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Resistance Training as a Powerful Tool in the Prevention and Treatment of Cardiovascular Diseases

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***Abstract*—**Regular exercise promotes reduction in blood pressure, reduction in body weight and it also helps to increase in insulin sensitivity. Participation in physical activity should always be linked to medical screening which can reveal serious medical problems. One of them is high blood pressure. Hypertension is risk factor for one billion people worldwide and the highest prevalence is found in Africa. Another component of hypertension is that people who suffer from hypertension have no symptoms. It is estimated that reduction of 3mm Hg in Systolic Blood Pressure decreases cardiac morbidity at least 5%. The most of the guidelines suggest aerobic exercise in a prevention of cardiovascular diseases. On the other hand, it is important to emphasize the impact of resistance training. Even, it was found higher effect for reduction on the level of systolic blood pressure than aerobic exercise.

***Keywords*—**Coronary artery disease, physical activity, prevention, resistance training.

I. Introduction

THE effect of regular physical activity is studied by many researchers and it is often described as an important factor of prevention and treatment for patients with cardiovascular disease. Cardiovascular diseases (CVDs) are connected with higher prevalence of morbidity and impairment of activities of daily living [1]. According the World Health Organisation (WHO), CVDs are most common cause of death in the world [2]. Group of CVDs include:

- deep vein thrombosis and pulmonary embolism
- coronary heart disease
- cerebrovascular disease
- peripheral arterial disease
- rheumatic heart disease
- congenital heart disease [2]

The one way to reduce the severity of coronary artery disease (CAD) is prevention which always should include appropriate physical activity.

In literature, it could be found some factors which can lead to CAD. Hypertension, smoking, dyslipidemia, male gender, family history and diabetes are undeniable factors of coronary heart disease (CHD) [3]-[5]. We mentioned the terms coronary artery disease and coronary heart disease which can be also interpreted as the same. However, CHD is a common term for build-up of plaque in the heart´s arteries that means CHD is a result of CAD. This process is not always connected with adulthood but some research works indicate that build-up of plaque starts in childhood [6]. One of the components which can lead to cardiovascular disease is overweight and obesity. It was proved that the childhood obesity is associated with higher risk of cardiovascular disease [7]. Additionally, childhood obesity leads to obesity in adulthood [8]. In the case of health problem, obese inpatients have longer time for recovery and the cost of treatment is much higher than the inpatients with normal weight (BMI=18.5-24.9 range) [9], [10]. Body mass index (BMI>25.0) is related with high blood pressure in group of children and adolescents [11]. Several studies have proved a relationship between overweight and cardiovascular morbidity or cardiovascular mortality [12]-[14].

The occurrence of paediatric chronic diseases like hypertension (HTN) and type 2 diabetes negatively affects the health status in adulthood [15]. Consequently, the public concern should focus on activities which can decrease the rates of childhood overweight and obesity.

Predicting risk of CVDs includes a full physical examination:

- measurement of height and weight; measurement of waist and hip circumference
- examination of the cardiovascular system
- examination of blood pressure
- examination of the abdomen for bruits
- examination of the central and peripheral nervous system
- examination of the optic fundi [16]

Correct blood pressure measurement is an essential for findings a high blood pressure (HBP). According by Guidelines for assessment and management of cardiovascular risk [16], it is better to measure blood pressure in both arms at first patient´s visit. In case of differences between systolic and diastolic pressure (systolic pressure > 20mmHg; diastolic pressure > 10mmHg), it is needed to refer to the next examination. If the blood pressure is measured in only one arm, it is possible that HTN does not have to be revealed. HTN is a key factor which is responsible for at least 45% deaths of all heart disease [17]. One of the reasons why this number is enormously high is fact that people who suffer from hypertension have no symptoms.

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TABLE I
CLASSIFICATION OF BLOOD PRESSURE FOR ADULTS

Blood pressure classification	Systolic Blood Pressure (mm Hg)		Diastolic Blood Pressure (mm Hg)
Normal	< 120	and	< 80
Prehypertension	120–139	or	80–89
Hypertension *Stage 1*	140–159	or	90–99
Stage 2	≥ 160	or	≥ 100

High blood pressure is warning sign of unhealthy lifestyle, therefore it is necessary to search effective solutions to prevent CVDs. HTN is often called as a high blood pressure and this situation causes that the blood vessels have persistently high pressure. Subsequently, the heart has to work harder in order to pump blood. According the WHO, HTN is the risk factor for one billion people worldwide and the highest prevalence is found in Africa (46%, adults aged 25 and above), while the lowest prevalence is found in the Americas (35%, adults aged 25 and above) [17]. It is needed to address the rules of healthy lifestyle which include reducing salt intake, use of alcohol, healthy diet and regular physical exercise to all groups of society. Level of education, income or fear of unemployment play a key role in the development of CDVs. Genetics also has big impact on HTN. Genetic disorders like Liddle´s syndrome or the syndrome of apparent mineralocorticoid excess lead to HTN [18]. Nowadays, there is a big public discussion about urbanization. The modern cities areas should provide enough opportunities to encourage healthy lifestyle e.g. access to places for sport or physical activity; opportunities for exercise programs in schools or opportunities for healthy diet etc.

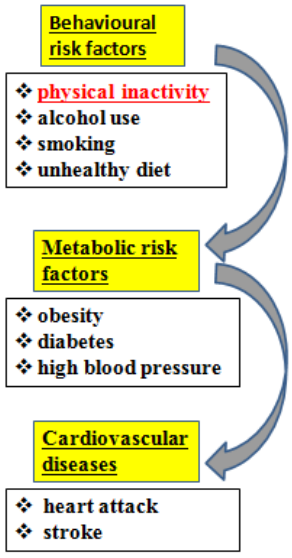

Fig. 1 Factors that cause high blood pressure and its difficulties

Most of the factors of CVDs are preventable (Fig. 1). Additionally, some studies have emphasized the role of the psychosocial factors (depression, social isolation or stress at work) as a strong predictor of CVDs. Stressful environment at work, high work demands are conditions which can lead to coronary heart disease [19], [20].

II. THEORETICAL BACKGROUND

A. Recommendations on Physical Activity for Health

The role of physical activity is often underestimated in prevention of CVDs. According to the guideline of WHO (Global Recommendations on Physical Activity for Health), amounts of time, intensity and type of physical activity has to be connected with age. The primary focus is provided recommendations on physical activity for healthy lifestyle for population levels. It is proposed at least 60 minutes of moderate to vigorous-intensity physical activity each day for children and young people (aged 5-17 years). In case of higher amounts of time, physical activity can provide other health benefits. Adults (aged 17-64 years) should accumulate at least 150 minutes of moderate-intensity during the week or it is possible to do at least 75 minutes of vigorous-intensity. According to the guideline, adults can increase moderate-intensity aerobic physical activity from 150 minutes to 300 minutes per week. In this group of population is also recommended to do muscle-strengthening exercises in frequency two or more days.

It is recommended at least 150 minutes of moderate-intensity during the week or it is possible to do at least 75 minutes for people who are 65 years old and above. Activities that improve maintain balance should also be included in physical exercises. This type of activity reduces the risk of falls by improving strength and coordination [21]. These recommendations provide initial instruction about range of physical activity. Participation in physical activity should always be linked to medical screening. The scientific works demonstrate that people (65 years old and above), who are more physical active, have lower rates of CVDs, high blood pressure and type 2 diabetes [22].

B. Blood Pressure and Physical Activity

The effectiveness of physical activity to lower blood pressure depends on type of exercise. In literature, it can be found several meta-analyses which are focused on evaluating effect of exercise. The most of the guidelines suggest aerobic exercise in a prevention of CVDs. On the other hand, it is important to mention the impact of resistance training (RT) on blood pressure, adipose tissue and body composition. RT can be divided on static and dynamic. Static RT requires muscle contraction against motionless load without change in length of the muscle group which is involved. Dynamic RT involves concentric or eccentric work and there is a change in length of the muscle [23]. There is a true that throughout resistance training blood pressure raises fast but SBP and DBP tend to decrease below resting levels after the resistance training [24]. There is needed to create right RT which respects recommendations for cardiac patients. Patients with CVDs can perform 1 set, from 10 to 15 repetitions (40%-60% of 1-repetition maximum); 8-10 exercises with frequency 2 days/week [25]. American College of Cardiology and

American Heart Association recommend 3 to 4 sessions a week; 40 minutes per session; moderate-to-vigorous intensity physical activity [26].

According to the systematic review, isometric resistance training can have higher effect for the largest reductions on the level of systolic blood pressure (SBP). 5223 participants (3401 in exercise groups; 1822 in control groups) were included in 93 trials. SBP was reduced after endurance training (-3.5 mm Hg), dynamic resistance training (-1.8 mm Hg) and isometric resistance training (-10.9 mm Hg). Diastolic blood pressure (DBP) was diminished after endurance training (-2.5 mm Hg), dynamic resistance training (-3.2 mm Hg) and isometric resistance training (-6.2 mm Hg) [27]. On the other hand, the role of aerobic exercise on its impact on reducing blood pressure should not be underestimated. This effect was also proved. More than 2400 participants were included in 54 randomized and controlled trials whose intervention groups performed only aerobic exercise. The results revealed reduction in mean SBP (-3.84 mm Hg) and DBP (-2.58 mm Hg) [28]. Although these blood pressures are small, it is estimated that reduction of 3mm Hg in SBP decrease cardiac morbidity by 5% to 9% [28]. Then, next research studies should focus on creating new guidelines for patients with CVDs. The appropriate level of physical exercise intensity is still unknown. At the Masaryk University, Faculty of Sport Studies (Czech Republic) was created a cardiovascular rehabilitation programme for people with CVDs. We decided to involve aerobic endurance training and RT in exercise plan. RT was added to the exercise regimen after 12 weeks of aerobic training. After that, it was added circuit weight training with weights from 40% to 60% of one repetition maximum and the rest between sets was 60 seconds. The exercise regimen is still undertaken twice a week including warm-up and cool-down (150 minutes per week; circuit weight training ranged from 45 to 60 minutes and aerobic endurance training lasts 90 minutes). The blood pressure, monitoring of heart rate is controlled every training lesson. The results will be published in spring 2015.

Another question, which was not still answered, is total amount of physical activities.

C. Risks of Exercise

One of the reasons of high prevalence of CVDs is lack of physical activity. Physical activity decreases insulin resistance and helps to decrease LDL cholesterol. Cardiac-related problems can occur during the exercise but the risk of cardiac event is small. Cardiac event can occur only once in 62 000 hours of exercise training [29]. It is estimated that risk of cardiac event is 50 times higher for sedentary lifestyle than regular participating on physical activity 5 times per week [30]. The main risk of physical activity is musculoskeletal injury. The risk of musculoskeletal injury increases with obesity and participation in vigorous type exercise [31], [32].

III. Conclusion

The health benefits of regular physical activity are important factor in prevention of CVDs. A sedentary lifestyle is considered one of the top risk factors for CVDs. The participation on regular exercise has many health benefits including lowering blood pressure, lowering low-density-lipoprotein, reducing body fat, reducing the prevalence of back pain, or prevention forms of bone loss.

There is needed to upgrade recommendations for physical activity in daily life which will include aerobic exercise and isometric resistance training.

References

[1] J. Juenger, D. Schellberg, S. Kraemer, A. Haunstetter, C. Zugck, W. Herzog, a M. Haass, „Health related quality of life in patients with congestive heart failure: comparison with other chronic diseases and relation to functional variables", *Heart*, vol. 87, no. 3, pp. 235–241, march 2002.

[2] „WHO | Cardiovascular diseases (CVDs)", *WHO*. [Online].: http://www.who.int/mediacentre/factsheets/fs317/en/. [seen: 15-may-2014].

[3] S. Yusuf, S. Hawken, S. Ounpuu, T. Dans, A. Avezum, F. Lanas, M. McQueen, A. Budaj, P. Pais, J. Varigos, L. Lisheng, a INTERHEART Study Investigators, „Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study", *Lancet*, vol. 364, no. 9438, pp. 937–952, sep 2004.

[4] J. G. Canto, C. I. Kiefe, W. J. Rogers, E. D. Peterson, P. D. Frederick, W. J. French, C. M. Gibson, C. V. Pollack Jr, J. P. Ornato, R. J. Zalenski, J. Penney, A. J. Tiefenbrunn, P. Greenland, a NRMI Investigators, „Number of coronary heart disease risk factors and mortality in patients with first myocardial infarction", *JAMA*, vol. 306, no. 19, pp. 2120–2127, nov 2011.

[5] „ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD. The Task Force on diabetes, pre-diabetes, and cardiovascular diseases of the European Society of Cardiology (ESC) and developed in collaboration with the European Association for the Study of Diabetes (EASD)", *Rev Esp Cardiol (Engl Ed)*, vol. 67, no. 2, pp. 136, feb 2014.

[6] N. J. Farpour-Lambert, Y. Aggoun, L. M. Marchand, X. E. Martin, F. R. Herrmann, a M. Beghetti, „Physical Activity Reduces Systemic Blood Pressure and Improves Early Markers of Atherosclerosis in Pre-Pubertal Obese Children", *Journal of the American College of Cardiology*, vol. 54, no. 25, pp. 2396–2406, dec 2009.

[7] R. Weiss, J. Dziura, T. S. Burgert, W. V. Tamborlane, S. E. Taksali, C. W. Yeckel, K. Allen, M. Lopes, M. Savoye, J. Morrison, R. S. Sherwin, a S. Caprio, „Obesity and the metabolic syndrome in children and adolescents", *N. Engl. J. Med.*, vol. 350, no. 23, pp. 2362–2374, jun 2004.

[8] A. S. Singh, C. Mulder, J. W. R. Twisk, W. van Mechelen, a M. J. M. Chinapaw, „Tracking of childhood overweight into adulthood: a systematic review of the literature", *Obes Rev*, vol. 9, no. 5, pp. 474–488, sep 2008.

[9] L. J. Bechard, P. Rothpletz-Puglia, R. Touger-Decker, C. Duggan, a N. M. Mehta, „Influence of obesity on clinical outcomes in hospitalized children: a systematic review", *JAMA Pediatr*, vol. 167, no. 5, pp. 476–482, may 2013.

[10] S. J. Woolford, A. Gebremariam, S. J. Clark, a M. M. Davis, „Incremental hospital charges associated with obesity as a secondary diagnosis in children", *Obesity (Silver Spring)*, vol. 15, no. 7, pp. 1895–1901, jul 2007.

[11] A. B. R. Maggio, Y. Aggoun, L. M. Marchand, X. E. Martin, F. Herrmann, M. Beghetti, a N. J. Farpour-Lambert, „Associations among obesity, blood pressure, and left ventricular mass", *J. Pediatr.*, vol. 152, no. 4, pp. 489–493, apr 2008.

[12] D. L. McGee a Diverse Populations Collaboration, „Body mass index and mortality: a meta-analysis based on person-level data from twenty-six observational studies", *Ann Epidemiol*, vol. 15, no. 2, pp. 87–97, feb 2005.

[13] G. Hu, P. Jousilahti, R. Antikainen, P. T. Katzmarzyk, a J. Tuomilehto, „Joint effects of physical activity, body mass index, waist circumference, and waist-to-hip ratio on the risk of heart failure", *Circulation*, vol. 121, no. 2, pp. 237–244, jan 2010.

[14] B.-F. Zhou, „Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases--report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults", *Biomed. Environ. Sci.*, vol. 15, no. 3, pp. 245–252, sep. 2002.

[15] S. R. Srinivasan, L. Myers, a G. S. Berenson, „Predictability of childhood adiposity and insulin for developing insulin resistance syndrome (syndrome X) in young adulthood: the Bogalusa Heart Study", *Diabetes*, vol. 51, no. 1, pp. 204–209, jan 2002.

[16] „WHO | Prevention of cardiovascular disease", *WHO*. [Online].: http://www.who.int/cardiovascular_diseases/publications/Prevention_of_Cardiovascular_Disease/en/. [seen: 16-may-2014].

[17] „WHO | A global brief on hypertension", *WHO*. [Online].: http://www.who.int/cardiovascular_diseases/publications/global_brief_hypertension/en/. [Viděno: 15-may-2014].

[18] R. P. Lifton, A. G. Gharavi, a D. S. Geller, „Molecular mechanisms of human hypertension", *Cell*, vol. 104, no. 4, pp. 545–556, feb 2001.

[19] H. S. Lett, J. A. Blumenthal, M. A. Babyak, A. Sherwood, T. Strauman, C. Robins, a M. F. Newman, „Depression as a risk factor for coronary artery disease: evidence, mechanisms, and treatment", *Psychosom Med*, vol. 66, no. 3, pp. 305–315, jun 2004.

[20] L. F. Berkman, J. Blumenthal, M. Burg, R. M. Carney, D. Catellier, M. J. Cowan, S. M. Czajkowski, R. DeBusk, J. Hosking, A. Jaffe, P. G. Kaufmann, P. Mitchell, J. Norman, L. H. Powell, J. M. Raczynski, N. Schneiderman, a Enhancing Recovery in Coronary Heart Disease Patients Investigators (ENRICHD), „Effects of treating depression and low perceived social support on clinical events after myocardial infarction: the Enhancing Recovery in Coronary Heart Disease Patients (ENRICHD) Randomized Trial", *JAMA*, vol. 289, no. 23, pp. 3106–3116, jun 2003.

[21] „WHO | Global recommendations on physical activity for health", *WHO*.[Online].:http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/. [seen: 18-may-2014].

[22] D. H. Paterson a D. E. Warburton, „Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines", *Int J Behav Nutr Phys Act*, vol. 7, pp. 38, 2010.

[23] V. A. Cornelissen, R. H. Fagard, E. Coeckelberghs, a L. Vanhees, „Impact of resistance training on blood pressure and other cardiovascular risk factors: a meta-analysis of randomized, controlled trials", *Hypertension*, vol. 58, no. 5, pp. 950–958, nov 2011.

[24] B. F. de Salles, A. S. Maior, M. Polito, J. Novaes, J. Alexander, M. Rhea, a R. Simão, „Influence of rest interval lengths on hypotensive response after strength training sessions performed by older men", *J Strength Cond Res*, vol. 24, no. 11, pp. 3049–3054, nov 2010.

[25] M. A. Williams, W. L. Haskell, P. A. Ades, E. A. Amsterdam, V. Bittner, B. A. Franklin, M. Gulanick, S. T. Laing, K. J. Stewart, American Heart Association Council on Clinical Cardiology, a American Heart Association Council on Nutrition, Physical Activity, and Metabolism, „Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism", *Circulation*, vol. 116, no. 5, pp. 572–584, jul 2007.

[26] R. H. Eckel, J. M. Jakicic, J. D. Ard, V. S. Hubbard, J. M. de Jesus, I.-M. Lee, A. H. Lichtenstein, C. M. Loria, B. E. Millen, N. H. Miller, C. A. Nonas, F. M. Sacks, S. C. Smith, L. P. Svetkey, T. W. Wadden, a S. Z. Yanovski, „2013 AHA/ACC Guideline on Lifestyle Management to Reduce Cardiovascular Risk A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines", *Circulation*, s. 01.cir.0000437740.48606.d1, nov 2013.

[27] V. A. Cornelissen a N. A. Smart, „Exercise training for blood pressure: a systematic review and meta-analysis", *J Am Heart Assoc*, vol. 2, no. 1, s. e004473, feb 2013.

[28] S. P. Whelton, A. Chin, X. Xin, a J. He, „Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials", *Ann. Intern. Med.*, vol. 136, no. 7, pp. 493–503, apr 2002.

[29] G. F. Fletcher, G. J. Balady, E. A. Amsterdam, B. Chaitman, R. Eckel, J. Fleg, V. F. Froelicher, A. S. Leon, I. L. Piña, R. Rodney, D. A. Simons-Morton, M. A. Williams, a T. Bazzarre, „Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association", *Circulation*, vol. 104, no. 14, pp. 1694–1740, oct 2001.

[30] J. Myers, „Exercise and Cardiovascular Health", *Circulation*, vol.107, no. 1, pp. e2–e5, jul 2003.

[31] J. M. Hootman, C. A. Macera, B. E. Ainsworth, C. L. Addy, M. Martin, a S. N. Blair, „Epidemiology of musculoskeletal injuries among sedentary and physically active adults", *Med Sci Sports Exerc*, vol. 34, no. 5, pp. 838–844, may 2002.

[32] J. P. Nicholl, P. Coleman, a B. T. Williams, „The epidemiology of sports and exercise related injury in the United Kingdom.", *Br J Sports Med*, vol. 29, no. 4, pp. 232–238, dec 1995.

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