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Effects of Combined Aerobic and Resistance Exercise on Health-Related Fitness in Sedentary Overweight Middle–Aged Men

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Abstract: Objective: Regular physical activity improves health-related fitness. However, the influence of different types of exercise has not been widely analyzed. The aim of this study was to analyze the effects of combined exercise (aerobic exercise and muscle strengthening) on physical capacity, lipid and cardiovascular profiles in overweight middle-aged men. Methods: Forty (40) men were randomly assigned to two groups: an experimental group (EG) and a control group (CG). The experimental group trained for 12 weeks, three times a week for 60 min per session at 60-75% of their reserve heart rate. The control group was told to stay without physical exercise. Results: The Mann-Whitney U test for paired samples was used. The experimental group recorded a significant increase (P>0.05) in $V0_2$max, flexibility, strength and muscular endurance. Waist to hip ratio (WHR) and body mass index were significantly decreased (P>0.05) while there was no improvement in control group. Exercise also significantly reduced resting heart rate and diastolic blood pressure. Triglycerides (TG), total cholesterol (TC), HDL and LDL were significantly improved (P>0.05). Conclusion: Our research suggests that physical exercise combining aerobic exercise and resistance exercises accomplished three times a week for 60 min a session to moderate intensity is effective positive to improve health-related fitness components in sedentary overweight middle –aged men.

Keywords: Blood Lipids, Cardiovascular Disease, Exercise, Health-Related Fitness

1. Introduction

Prospective studies have reported a relationship between occupational or leisure time physical activity and cardiovascular mortality [1, 2]. An inactive lifestyle contributes to the onset and premature progression of cardiovascular disease [3]. In contrast, regular physical activity increases exercise capacity and physical fitness which can lead to many benefits [4].

Indeed, Blair et al. [5] found that even small improvements in physical fitness can reduce cardiovascular mortality. Based on the known relationships between physical activity, fitness, and health, Pate [6] distinguished between health-related fitness and performance-related fitness. Health-related fitness refers to the physical and physiological characteristics that define the risk levels for the premature development of diseases or morbid conditions related to a sedentary lifestyle [7]. According to the Toronto model presented by Bouchard and Shepherd [8], health-related fitness can be expressed in five components: a morphological component, a muscular component, motor component, cardio-respiratory component and metabolic component. The concept postulates that regular exercise has a direct influence on the majority of these components [8]. In clinical research, several of them are therefore considered as precursors of disease and identified as risk factors [9].

Traditionally, to study the effects of exercise on the risk factors of cardiovascular disease, research has focused on aerobic exercise. This type of exercise primarily provides major stimulus to the oxygen transport system, energy substrate synthesis system (glycogen and fat) and oxidative processes in active skeletal muscle fibers, particularly slow twitch fibers. In contrast, resistance exercise primarily activates fast twitch muscle fibers and puts stress on the body's support structures such as bones and connectives tissues [10]. It is mainly used for muscle strengthening and as means of rehabilitation of musculoskeletal injuries.

For this purpose, for a systematic and comprehensive training, the American College of Sports Medicine has recommended a combination of 30 min of aerobic exercise and 20 min of resistance exercise each day [11]. Thus, improvements in cardio-respiratory and musculoskeletal function would allow individuals to prevent or reduce the risk of disease and symptoms associated with physical inactivity and to perform activities of daily living with ease and without risk [11].

However, those recommendations are for normal individuals. On another hand, the studies that have analyzed the effects of this combined training on health-related fitness are few, particularly in southern countries, and sometimes contradictory. Indeed, Yavari et al. [12] found additional improvements in triglycerides, muscle percentage and body fat from combined training compared to aerobic training and resistance training in diabetic men and women. Ho et al. [13] found greater benefits of combined training for body weight and fat loss, cardio-respiratory fitness than aerobic and resistance training modalities without any improvement in blood lipids in obese or overweight men. In contrast, after a 12-week exercise, Martin [14] found no significant difference between the three types of training for lipid profile in untrained young men. LeMura et al. [15] also reported that 16 weeks of combined aerobic and resistance training did not improve blood lipids in untrained young women.

Given those contradictions, more research is needed to better understand the effect of combined training. The American College of Sports Medicine promotes a combination of 30 min of moderate-intensity exercise most days of the week and resistance exercise on 2-3 days a week for each major muscle group. As many people are in lack of time to exercise every day, the study aims to determine if 60 min moderate-exercise performed three times a week is effective for improving health-related fitness in overweight men. It also attempts to verify if the effects of this of training reported in the studies conducted in developed countries are the same for southern countries.

2. Materiel and Methods

2.1. Nature of Study and Settings

It is a controlled intervention study carried out at Bujumbura in University Laboratory Research in Physical and Sports Activities for Social Development and Health (LURADS) at University of Burundi.

2.2. Population and Study Sample

A total of forty (40) overweight men ($25 < BMI < 30$) recruited from a database of a study that we previously conducted [16] were randomly and equally assigned to the experimental group (N=20) and the control group (N=20) by using a numbering table for randomization. They had not participated in any regular exercise training for six months but showed their willingness to begin and finish the all physical program set by the study. Prior to the study, all the subjects were informed on the objective of the study, his process and duration. Subjects firstly visited physician or different examinations purpose. They were examined in terms of health status, history of disease in order to be sure that they can participate in the training program without any danger. Individuals with heart disease, lung disease, uncontrolled hypertension, musculoskeletal or neurological limitations to exercise were excluded.

2.3. Variables Measured

Three types of variables were performed three days before exercise treatment and two days after exercise program terminated: physical capacities (flexibility, muscular endurance, and hand grip), physiological parameters (blood pressure, heart rate and maximal oxygen uptake) and lipids parameters (triglycerides, total cholesterol, HDL and LDL cholesterols).

2.4. Materials and Measurements

Body mass was measured using scale (Seca, electronic, France, senility of 0,5kg) and height with a vertical height gauge (sensitivity of 0, 5 cm). A flexible 2-meter standard tape measure was used to measure the waist circumference, taking as reference the midpoint between the lower costal edge and the iliac crest at the level of the mid-axillary line, parallel to the floor, he participant in a standing position. The hip circumference was measured around the widest portion of the buttocks, with the tape measure parallel to the floor. To obtain the waist/hip ratio, we divided the waist circumference by the hip circumference.

The "sit-and-reach" test was used to measure the flexibility of the hamstrings and lower back according to ACSM's Guidelines for Exercise Testing and Prescription [17]. After a small warm up, the participant were asked to remove their shoes and sit on the floor, the legs stretched out straight ahead, with the soles of the feet flat against the sit and reach box. Both knees were locked and pressed flat to the floor. Then, the participants placed the hands one on top of the other, palms facing downwards. They reached forward with a slow and steady movement as far as possible and held that position for two seconds. The best score of three trials was recorded.

Endurance muscle was measured according to Sparling proceeding [18]. Lying on their back with their knees bent at right angles (90°), the subjects performed full sit-ups for one minute. Number of performed sit ups was counted.

Grip strength was assessed using a Japanese dynamometer (T.K.K 5401). The test was performed with the participants in a standing position. Holding the dynamometer in the hand to be tested, the forearm bent at a right angle (90°) and the elbow suspended alongside the body, the participants squeezed with maximum isometric effort for 5 seconds without another movement. The test was repeated twice with both hands. Between measurements, one minute rest intervals were allowed, and the highest score was registered [17].

One-mile walk test was used to estimate the maximal oxygen uptake (VO_2 max). A distance of 1.6 km was walked as fast as possible. The subject was equipped with a heart rate monitor. The performance (time in minutes and fractions of minutes) was registered, and the heart rate was recorded immediately after the walking and 15 seconds after. The VO_2max was estimated using the following equation [19]:

$$VO_2max\ (ml/kg/min) = 132{,}853 - (0{,}0769 \times weight) - (0{,}3877 \times age\ in\ years) + (6{,}315 \times Sex) - (3{,}2649 \times time\ taken) - (0{,}1565 \times Fc\ at\ end).$$

Where sex = 1 for men and 0 for women

Weight = pound (1 pound= 0.453 kg) and the time of the walk in minutes and fractions of minutes.

Measurement of the resting heart rate was achieved in the morning immediately after the participants were awake. It was taken from the radial artery with forefinger and the middle finger of the right hand placed horizontally across the subject's wrist while sitting on the chair.

Systolic and diastolic blood pressures were obtained using an automatic digital blood pressure monitor (Omran Digital Hem-907, Japan).

For the blood lipid measurement, blood samples were drawn in the morning from subjects who had fasted for at least 12 hours. Five (5) ml of venous blood were taken in a dry tube from each subject in sitting position. The blood samples obtained were centrifuged at 4000 rpm for 5 minutes in the laboratory. The decanted serum was refrigerated (-5°C) and analyzed within 48 hours, to obtain lipids measurements, using the Enzymatic Method with auto analyzer alpha x device with (E2HL-100) kits and 0,1 (mmol/d) sensitivity (Hitachi, Tokyo, Japan).

The lipid variables analyzed were low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TG) and total cholesterol (TC).

2.5. Training Program

Our training program was adapted from Anek et al. [20]. While the experimental group followed a 12-week training program which involves exercising 3 days a week for 60 minutes a day, the subjects in the control group were instructed to remain sedentary. To respect the principle of progressive overload, the training program was divided into three periods: a first period of three (3) weeks, a second of four (4) weeks and a third of five (5) weeks. As the subjects became fitter, the exercise intensity was increased. During the training, music was used to set the tempo for the aerobics and resistance training sessions consisting of step aerobics with a height of 20 cm combined with lifting a 1 kg dumbbell. In order to monitor their pulse, the participants were equipped with a heart rate monitor (polar 1S). During the first period, participants gradually warmed up to reach 50% of their maximum heart rate in 5 minutes. This intensity was maintained for 40 minutes, followed by 10 minutes of stretching of the large joints and 5 minutes of cool-down. This gave a total duration of 60 minutes for each session. During the 2nd period, the participants followed the same program to reach a range of 60-70% of maximum heart rate with a musical tempo. In the last period, they warmed up to reach 60% of maximum heart rate within 5 minutes, then performed the combined program with a musical tempo at 70-80% of maximum heart rate, maintaining this intensity for 40 minutes and followed by 10 minutes for stretching finishing by a 5-minute cool-down.

2.6. Ethical Consideration

The ethic committee of the faculty of medicine within the Burundi University approved the study method and protocol.

2.7. Data Analysis

The data were analyzed with SPSS version 20 software. The normality of the distribution of the variables was verified by the Kolmogorov-Smirnov test. Intra-group and intergroup comparisons were made with the Wilcoxon rank test and the Mann-Whitney U test, respectively. The significance level was set at $p < 0.05$.

3. Results

No significant differences (p> 0.05) were observed between the GE and the GC for age, height, weight, BMI and heel to hip ratio at the beginning of training program (Table 1).

Table 1. *Baseline Characteristics.*

	mean values ± standard deviations		P value
	EG	CG	
Age (years)	44,16 ± 5,68	43,50 ± 437	0.35
Height (cm)	174,03 ± 8,77	173,51 ± 9,72	0.74
Body mass (kg)	79,16 ± 8,77	77,29 ± 7,99	0.24

Numbers in boxes represent mean values ± standard deviations; *: significant difference at p ≤ 0.05 between EG and CG subjects.

3.1. Changes in Body Composition and Physical Capacities Values After the Training Program

Body composition and physical capacities values observed after the training program are presented in table 2. At the beginning, there was no significant difference (p>0.05) between the control group and the experimental group. At the end of the training program, all anthropometric and physical capacities values changed significantly ($p<0.05$). In contrast, the changes observed in the control group were not significant ($p> 0.05$). The comparison of the values of the parameters studied shows a significant difference ($p<0.05$) between the experimental group and the control group.

Table 2. *The Comparison of Body Composition and Physical Capacities Between Baseline and 12 Weeks.*

Variables		EG	Δ	CG	Δ	P-Value
BMI (kg/m2)	Pre-test Post-test	26,38 ± 3,17 25,10 ± 1,11*	-1,27 ± 0,01	25,68 ± 2,11 25,88 ± 1,25	0,2 ± 0,2	0,03
WHR	Pre-test Post-test	0,92 ± 0,7 0,86 ± 0,9*	-0,06 ± 0,2	0,90 ± 5,0 0,91 ± 4,4	0,01 ± 0,1	0,04
HG (Kg)	Pre-test Post-test	41,38 ± 9,31 48,12 ± 2,13*	6,74 ± 1,1	40,02 ±1,21 41,12 ± 8,9	1,10 ± 0,04	0,02
Flexibility (cm)	Pre-test Post-test	22,71 ± 8,31 30,80 ± 10,11*	8,1 ± 3,1	21,05 ± 2,31 20,4 ± 9,60	-0,65 ± 0,4	0,04
AME (number of sit and reach /min)	Pre-test Post-test	25,9 ± 8,01 32,07 ± 6,10**	6,17 ±2,1	24,21 ± 5,4 25,32 ± 3,91	1,11 ± 0,1	0,002

The numbers in the boxes represent the mean values ± standard deviations; CG: control group; EG: experimental group; Δ: difference between the data recorded before and after the intervention; BMI: body mass index; WHR: waist hip ratio; HG: hand grip; AME: abdominal muscle endurance; *: significant difference at $p < 0.05$ between the mean± standard deviations values of the CG and EG after the intervention.

3.2. Changes in Physiological Parameters After Training Program

The changes in physiological parameters are presented in Table 3. At the beginning of the program, there was no significant difference between the control and experimental groups. At the end of the program, DBP, SBP and VO_2max decreased significantly ($p<0.05$) in the experimental group. No variables changed significantly in the control group.

Table 3. *Comparison of Physiological Parameters Between Baseline and 12-Weeks.*

Variables		EG	Δ	CG	Δ	P- Value
HR (beats /min)	Pre-test Post-test	72,12 ± 12,20 68,02 ± 2,02*	-4,01 ± 0,32	73,01 ± 2 74,14 ± 6	1,10 ± 0,12	0,03*
SBP (mm Hg)	Pre-test Post-test	129,03 ± 2,01 120,01± 4,10*	-12 ± 5,21	125 ± 3,12 122 ± 3,21	-3,01 ± 1,01	0,02*
DBP (mm Hg)	Pre-test Post-test	83,14 ± 0,22 80,02 ± 0,12*	-3 ± 1,10	81 ± 5,20 80 ± 2,13	-2,11 ± 2,10	0,18
VO_{2max} (ml/kg/min)	Pre-test Post-test	34, 01 ± 1,4 41,05 ± 0,82**	7,99 ± 0,4	32,45 ± 7,14 32,72 ± 5,52	0,27 ± 0,2	0,001

Numbers in boxes represent mean ± standard deviation; CG: control group; EG: experimental group; VO2 max; HR: heart rate; DBP: diastolic blood pressure; SBP: systolic blood pressure; Δ: difference between data recorded before and after intervention; *: significant difference at $p < 0.05$ between mean ± standard deviations values of the CGs and EGs after intervention.

3.3. Changes in Lipid Profile After Training Program

The changes in the lipid profile are presented in table 4. At the beginning of the program, there was no significant difference between the control group and the experimental group. At the end of the program, a significant increase in HDL-C concentrations ($p<0.05$) was observed while TG, LDL-C levels decreased significantly ($p<0.05$) in the training group. No variables were significantly changed in the control group.

Table 4. *Comparison of Lipid Parameters Between Baseline and 12 Weeks.*

Variables		EG	Δ	CG	Δ	P-Value
TG (mmol/l)	Pre-test Post-test	1,91 ± 0,99 1,67 ± 0,55*	-0,24 ± 0,21	1,94 ± 0,92 1,95 ± 0,96	0,01± 0,00	0,04*
TC (mmol/l)	Pre-test Post-test	4,97 ± 1,15 4,90 ± 2,88	-0,07 ± 0,56	5,07 ± 2,47 5,12 ± 1,49	0,05 ± 0,01	0,15
LDL-C (mmol/l)	Pre-test Post-test	2,98 ± 0,80 2,58 ±1,34*	-0,40 ± 0,25	2,76 ± 188 2,74 ± 1,50	-0,02 ± 1,01	0,03*
HDL-C (mmol/l)	Pre-test Post-test	1,58 ± 0,68 1,71 ± 0,6**	0,13 ± 0,03	1,55 ± 0,67 1,49 ± 0,94	-0,06 ± 0,01	0,01*

Numbers in boxes represent mean values ± standard deviations; CG: control group; EG: experimental group; TG: triglycerides; TC: total cholesterol; LDL: low density lipoprotein; HDL: high density lipoprotein; Δ: difference between data recorded before and after intervention; *: significant difference at p <0, 05between mean values± standard deviations of CG and EG after intervention

4. Discussion

The results of this study show that a 12-week physical program combining aerobic exercise and resistance exercise performed three times a week is effective to improve aerobic endurance, anthropometric, blood pressure and lipid profiles.

The improvement in body composition observed are consistent with similar changes in WHR and BMI that have been observed in adult men with training programs ranging from 8 to 36 weeks. In our program, BMI and WHR had significantly decreased in the experimental group, while there was a trend towards an increase in the control group. These results are similar to those recorded by Baley et al. [21] in obese adults after a 12-week mixed exercise program. High levels of fat, especially in the abdomen, increase the risk of developing type 2 diabetes and cardiovascular disease [22]. Thus, combined exercise training may be beneficial in reducing this risk.

We observed a significant ($p<0.05$) increase in maximal oxygen uptake (VO_2max) in the experimental group compared to the control group. This is consistent with previous studies. Indeed, several studies have shown that in individuals adult, maximal aerobic capacity is positively correlated with the level of physical activity [23-24]. In addition, higher cardio-respiratory fitness has been associated with a reduced risk of disease and mortality [25]. As individuals age, there is a progressive reduction in the capacity of the cardio-respiratory system [26]. However, despite this inevitable decline, regular exercise improves and/or delays this reduction [24].

The results recorded in the muscle parameters are consistent with those of Lee [24] who observed significant increases in grip strength and abdominal endurance in people aged over 50 years after a 12-week exercise training. Muscular endurance refers to the duration of time a person can perform an effort or action with certain intensity. Good endurance prevents premature fatigue and allows a person to sustain a prolonged effort or activity. In addition to building strength, participation in resistance or strength exercise can slow or even reverse the degeneration of bone mineral density in individuals with osteoporosis [26]. In addition, good muscle fitness improves the maintenance of functional independence in older people [27]. Furthermore, in a prospective seven-year study involving 9105 men, Fits Gerald et al. [28] showed that muscle strength and muscular endurance are inversely associated with the risk of all-cause mortality after controlling for potential confounders. In general, studies that have assessed the effect of exercise on strength, muscular endurance and flexibility have, in most cases, shown significant improvements in these parameters [29-30].

The reductions in diastolic and systolic blood pressure observed in the present study are consistent with those found by several authors [21, 31]. However, they are contrary to the results of the studies by Arslanoglu and Senel [30] and Osecki et al [32], which recorded significant reductions in systolic blood pressure but not in diastolic blood pressure. We believe that these differences are due to the sex of the subjects or the duration of the training sessions. Indeed, the duration of the sessions in their programs were respectively 15 and 45 min with female subjects, whereas in our study the training session lasted 60 min. A meta-analysis of 54 randomized controlled trials, prior to the above- mentioned studies, including subjects over 18 years of age, found a systolic blood pressure in the experimental group (subjected to aerobic exercise) 3.84 mm Hg lower than in the control group and a diastolic blood pressure 2.58 mm Hg lower [33]. This reduction was significant and observed in both hypertensive and normotensive subjects, overweight subjects ($24.9<BMI<26.4$) as well as normo-weighted subjects ($BMI<24.5$) [33]. Another meta-analysis suggested that in hypertensive or normotensive individuals, a reduction in diastolic blood pressure confers a reduced risk of heart attack or cardiovascular disease [34]. The mechanisms related to blood pressure adaptations to chronic exercise are more complex [36]. However, Comelissen and Fagard [35] have shown that the chronic effect of exercise is partly explained by a decrease in resistance of the vascular system, in which the autonomic nervous system and the renin-angiotensin system are most likely the underlying regulatory mechanisms. Indeed, the renin-angiotensin system is a hormone system involved in the normalization of blood pressure and blood volume. Another factor contributing to this decrease in vascular resistance is the increased production of nitric oxide, which causes vasodilation in response to regular aerobic exercise [35].

A low resting heart rate reflects good health, while higher values are associated with mortality risk. Indeed, studies suggest that exercise training produces elevated resting vagal activity responsible for a low resting heart rate [36].

The results of this research showed that there were statistically significant decreases in triglyceride levels, total cholesterol, LDL cholesterol and an increase in HDL at post-test compared to pre-test in the experimental group. In addition, significant differences between the experimental and control groups were observed after the 12 weeks of training. These results were consistent with those of several other authors who have observed significant improvements in TG, LDL-C and HDL-C concentrations in healthy middle-aged men at the end of a mixed exercise program of eight weeks or more [37-39]. Hussein et al [31] also found the same results in obese coronary patients after a 12-week mixed exercise program. However, Ho et al.[13] did not find significant changes in lipid concentration levels in overweight and obese men aged 40-60 years. A systematic review prior to the above studies found eight studies that used mixed endurance resistance exercise as an intervention to investigate its effects on blood lipids [40]. Three of these showed significant improvements in LDL levels while three others found significant improvements in HDL in both sexes. Two studies showed decreases in total cholesterol and triglyceride levels in elderly and middle-aged subjects. In contrast, two studies comparing aerobic exercise, resistance exercise and mixed exercise found no significant differences between the experimental and control groups. The differences in results may be due to several factors, including the age and sex of the subjects and the intensity of the exercise [41]. In general, mixed exercise has a positive effect on lipid profile, although the mechanisms by which regular physical activity acts to alter the blood lipid profile have not yet been well clarified. However, changes in the activity of glucose transporters and skeletal muscle lipoprotein lipase are some explanations that have been proposed [42]. Indeed, one of the first and most obvious changes observed during aerobic exercise is the reduction in plasma insulin, the level of which could influence plasma cholesterol [43]. A high correlation has also been found between lipoprotein lipase enzyme activity and blood triglyceride release. During aerobic exercise, this enzyme catalyses triglycerides which release free fatty acids providing energy for exercise. Regular exercise appears to increase the storage of this enzyme in the muscle fibers [44]. This may favorably influence the metabolic capacity of triglycerides by mechanisms probably involving effects on other lipoprotein species, and consequently improve the circulation of cholesterol.

5. Conclusion

Twelve weeks of directed mixed training produced significant improvements in health-related indicators, similar to the response observed in other long-term studies. These results demonstrate the effectiveness of this type of exercise in preventing cardiovascular risk factors. With the emergence of chronic non-communicable diseases in Burundi, physicians and health educators may insist on combined exercise program for the achievement of long-term health benefits. Specifically, these include reducing central obesity, dyslipidaemia and improving muscular and cardio-respiratory fitness.

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