibitor drugs channel (Brazilian Society of Hypertension, 2010). The benefits of resistance training are already known in the skeletal and muscular systems, but only in recent years its effect on the vascular system has been studied with greater frequency. In the case of hypertension, it must be realized as a complement to aerobic training between two and three times/week with 1 to 3 sets of 8 to 15 repetitions until concentric failure (Brazilian Society of Hypertension, 2010). But aerobic exercise can be done every day of the week in intensity between 40% and 60% of reserve VO$_2$ in activities such as walking, running and cycling that has duration longer than 30 min, continuous or accumulated through the day (Pescatello et al., 2004). Table 1 presents the types of exercises, physical modality, as well as intensity and frequency based on systematic studies on this topic.

It is worth emphasizing, that although exercises are indicated for hypertension, it should be prevented if the individual has blood pressure above 160 mmHg and 105 mmHg for systolic and diastolic, respectively, because these pressure levels can cause cardiac ischemia or intracranial aneurysms (Brazilian Society of Hypertension, 2010).

It is also recommended that the patient be evaluated by a cardiologist before commencing physical activity, as well as the activity is accompanied by a physical education professional, qualified to prescribe and evaluate the training.
<table>
<thead>
<tr>
<th>Exercises</th>
<th>Time</th>
<th>Intensity</th>
<th>Volume</th>
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<tbody>
<tr>
<td>Aerobic Training</td>
<td>&gt;30 minutes</td>
<td>Between 40-60% VO$<em>{2\text{max}}$ or 50-70% HR$</em>{\text{max}}$</td>
<td>3 times/week</td>
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<td>- Walking</td>
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<td>- Bicycling</td>
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<tr>
<td>Resistance Training</td>
<td>*</td>
<td>Between 40-55% of 1RM</td>
<td>Among 1-3 sets of 12 to 20 reps; 6-8 exercises per training. With intervals of 1 minute rest between sets and repetitions to allow the reduction of BP before a new stimulus.</td>
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* The duration of resistance exercise will depend on the amount present in the training exercises, as well as the rest interval during the sessions and repetitions numbers.

Table 1: Recommended Physical Activities for hypertensive population.

7 Final Considerations

Recent advances on the understanding of the influence of physical activity as non-pharmacological treatment in the prevention and control of cardiovascular disease, in particular to hypertension are evident in scientific literature. With that, monitoring by adequately trained health professionals in a multidisciplinary and interdisciplinary relationship with a physical education professional, cardiologist, nutritionist, among others, allows the elderly has better quality of life through the exercises programs. Thus, physical exercise, especially, the aerobic exercise being complemented by low-intensity resistance training is a good recommendation because they presented real gains in reducing blood pressure in hypertensive patients, particularly when combined with pharmacological treatment.

It is worth noting also, that the cultural habits of a population, ease of access, as well as costs related to the practice of physical exercise can be determinant to motivate the elderly to practice this or that type of training. Given all that was addressed, and also considering the recommendations of the official health organs such as the World Health Organization, American College of Sport Medicine and National Institute on Aging, the controlled exercises can benefit the people with hypertension.

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