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EFFECTIVENESS OF YOGA EXERCISES IN PREVENTION AND TREATMENT OF METABOLIC SYNDROME

A Dissertation

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Acknowledgement:

My heartfelt thanks go to Professor Eliška Sovová who has guided me throughout my studies.

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Abstract

Background: Cardiovascular disease is the leading cause of death globally. Presence of metabolic syndrome is associated with a twofold risk of cardiovascular disease and death from cardiovascular disease. It is a necessity of our times to search for new methods of prevention and treatment of risk factors of cardiovascular disease. Yoga exercises may provide a potentially significant support to standard pharmacological therapy.

This study aimed at assessing the effect of regular yoga exercise on the risk factors of cardiovascular disease, parameters of metabolic syndrome, and body composition, as well as spiroergometry as a measure of physical fitness. Additionally, we examined the lifestyle and dietary habits of yoga practitioners in comparison with general population.

Subjects and Methods: We examined 58 persons, 17 men and 41 women, who had been practicing yoga according to the Yoga in Daily Life ™ system for over 2 years on a daily basis. The study focused on five separate areas and is therefore divided into 5 subsections: 1. Presence of Risk Factors of Cardiovascular Disease; 2. Metabolic and Homeostatic Parameters of Insulin Resistance; 3. Lifestyle; 4. Body Composition; 5. Fitness Performance. Results of the Yoga group were compared with four different control groups counter-matched to the Yoga group for age and sex. In subsection 4, Body Composition, the results were compared with a norm instead of a control.

Results and Conclusion: Our work showed statistically significant differences in the risk factors between the Yoga and control groups in the following parameters: blood pressure, BMI, triglycerides, blood glucose and insulin, as well as in the homeostatic index HOMA-IR and QUICKI. These results indicate that yoga may well be an appropriate form of exercise and may be recommended as an effective method of prevention of Metabolic Syndrome and Risk Factors of CVD.

The study also found that the consumption of certain foodstuffs associated with increased CVD risk is lowered in yoga practitioners. Additionally, the number of smokers was significantly lower in the yoga group. Since these lifestyle factors are associated with the incidence of CVD, further studies are needed to determine the effect of lifestyle modifications versus practice of yoga alone, however, the present study indicates that the practice of yoga itself may positively influence the willpower and desire to lead a healthier lifestyle.

1. Introduction

Cardiovascular disease (CVD) is the number one cause of death globally. In the Czech Republic, the mortality caused by CVD is very high at 51% of total mortality [1]. In countries of the EU, the mortality caused by CVD is at 35% [2]. The risk factors (RF) associated with CVD can be categorized either as non-modifiable (age, sex, and genetic factors) or modifiable (smoking, hypertension, lipid metabolism disturbances, excess weight and obesity, diabetes mellitus, sedentary lifestyle, and stress) [3].

Metabolic syndrome (MetS) is a condition defined as a combination of three out of five of the following factors: abdominal (central) obesity, elevated blood pressure, elevated fasting plasma glucose, high serum triglycerides, and low high-density cholesterol (HDL) levels [13].

The best available evidence suggests that people with MetS are at increased risk of cardiovascular events [5,6]. For example, MetS is present in up to 30% of patients after myocardial infarction [8]. According to WHO, cardiovascular disease is the leading cause of death globally. Presence of metabolic syndrome increases the risk of death from cardiovascular disease twofold [8,9,10].

According to the Czech National Program for Complex Internal Care [11] about 30% of the adult population in the Czech Republic fits into the criteria for MetS and the prevalence of hypertension is 1.8 million and of Type II diabetes mellitus 850,000. Considering the high prevalence of RF of CVD, it is important to focus on prevention and search for possibilities to influence the incidence of RF of CVD through lifestyle changes [12].

According to the recommendations by the International Diabetes Federation (IDF), the primary means of preventative intervention in persons with MetS and in persons with an increased risk for CVD consists of reduced calorie intake, increase in regular exercise, and dietary changes which include lowering the fats and sugars intake [13,14].

According to WHO, '60 to 85% of people in the world—from both developed and developing countries—lead sedentary lifestyles, making it one of the more serious yet insufficiently addressed public health problems of our time' [15]. Regular exercise leads to economization of cardiac performance which shows as a lower heart rate and blood pressure under load, resulting in a lower myocardial oxygen consumption, improved myocardial contractility, improved economy of arterial blood distribution, improved

oxygen utilization, lowered LDL cholesterol in the blood and lowered sympathetic tonus [16,17]. Properly selected exercise can lower the incidence of RF of Cardiovascular Diseases [19,20].

Yoga, as a system of psychosomatic exercises which has been shown in a number of studies to have positive influence on health, may become a valuable tool for primary prevention as well as management of RF of CVD [21,22,23,24,25].

2. Aims of Study

The purpose of our study was to assess the effect of regular yoga exercise on the risk factors of cardiovascular disease, parameters of metabolic syndrome, body composition, as well as spiroergometry as a measure of physical fitness. Part of our study was to examine the lifestyle and dietary habits of yoga practitioners in comparison with general population.

3. Subject Overview

3.1. METABOLIC SYNDROME

Metabolic syndrome, also known as Reaven's syndrome, or insulin resistance syndrome, is a cluster of medical conditions which is present in approximately 30% of adult population in Europe and North America [26].

MetS has a complex pathogenesis. Generally, insulin resistance is considered to be the main pathophysiological basis of MetS; however, science has not yet achieved a complete understanding of the causality and pathogenesis of MetS. There is, however, a consensus that obesity, type II diabetes mellitus, dyslipidemia and arterial hypertension are caused by a combination of genetic and environmental factors [11,12,27].

The syndrome was first defined by Reaven as a Syndrome X in 1988.

Original definition of Syndrome X by G.M. Reaven (1988) [4,27]

- Resistance to insulin-stimulated glucose uptake
- Glucose intolerance
- Hyperinsulinemia
- Increased very-low-density lipoprotein triglyceride
- Decreased high-density lipoprotein cholesterol
- Hypertension

The original 1988 definition by Reaven did not include abdominal obesity.

In 1998, the World Health organization attempted to create an internationally accepted working definition of the syndrome which included abdominal obesity as part of the criteria and they chose to use the term Metabolic Syndrome. "A potential disadvantage of the WHO criteria was that special testing of glucose status beyond routine clinical assessment was necessary to diagnose metabolic syndrome" [28].

1999 Definition of MetS by WHO [4]

At least one of the following components:

- **Glucose intolerance**
- **Impaired glucose tolerance (IGT) or diabetes mellitus**
- **Insulin resistance**

  (Insulin resistance measured under hyperinsulinemic euglycaemic conditions, glucose uptake below lowest quartile for background population under investigation.)

and two or more of the four following components:

- **Raised arterial pressure** ≥140/90 mmHg
- **Raised plasma triglycerides** (≥1.7 mmol/L; 150 mg/dL) and/or low HDL cholesterol (<0.9 mmol/L, 35 mg/dL men; <1.0 mmol/L, 39 mg/dL women)
- **Central obesity** (males: waist to hip ratio >0.90; females: waist to hip ratio >0.85) and/or BMI >30 kg/m^2
- **Microalbuminuria** (urinary albumin excretion rate ≥20 g/min or albumin:creatinine ratio ≥30 mg/g)

The National Cholesterol Program Expert Panel created a new definition of Metabolic Syndrome in their Adult Treatment Panel III in 2001 to facilitate diagnosis of MetS in clinical practice. Later, the International Diabetes Federation published a new definition in the year 2005 to create a unified, universally accepted diagnostic tool for both clinical practice and research [60].

IDF 2005 Definition of MetS [29]

According to the new 2005 IDF definition, for a person to be diagnosed with MetS, they must have:

- **Central obesity**

  Central obesity is defined as waist circumference* with ethnicity specific values. For persons of European descent, the values are 90 cm for men and 80 cm for

women. (In the USA, the ATP III values 102 cm male; 88 cm female) are likely to continue to be used for clinical purposes for persons of European descent)

plus any two of the following four factors:

- **Raised triglycerides** - ≥ 150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality
- **Reduced HDL cholesterol:**
  - 40 mg/dL (1.03 mmol/L) in males
  - < 50 mg/dL (1.29 mmol/L) in females

  or specific treatment for this lipid abnormality
- **Raised blood pressure:** systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg or treatment of previously diagnosed hypertension
- **Raised fasting plasma glucose:** (FPG) ≥ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes

  If above 5.6 mmol/L or 100 mg/dL, OGTT is strongly recommended but is not necessary to define presence of the syndrome.

* If BMI is >30kg/m², central obesity can be assumed and waist circumference does not need to be measured

In 2009, a joint statement by the IDF, AHA, and other medical societies named *Harmonizing the Metabolic Syndrome* was published [27-A]. This joint statement was issued as an attempt to unify the criteria for diagnosing Metabolic Syndrome and presented a definition of Metabolic Syndrome which included abdominal obesity as one of the five components of the MetS.

The 2009 Harmonized Definition of MetS [27-A]

At least three of the following five criteria

- **Elevated waist circumference** - population- and country-specific definitions

  For men of European origin that means 94/102 cm (as defined by IDF/AHA, respectively) and for women 80/88 cm (IDF/AHA).

- **Elevated triglycerides** (drug treatment for elevated triglycerides is an alternate indicator) > 150 mg/dL (1.7 mmol/L)

- **Reduced HDL cholesterol** (drug treatment for reduced HDL cholesterol is an alternate indicator) < 40 mg/dL (1.0 mmol/L) in males; <50 mg/dL (1.3 mmol/L) in females

- **Elevated blood pressure** (drug treatment for elevated blood pressure is an alternate indicator) Systolic >130 mm Hg and/or diastolic >85 mm Hg
- **Elevated fasting glucose** (drug treatment for elevated glucose is an alternate indicator) >100 mg/dL

3.1.1 Abdominal Obesity

Abdominal (central) obesity is a key risk factor in the international definitions of MetS. Unlike general obesity, which is defined by weight or BMI, abdominal obesity is defined by abdominal circumference in the Harmonized Definition or by abdominal circumference or by the waist to hip ration in the earlier WHO definition.

3.1.2. Insulin Resistance and Type II Diabetes Mellitus

All definitions of MetS include either Insulin Resistance (IR) or Hyperglycemia as part of the criteria for MS diagnosis.

IR is the resistance of cells to respond to the action of insulin in transporting glucose into muscles [and other tissues]. Combination of IR and disordered secretion of insulin gradually leads to manifestation of type 2 diabetes mellitus [4,27].

Insulin resistance, which is difficult to measure in day to day clinical practice, was not included in the newer definitions. The 2009 Harmonized Definion includes a raised fasting plasma glucose (FPG) ≥ 100 mg/dL (5.6 mmol/L) as one of the criteria for MetS.

3.1.3 Arterial Hypertension

Hypertension at ≥ 130/85 mm is one of the criteria of MetS according to the Harmonized Definition. According to guidelines issued by the ESC and ESH, in adult population, approximately one third suffers from hypertension and of these two thirds is aware of their illness and half receive proper medical care [30]. Proper BP management is known to lower the incidence of CVD. This conclusion was published already in 1971 by the Framingham study. The treatment aims to lower diastolic BP to levels below 90 mmHg and systolic BP to levels below 140 mmHg in low risk patients [31,32,33].

3.1.4. Dyslipidemia

In the 2009 Harmonized Definition, the criteria for dyslipidemia are listed as TAG 1.7 mmol/l and reduced HDL cholesterol < 1.0 mmol/L in males and <1.3 mmol/L in females.

Atherogenic dyslipidemia is defined as a combination of raised triglycerides, low HDL cholesterol, raised apolipoprotein B and presence of small atherogenic LDL particles [27].

3.1.5. Additional Risk Factors

Additional Risk Factors of MetS and CVD include smoking, alcohol consumption, low levels of Physical Activity, as well as psychosocial and socio-eceonomic factors [12,27,35] and psychological factors and behavioral / psychological patterns such as night eating, depression, stress, negative emotions and a lack of compliance with prescribed treatment [4].

According to a 2010 study by Rodriguez et al., 'The risk factors for metabolic syndrome in type 2 diabetes mellitus patients are highly dependent on the criteria used to define the syndrome, supporting the need for a single clinically useful and epidemiologically useful definition." For example, the risk of developing MetS according to the NCEP-ATP III criteria is elevated by the presence of endocrine disorders (Odds Ratio, 1.64; 95% Confidence Interval: 1.06–2.57. According to the IDF criteria, female patients and patients with left ventricular hypertrophy or insulin treatment were at a higher risk for the development of metabolic syndrome (OR, 4.00; 95% CI: 2.35–6.80; OR, 2.72 95% CI: 1.22–6.04; and OR, 1.96 95% CI: 1.24–3.11, respectively). On the other hand, older age over 65 and intense and moderate physical activity lowered the risk of MetS according to the WHO definition [36].
There is also a known relationship between MetS and oxidation, stress, and neuropathy [4].

3.2. METABOLIC SYNDROME AND TREATMENT OPTIONS

It is important to offer proper non-pharmacological treatment alternatives to patients with MetS and supplement with pharmacological treatment as required [29].

The IDF recommends that the primary management of MetS is through a healthy lifestyle including:

- moderate calorie restriction (to achieve a 5–10 per cent loss of body weight in the first year)
- moderate increase in physical activity
- change in dietary composition

As a secondary intervention IDF recommends that, "in people for whom lifestyle change is not enough and who are considered to be at high risk for cardiovascular disease, drug therapy may be required to treat the metabolic syndrome."[13]

3.2.1. Lifestyle Modifications

Nutrition

The new European Guidelines for the management of dyslipidemias recommend lowering the intake of saturated fatty acids, trans fatty acids, cholesterol, total amount of dietary carbohydrates and mono- and poly-saccharides and increase dietary fiber, phytosterols, replace saturated fat with mono- or polyunsaturated fats, utilize supplements with n-3 polyunsaturated fat, utilize soy protein products and use alcohol with moderation [39].

Increasing the consumption of fruits and vegetables is an important part of dietary changes aimed at heart health. According to the EPIC Heart study, which followed 313,074 men and women, persons who consumed at least 8 portions (80g each) for a total of 640g of fruits and vegetables per day had 22% lower risk of fatal ischemic heart disease (IHD) compared with persons consuming less than three portions. After full analysis of data, it was determined that one portion (80g) increment was associated with a 4% lower risk of fatal IHD. [40]

Additional dietary modifications should include consuming low amounts of salt, maximum 5g per day and moderate alcohol consumption not to exceed 10-20g per day for women and 20-30 g per day for men. Persons with high triglyceride levels should avoid alcohol altogether [39].

Physical Activity

Physical Activity (PA) including manual work, exercise, and sports is generally very beneficial. It improves digestion and utilization of fat reserves, as well as the function of the vascular and respiratory systems. PA also contributes to release of tension and stress relief and in that way contributes to overall physical and mental health. PA should be done systematically and regularly [2]. Irregular, random PA does not offer the same benefits [7,37,38].

Education

Education is a necessary component of care for patients with MetS. Based on a systematic review, it has been found that psycho-educational rehabilitation had a significant positive

effect on levels of physical activity, but limited positive effect on dietary habits and smoking. No effect was found on physiological risk factors [42].

3.2.2. Pharmacotherapy

Treatment of Hypertension

The American Society for Hypertension [ASH] has issued updated guidelines for management of hypertension in 2014 [43]. European Society of Hypertension (ESH) and European Society of Cardiology (ESC) published their *Guidelines for the management of arterial hypertension* in 2013, an updated document to guidelines published in 2003 and 2007 [30,44]. The Czech Hypertension Society issued their guidelines in 2013 [45]. Based on finding of extensive studies which failed to prove the benefits of intensive BP lowering in patients with cardiovascular risk, the target BP recommendations were adjusted. The target BP in all patients with hypertension stays at 140/90 mmHg. In high risk patients, for example patients with diabetes or individual after a cardiovascular event or with renal disease, the target BP is around 130/80 mmHg and not less than 130/80 mmHg. In persons older than 65, it is possible to allow systolic BP under 150 mmHg provided that there are no significant comorbidities. In cases of diastolic BP < 70 mmHg it is necessary to adjust treatment individually. For disease prognosis, the BP achieved with treatment is more important than the initial BP levels [44,45].

Treatment of Diabetes Mellitus

Management of diabetes mellitus [DM] is one of the main components of care for patients with MetS. Current standards of care with patients with diabetes were published by the American Diabetes Association (ADA) 2013 [47]. The first choice treatment of DM is metformin administered together with lifestyle interventions. In case of insufficient compensation, oral anti-diabetic medication, incretins or insulin is then added to the treatment [47,48].

Treatment of Dyslipidemia

American College of Cardiology (ACC) and American Heart Association (AHA) issued updated guidelines for the treatment of dyslipidemia in 2013 [49]. In guidelines issued by the Czech Atherosclerosis Society, the international guidelines are modified to the Czech conditions [50]. Target lipid levels in patients with MetS are defined in the criteria for MetS. Preferred treatment is with statins and fibrates and additional combined treatment as needed [3,50].

3.2.3. Physical Activity as a Method of Prevention and Treatment

Physical activity leads to improvement of cardiovascular health and is an efficient method which may prevent or delay the development of MetS as well as support the treatment of the various risk factors.

Combination of lowered calorie intake and increased energy expenditure through regular and systematic exercise has been found to be an effective method to prevent or delay the development of MetS [51].

Physical Activity (PA) has an irreplacable position in the methods of both prevention and treatment of the so-called civilization diseases. Doctors are a respected source of health-related information for patients and their families and can provide continuous guidance related to PA to their patients. However, according to Lobela et al, in the US, only 34% of patients leave the doctor's office with the correct recommendations for PA. Research shows that doctors' own PA practices influence their clinical attitudes towards PA and doctors who exercise are better able to motivate their patients to do the same [52]. Similar results were published by Zapletalova et al. [53].

There are many myths and inaccuracies in recommending PA and physicians who are not fully educated on the subject may not give proper guidance to their patients. It is important for physicians to offer their patients a variety of PA options as this may increase the compliance of patients with the exercise recommendations [46].

Current Guidelines in the Czech Republic

In the Czech Republic, the currently used guidelines are the *Guidelines for the prevention of cardiovascular disease* from 2005. The recommendations included in these guidelines state as a goal to achieve at least 30 minutes of PA on most days of the week, although even lighter activity may lead to improvement in health. It is important to advise healthy individuals to choose enjoyable form of PA which they could easily incorporate in their daily lives. The PA should be 30-45 minutes long four or five times per week averaging at 60-75% of maximum heart rate [54].

European Guidelines

The original EU PA guidelines from 2008 [55] were superseded by the *Cardiovascular disease prevention guidelines in clinical practice* document published in 2012 by the European Society of Cardiology together with representatives of 9 different societies and other experts. According to this document, less than 50% of citizens of EU are involved in

regular aerobic activity. According to the guidelines, healthy adults should spend 2.5-5 hours per week doing physical activity or aerobic exercise training of at least moderate intensity (40–59% of VO2 or heart rate reserve, or at a rate of perceived exertion of 5–6 in the CR10 Borg scale), or 1-2.5 hours per week doing vigorous intensive exercise (at 60–85% of VO2 or heart rate reserve, or at a rate of perceived exertion of 7–8 in the CR10 Borg scale), or a combination of these.

This activity should be performed in multiple bouts each lasting 10 minutes or longer and should be evenly spread throughout the week, i.e. on 4-5 days a week. Examples of suitable physical activity include hiking, running or jogging, skating, cycling, rowing, swimming, cross-country skiing, and performing aerobic classes, and also lifestyle-common activities such as walking briskly, climbing stairs, doing more housework and gardening work, and engaging in active recreational pursuits [56].

American Guidelines

Guidelines published in America are the most thorough of all. The original recommendations published by the Center of Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) in 1995 can be considered as the foundation of guidelines on this subject. These guidelines state that, “Every US adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week.“ [57]

In 2007, a new document was published by the American Heart Association and the ACSM, which included updated recommendations based on new research [58]. The recommendations for persons aged 18-65 are summarized in Table No. 1. To promote and maintain health, all healthy adults 18-65 of age need moderate-intensity aerobic (endurance) physical activity for a minimum of 30 min on five days each week or vigorous-intensity aerobic physical activity for a minimum of 20 min on three days each week. Combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation. Moderate-intensity aerobic activity which noticeably accelerates the heart rate, such as brisk walk, can be accumulated toward the 30-min minimum by performing bouts each lasting 10 or more minutes. Vigorous-intensity activity, for example jogging, causes rapid breathing and a substantial increase in heart rate. In addition, every adult should perform activities that maintain or increase muscular strength and endurance a minimum of two days each week.

This recommended amount of aerobic activity is in addition to routine light intensity daily activities such as casual walking or shopping or in addition to activities lasting less than 10 min in duration such as walking around home or office, walking from the parking lot, etc.

Because of the dose-response relation between physical activity and health, persons who wish to further improve their personal fitness, reduce their risk for chronic diseases and disabilities or prevent unhealthy weight gain may benefit by exceeding the minimum recommended amounts of physical activity [58].

For adults over 65 years of age, the recommendations are similar, but with a few differences including: the recommended intensity of aerobic activity takes into account the older adult's aerobic fitness; activities that maintain or increase flexibility are recommended; and balance exercises are recommended for older adults at risk of falls [58-A].

The recommendations use MET (Metabolic Equivalent) minutes as a measurement of activity intensity. For example, a moderate-intensity walk at 3 mph for 30 minutes accumulates 99 METS (3.3 MET x 30 min = 99 MET minutes). To meet the minimum moderate-intensity recommendation by walking for 30 min at 3 mph on 5 days of the week, a person needs to accumulate about 495 MET minutes (99x5). Generally, a person needs to accumulate a minimum of 450-750 MET minutes weekly. Distribution of PA according to their intensity in MET units is in Table 2.

American College of Sports Medicine (ACSM) issued updated guidelines in 2011 as summarized in Table 3. These recommendations include flexibility and neuromotoric exercises in addition to standard physical activity and further increase PA recommendations to 500-1000 MET minutes per week. The guidelines also include detailed recommendations for muscle strengthening exercises as well as recommendations on exercise progression for persons with sedentary lifestyles just starting exercise [59].

Table 1. 2007 Recommendations of Physical Activity by ACSM/AHA

Type of Physical Activity	Intensity	Minimum Duration	Minimum Frequency	Example
Aerobic Activity	Moderate	30 min	5x per week	Brisk Walk
	Vigorous	20 min	3x per week	Jogging
	Combination of aerobic activity example	30 min of moderate activity 2x per week & 20 min of vigorous activity 2x per week for a total of 4 times per week		
Muscle Strengthening in addition to aerobic activity	8-12 repetitions of each exercise resulting in volitional fatigue		2x per week	Progressive weight training, weight bearing calisthenics, stair climbing, etc.

Table 2. Examples of MET equivalents of physical activities classified as light, moderate, or vigorous.

Light <3 MET	Moderate 3.0 – 6.0 MET	Vigorous >6.0 MET
Sitting – using computer = 1.5	Brisk walk = 3.3	Jogging at 5 mph = 8.0
Walking slowly around home =2	Heavy cleaning such as washing windows or vacuuming =3.0 - 3.5	Basketball game =8.0
Light work in standing position, washing dishes, ironing, store clerk, etc =2.0-2.5	Badminton =4.5	Bicycling on flat; moderate effort 12-16 mph =8.0-10.0
Leisure activity such as playing darts, arts and crafts, etc = 2.5	Bicycling – on flat: light effort = 6.0	Tennis singles =8.0
	Swimming leisurely =6.0	Competitive volleyball =8.0
	Table tennis =4.0	
	Tennis doubles =5.0	
	Volleyball noncompetitive =3.0-4.0	

Table 3. Cardiorespiratory Fitness Recommendations published by ACSM in 2011 [59]

Cardiorespiratory (aerobic) exercise	Frequency	≥5 day per week of moderate* intensity or ≥3 days/wk vigorous exercise ** or a combination of both on ≥3-5 days/wk
	Intensity	Moderate and/or vigorous is recommended for most adults
	Time	30-60 min per day (150 min per week) at a moderate intensity or 20-60 min per day (75 min per week) at a vigorous intensity or a combination of both
	Type	Regular, purposeful, continuous, rhythmic exercise involving the major muscle groups of the body
	Volume	Target volume of 500-1000 MET minutes per week and minimum step count of 7,000 steps per day, although exercising below these volumes may still be beneficial for persons unable or unwilling to reach this amount of exercise.
	Pattern	Exercise may be performed in one session per day or multiple sessions of 10 min or more to accumulate the desired duration and volume per day.
	Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity until the desired exercise goal is attained
Resistance exercise		
	Frequency	Each major muscle group should be trained on 2-3 days per week
	Intensity	60%-70% of the 1RM (one repetition maximal) (moderate to hard intensity) for novice through intermediate exercisers to improve strength. ≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers. 40-50% 1RM for older persons beginning exercise and for sedentary persons beginning resistance training. Less than 50% of the 1RM (light to moderate intensity) to improve muscular endurance.
	Type	Resistance exercises involving each major muscle group are recommended.
	Repetitions	8-12 repetitions is recommended to improve strength and power in most adults
	Sets	Two to 4 sets are recommended for most adults to improve strength and power
	Pattern	Rest intervals of 23 min between each set

		of repetitions are effective A rest of 48 hours or more between sessions for any single muscle group is recommended
Flexibility Exercise	Frequency	≥2-3 days per week is effective, daily exercise provides the greatest benefits
	Intensity	Stretch to the point of feeling tightness or slight discomfort
	Time	Holding a static stretch for 10-30 seconds is recommended for most adults.
	Type	Series of flexibility exercises for each of the major muscle-tendon units. Static flexibility, dynamic flexibility, ballistic flexibility and PNF are effective.
	Volume	60 seconds of total stretching time for each exercise
	Pattern	2-4 repetitions
Neuromotor exercise training	Frequency	≥2-3 days per week
	Time	>20-30 min per day
	Type	Exercises involving motor skills (e.g. balance, agility, coordination, and gait), proprioceptive exercise training, and multifaceted activities (e.g. tai-chi and yoga) are recommended for older persons.

3.2.4. Yoga as a Possible Way to Influence the Risk Factors of Metabolic Syndrome

Physical Activity is an inherent part of primary prevention which can influence the modifiable RF of CVD [61]. Yoga as a system of physical and breath exercises which can help improve overall health and well-being is one of the choices of physical activity. Yoga has been recommended for example in the European Guidelines on cardiovascular disease prevention in clinical practice prepared by the *European Guidelines on cardiovascular disease prevention in clinical practice (version 2012)* by the European Society of Cardiology and other societies [62]. Yoga is also recommended by the American College of Sports Medicine for its positive influence on health including the RF of CVD [57].

Overview of Yoga and Yogic Techniques

The meaning of the Sanskrit word Yoga is union, harmony, and balance. Yoga exercises are designed to harmonize the human body, mind and consciousness. It is believed that achieving inner balance promotes the natural healing and regeneration of the body and the organs [21,22,23,64].

In our study on the effectiveness of yoga exercises in prevention and treatment of metabolic syndrome, we chose yoga exercises and techniques according to the system Yoga in Daily Life™ [23]. The Yoga in Daily Life system was designed by Paramhans Swami Maheshwarananda in cooperation with doctors and physiotherapists to fulfill the needs for a holistic and comprehensive system of yoga exercises. The YIDL system is built on the principles of classical yoga and adapted to the needs of modern lifestyle. We have chosen the Yoga in Daily Life system for its authenticity and systematic progressive structure of classes safely leading practitioners from gentle to advanced techniques.

Yoga classes according to the Yoga in Daily Life system are taught by certified yoga teachers who are trained to safely guide practitioners through the asana practice including correct breathing. Each movement in the yoga class is harmonized with breath (pictures 9-13).

Picture 9. Instruction in Marjari asana (cat pose)

Picture 10. Instruction in Ashva Sanchalana Asana – Riding Posture

Picture 11. Ardha Matsyendrasana – Seated Twist Pose

Picture 12. Trikona Asana – Triangle Pose

Picture 13. Tada Asana (Palm Tree)

The Yoga in Daily Life system is based on holistic, traditional yoga techniques which include the following:

1. Asanas (the physical postures and movements)
2. Pranayama(breathing exercises)
3. Hatha Yoga Kriyas (purification techniques)
4. Dhyana (concentration and meditation techniques)
5. Deep Relaxation

In the Yoga in Daily life system, the yoga session begins with relaxation, which releases tension from the body and mind and results in a subjective state of relaxation. The deep relaxation as taught in yoga classes has been found to lower the sympathetic tonus [23-A]. The yoga session then continues with the practice of asanas, yoga postures and movements, which include both dynamical movements as well as postures which are held for a longer period of time. The yoga session ends with a breathing exercise and concentration/meditation technique [23].

The Yoga in Daily Life system includes asanas designed to support all the systems of the body. There are asanas supporting the function of the cardiovascular system, for example the Khatu Pranam (Picture 1), a dynamic sequence of 20 postures. There are asanas which support the digestive system, such as the Vyaghrasana (Picture 2) and Kati Asana (Picture 3), as well as asanas supporting the kidney function, such as Vyaghrasana (Picture 2) and Hansa Asana (Picture 4).

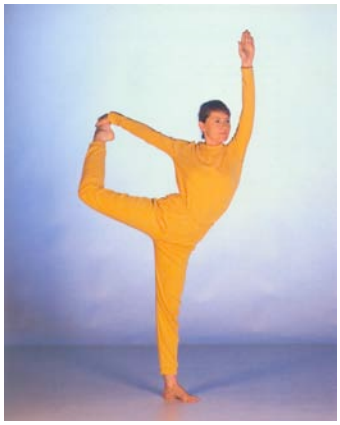
Picture 1. Khatu Pranam [Yoga in Daily Life: The System, 2000]

Picture 2. Vyaghrasana – Tiger [Yoga in Daily Life: The System, 2000]

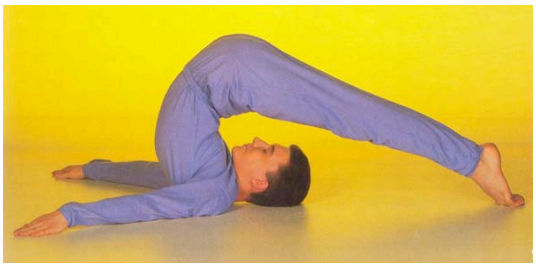
Yoga in Daily Life includes many postures designed to help relieve back pain and improve flexibility of the spinal column. Examples of postures which can contribute to spinal health are Vyaghrasana, Kati Asana, Hansa Asana, Hal asana and Marjari asana [Picture 2,3,4,5 and 9, respectively].

Picture 3. Kati Asana – Twist in Knee-Stand
[Yoga in Daily Life: The System, 2000]

Picture 4 - Hansa Asana – The Swan [Yoga in Daily Life: The System, 2000]



Picture 5. Hala Asana – The Plough [Yoga in Daily Life: The System, 2000]



Research shows that the practice of yoga postures can improve the quality of our breath and increase the vital capacity of the lungs. [21-A]. In addition to yoga postures, yoga offers relaxation and breath techniques which help to regulate breath and improve the function of the lungs [22]. The basis of all yogic breath techniques is deep abdominal breathing. The abdominal breathing, also known as diaphragmatic breathing, "encourages full oxygen exchange, slows the heartbeat and can lower or stabilize blood pressure" [22-A], it reduces postprandial oxidative stress [22-B], and increases the activity of parasympathetic nervous system, facilitating full relaxation [22-C]. This technique offers practitioners an opportunity to correct patterns of habitual chest or collar bone breathing and create a new, healthier, pattern of breathing.

The abdominal breathing is the foundation of the *full yogic breath*, a combination of abdominal, thoracic, and clavicular breathing, which improves the utilization of the lung capacity to an even greater extent.

There are a number of breath exercises in yoga. One of the main yogic breathing techniques is the alternate nostril breathing, also known as nadi shodhana. The practice of alternate nostril breathing has been shown to decrease blood pressure and harmonize cardiorespiratory function and autonomic system activity [21-B,C,D].

Picture 6. Pranayama – breath exercise [Yoga in Daily Life: The System, 2000]

Traditional techniques of Hatha Yoga include six purification techniques called the Hatha Yoga Kriyas. These techniques are designed for purification and removal of waste materials from the body. The easiest and most widely practiced is the practice of Neti – purification of the nose using a saline solution. This technique is commonly recommended by alergologists. Neti purifies the nasal cavities and helps prevent infection in the sinuses as well as improve the symptoms of hay fever. It is also believed to positively influence all the sense organs in the head (Picture 7) [21,22,23].

Picture 7. Neti – Purification of the sinuses using saline solution
[Yoga in Daily Life: The System, 2000]

Meditation techniques facilitate the achievement of inner equilibrium and harmonize the autonomic nervous system (Picture 8) [21,22].

Picture 8. Dhyana – meditation [Yoga in Daily Life: The System]

The above mentioned yogic methods are believed to harmonize all of the functions of the body, mind, and consciousness [7,38,70,71].

Scientific research suggests that regular yoga practice has positive effect on human health. Regular practice of yoga may help lower blood pressure [2,64,65,66], improve the lipid profile, correct hyperglycemia [67,68] and support weight loss [69].

According to Akhtar et al. „Yoga has proven beneficial effects on various health domains including musculoskeletal conditions, cardiopulmonary conditions through the practice of asana and pranayamas as well as on mental health, as it is known to enhance the body-and mind coordination.“ According to this study: “Yoga practices are beneficial in improving the functional capacity in young healthy adults. Yoga can very well be incorporated in medical practice for increasing the patient's functional capacity, for those who have limitations in performing aerobic training due to various health reasons. The improved state of well being motivates the patients to adhere to yogic practices.“ Akhtar et al. [72]

Innes et al. [67] conducted a systematic review of the possible benefits of yoga on the risk factors of CDV and metabolic syndrome. Their review of 70 studies indicated that “yoga may be instrumental in improving core indices of the IRS, including glucose tolerance and insulin sensitivity, lipid profiles, anthropometric characteristics, and blood pressure in both healthy populations and those with chronic IRS-related condition“. Their findings also suggests that yoga “May reduce sympathetic activation and enhance cardiovagal function, factors strongly associated with both IRS [Insulin Resistance Syndrome] and CVD risk“. Additionally, the findings suggest that yoga “may be useful in the management of CVD and related conditions and in the prevention of CVD in those at risk.“ The authors also concluded that more high quality studies need to be conducted to confirm these results.

Additional studies support these findings [69,73,74].

Ray et al [71] conducted a study to observe the energy expenditure, exercise intensity and respiratory changes during yoga practice. They measured oxygen consumption ($VO_{2)}$, carbon dioxide output ($VCO_{2)}$, pulmonary ventilation ($V_{E)}$, breath frequency (BF) and tidal volume (VT). These values were measured during a practice performed by 20 yoga instructors (age 27.3 ± 3.5 years, height 166.6 ± 5.4 cm and body weight 58.8 ± 9.6 kg) and included 16 yoga postures, 5 types of breath exercises and two types of meditations. The exercise intensity during asana practice was expressed as a percentage of VO_2max. The asana exercise intensity varied from 9.9 – 26.5% VO_2max. The highest energy expenditure was 3.02 kcal/min^{-1}. During breath exercises, the maximum pulmonary ventilation was 53.7 ± 15.5 l min^{-1} and tidal volume was 0.97 ± 0.59, 1.41 ± 1.27 and 1.28 ± l/breath with corresponding respiratory frequency of 14.0 ± 5.3, 10.0 ± 6.35, 10.0 ± 5.8 breaths/min.

The average energy expenditure during asana, breath, and meditation practice was 2.29, 1.91 and 1.37 kcal min^{-1}, respectively. Metabolic rate was generally in the range of 1-2 metabolic equivalents (MET) except during the practice of 3 asanas where it was >2 MET.

VO_2 was was 0.27 ± 0.05 and 0.24 ± 0.04 l min^{-1} in meditation and Shavasana, a relaxation position, respectively.

The authors concluded that: "Although yogic practices are low intensity exercises within lactate threshold, physical performance improvement is possible owing to both better economy of breathing by BM and also by improvement in cardiovascular reserve. Other factors such as psycho-physiological and better relaxation may contribute to it." Figure 1 shows the exercises used in the study and Figure 2 shows the possible mechanisms responsible for physical performance improvement by yoga. [71]

Figure 1. The various yoga postures as practiced by the subjects during a full yoga session in the study by Ray et. al. [71]

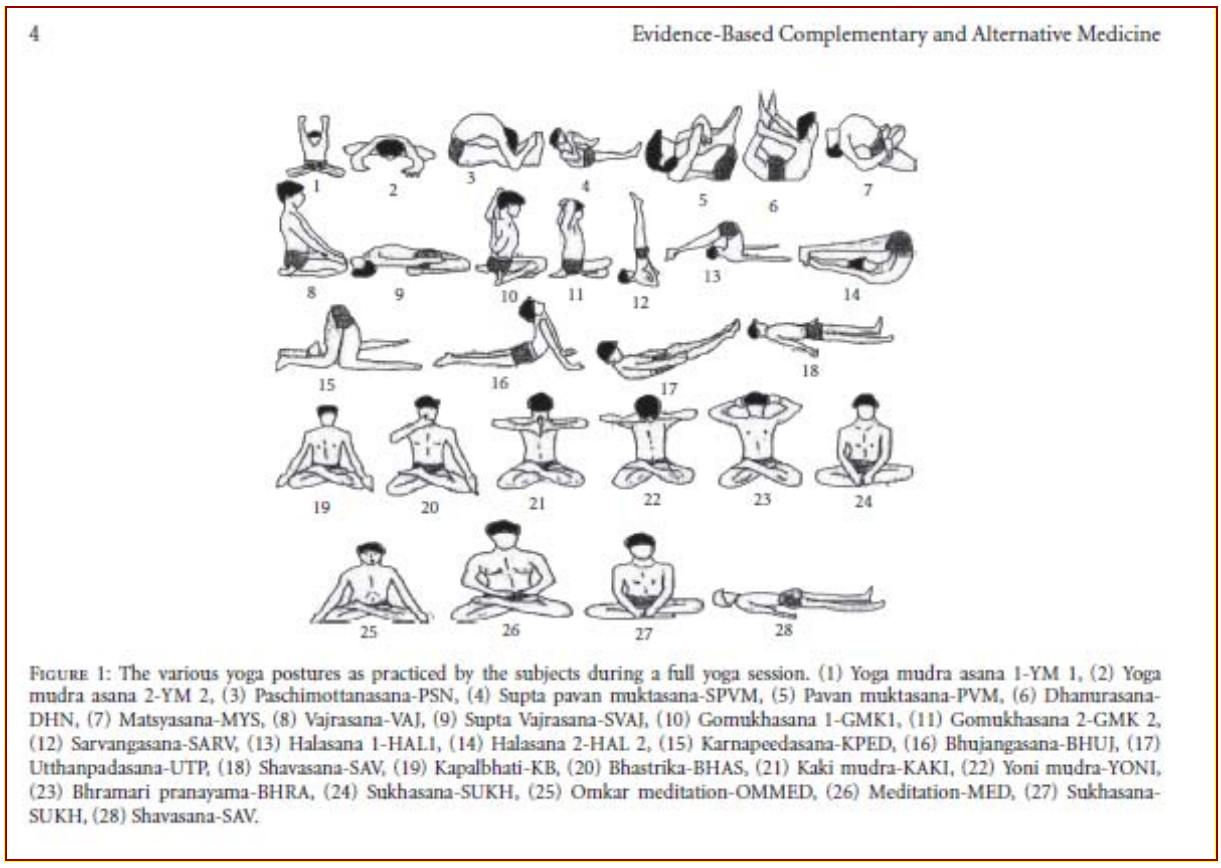
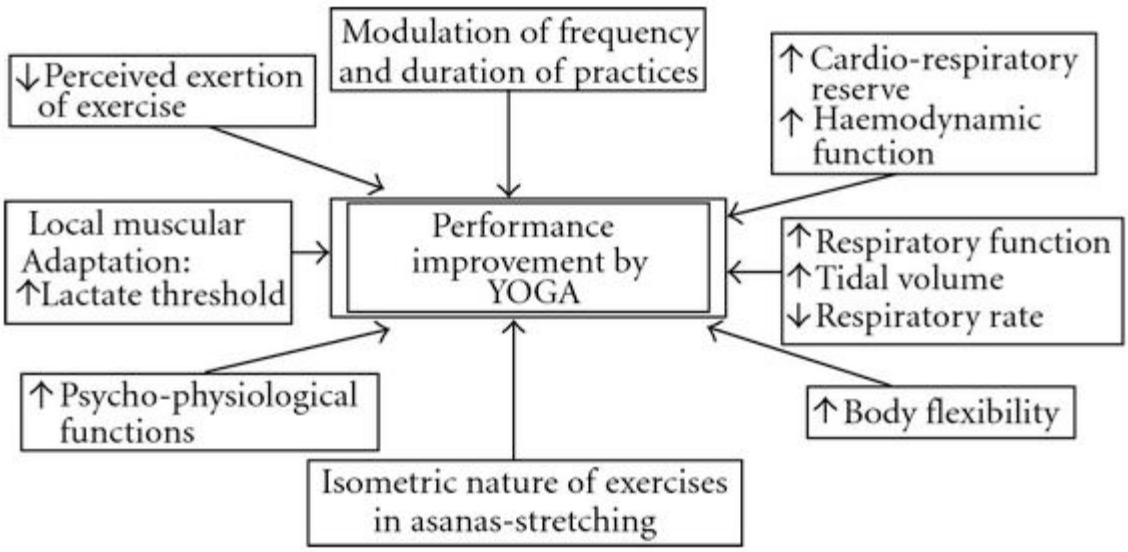


FIGURE 1: The various yoga postures as practiced by the subjects during a full yoga session. (1) Yoga mudra asana 1-YM 1, (2) Yoga mudra asana 2-YM 2, (3) Paschimottanasana-PSN, (4) Supta pavan muktasana-SPVM, (5) Pavan muktasana-PVM, (6) Dhanurasana-DHN, (7) Matsyasana-MYS, (8) Vajrasana-VAJ, (9) Supta Vajrasana-SVAJ, (10) Gomukhasana 1-GMK1, (11) Gomukhasana 2-GMK 2, (12) Sarvangasana-SARV, (13) Halasana 1-HAL1, (14) Halasana 2-HAL 2, (15) Karnapeedasana-KPED, (16) Bhujangasana-BHUJ, (17) Utthanpadasana-UTP, (18) Shavasana-SAV, (19) Kapalbhati-KB, (20) Bhastrika-BHAS, (21) Kaki mudra-KAKI, (22) Yoni mudra-YONI, (23) Bhramari pranayama-BHRA, (24) Sukhasana-SUKH, (25) Omkar meditation-OMMED, (26) Meditation-MED, (27) Sukhasana-SUKH, (28) Shavasana-SAV.

Figure 2. Possible factors responsible for physical performance improvement by yoga though it is low to moderate intensity of exercise in terms of % VO2max, energy cost, MET and Percent MHR as observed in this study. Ray et al. [71]



4. Subjects, Methods, and Results

4.1. Subjects and Methods

In the year 2010, we examined 58 persons at the Department of Preventative Cardiology of the First Internal Clinic as well as at the Sports Education Clinic. Out of the 58 persons, 17 were men and 41 were women in the age range 26 – 68 years (mean 46.6 ± 11.5). The participants in the yoga group had been practicing yoga for a minimum of 2 years (ranging from 2-24 years with mean at 10.2 ± 7.5) on a daily basis for at least an hour per day, according to the system Yoga in Daily Life [23].

The control group was selected out of larger samples obtained from previously published studies. The control group was counter-matched to the yoga group for age and sex.

4.2. Statistical Analysis

The categorical parameters were compared using the chi-square test or, where the sample number was small, Fisher's exact test. The quantitative data was compared using the Mann-Whitney U-test or Student's t-test depending on data distribution. To verify normal distribution of data, we used the Shapiro-Wilk test.

4.3. Results

4.3.1. Presence of Risk Factors of Cardiovascular Disease in Yoga Practitioners in Comparison with General Population

This section contains a summary of a previously published study [25-A]. Results of the yoga group (Y) were compared with results of the control group representing general population (GP1). The control group consisted of 58 persons, 17 men and 41 women ages 28 - 65 (mean age 43.6 ± 8.3), who were employees of the Olomouc University Hospital. Our control group was selected out of a larger sample from a previously published study [76] which had measured the occurrence of RF CVD in the University Hospital employees.

We measured anthropometric parameters (BMI, abdominal circumference), as well as clinical (BP) and biochemical (lipid profile and blood glucose, insulin, urea, C reactive

protein, interleukin 6, and fibrinogen levels) parameters focusing on indicators of cardiovascular diseases and metabolic syndrome.

Table 4 shows the results of measurements in the yoga group and Table 5 shows comparison between the yoga and GP1 groups.

There was a difference in the number of smokers between the groups. There were 2 smokers in the yoga group and 14 smokers in the GP1 group. There were 6 former smokers in the yoga group and out of these, 4 stopped smoking after beginning their yoga practice. Information about former smokers is not available in the control group.

The Yoga group had significantly lower levels of triglycerides (median 0.86) compared to the control group (median 1.10), P = 0.003, see Chart 1.

The Yoga group had normal BMI (median 22.75) and the BMI of the Yoga group was significantly lower than the BMI of the GP1 group (median 24.40), P = 0.008. See Chart 2.

The median total cholesterol and HDL and LDL cholesterol levels were 4.92, 1.52, and 2.94 in the Yoga group, respectively, and 5.20, 1.65, and 3.05 in the control group, respectively. The differences between the groups were not statistically significant (P = 0.345, P = 0.953, P = 0.684, respectively)

The YIDL group had significantly lower SBP and DBP (median 115/80, mean 117/74) in comparison with the control group (median 120/80, mean 125/78), SBP, P = 0.011, DBP, P = 0.033. See chart 3 and 4.

The median abdominal circumference in men in the YIDL group was 84 cm in men and 77cm in women and the measurements were below the risk for CVD. Abdominal circumference measurements were not made in the control group.

Table 4. Anthropometric and biochemical indicators of cardiovascular diseases and metabolic syndrome in the yoga group.

Parameters – YIDL group	Total Participants - 58 Median Mean ±SD	Men - 17 Median Mean ±SD	Women - 41 Median Mean ±SD
Age	45.0 46.6±11.5	44.0 45.2±8.3	49.0 47.2±12.6
Height (cm)	170.0 170.7 ±9.0	179.0 180.4±7.3	168.0 166.7±6.1
Weight (kg)	67.0 67.7 ±11.6	73.0 76.2±12.4	62.0 64.2±6.1
Abdominal Circumference (cm)	80.0 80.0±9.4	84.0 84.1±9.9	77.0 78.3±8.7
BMI	22.8 23.2±3.2	22.8 23.3±2.5	22.0 23.1±3.5
SBP (mmHg)	115.0 117.1±18.4	110.0 115.3±17.1	115.0 117.8±19.0
DBP (mmHg)	80.0 74.4±11.6	80.0 74.4±8.3	70.0 74.4±12.8
Total Cholesterol (mmol/l)	4.92 5.11±1.10	4.48 4.59±0.73	5.38 5.32±1.16
HDL Cholesterol (mmol/l)	1.52 1.61±0.41	1.37 1.32±0.21	1.72 1.73±0.42
LDL Cholesterol (mmol/l)	2.94 3.06±0.87	2.76 2.87±0.57	3.07 3.14±0.96
Index CH/HDL	3.17 3.31±0.90	3.43 3.57±0.53	2.99 3.21±0.99
Uric Acid (umol/l)	258.5 264.1±57.6	299.0 304.0±47.7	239.0 247.6±53.5
CRP (mg/l)*	0.65 1.37±1.84	0.40 0.49±0.26	0.90 1.73±2.09
Triglycerides (mmol/l)	0.86 0.93 ±0.41	0.86 0.90±0.34	0.86 0.95±0.44
Apolipoprotein A I (g/l)	1.59 1.58±0.39	1.44 1.27±0.36	1.72 1.71±0.33
Apolipoprotein B (g/l)	0.80 0.80±0.24	0.77 0.72±0.24	0.81 0.83±0.24
Lipoprotein (a) (g/l)	0.132 0.203±0.220	0.095 0.172±0.223	0.142 0.216±0.220
Blood Glucose (mmol/l)	4.90 4.97±0.65	4.90 4.85±0.39	4.90 5.02±0.73
Insulin (mlU/l)	3.20 4.49±3.30	2.00 3.09±1.93	4.50 5.07±3.58
Fibrinogen (g/l)	2.55 2.59±0.43	2.47 2.39±0.39	2.67 2.68±0.42
Interleukin – 6 (mg/l)	2.55 3.18±5.77	2.10 2.25±1.32	2.60 3.57±6.80

CRP = C-reactive protein

Table 5. Comparison between Y and GP1 Groups - Main Parameters

Parameters	Y group 58 Participants Median Mean ±SD	GP Group 58 Participants Median Mean ±SD	Statistical Comparison (P)
Smokers (%)	3.5	21.4	P = 0.0005
BMI	22.75 23.20±3.22	24.40 25.49±5.33	P = 0.008
BP – Systolic (mmHg)	115 117.1±18.4	120 125.4±17.3	P = 0.011
BP - Diastolic (mmHg)	80 74.4±11.6	80 78.1±11.0	P = 0.033
Total Cholesterol (mmol/l)	4.92 5.11±1.10	5.20 5.26±0.94	P = 0.345
HDL Cholesterol (mmol/l)	1.52 1.61±0.41	1.65 1.64±0.39	P = 0.953
LDL Cholesterol (mmol/l)	2.94 3.06±0.87	3.05 3.06±0.88	P = 0.684
Triglycerides (mmol/l)	0.86 0.93±0.41	1.10 1.24±0.72	P = 0.003

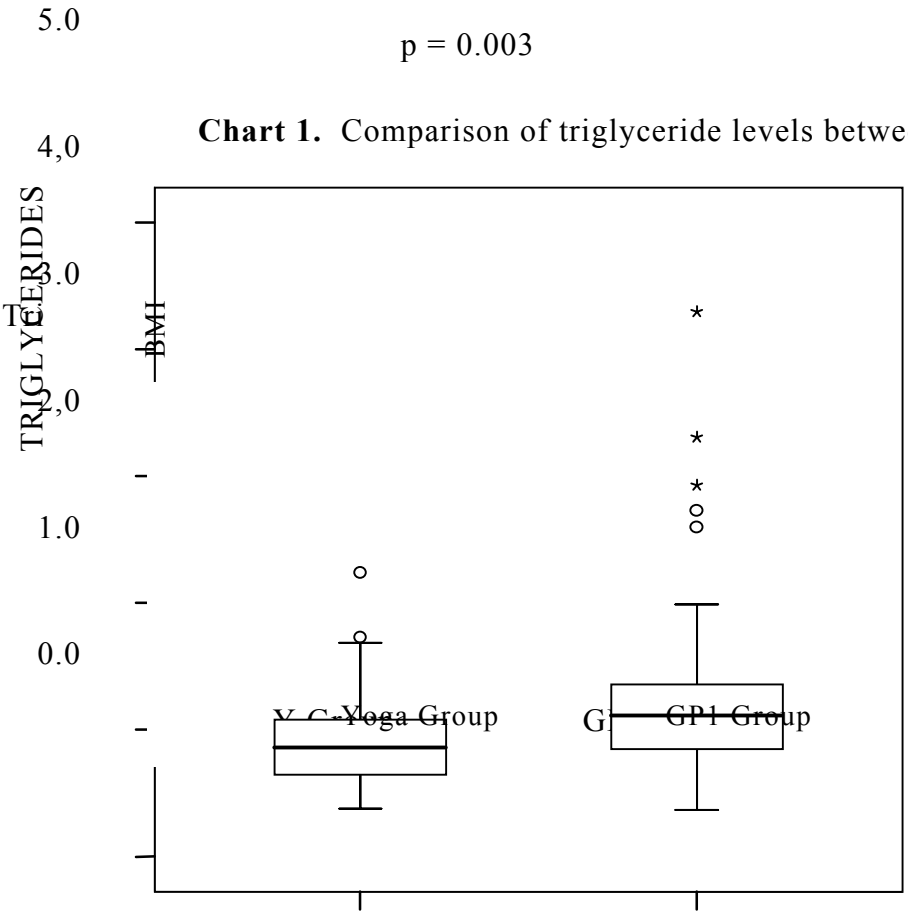


Chart 1. Comparison of triglyceride levels between Y and GP1 groups

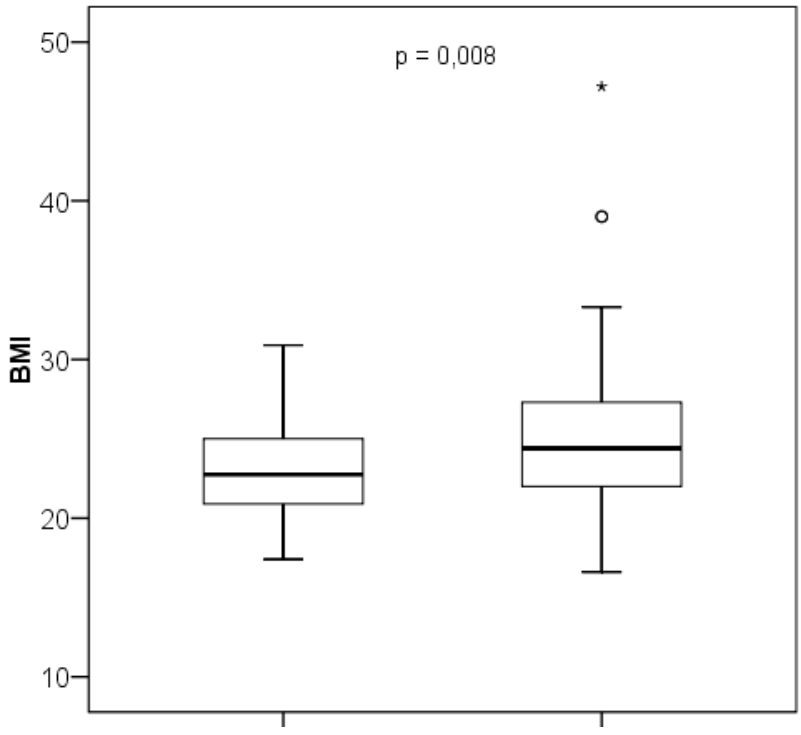


Chart 2. Comparison of BMI between Y and GP1 groups

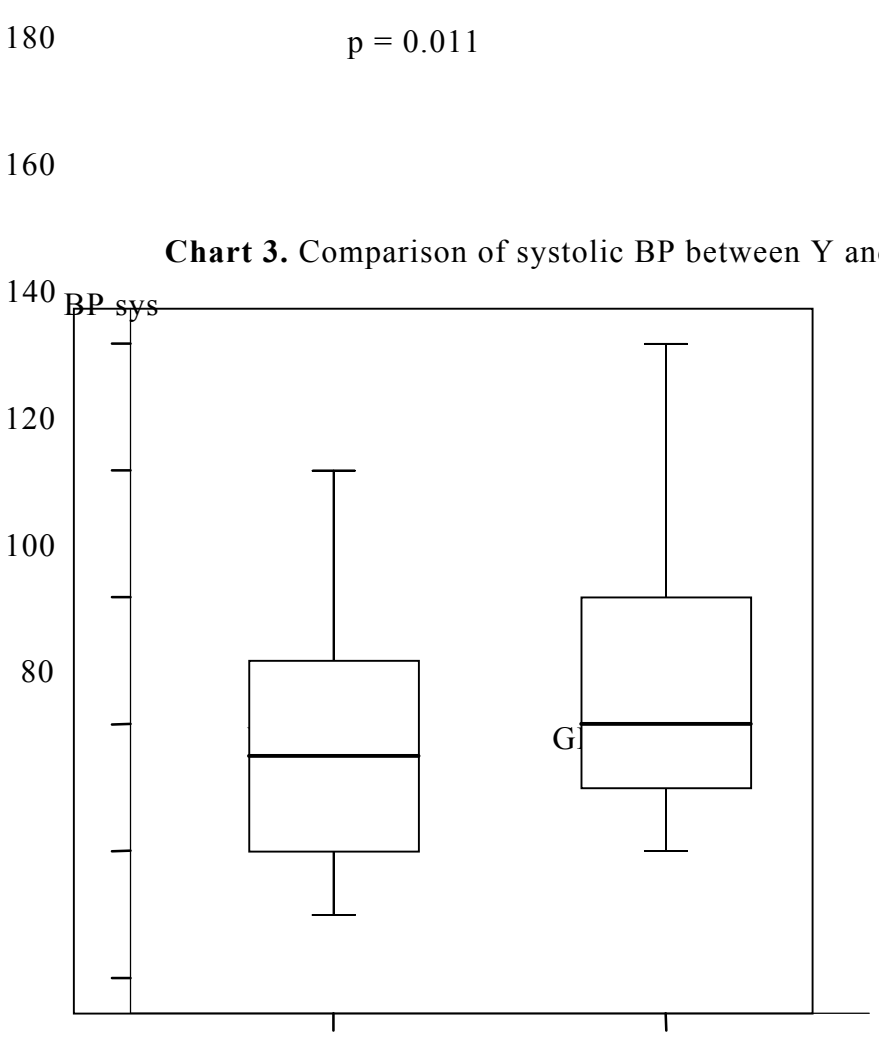


Chart 3. Comparison of systolic BP between Y and GP1 groups

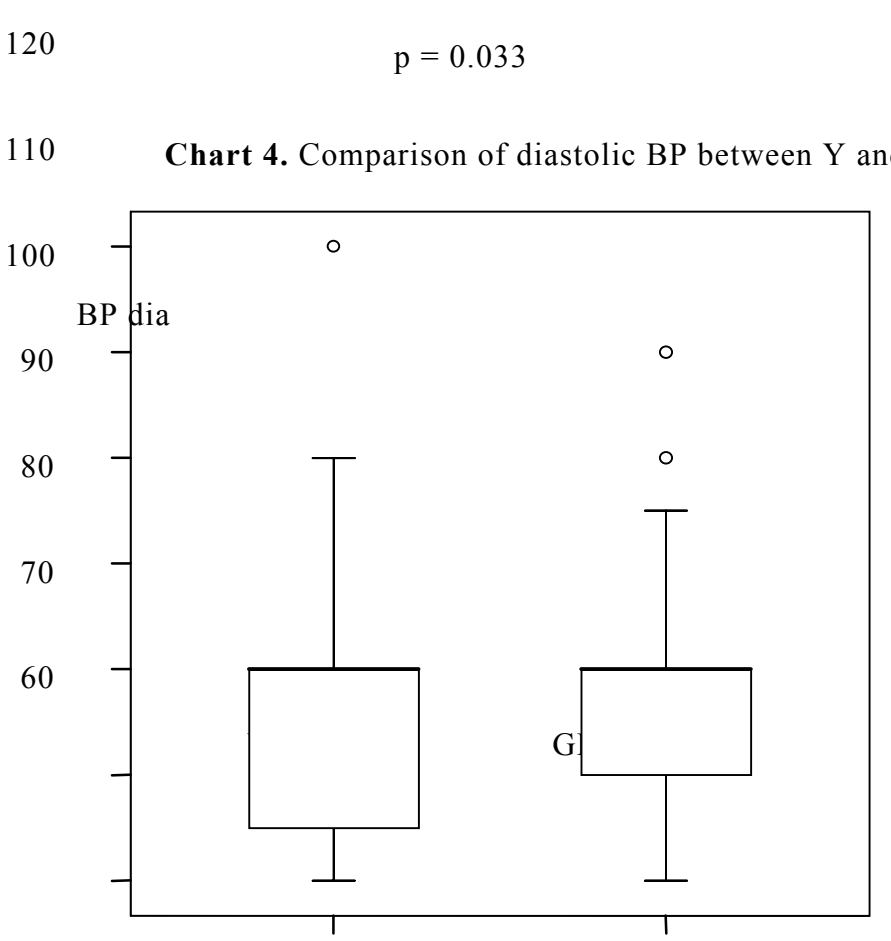


Chart 4. Comparison of diastolic BP between Y and BP1 groups

4.3.2. Yoga and Metabolic and Homeostatic Parameters of Insulin Resistance.

This section contains a summary of a previously published study [25-B]. Results of yoga group were compared with GP2 Group which consisted of 58 persons (41 women and 17 men, mean age 50.93 ± SD 9.58) without clinical or metabolic signs of insulin resistance and the subjects were selected out of larger group of patients monitored by physicians in a previous study [76] by a method of counter-matching.

We measured anthropometric parameters (BMI), blood pressure, total cholesterol, triglycerides, HDL and LDL cholesterol, blood glucose, and insulin. Blood glucose and insulin concentration were used to calculate HOMA-IR and QUICKI.

HOMA-IR was calculated according to the homeostatic mode [77,79,80] as HOMA IR = fasting insulin (IU/ml) x fasting blood glucose (mmol/l)/ 22.5.

QUICKI was calculated according to formula:

QUICKI = 1 / [log fasting insulin (IU/ml) + log fasting blood glucose (mmol/l) x 18.182

Statistical evaluation was done using Statistics software, version 6.0, for
mean, median and standard deviation analysis. T-test was calculated to determine the statistical significance ($p < 0.05$) of clinical and biochemical characteristics.

Results:

Table 6 shows results of GP2 versus Y.

Table 7 shows a comparison of parameters where differences between the two groups were statistically significant.

Table 8 shows a comparison of statistically significant parameters between the groups based on sex.

Table 6. Results of examination in the groups GP2 and Y [2012 Pastucha et al. 25-B]

	N	Average	95% Confidence limit		Median	Min	Max	SD
SYSTOL BP	58	118.68	113.92	123.45	120.00	90.00	160.00	18.61
DIASTOL BP	58	74.75	71.83	77.67	80.00	60.00	120.00	11.4
GLY (mmol/l)	58	5.02	4.86	5.19	4.90	4.10	8.80	0.65
HDL (mmol/l)	58	1.60	1.50	1.70	1.52	0.82	2.95	0.39
LDL (mmol/l)	58	3.12	2.90	3.33	3.07	1.79	5.87	0.83
BMI (kg/m2)	58	23.11	22.32	23.90	22.70	17.40	30.90	3.08
INZULIN (mlU/l)	58	4.53	3.66	5.40	3.20	2.00	19.80	3.39
Quicki	58	0.40	0.38	0.41	0.39	0.30	0.46	0.04
HOMA_IR	58	1.03	0.81	1.24	0.78	0.36	4.92	0.84
Age at examination	58	48.62	45.65	51.59	48.00	26.00	68.00	11.60
SYSTOL	58	125.08	121.28	128.88	125.00	95.00	170.00	14.31
DIASTOL	58	76.31	73.66	78.96	75.00	60.00	110.00	9.97
GLY (mmol/l)	58	5.18	5.06	5.31	5.10	4.30	6.40	0.45
HDL (mmol/l)	58	1.68	1.59	1.77	1.70	1.08	2.47	0.34
LDL (mmol/l)	58	3.23	3.07	3.38	3.30	1.30	4.26	0.58
BMI (kg/m2)	58	24.42	23.75	25.09	24.44	19.03	29.32	2.52
INZULIN (mlU/l)	58	8.57	7.34	9.80	7.70	2.20	22.10	4.59
Quicki	58	0.35	0.34	0.36	0.34	0.29	0.44	0.03
HOMA_IR	58	2.01	1.69	2.33	1.81	0.43	5.83	1.19
Age at examination	58	50.92	48.38	53.47	54.00	22.00	63.00	9.58

Table 8. Comparison of statistical significance of individual parameters in GP2 and Y groups based on gender [2012 Pastucha et al. 25-B]

	Men			Women		
	N (A)	N (B)	p-value (Mann-Whitney)	N (A)	N (B)	p-value (Mann-Whitney)
SYSTOL BP	18	18	0.043543	39	43	0.218130
DIASTOL BP	18	18	0.742798	39	43	0.287289
GLY	18	18	0.050859	39	43	0.121413
HDL	18	18	0.481230	39	43	0.517727
LDL	18	18	0.008714	39	43	0.904451
BMI	18	18	0.007105	39	43	0.068615
INZULIN	18	18	p<10-6	39	43	0.000300
Quicki	18	18	p<10-6	39	43	0.000336
HOMA_IR	18	18	p<10-6	39	43	0.000336

The Yoga group demonstrated significantly lower value of systolic blood pressure, serum insulin, both homeostatic indicators HOMA-IR and QUICKI, BMI, and serum glucose.

We also compared the individual parameters in both groups separately for men and women. Comparing men from both groups, the Yoga group had significantly lower BMI,

systolic blood pressure, insulinemia, LDL cholesterol and both homeostatic indices HOMA-IR and QUICKI.

Comparing women from both groups, we found in the Yoga group a significantly lower insulinemia and significant difference in both homeostatic indices HOMA-IR and QUICKI; however, we did not find a significant difference in systolic blood pressure, LDL cholesterol and BM; therefore, the results of the women's groups' comparison differed from that of the men's.

4.3.3. Yoga and Lifestyle

Control group GP3 consisted of 58 persons, out of which 17 were men and 41 women ages 28 – 65 (mean age 52.9 ± 10.6). The participants were included in the study by a method of counter-matching for age and sex from a database of patients in the author's general physician's practice in Novy Malin. The participants in both groups filled out a Lifestyle Questionnaire by Kudlova (Appendix 1) which had been approved by the Ethical Commission of the Faculty of Medicine Palacky University and the University Hospital.

The questionnaire included questions pertaining to basic (lifestyle related) risk factors of CVD, anthropometric parameters, and lifestyle and dietary habits.

Results

The results are shown in Tables 9 - 12.

Table 9. Anthropometric parameters – Comparison of yoga and GP3 Groups

Parameters	Yoga Group N = 58 Median Mean ±SD	BP3 Group N= 58 Median Mean ±SD	Statistical Comparison (P)
Age (years)	46.5 46.6 ± 12.8	55.0 52.9 ±12.8	P = 0.004
Body weight(kg) - men	68.8 69.3±11.8	78.0 79.9±15.8	P = 0.003
Body weight(kg) - women	63.0 65.8±10.3	74.0 75.6±14.5	P = 0.002
Body weight(kg) - whole group	74.0 77.3±10.8	85.5 90.3±14.3	P < 0.0001
BMI - men	23.0 23.6±3.3	28.3 28.2±4.8	P < 0.001
BMI - women	22.6 23.5±3.5	28.3 28.2±5.2	P = 0.003
BMI - whole group	23.5 23.9±2.5	27.9 28.3±3.8	P < 0.0001
Height (cm) - men	170.5 171±8.6	168.0 168.2±9.2	P = 0.730
Height (cm) - women	168.0 167.2±6.2	165.0 163.8±6.0	P = 0.010
Height (cm) - whole group	178.5 179.4±7.1	180.0 178.6±6.4	P = 0.037

Table 10. Dietary habits – comparison of Yoga and GP3 Groups

Parameters	Yoga Group N = 58 Consumption in %	GP 3 Group N = 58 Consumption in %	Statistical comparison (P)
Butter	80.6 %	59.0 %	P = 0.007
Lard	5.6	37.7	P < 0.0001
Vegetable Oil	86.1	77.0	P = 0.176
Vegetable Shortening	54.2	65.6	P = 0.182
Sugar Free Drinks	91.7	75.4	P = 0.010
Fruit Juice	16.7	4.9	P = 0.033
Soft Drinks with Sugar	9.7	32.8	P = 0.0001
Coffee	36.1	77.0	P < 0.0001
Alcohol	6.9	21.3	P = 0.016
Black Tea	40.3	29.5	P = 0.195
Herbal or Fruit Teas	77.8	78.7	P = 0.899
Milk	55.6	55.7	P = 0.983
Beer	24.6	36.1	P = 0.229
Wine	16.7	26.2	P = 0.178
Vegetables	77.9	14.8	P < 0.0001
Fruits	34.3	27.9	P = 0.128
Whole Grain Bread	23.9	13.3	P = 0.014
Legumes	18.3	1.8	P = 0.009
Fried Food	1.4	13.8	P = 0.026
White Flour Bakery	5.7	25.4	P = 0.004
Sweet Bakery	5.6	19.7	P = 0.041

Table 11. Dietary habits – comparison of yoga and GP3 groups

Parameters	Yoga Group N = 58 **Not** Consumed (in %)	GP3 Group N = 58 **Not** Consumed (in %)	Statistical Comparison
Red Meat	55.9	3.4	P < 0.0001
Entrails	71.9	23.6	P < 0.0001
White Meat	55.9	0	P < 0.0001
Fish	51.5	0	P < 0.0001
Sausages	61.2	5.1	P < 0.0001
Eggs	43.3	1.6	P < 0.0001
Dumplings	20.8	6.8	P < 0.0001
Canned Food	65.7	35.7	P < 0.0001

Table 12. Lifestyle habits comparison between yoga and GP3 groups

Parameters	Yoga Group N = 58 %	GP3 Group N = 58 %	Statistical Comparison (P)
Did not change dietary habits in past 10 years	56.7	52.2	P = 0.860
Food allergies	26.2	38.3	P = 0.145
Maintains stable weight	56.9	53.3	P = 0.064
Considers his/her diet as healthy	60.9	30.0	P = 0.002
Would like to eat healthier	85.3	77.6	P = 0.175
Would like to eat healthier but does not know how	4.5	19.7	P = 0.006
Would like to eat healthier but there are other obstacles	0	16.7	P = 0.0004
Uses food supplements	34.8	32.2	P = 0.755
Smoker	3.5	24.6	P < 0.0001
Recreational physical activity	93.1	62.5	P < 0.0001

The participants in the yoga group had significantly (P < 0.0001) lower body weight, BMI, consumption of red and white meat, fish, sausages, entrails, lard, eggs, dumplings, canned and fried food, and coffee, as well as lower number of smokers and a higher number of former smokers. The yoga group had lower (P=0.016) consumption of liquor. The yoga group had significantly higher (P< 0.0001) consumption of vegetables and physical activity. The Y group also had a higher, but without statistical significance, consumption of legumes (P= 0.009) and whole grain bread (P=0.014).

4.3.4. Yoga and Body Composition

We measured body composition parameters in the yoga group. The results were compared to a norm determined in a project called “Live Healthy” organized by the General Medical Insurance Co. of the Czech Republic (VZP CR) and conducted by STEM/MARK company in 2013 [82] as well as with the results of the European Health Interview Survey in the Czech Republic EHIS 2008 [83].

In the yoga group, we conducted basic physical exam and measured anthropometric parameters (weight, height) out of which we calculated BMI (weight in kg divided by height in m^2). BMI was divided into 3 categories: BMI <25 normal weight, BMI≥ 25 <30 overweight, BMI≥30 obesity.

We used the BodyStat 1500 MDD device for analysis of body composition by measuring the bioelectrical impedance of the body. We measured the following parameters: body fat

mass (BFM) in kg and percents, fat free mass (FFM) in kg and percents, fat free mass – water free - in kg and percents, total body water in liters and percents. [84].

Statistical analysis was made using software SPSS, version 15 (SPSS Inc., USA). We used Fisher's exact text for analysis of male/female distribution based on BodyStat norms for weight, BFM, FFM and body water. We used 95% confidence interval to compare our results with the results of STEM/MARK 2013 and EHIS 2008 studies.

Table 13 shows the descriptive characteristics of parameters measured using BodyStat separately for men and women in the group. Due to the abnormal distribution of data for some of the parameters, we included, in addition to the mean values, also the medians which express more accurately the average data values.

Table 13. Body Composition parameters in the yoga group

	Men (N = 17)	Women (N = 41)
Body weight(kg)	75.0 ± 14.2 72.6 (53.6 - 117.3)	63.1 ± 9.1 63.0 (45.4 - 88.0)
BMI	23.3±2.5	23.1±3.5
BFM (kg)	13.6 ± 5.6 12.7 (4.9 - 30.6)	18.5 ± 6.3 17.1 (7.3 - 34.2)
BFM (%)	17.8 ± 5.0 16.9 (7.7 - 27.3)	29.0 ± 7.1 28.5 (14.8 - 44.3)
FFM (kg)	57.0 ± 17.9 59.6 (1.8 - 86.7)	44.6 ± 6.0 44.2 (30.5 - 57.7)
FFM (%)	82.2 ± 5.0 83.2 (72.7-92.3)	71.0 ± 7.1 71.5 (55.7-85.2)
Body Water (l)	45.2 ± 6.3 44.4 (34.8 - 60.5)	34.3 ± 4.7 34.1 (27.0 - 52.4)
Body Water (%)	60.8 ± 4.7 60.8 (51.6 - 69.5)	54.4 ± 5.2 55.4 (43.8 - 68.0)
FFM – Water Free (kg)	16.3 ± 4.6 15.9 (7.3 – 26.2)	10.5 ± 3.0 10.6 (3.5 – 14.9)

mean ± SD, median (min-max), SD = Standard Deviation, BMI = body mass index, BFM = Body Fat Mass, FFM = Fat Free Mass

For some parameters, BodyStat offers the normal range values defined by the age and sex of the subject. Table 14 shows our sample distribution as compared with the norm, that is, the number and percentage of subjects in our sample within the normal range for the given parameter, as well as of those outside of the norm. The last column of the table shows the statistical significance based on the Fishers' exact test (P value) for comparing the males and females in this sample distribution. The table shows that there was no statistical difference between men and women for the parameters measured.

Charts 5. – 8. show the statistical sample distribution of the Yoga group.

Table 14. Statistical distribution of the yoga group as compared with norm

	Men (N = 17)	Women (N = 41)	P
Body weight			
normal	9 (56.3%)	16 (39.0%)	0.299
below norm	4 (25.0%)	8 (19.5%)	
above norm	3 (18.8%)	17 (41.5%)	
BFM			
normal	10 (62.5%)	17 (41.5%)	0.247
below norm	3 (18.8%)	7 (17.1%)	
above norm	3 (18.8%)	17 (41.5%)	
FFM			
normal	14 (87.5%)	38 (92.7%)	0.613
below norm	2 (12.5%)	3 (7.3%)	
above norm	0	0	
Body Water			
normal	12 (75.0%)	31 (75.6%)	0.600
below norm	2 (12.5%)	8 (19.5%)	
above norm	2 (12.5%)	2 (4.9%)	

BFM = body fat mass, FFM = fat free mass

In the yoga group, 18% of men (95% CI:4.1% - 45.7%) and 41.5% of women (95%CI:26.3% - 57.9%) had weight above norm.

Compared with results of EHIS 2008 and STEM/MARK 2013 surveys, the proportion of overweight men in the yoga group was significantly lower while the proportion of overweight women was comparable to the results of these surveys.

Chart 5. Body weight in the yoga group

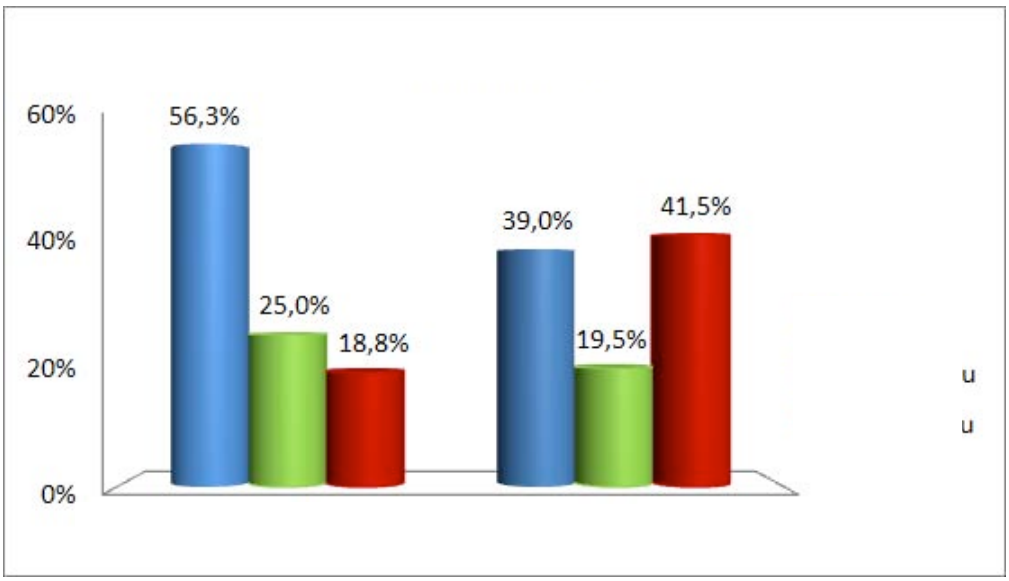


Chart 6. BFM (Body Fat Mass) in the yoga group

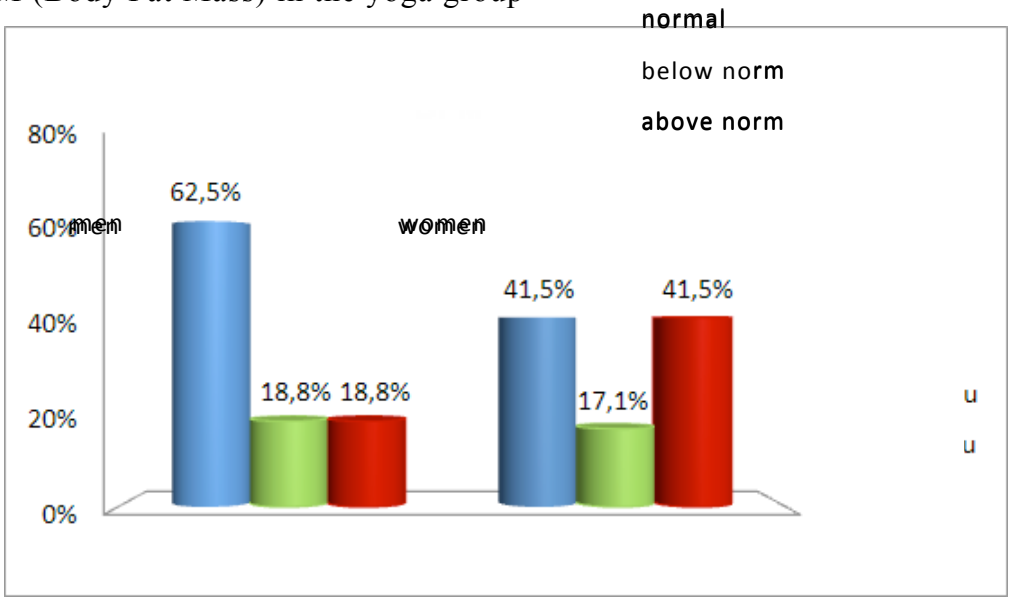


Chart 7. FFM (Fat Free Mass) in the yoga group

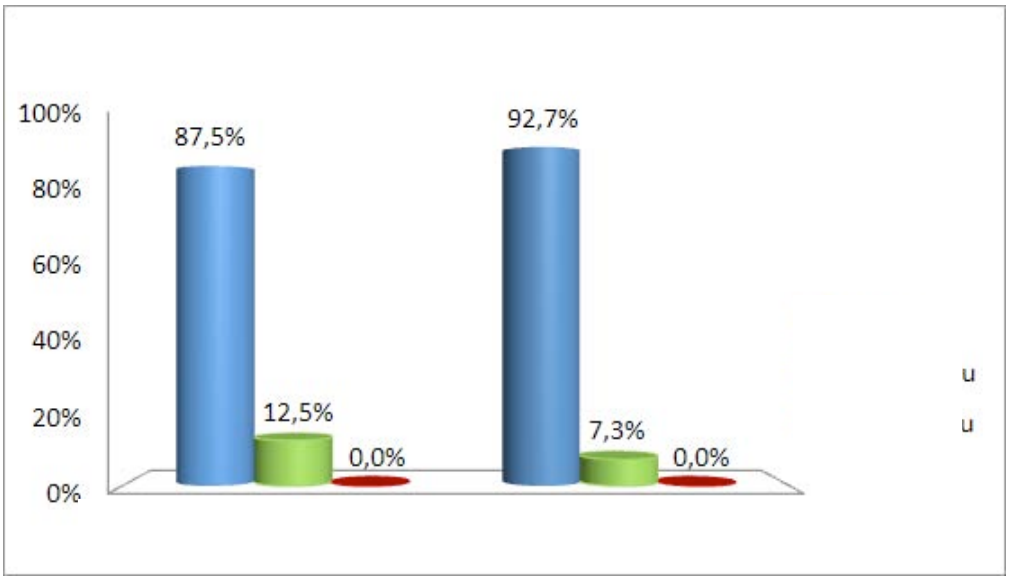
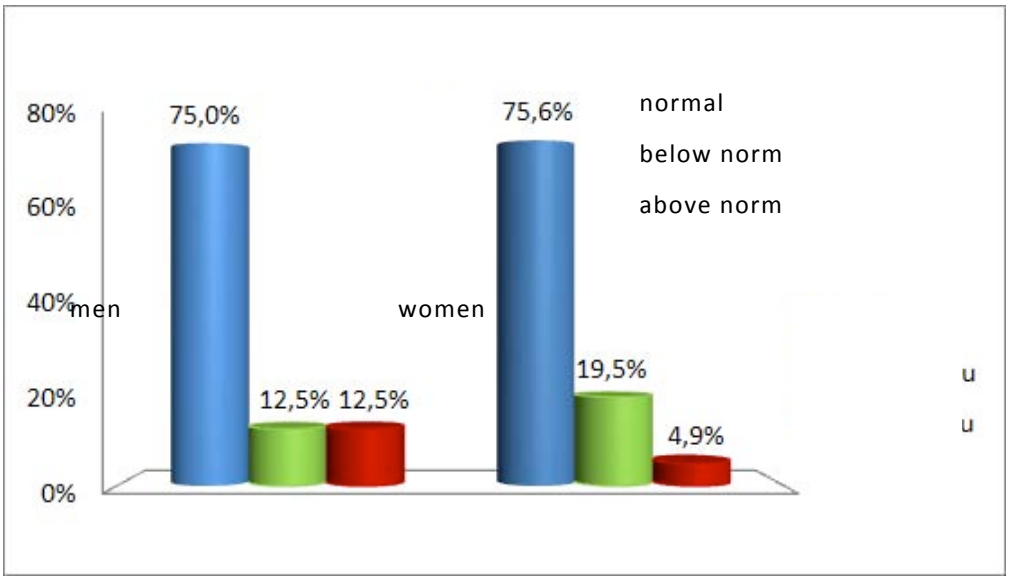


Chart 8. Body Water in the yoga group



We found the following percentages of normal values for the measured parameters: body weight in 56.3% of men and 39.0% of women, BFM in 62.5% men and 41.5% women, FFM in 87.5% men and 92.7% women and a body water in 75.0% men and 75.6 % women. While there was a significantly lower ratio of overweight men in our group as compared with results of STEM/MARK and EHIS surveys, the ratio of women as compared with the above surveys was not significantly different.

4.3.5. Yoga and Fitness Performance

Control group (GP4) consisted of 54 persons,16 were men and 38 women, ages 25 – 70 years (mean age 48.2 ± 11.86). This group was selected from the database of the Department of Sports Medicine and Cardiovascular Rehabilitation of the Palacky University and counter-matched to the yoga group as closely as possible for age and sex. The condition of inclusion in the group was regular physical exercise at least 7 hours weekly.

In both groups, we conducted an ergospirometry test using the Oxycon device to a maximum, according to these instructions: 3 minutes under load at 1W/kg and then increasing ramp till maximum individual effort, with maximum duration of the test at 12 min. We measured resting heart rate (HR) and blood pressure (BP), maximum HR and BP, Peak Power (PP) in W/kg, maximal oxygen uptake (VO_2max) in kg/min, maximal expiratory volume (VO_2max) in kg/min, maximum MET, maximal minute ventilation (V_E max), maximal carbon dioxide production (VCO_2max).

The results of these measurements are summarized in Table 15 and in Charts 9 – 22.

The yoga group had significantly higher maximum heart rate, peak power, VO_2max/kg/min, maximum MET and lower resting BP, $V_E$max, VO_2max, and VCO_2max. These results indicate that persons practicing yoga may be performing movements more economically.

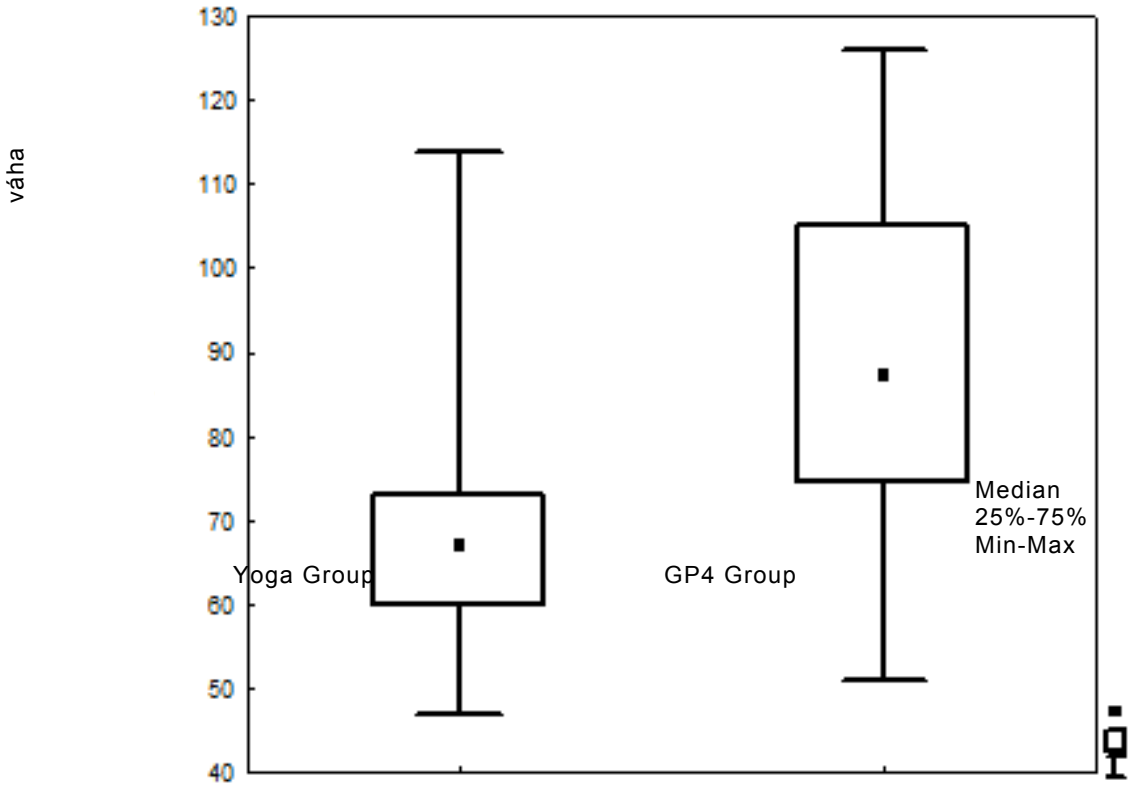
Table 15. Parameters measured during spiroergometry testing

	Both Groups N=112 ø±SD	Yoga Group N=58 ø±SD	Control (GP 4) N=54 ø±SD	P
Age (years)	48.18±11.41	48.14±11.07	48.22±11.86	0.1
Weight (kg)	77.71±18.86	67.28±11.43	88.71±18.96	$<10^{-6}$
Height (cm)	171.18±9.33	170.25±9.22	172.17±9.43	0.402
BMI	26.51±6.19	23.17±3.11	30.03±6,68	$<10^{-6}$
HR resting mm Hg	74.44±13.82	70.98±12.25	77.04±14.98	0.065
BP resting systol. mm Hg	125.41±14.85	121.67±15.25	129.35±13.46	0.004
BP resting distol. mmHg	79.55±11.41	76,84±10.59	82.41±11.64	0.003
BPmax load systol. mmHg	182.84±26.07	181.26±23.23	184,53±28.94	0.024
BPmax load diastol. mmHg	81.97±14.47	80.53±11.01	83.56±17.47	0.638
Wmax/kg	2.47±0,91	2.62±0.64	2.32±1.12	0.007
VO_2max/kg/min	27.45±8.24	28.41±6.34	26.45±9.82	0.028
HR Oxygen max/kg/min	12.89±3.86	11.37±3.16	14.50±3.90	$<10^{-6}$
MET	7.79±2.30	8.11±1.80	7.44±2.70	0.018
V_E	84.22±30.74	74.98±23.03	93.96±34.82	0.008
RER	1.22±0.12	1.24±0.10	1.20±0.14	0.078
VCO_2max	2496.280±857.70	2327.72±686.92	2674.20±982.57	0.094
VO_2max	2113.53±681.22	1943.07±586.96	2293.46±731.35	0.011

BP = Blood Pressure, BMI = Body Mass Index, HR = Heart Rate, Wmax = Peak Power, VO_2max = maximal oxygen uptake, HR Oxygen max = Maximum Heart Rate Oxygen, MET = metabolic equivalent, V_E = minute ventilation, RER = Respiratory Exchange Ratio, VCO_2max = maximal carbon dioxide production.

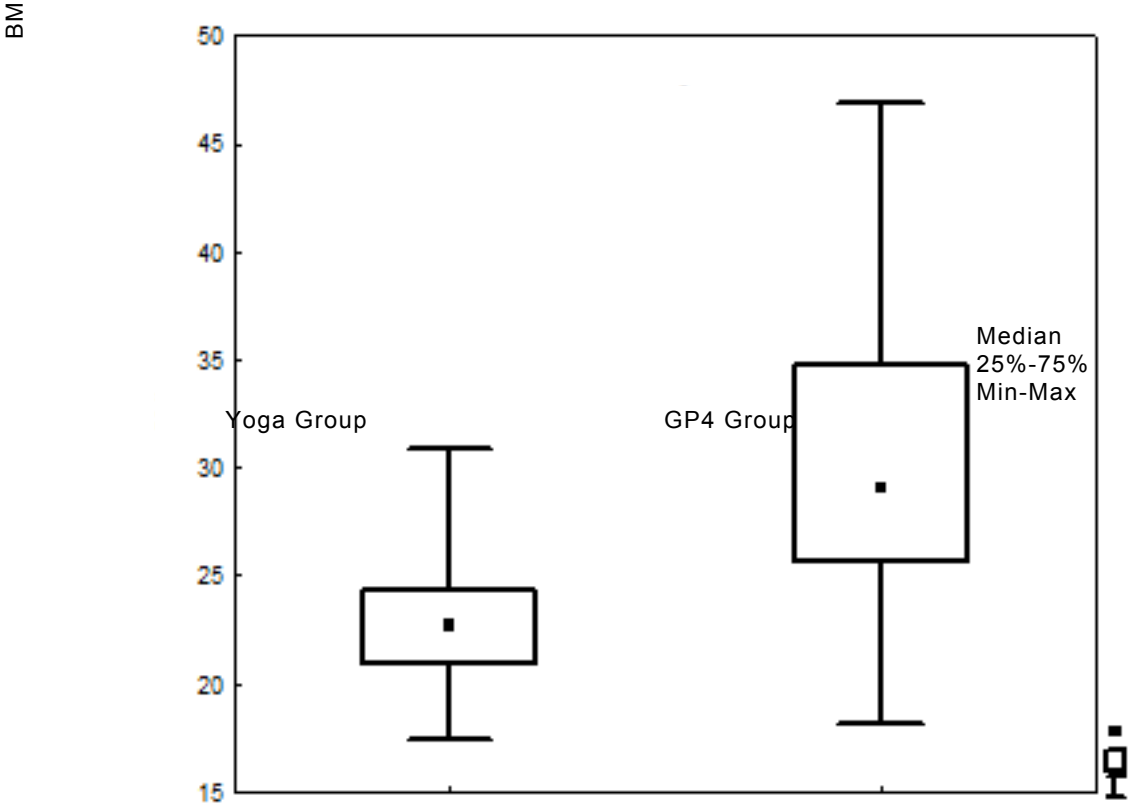
$p<10^{-6}$
(Mann-Whitney)

Chart 9. Body weight(kg) in Yoga group and GP4 groups



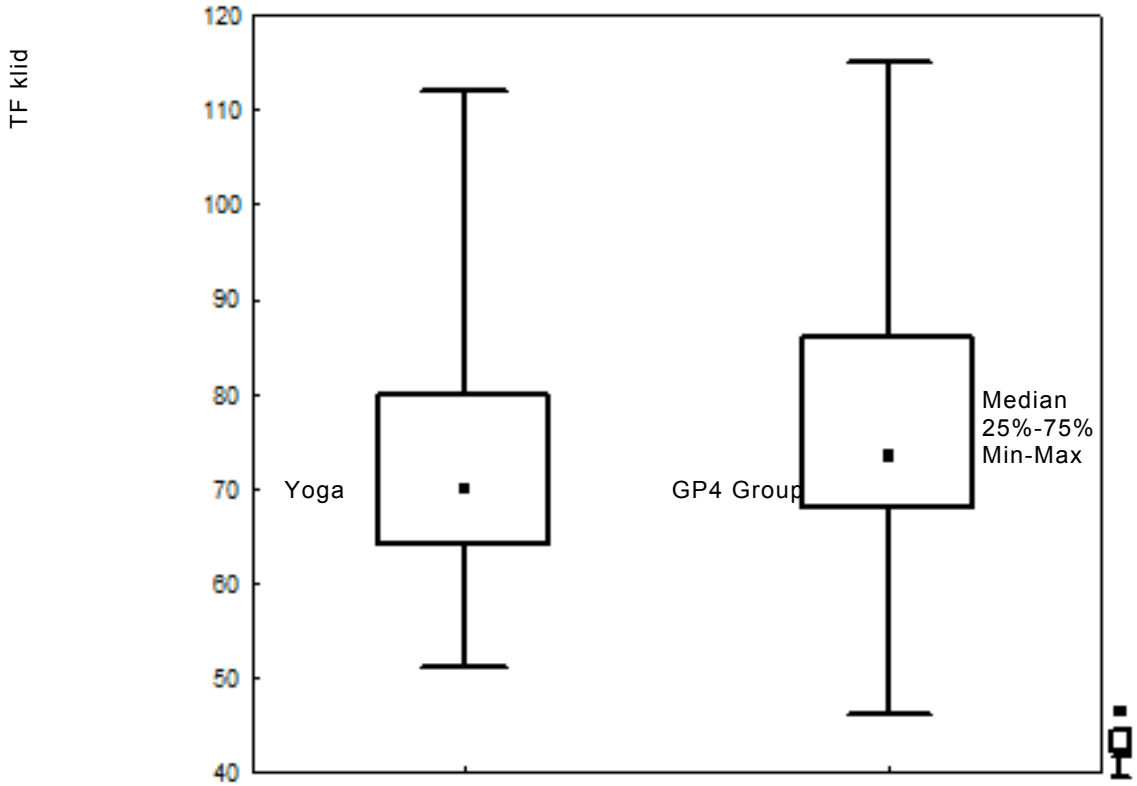
$p<10^{-6}$
(Mann-Whitney)

Chart 10. BMI in the Yoga and GP4 groups



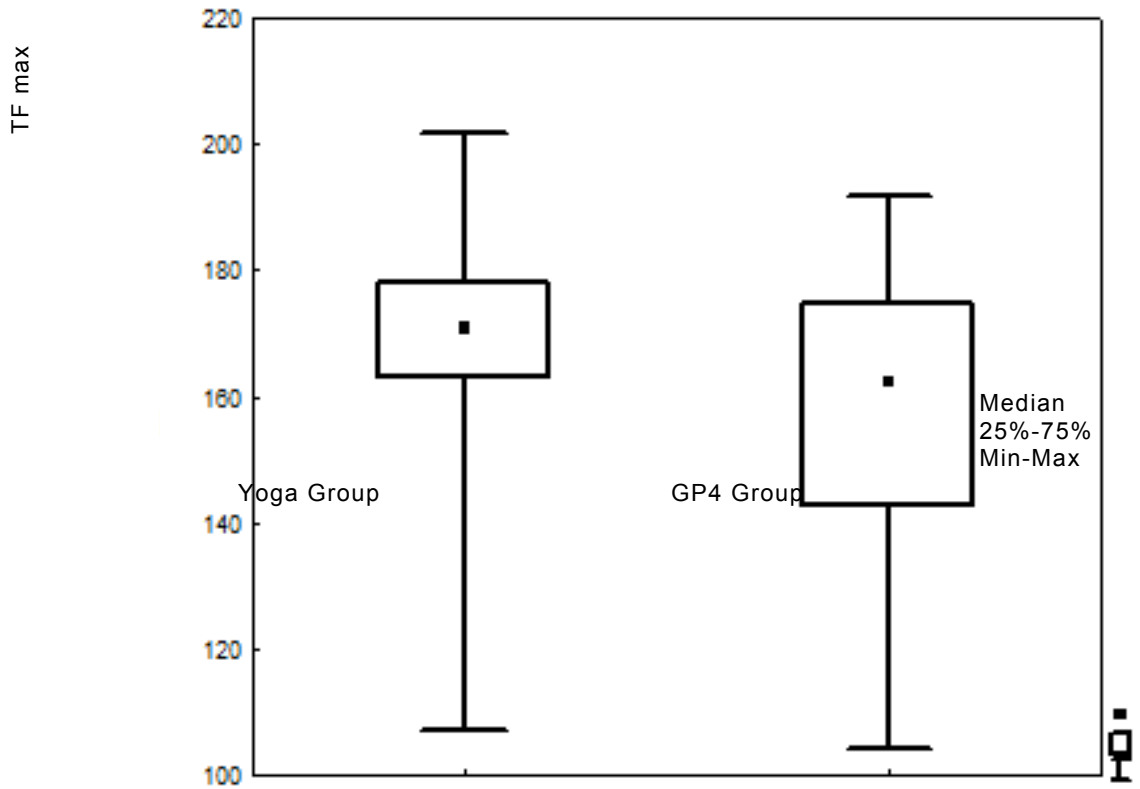
p<0,065
(Mann-Whitney)

Chart 11. Resting HR in the Yoga and GP4 groups



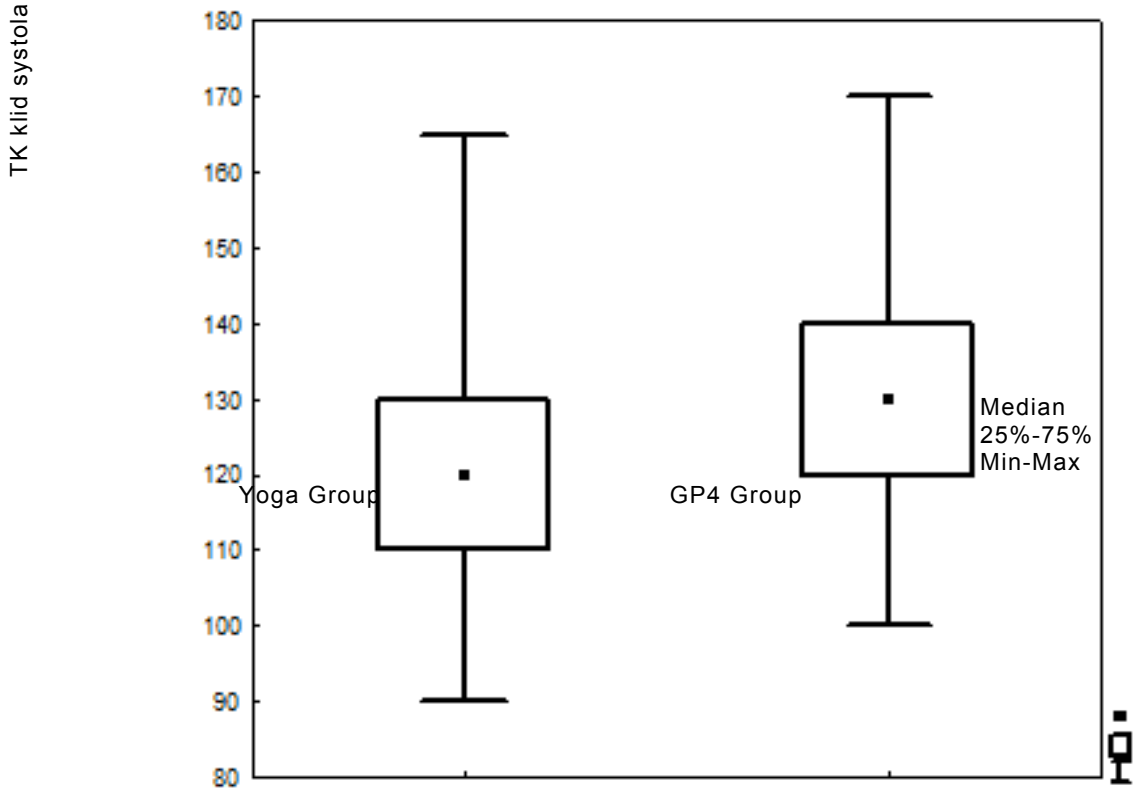
p<0,004
(Mann-Whitney)

Chart 12. Maximum Heart Rate in the Yoga and GP4 groups



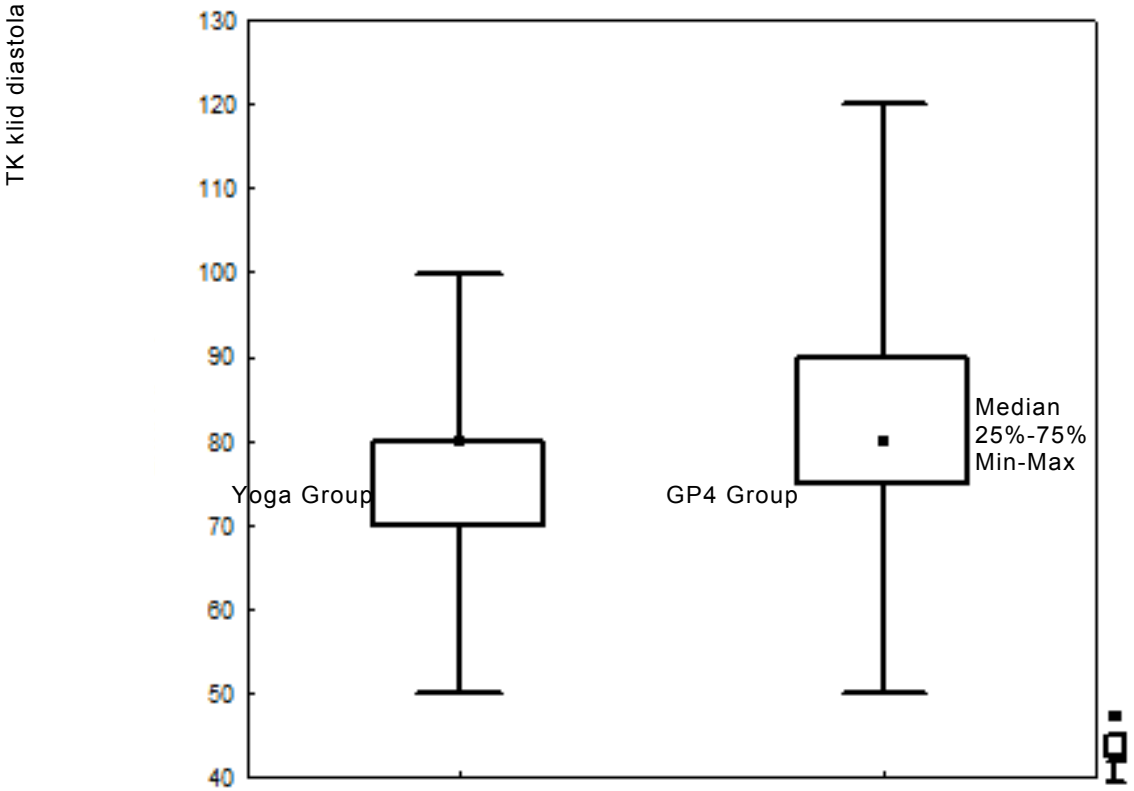
p<0,003
(Mann-Whitney)

Chart 13. Resting systolic BP in the Yoga and GP4 groups



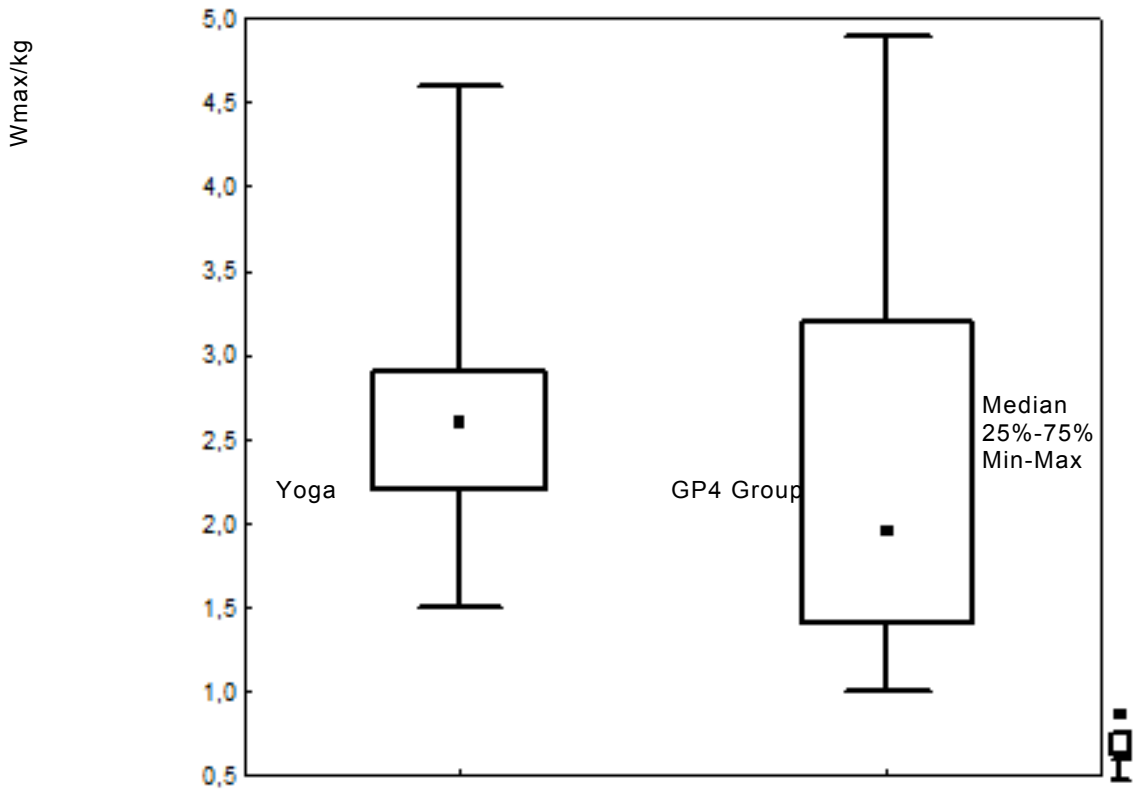
p<0,025
(Mann-Whitney)

Chart 14. Resting diastolic BP in the Yoga and GP4 groups



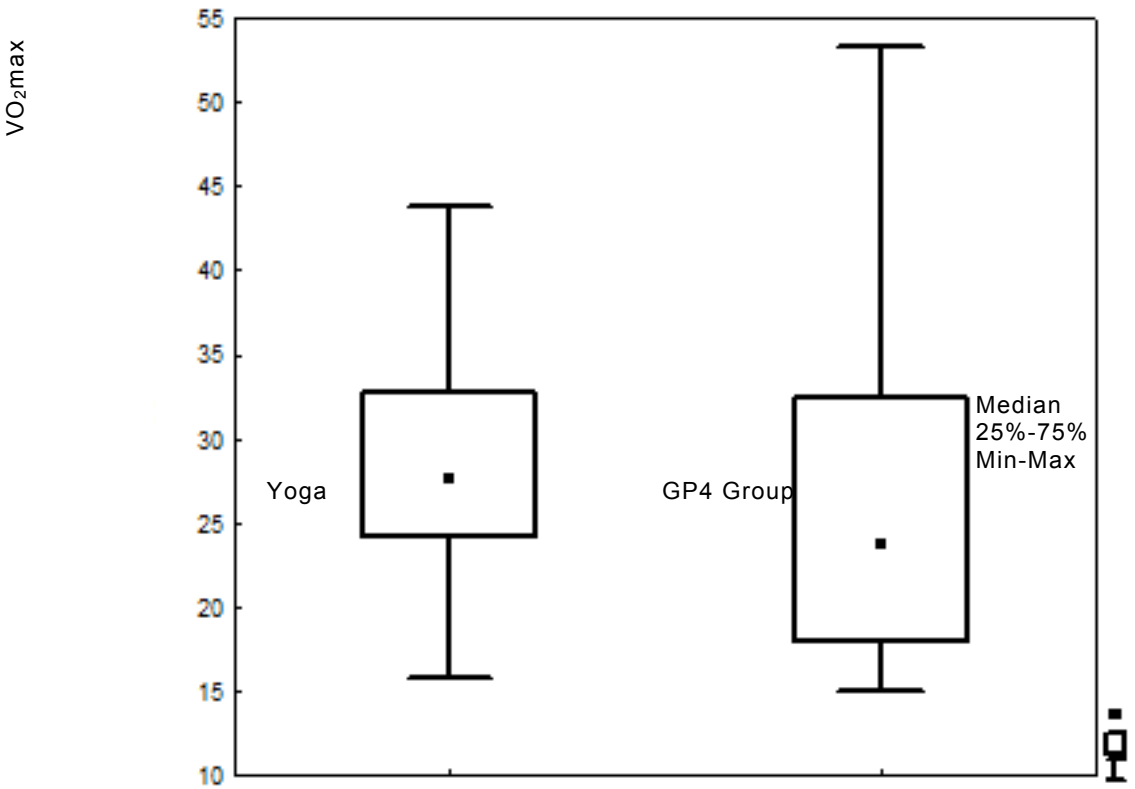
p<0,007
(Mann-Whitney)

Chart 15. Peak Power (Wmax/kg) in the Yoga and GP4 groups



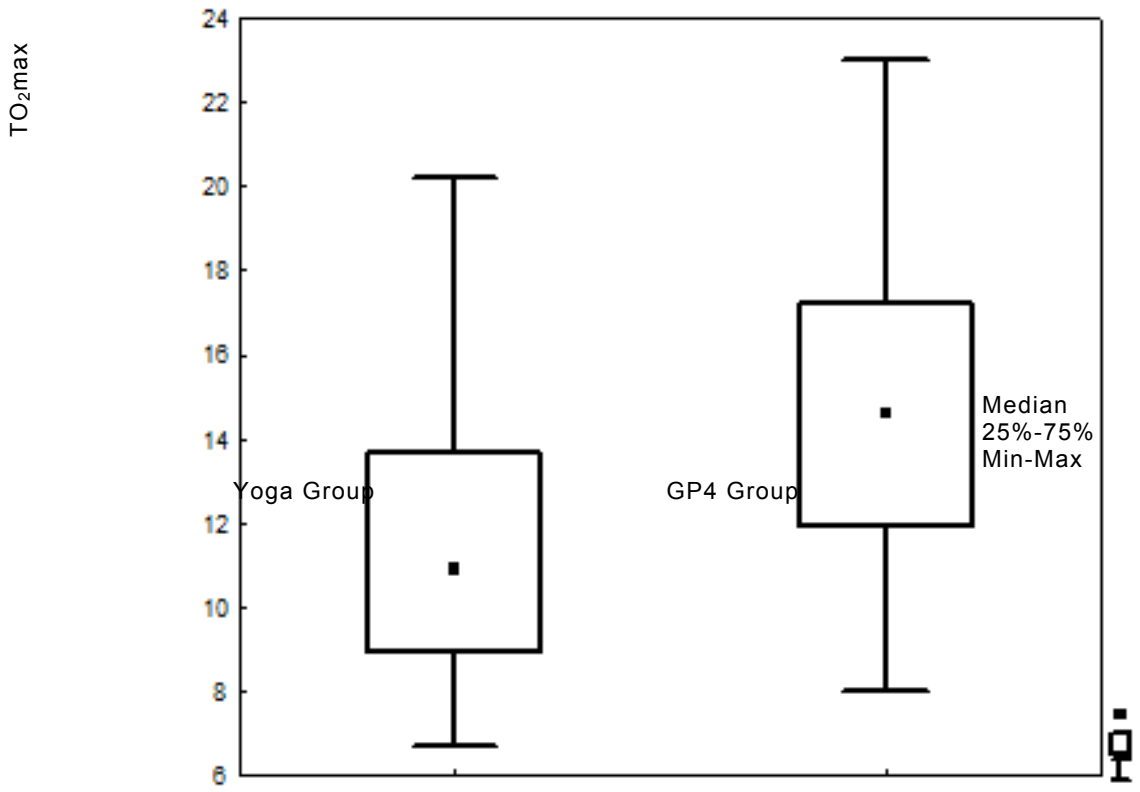
p<0,028
(Mann-Whitney)

Chart 16. VO2max in Yoga and GP4 groups



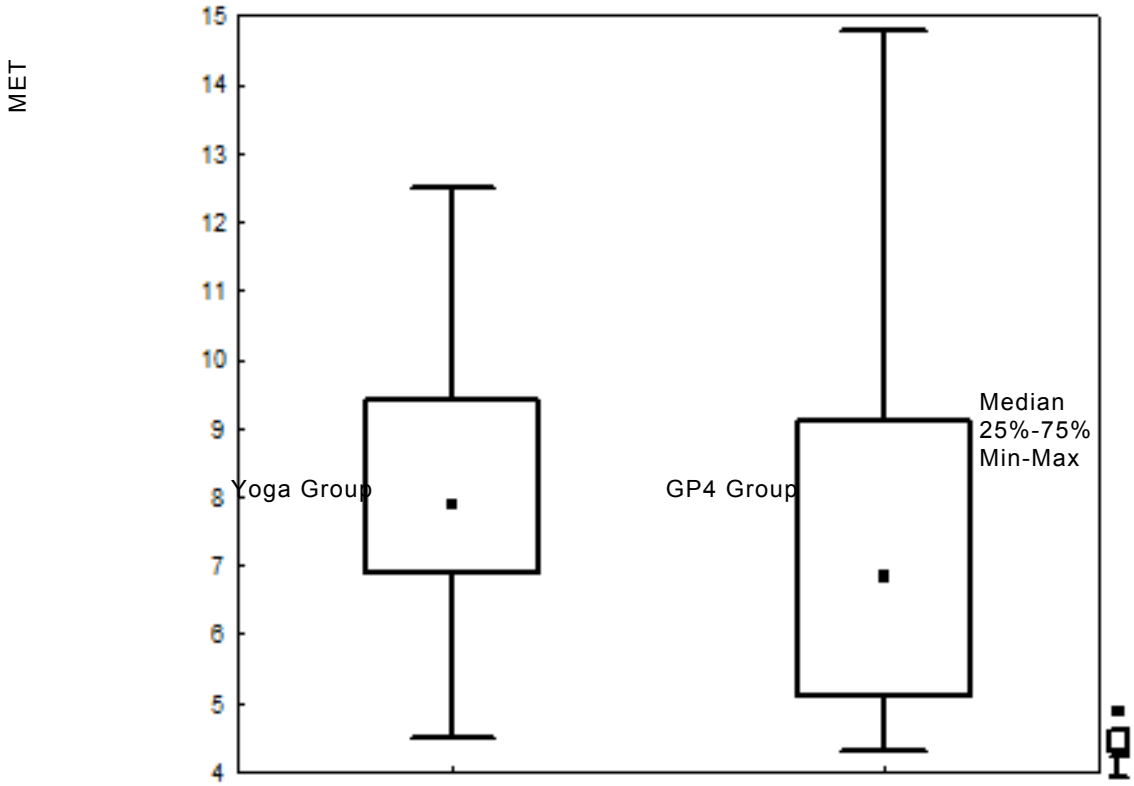
$p<10^{-6}$
(Mann-Whitney)

Chart 17. TO2max in the Yoga and GP4 groups



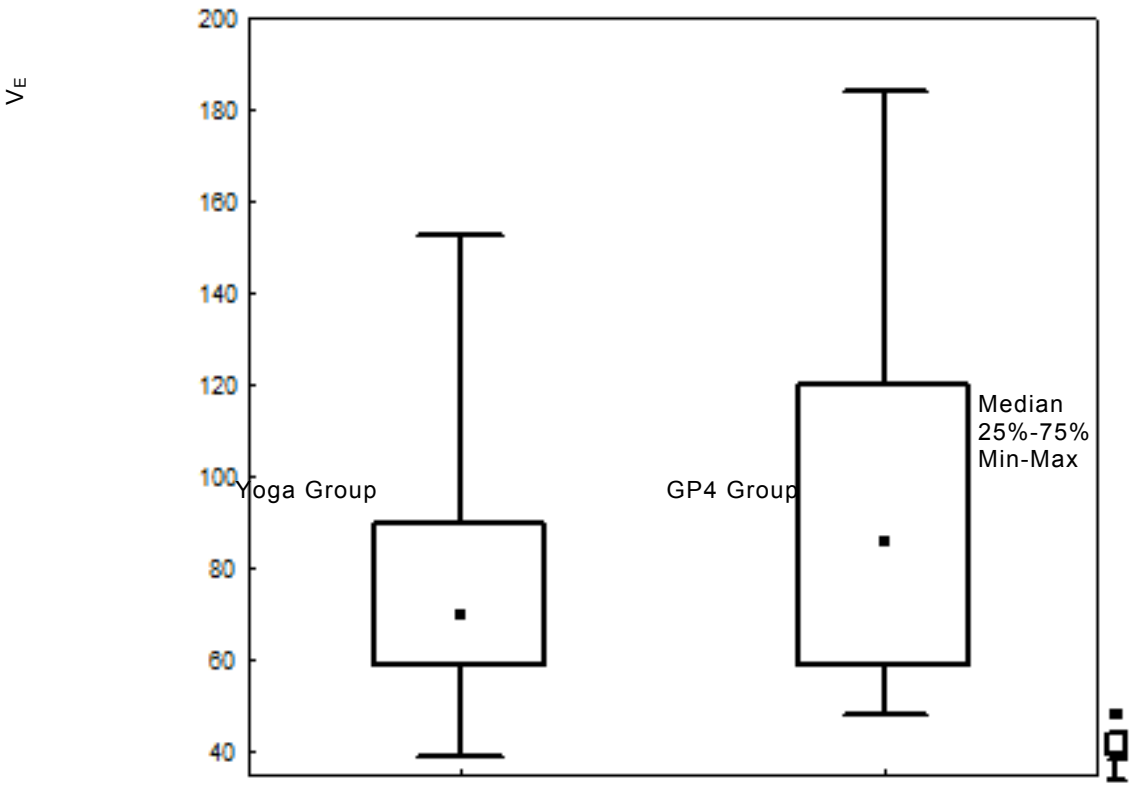
p<0,02
(Mann-Whitney)

Chart 18. MET in the Yoga and GP4 groups



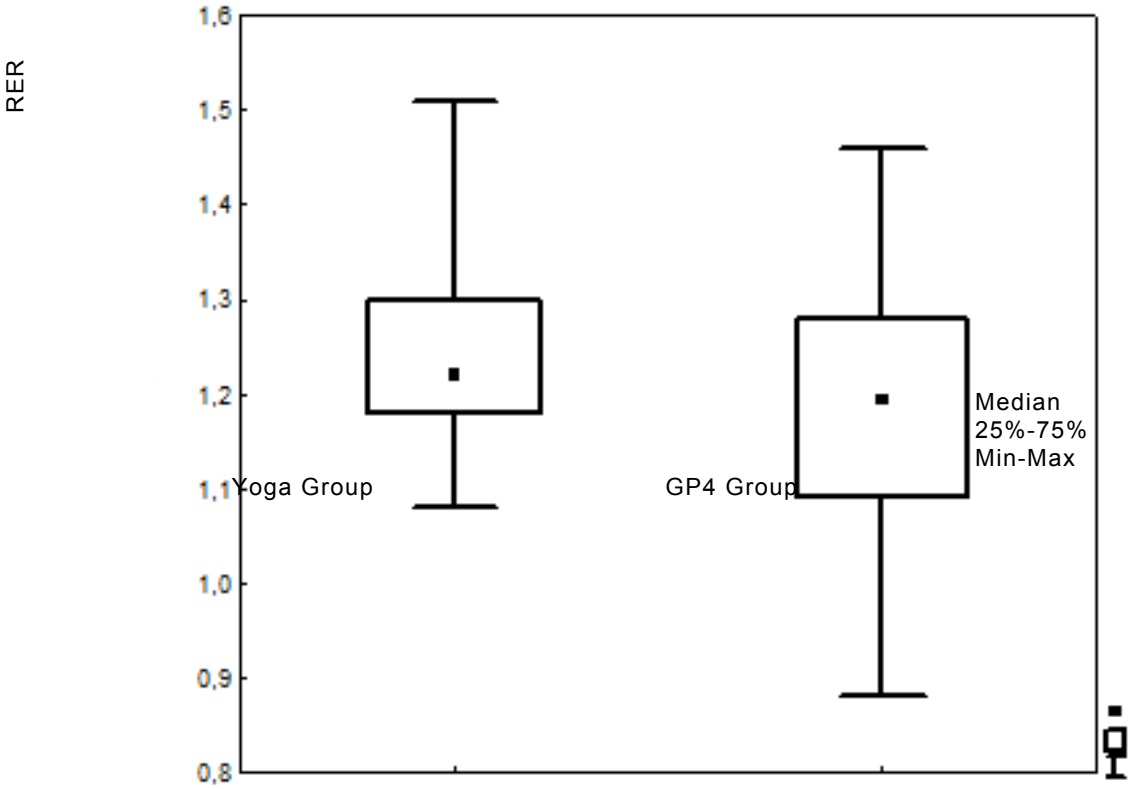
p<0,008
(Mann-Whitney)

Chart 19. VE in the Yoga and GP4 groups



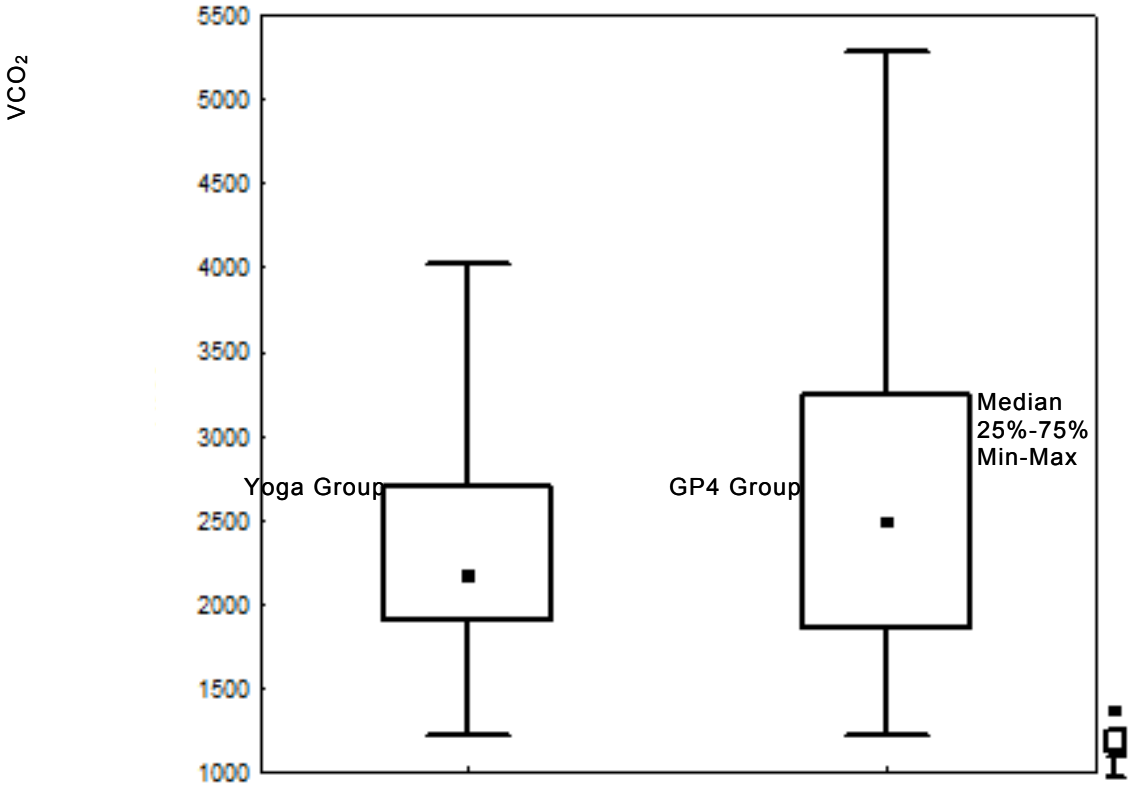
p<0,08
(Mann-Whitney)

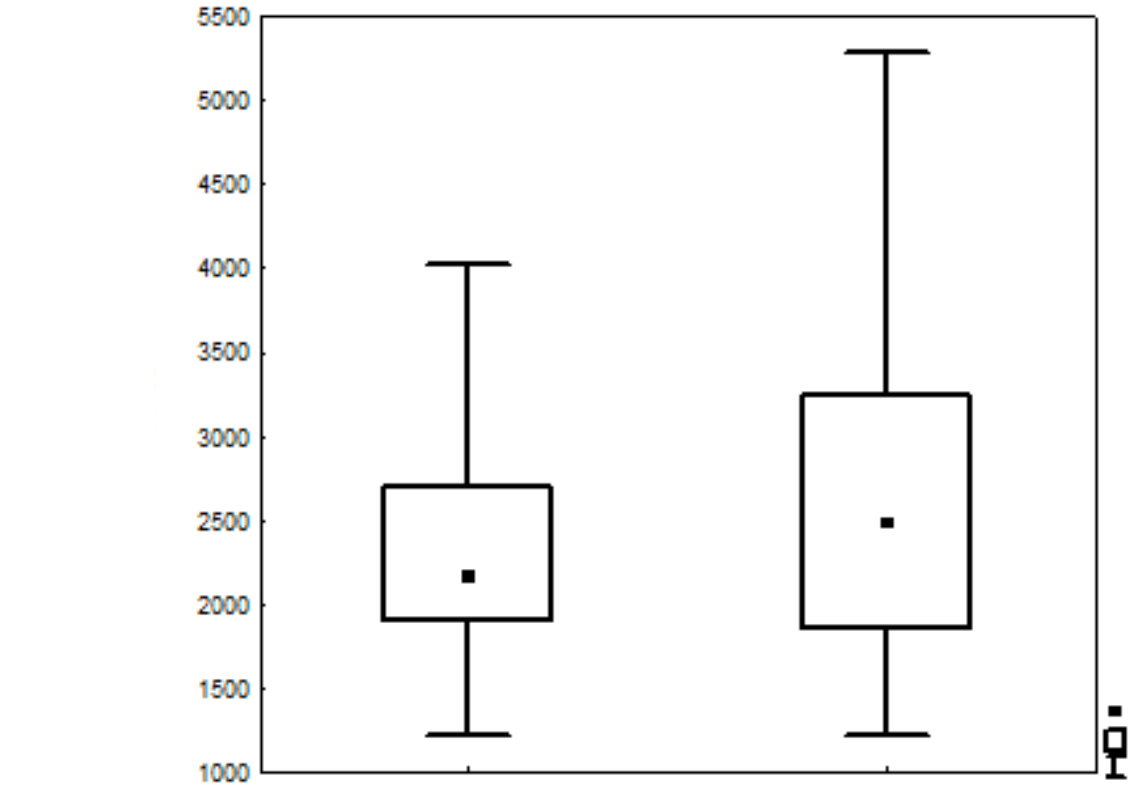
Chart 20. RER in the Yoga and GP4 groups



p<0,095
(Mann-Whitney)

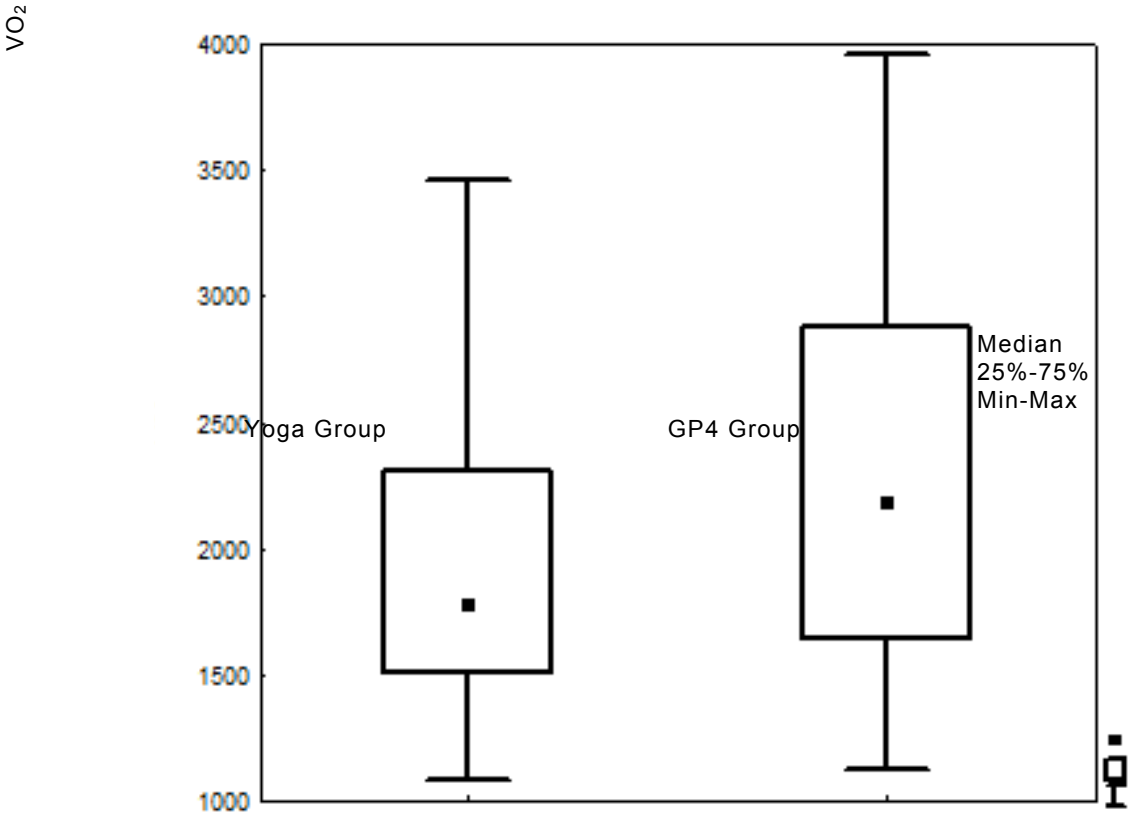
Chart 21. VCO2 in the Yoga and GP4 groups





p<0,015
(Mann-Whitney)

Chart 22. VO2 in the Yoga and GP4 groups



5. Discussion

Considering the significant influence of psycho-social factors on the development of MetS and CVD as well as the key role that excessive activation of the sympathetic nervous system seems to have on the pathogenesis of insulin resistance and also the potential to reverse the changes associated with MetS, the combined mind-body treatment approach seems to present a great potential in both prevention and treatment of CVD [4,85,87]. From this point of view, yoga may become a most useful tool of prevention and management of this condition. Yoga is the oldest known system of health and personal development which influences the body, mind, and consciousness. Unfortunately, the number of high quality studies on the influence of yoga on the RF of CVD is limited. However, the available studies indicate that regular yoga practice may regulate arterial hypertension, improve the cardiac output, positively influence IR, abdominal obesity, type II diabetes, normalize lipid profile as well as coagulopathy and oxidation stress by harmonizing the function of the sympathetic and parasympathetic parts of the autonomic nervous system. Research also shows that yoga may positively influence some anthropometric parameters and other clinical indicators [34,38,67]. Additionally, yoga helps to improve posture control and stability, which means the ability to maintain balance and posture of the body and its parts in a constantly changing environment. This is an important regulatory mechanism of the body because it precedes movement and influences the entire system which maintains body posture [87].

5.1. Yoga and Risk factors of Metabolic Syndrome and Cardiovascular Disease

Our study revealed a significantly lower both systolic and diastolic blood pressure in the yoga group in comparison with the control group. These findings are consistent with the results of a study by Sundar et al. which followed twenty five patients with essential hypertension. Of these, 20 patients were not given any antihypertensive drug treatment (Group A); other 5 had to be put on antihypertensive drugs before being included in the study (Group B). All 25 patients practiced a yoga relaxation technique for 6 months. There was a statistically significant fall in both mean systolic and diastolic pressure of both groups. Further, there was a significant reduction in doses of antihypertensive drugs being given to patients in group B. In 65% patients in group A, BP could be controlled with the relaxation only and no drug was needed in them at all. Additionally, BP rose

significantly to previous levels in patients who left practicing yoga. The authors concluded that, with use of yoga relaxation in therapy of hypertension, 'requirement of antihypertensive drugs may be significantly decreased and in some cases may be totally dispensed with and it may be a useful adjunct in treatment of hypertension' [88]

Murthy et al. studied the effect of a 21- day program of yoga, naturopathy, and a low calorie, low sodium diet on 104 subjects diagnosed with mild to moderate hypertension. The patients were followed for a period of one year. The systolic BP came down from mean of 139.6 to 129.6 where as it came down from 91.2 to 86.1 for diastolic BP. At the same time favorable effect was also seen in other variables such as lipid profile and body weight. At the end of one year, out of 57 patients who came for follow-up, 14 persons were found to have BP within normal ranges without any medication over the previous 12 months. The study suggests that naturopathy and yoga therapy may be considered as an effective alternative approach to the treatment of hypertension [89].

Cohen et al. conducted a randomized controlled trial to assess the effects of 12 weeks of Iyengar Yoga (IY) practice versus enhanced usual care (EUC), which included personalized dietary adjustments, on BP in adults with untreated prehypertension or Stage 1 hypertension. 26 and 31 participants in the IY and EUC groups, respectively, completed the study. In the IY group, systolic BP was reduced by 6 mmHg at 12 weeks compared to baseline ($P = 0.05$) and diastolic BP decreased significantly by 5 mmHg ($P < 0.01$). In the EUC group, systolic BP and diastolic BP significantly decreased by 5 and 3 mmHg, respectively, from baseline at 6 weeks ($P < 0.05$), but were no longer significant at 12 weeks. The authors concluded that twelve weeks of IY produced clinically meaningful improvements in both systolic and diastolic BP [31].

Bharshankar et al. conducted a study to examine the effect of yoga on cardiovascular function in persons above 40 years of age. The study included 50 participants who had been practicing yoga for 5 years and 50 participants in a control group (not doing any type of physical exercise). The difference in the mean values of systolic and diastolic BP between study group and control group was statistically significant ($P < 0.01$ and $P < 0.001$ respectively). (10). The results of this study support our findings [7].

Saptharishi et al. conducted a study with 102 young pre-hypertensive and hypertensive adults, ages 20-25 divided into four groups: 1. control, 2. physical exercise using brisk walking 50-60 minutes four days a week, 3.salt intake reduction diet, 4. practice of yoga for 30-45 minutes/day on at least five days a week. All three intervention groups showed

a significant reduction in BP while there was no significant change in the control group. Although physical exercise was the most effective, yoga practice was also found to be one of the non-pharmacological interventions effective in significantly reducing BP in young adult hypertensives and pre-hypertensives and can be positively recommended as a treatment option [38].

Non-drug therapy is a very vital aspect in prevention and treatment of hypertension. The successive reports of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of Hypertension, WHO scientific report on primary prevention of essential hypertension and national High Blood Pressure Education Program's working groups report on primary prevention of hypertension have stressed on the non-drug therapy.

In his review *Non-drug therapy in prevention and control of hypertension*, Sainani says that, "Non-drug therapy is a very vital aspect in prevention and treatment of hypertension" and mentions reports by WHO as well as the Joint National Committee on Prevention, Detection, Evaluation and Treatment of Hypertension, and others, which have stressed the importance of non-drug therapy. As Sainani states, "Today a busy family physician does not spend enough time to explain to the patient various dietary and lifestyle modifications but straightaway prescribes the drugs. Every patient of hypertension from the stage of pre-hypertension to grade 2 hypertension should follow non-drug therapy. If non-drug therapy is strictly adhered, one can prevent cases of pre-hypertension from progressing to hypertension stage and one can reduce or stop the medications in Grade I (mild) hypertension." Sainani discusses role of lifestyle modifications including yoga, meditation, physical exercise, diet, etc. which he believes should be targeted to general population through public health authorities, news media, etc. [37].

Therefore, we can agree with the conclusions of other authors that it is possible to recommend yoga as an effective, non-pharmacological approach to the treatment of hypertension, which can help lower blood pressure in hypertensive adults, particularly in men [38,90].

In our study, the mean BMI of the Yoga group was within the normal range and the BMI values were significantly (median 22.8) than in the control group (median 24.4), ($P = 0.008$).

Gokal at al. [91] conducted a research during yoga camps which took place in Great Britain. The study included data from 428 volunteers (150 male, 278 female) who practiced yoga at the camps for 7 days 3 hours daily. Of these volunteers, 65% had

diabetes, 81% had hypertension, 65% had hyperlipidemia and 41% were obese (BMI above 25). Measurements were done at the end of the camp and compared with initial data. Overall, 56% of participants lost weight. In 36% of hypertensive patients, BP was normal (mean 163/98 to 135/80). 66% of patients had decreased cholesterol after the study period. The authors concluded that although the results were promising in terms of the effect of yoga on the cardiovascular system, the study had several drawbacks: it was not controlled, measurements were done during a short period of time and it was not clear whether the effects would persist. The authors therefore recommended a longer study.

Kosuri et al. [41] studied the effect of yoga practice on clinical and psychological outcomes in 35 subjects with Type 2 diabetes mellitus in a 40-day yoga camp. Clinical, biochemical, and psychological well-being were studied at baseline and at the end of the camp. At the end of the study, there was a reduction in BMI from 26.51 to 25.77; $P < 0.001$, as well as a reduction in anxiety and an improvement in general well-being.

In our study, the Yoga group had significantly lower level of triglycerides (P=0.003). The results are consistent with a study by Bijlani et al [34], which showed a significant reduction of cholesterol, LDL cholesterol, index CH/HDL index, triglycerides as well as increased HDL cholesterol in a group of persons practicing yoga within 9 days of commencing the yoga program.

Our study found a significant difference in LDL cholesterol (P=0.008714) and BMI (P=0.007105) in men in the yoga group versus control group. We assume that this is a result of a yoga practice which, as we show in our work, is often associated with a healthy diet and overall healthier “yogic” lifestyle. Further studies are needed to confirm these results and determine the effect of yoga practice alone. In women, the differences were not statistically significant. This may be a result of a more consistent yoga practice for a greater number of years found among men in the yoga group.

In addition to improved anthropometric parameters with significantly lower BMI in men in the Yoga group versus control, our study also showed significant differences in the HOMA-IR and QUICKI homeostatic indices. There was a significant difference in the blood glucose levels, insulin (P<10-6) and homeostatic indices derived from these values (HOMA-IR (P<10-6) a QUICKI P<10-6). We view these results as very promising as they indicate possible preventive effect that yoga practice when combined with a healthy lifestyle may have on prevention of insulin resistance and development of metabolic syndrome.

Our study indicates that the occurrence of risk factors of CVD may be lower in persons practicing yoga versus general population. One of the risk factors is smoking. The majority of participants in the Yoga group in our study started practicing yoga already as non-smokers. Out of 6 smokers in the Yoga group, 4 stopped smoking after starting with yoga. Comparable results from our GP group are not available, however, previous studies (93,94) suggest that yoga may help in efforts to stop smoking and in this way it can contribute to reducing the risk of CVD occurrence.

5.2. YOGA AND LIFESTYLE

This study compared the yoga group with a GP3 group. As with the GP1 group, there were significantly more smokers in the control group as compared with the yoga group.

In the Yoga group, we found more effort to live a healthy lifestyle. This is not surprising; a healthy lifestyle and a vegetarian diet are often considered to be a part of the yogic way of life. The Yoga group had a significantly greater variety of recreational physical activity in addition to yoga practice (aerobic and other exercise, jogging, skiing, cycling, dance, ball games, tennis, snowboard, windsurfing, gardening, etc.) than group GP3.

Schmidt et al. [95] conducted a study using a residential three month yoga and meditation program which included a low fat lacto-vegetarian diet and studied the changes in cardiovascular risk factors and hormones. They found significant reduction in BMI, total serum and LDL cholesterol, fibrinogen, and blood pressure,

Research indicates that vegetarian diet in combination with a complex lifestyle modification may lead to regression of even serious cases of coronary atherosclerosis even without lipid lowering drugs. [95]

Manchanda et al. [78] conducted a randomized controlled trial which studied the possible role of yoga and a yogic lifestyle including a vegetarian yogic diet on retardation of coronary atherosclerotic disease. They followed 42 men with angiographically proven coronary artery disease. 21 men were randomized to a control and 21 men to a yoga intervention group. Both groups were followed for one year. The active group underwent a lifestyle modification program which included yoga, control of risk factors, diet control, and moderate aerobic exercise. The control group received conventional treatment program with risk factor control and American Heart Association step I diet.

At one year of the study, “the yoga groups showed significant reduction in number of anginal episodes per week, improved exercise capacity and decrease in body weight.

Serum total cholesterol, LDL cholesterol and triglyceride levels also showed greater reductions as compared with control group. Revascularization procedures (coronary angioplasty or bypass surgery) were less frequently required in the yoga group (one versus eight patients; relative risk = 5.45; P = 0.01). Coronary angiography repeated at one year showed that significantly more lesions regressed (20% versus 2%) and less lesions progressed (5% versus 37%) in the yoga group (chi-square = 24.9; P < 0.0001).“

Kahleová et al. [97] conducted a 24-week, randomized, open, study which aimed to compare the effects of calorie-restricted vegetarian and standard diabetic diets alone and in combination with exercise on insulin resistance, visceral fat and oxidative stress markers in persons with Type 2 diabetes. Seventy four patients with Type 2 diabetes were randomized into an experimental group which received a vegetarian diet and into a control group which received standard anti-diabetic diet. Both groups received isocaloric diet and all meals were provided to the patients. Forty-three per cent of participants in the experimental group and 5% of participants in the control group reduced diabetes medication. Body weight decreased more in the experimental group than in the control group. The study found significant improvements in the group which followed vegetarian diet versus control group and the researchers concluded that “A calorie-restricted vegetarian diet had greater capacity to improve insulin sensitivity compared with a conventional diabetic diet over 24 weeks. The greater loss of visceral fat and improvements in plasma concentrations of adipokines and oxidative stress markers with this diet may be responsible for the reduction of insulin resistance. The addition of exercise training further augmented the improved outcomes with the vegetarian diet.”

The conventional diabetic diet recommended is typically not a vegetarian diet. And yet it is known that the prevalence of Type 2 diabetes is 2x lower in vegetarians as compared with non-vegetarians [97].

In 2009, the American Dietetic Association [98] issued a position on vegetarian diet which acknowledged the full nutritional value of properly planned vegetarian diet and the benefits of such diet in prevention and management of a variety of diseases including Type 2 diabetes. The Czech Diabetes Society accepted vegetarian diet as a suitable diet for patients with diabetes with recommended monitoring by a physician and a nutritionist [86].

Therefore, there is a strong case for promoting vegetarian diet as a means to support optimal health including as a support in prevention and management of the RF of CVD and metabolic syndrome.

According to the Czech Statistical Office, the consumption of meat in the Czech Republic per person per year was 22/kg in 1922, 33.3 kg in 1948 with a maximum of 97.4 in 1989. There has been a decrease since 1989 to 80 kg [99], however, the figures still show almost 4 times increase in less than a century. Given that vegetarian diet has been proven to be fully nutritionally adequate and associated with significantly lower incidence of many diseases as well as offering potential in prevention and treatment of hypertension, diabetes, and other components of MetS, in our opinion, there is a strong case for physicians and nutritionists to begin promoting vegetarian diet as part of prevention as well as support of a treatment program for these diseases.

Based on the presented findings, we can conclude that the yogic lifestyle which includes regular practice of yoga asanas (postures), breathing and meditation techniques as well as a balanced, nutritious lacto-vegetarian diet may help prevent as well as manage and in some cases even reverse the symptoms of MetS.

5.3. YOGA AND BODY COMPOSITION

Body Composition is a better measure of the risk for CDV than BMI. There are several methods for determining Body Composition and one of them is the bioelectric impedance analysis. The results using bioelectric impedance, a method which we have used in our study, are comparable to the DEXA method considered to be the most accurate test for determining body composition [100] as well as with more traditional methods such as measuring of skinfold thickness with caliper [101]. Bioelectric impedance analysis can be used to measure body composition in athletes as well [102].

In the yoga group, 18% of men (95% CI:4.1% - 45.7%) and 41.5% of women (95%CI:26.3% - 57.9%) had weight above norm.

Compared with results of EHIS 2008 and STEM/MARK 2013 surveys, the proportion of overweight men in the yoga group was significantly lower while the proportion of overweight women was comparable to the results of these surveys.

Přidalová et al. [104] studied body composition in 1970 healthy Czech women ages 18 – 89. The mean values for the experimental group in this study were BFM 19.7 ± 8.9 kg (in our study 18.5 ± 6.3 kg), FFM 45.6 ±5,5 kg (in our study 44.6 ± 6.0 kg).

Riegrová et al. [105] studied progression of body composition in 174 Czech men and women ages 30 - 80 over several decades. BFM values in the forth decennium were 18.19 ± 8.04 kg (the mean age in our yoga group was 46.6 ±12.8 and the BFM value was 13.5 ± 5.6 kg). The BFM (%) value was 20.3 ± 5.6 % (in our study 17.8 ± 5.0 %). FFM (%) in the 4. decennium was 69.46 ± 9.00 % (in our study 82.2 ±5.0 %), which also shows favorable results for men in the yoga group in our study.

5.4. YOGA AND FITNESS PERFORMANCE

In our Yoga group, we measured improved fitness performance versus control group which exercised 7 days a week.

Alexander et al. [74] conducted a study of the influence of yoga practice on cardiovascular risk. The study involved 42 older persons, mostly overweight, at risk for cardiovascular disease, who practiced a gentle Iyengar yoga program for 8 weeks. " Four broad themes emerged from content analysis: practicing yoga improved overall physical function and capacity (for 83% of participants); practicing yoga reduced stress/anxiety and enhanced calmness (83% of participants); practicing yoga enriched the quality of sleep (21% of participants); and practicing yoga supported efforts toward dietary improvements (14% of participants)." The authors concluded that yoga may offer " benefits in terms of improved physical function, enhanced mental/emotional state, enriched sleep quality, and improved lifestyle choices, and may be useful as a health promotion strategy in the prevention and management of chronic disease."

Ray et al. [71] studied 20 yoga instructors during a yoga, breath, and meditation practices as previously discussed in this work. They measured Oxygen consumption, carbon dioxide output, pulmonary ventilation, respiratory rate and tidal volume. The authors concluded that "Although yogic practices are low intensity exercises within lactate threshold, physical performance improvement is possible owing to both better economy of breathing by BM and also by improvement in cardiovascular reserve. Other factors such as psycho-physiological and better relaxation may contribute to it."

In a recent study, Akhtar et al [72] conducted a longitudinal study with 30 physiotherapy students as subjects. They studied the effect of a daily yoga (asana, breathing, and chanting) practice for 5 days a week over a period of 6 weeks on 6-min walked distance, rating of perceived exertion (RPE), recovery time following the walk and state of well being. A baseline 6-min walk test was conducted on subjects and the 6-min walked

distance, rating of perceived exertion (RPE) on modified Borg's scale were recorded. Statistically significant improvements were observed after the 6 weeks of yoga practice on the 6-min walk, RPE, recovery time (and sense of well being score. The authors concluded that, “Yoga practices are beneficial in improving the functional capacity in young healthy adults.“

5.5. STUDY LIMITATIONS

Blood glucose and abdominal circumference parameters were not available in GP1 group. As these are the risk factors of CDV, this was a limitation of our study.

The groups differ in number of smokers. It is possible that some of the differences between the yoga and control groups may be attributed to influence of smoking. Future studies need to equalize number of smokers between control and experimental groups.

In the Yoga and Lifestyle section of our study, our groups differed in the median age. The Yoga group median age was 47 and control group 55.

6. Conclusion

Our work showed statistically significant differences in the risk factors between the Yoga and control groups in the number of smokers, blood pressure, BMI, triglycerides, blood glucose and insulin, as well as in the homeostatic index HOMA-IR and QUICKI. These results indicate that yoga may well be an appropriate form of exercise and may be recommended as an effective method of prevention of Metabolic Syndrome and Risk Factors of CVD. It is our opinion that the regular practice of Yoga has its place also in the treatment of existing RF of CVD.

In many cases, persons practicing yoga on a daily basis will adapt such dietary and lifestyle habits which are known to positively influence the RF of CVD. The traditional yogic diet consists of fresh food items such as fresh vegetables, whole grain bread and bakery, legumes, cereals, fruit juice, unsweetened beverages, and butter. The consumption of certain foodstuffs associated with increased CVD risk is lowered. Overall, in yoga practitioners, we found significantly lower consumption of meat, fish, lard, eggs, alcohol, coffee, sweet beverages, white flour, as well as fried and preserved foods. Although participants in the yoga group as well as in the control group indicated an interest to eat healthy and live a healthy lifestyle, in the Yoga group, the participants overall considered their current lifestyle as healthy, while in the control group, the participants acknowledged they did not know how to improve their diet and quality of life.

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8. Acronyms

ACC American College of Cardiology

ACSM American College of Sports Medicine

ADA American Diabetes Association

AHA American Heart Association

ASH American Society of Hypertension

ATP Adult Treatment Panel

BF Breath Frequency

BFM Body Fat Mass

BMI Body Mass Index

GP General Population

CDC Centers for Disease Control and Prevention

ECS European Society of Cardiology

ESH European Society of Hypertension

FFM Fat Free Mass

FPG Fasting Plasma Glucose

HOMA-IR Homeostasis Model Assessment of Insulin Resistance

IDF International Diabetes Federation

IM Myocardial Infarction

IR Insulin Resistance

Y Yoga

CVD Cardiovascular Disease

MET Metabolic Equivalent

MetS Metabolic Syndrome

NCEP National Cholesterol Program Expert Panel

NPKIP Národní program komplexní interní péče

PA Physical Activity

QICKI Quantitative Insulin-Sensitivity Check Index

RER Respiratory Exchange Ratio

RF Risk Factor

V_E Maximal Minute Ventilation

VT Tidal Volume

TAG Triglyceride

HR Heart Rate

BP Blood Pressure

HR Oxygen Max Maximal Heart Rate Oxygen

VCO_2max Maximum CO_2 Production

VO_2max Maximal Oxygen Uptake

WHR Waist to Hip ratio

Wmax Peak Power

9. Related Publications by Vít Čajka

1. Čajka V., Sovová E., Pastucha D. Vliv cvičení jógy na risk factors of cardiovascular disease. Prakt. Lék. 2010;12:715-717

2. Čajka V., Sovová E., Pastucha D. et. al. Výskyt risk factors of cardiovascular disease u lidí cvičících jógu ve srovnání s běžnou populací. Prakt. Lék. 2012;1:41-44

3. Čajka V., Sovová E., Pastucha D. et. al. Analýza životního stylu osob cvičících jógu ve srovnání s běžnou populací. Prakt. Lék. 2013;6:260-263.

4. Čajka V., Sovová E., Pastucha D. et. al. Tělesné složení u osob cvičících jógu. Čs. Antropol. 2014, ročník 64/1. (přijato do tisku)

5. Pastucha D., Sovová E., Čajka V. et. al. Effect of yoga exercise on metabolic and homeostatic parameters of inzuline resistance. Acta Medica Martinina 2012;12(1):35-40.

6. Pastucha D., Sovová E., Čajka V. et. al. Clinical anatomy aspects of functional 3D training – case study. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2012;156(1):63–69.

10. Appendix

Appendix 1

Lifestyle Questionnaire Name:……

1. a) Male o b) Female o

2. Please indicate below if and how regularly you eat the following meals and also indicate which daily portion is the biggest

	2a Regularity			2b Largest portion
	Regularly	Occasionally	Not at all	Please select only one of the following
Breakfast	a)	b)	c)	a)
Snack	a)	b)	c)	
Lunch	a)	b)	c)	b)
Afternoon Snack	a)	b)	c)	
Dinner	a)	b)	c)	
Another meal/snack after dinner	a)	b)	c)	c)

3. Who prepares your lunch (or your warm meal of the day) ?

a) Myself o

b) A family membero

c) A restaurant o

d) Cafeteria at my job/school o

e) Other - Specify ……

4. Which type of foods do you typically eat for the following meals? (type of foods, eg. milk products, meat, fruit, vegetable, bakery, etc.

a) for breakfast ……..

b) for lunch ……..

c) for dinner ……..

d) for snacks……

5. When choosing milk products, do you choose low fat?

Definitely yes, almost always	Usually yes	Sometimes	Usually not, only occasionally	No, I don't check for fat content
a)	b)	c)	d)	e)

6. Which type of fat do you use (choose all that apply)?

a) Butter o

b) Vegetable Shortening, flavored butters o

c) Vegetable Oil o

d) Lard o

7. How often do you put fat on your bread (butter, vegetable shortening, lard)?

Several times per day	Once per day	4-6x weekly	1-3x weekly	1 - 3x monthly	< 1 monthly	Never
a)	b)	c)	d)	e)	f)	g)

8. Do you choose whole grain bakery?

Definitely yes, almost always	Usually yes	Sometimes	Usually not, only	No

			occasionally	
a)	b)	c)	d)	e)

9. How many packets/teaspoons of sugar do you use daily?

a) None o

b) 1 – 4 teaspoons o

c) 5 – 9 teaspoons o

d) 10 teaspoons or more o

10. Please estimate how many of the following types of beverage do you drink daily:

Unsweetened nonalcoholic beverages (water, soda, soft drinks light)____ liters per day

Soft Drinks with Sugar ____ liters per day

Juice ____ liters per day

Coffee ____ cups per day

Black Tea ____ cups per day

Herbal or Fruit Tea ____ cups per day

Milk ____ liters per week

Beer ____ liters per week

Wine ____ liters per week

Alcohol ____ ml per week

11. Please estimate how often do you eat the following types of foods

	Several times per day	Once per day	4-6x per week	1-3x Per week	1 - 3x Per month	< 1 Per month	Never

Fruit	a)	b)	c)	d)	e)	f)	g)
Vegetable	a)	b)	c)	d)	e)	f)	g)
Read meat	a)	b)	c)	d)	e)	f)	g)
Entrails	a)	b)	c)	d)	e)	f)	g)
White meat (fowl / rabbits)	a)	b)	c)	d)	e)	f)	g)
Fish and fish products	a)	b)	c)	d)	e)	f)	g)
Sausages and other meat products	a)	b)	c)	d)	e)	f)	g)
Eggs	a)	b)	c)	d)	e)	f)	g)
Milk, kefir	a)	b)	c)	d)	e)	f)	g)
Milk products (cheese, yogurt)	a)	b)	c)	d)	e)	f)	g)
Dark/whole grain bread or bakery	a)	b)	c)	d)	e)	f)	g)
White bread/bakery	a)	b)	c)	d)	e)	f)	g)
Sweet bakery, donuts,etc.	a)	b)	c)	d)	e)	f)	g)
Potato	a)	b)	c)	d)	e)	f)	g)
Dumplings	a)	b)	c)	d)	e)	f)	g)
Rice	a)	b)	c)	d)	e)	f)	g)
Pasta	a)	b)	c)	d)	e)	f)	g)
Legumes	a)	b)	c)	d)	e)	f)	g)
Sweet main dish	a)	b)	c)	d)	e)	f)	g)
Sweets, and candies	a)	b)	c)	d)	e)	f)	g)
	a)	b)	c)	d)	e)	f)	g)
Fried Foods	a)	b)	c)	d)	e)	f)	g)
Instant Soups and foods	a)	b)	c)	d)	e)	f)	g)

Canned food	a)	b)	c)	d)	e)	f)	g)

12. Have you changed your diet in the past 10 years?

a) Yes o b) no o c) I don't remember o

13. If you have changed your diet, for what reason?

……

If you have changed your diet, please specify how:

……

……

15a. Do you dislike certain foods?

oa) Yes ob) No

15b. If yes, which ……

16. Please indicate if you weight has changed in the past year. Has your weight:

a) Increased o c) Decreased o

b) Been the same o d) I don't keep track o

17. Do you believe that you lead a healthy lifestyle?

oa) Yes ob) No oc) I am not sure

18. Would you like to eat a healthier diet?

oa) Yes ob) No oc) I don't care

19. If you would like to eat healthier, what is the main obstacle

lack of time o

lack of money o

health problems o

habits o

I don’t know how o

other- please specify ……

20. Do you take any food supplements, vitamins or minerals

a) oYes b) oNo

If yes, please specify which ……

21. Do you smoke?

No o

Occasionally o

Less than 5 cigarets per day o

5-10 cigaret per day o

More than 10 cigarets per day o

22. Do you do any regular recreational physical activity?

oa) Yes ob) No

23. If yes, which physical activity do you do?

If yes, please circle or specify

Walking, hiking, gardening, cycling, swimming... ……

24. If yes, how often do you do these activities:

Daily o

3x per week or more o

Less than 3x per week o

25. Do you have a job (paid or unpaid)

5x weekly o

4x weekly o

3x weekly o

2x weekly o

1x weekly o

No o

26. What type of work do you do

Mental o

Light Manual o

Medium Manual Labor o

Heavy Physical Labor o

Unemployed /Household o

27. I live:

alone o

with partner o

with family o

other - specify ……

28. What is your education?

Elementary School o

Specialized Certification/no high school o

High School o

College o

29. Weight ……

30. Height ……

31. BMI ……

32. Age ……

33. City……

33. Date ……