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Effects of 3-months sitting callisthenic balance and resistance exercise on aerobic capacity, aortic stiffness and body composition in healthy older participants. Randomized Controlled Trial

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ABSTRACT

Background: Arterial stiffness (AS) is a reduction in the ability of large arteries to readily accommodate the increase in blood ejected from the heart during systole related with aging. Physical exercise is associated with AS reduction. However, it remains controversial as to which modality and intensity (resistance vs aerobic, high vs low) would be the most effective. The aim of these studies is to examine the effects of 3-months sitting callisthenic balance (SCB) and resistance exercise (RET) on aerobic capacity, aortic stiffness and body composition in older participants.
Material and methods: Aortic *pulse wave* velocity (PWVao), return time (RT), diastolic reflection area (DRA) and blood pressure (BP) level changes were measured with Arteriograph. Aerobic capacity was examined with 6-min walk test (6-MWT) and spiroergometry (VO2max). Body composition was analyzed by Bioelectric Impedance Analysis using Tanita.
Results: Significant improvements of BP, PWVao, RT and DRA were observed in the SCB group ($p = 0.018$, $p = 0.017$ and $p = 0.012$, respectively). % of fat mass improved in RET and SCB group ($p = 0.003$, $p = 0.012$, respectively). Visceral fat significantly improved in SCB group ($p = 0.03$).
Conclusions: Despite no significant changes in indicators of aerobic capacity (VO2max and 6MWT result) in both groups, significant improvement in all measures of AS, except SBPao were observed in the SCB group, while no AS improvement in the RET group was noted. There were some differences in pattern of body compositions improvement between two groups.

1. Introduction

Arterial stiffness (AS) is a reduction in the ability of large arteries to readily accommodate the increase in blood ejected from the heart during systole. Propagation of the pulse wave or pulse wave velocity (PWV) is a relatively simple, non-invasive, and reproducible method to determine arterial stiffness (Sutton-Tyrrell et al., 2005). Increased carotid and femoral artery local stiffness was independently related to a number of cardiovascular events and all-cause mortality (van Sloten et al., 2014). Age-related anatomical changes in large elastic arteries: increased fibrosis, collagen deposition together with collagen cross-linking, and a depletion of elastin content and integrity, ultimately results in elevated AS (Dao et al., 2005; Zieman et al., 2005). This age-related mechanism also applies to older adult(s) free from cardiovascular disease (AlGhatrif et al., 2013; Vaitkevicius et al., 1993).

Previous studies on AS reduction as adaptation to regular physical exercise showed substantial differences exist in exercise modality used, examined groups and obtained results. Some reports have shown that

Abbreviations: AS, arterial stiffness; SCB, sitting callisthenic balance training; RET, resistance exercise training; PWVao, *aortic* pulse wave *velocity*; RT, return time; DRA, diastolic reflection area; 6-MWT, 6-min walk test; VO2max, maximal oxygen uptake

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AS could be reduced as a chronic adaptation to aerobic exercise in healthy older adults (Sherlock et al., 2014). In contrast, one year of an aerobic exercise training protocol (70–85 heart rate reserve (HRR), 30 min of cycling each bout) did not significantly change AS in healthy, older participants (Oudegeest-Sander et al., 2013). Effects of continuous vs interval aerobic exercise protocols (with same single bout intensity assumed) on treated hypertensive subjects showed that both groups improved in terms of blood pressure level, but only interval modality reduced AS (Guimaraes et al., 2010). Moreover, swimming exercises were effective in control of BP and in AS improvement in older, prehypertensive patients (Nualnim et al., 2012). However, moderate-intensity resistance training (RET) did not induce increased AS in middle-aged women (Yoshizawa et al., 2009). Study group examined in Beck et al. (Beck et al., 2013) consisted of young prehypertensive subjects. On the other hand, training protocol applied by Figueroa et al. (Figueroa et al., 2011) consisted of combined training of both aerobic and anaerobic modalities, therefore it is impossible to distinguish separate effects of each of these modalities on AS. Others (Ho et al., 2012) implemented study protocol including 3 separate groups (resistance, aerobic, and combination training) on group of overweight and obese adults. In addition, most studies have been carried at with young populations (Krustrup et al., 2013; Goldberg et al., 2012; Ciolac et al., 2010).

Taking all these into account, it is important to conduct randomized trial in healthy older population on separate effects of different physical exercise modalities. Moreover, results of previous studies have shown that AS is associated with visceral adiposity (Sutton-Tyrrell et al., 2001). Presumably improvement in body composition by adaptation to physical exercise could be a confounder in any reduction in AS and it is therefore important that it be controlled.

Therefore, the aim of these studies is to examine the effects of 3-months sitting callisthenic balance and resistance exercise protocols on aerobic capacity, aortic stiffness and body composition in older participants.

2. Material and methods

2.1. Enrollment

Participants were enrolled into studies based on advertisement in regional TV and radio, during health-promoting lectures, in Day Care Centers for the Elderly, and at various meeting-groups for older people. Initial examination was conducted in the Department and Clinic of Geriatrics, Department of Hygiene, Epidemiology and Ergonomics Collegium Medicum University Hospital in Bydgoszcz, Poland. A total number of 327 (aged 58–91 years old) subjects were examined to select those who meet the inclusion criteria (Chart 1). The only initial criterion for sample was age 55+, as set in previous studies based on physical exercise in older subjects (Nualnim et al., 2012; Colcombe and Kramer, 2003). The study was approved by the Ethics Committee, Ludwik Rydygier Memorial Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University, Torun. Written, informed consent was obtained from all participants.

A complete physician examination was performed in the doctor's office. Co-morbidities and current symptoms were considered in terms of exclusion. Physiotherapy examination was performed to assess current physical capabilities. Past and current cardiac and neurological diseases, disturbances of motor system (including fractures, substantially decreased range of motion, diagnosis of osteoporosis) and psychiatric diseases which could significantly impede or prevent execution of exercises in training protocol were excluding factors. Then, for subjects who met the inclusion criteria, a second day of examination was conducted, where spiroergometry, aortic stiffness and body composition analysis were done.

2.2. Aerobic capacity assessment

The spiroergometry test was performed in the presence of physician with Balke protocol applied (Cardiovit CS-200 Ergo-Spiro, Schiller AG, Baar, Switzerland). Before each trial, a brief instruction of walking on treadmill has been provided if needed. A trained technician advised every participant that the test would end at the moment of full exertion. Otherwise, the test was ended by physician command on the basis of the American College of Sports Medicine criteria (Thompson et al., 2010). Every test was done in the same in an air conditioned room with constant conditions (temperature between 20 and 22 °C and relative humidity of the air between 50 and 60%).

In addition, the 6-min walk test (6MWT) was performed. The testing area was indoor and flat, as previously described (Troosters et al., 1999). The corridor distance was 50 m, to reduce time spent turning, no practice walking was performed before the actual test started. Participants were asked to walk as fast as they were able, and to maintain the same velocity during the whole test. Moreover, participants were reminded twice about the duration of the test and to think about the walk velocity which he, or she, was able to maintain. Most subjects walked alone. Some studies (Roomi et al., 1996) have shown that competitive conditions can increase the mean results of participants in this test up to 30%, compared to groups without such conditions.

2.3. Body composition analysis

To measure body composition changes a multi frequency bioelectrical impedance analyzer (Tanita MC-180MA Body Composition Analyzer, Tanita UK Ltd.) was applied. All subjects were attributed a 'normal' proprietary algorithm for the impedance measurement. Before measurement the soles of the feet and the inner part of the hand were cleaned with a sterile dressing to remove any lipid layer. Subjects stood with the ball and heel of each foot in contact with the electrodes on the floor scale. After recording weight in kilograms, participants grasped the hand grips with electrode and hold down by their sides with arms extended and abducted away from the body to continue body composition analysis based on bioelectrical impedance signal.

2.4. Aortic stiffness measurement

AS examination was performed using Arteriograph (TensioMed Kft., Budapest, Hungary, www.tensiomed.com). A simple upper arm cuff as a sensor with the cuff pressurized to at least 35 mmHg over the actual systolic pressure is used during measurement. These very small supra-systolic pressure changes are recorded by a high-fidelity pressure sensor in the device, while conduit arteries (subclavian, axillary, brachial) act like a cannula to transfer the central pressure changes to the edge-position sensor (similar to the central pressure measurement during cardiac catheterization). The Arteriograph first measures the actual systolic (sBP), diastolic (dBP) and mean (mBP) blood pressures (BPs) oscillometrically, then the device decompresses the cuff. In a few seconds the device starts inflating the cuff again, first to the actually measured diastolic pressure, then to the suprasystolic (actually measured systolic þ35 mmHg) pressure, and records the signals for 8 s (optionally up to 10) at both cuff pressure levels. All of the signals received by the device are transmitted to a PC. The device software determines the augmentation index according to the manufacturer's instructions. To determine Pulse Wave Velocity of aorta (PWVao), the Arteriograph uses the physiological behaviour of the wave reflection, namely that the ejected direct (first systolic) pulse wave is reflected back mostly from the aortic bifurcation (Németh et al., 2002; Ring et al., 2014; Horvath et al., 2010). The RT is the time of the pulse wave travelling from the aortic root to the bifurcation and back, expressed in ms. RT, together with PWVao and central systolic blood pressure expressed in mmHg (SBPao) are aortic stiffness indicators. Moreover, the coronary filling in diastole (DRA) an indicator of diastolic filling in the

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