Thesis

Effects of Yoga on Cardiovascular Responses in Patients During Cardiac Rehabilitation

Submitted by

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2 Abstract in German

Einleitung: Herz-Kreislauf-Erkrankungen stellen weltweit eine große Gefahr für die Gesundheit dar. Viele Menschen, die sich von einem akuten Myokardinfarkt oder einer invasiven kardiologischen Behandlung erholen, profitieren von Rehabilitationsprogrammen. **Ziele der Studie**: In dieser Studie wird die Wirkung von Yoga auf das Herz-Kreislauf-System in einem kardialen Rehabilitationsprogramm untersucht. Diese Studie wurde als Pilotstudie mit einer kleinen Teilnehmerzahl konzipiert, um auch die Durchführbarkeit einer solchen Studie zu untersuchen. **Methoden:** Es wurden 20 Teilnehmer im Alter zwischen 43 und 79 Jahren rekrutiert. Zehn von ihnen wurden zufällig für die Yoga-Gruppe und zehn für die Kontrollgruppe ausgewählt. Jeder Teilnehmer der Kontrollgruppe absolvierte das standardisierte vierwöchige kardiale Rehabilitationsprogramm. Die Teilnehmer der Yogagruppe nahmen zusätzlich von Montag bis Freitag morgens und abends an einer 25-minütigen, angeleiteten Yogaeinheit teil. Am Tag nach der Ankunft und am Tag vor der Abreise wurde mit jedem Teilnehmer der „supine to stand“ Test durchgeführt. Der Herzindex (CI), der Gesamtindex des peripheren Widerstands (TPRI), die Herzfrequenz (HR), der systolische und diastolische Blutdruck (sBP, dBP), der mittlere arterielle Druck (MAP) und der Schlagvolumenindex (SI) wurden berechnet und analysiert. **Ergebnisse:** 20 Teilnehmer absolvierten das gesamte Studienprotokoll. Unter Verwendung metrischer statistischer Verfahren wurden keine signifikanten Auswirkungen der Yoga-Intervention auf CI, TPRI, HR, MAP, sBP, dBP und SI nachgewiesen. Für TRPI wurde ein Trend zu einer Interaktion festgestellt (p=0,077). Bei der getrennten Analyse der Gruppen mit dem nichtparametrischen Wilcoxon-Test zeigte die Yogagruppe mehr Signifikanz zwischen Vor- und Nachmessungen. **Diskussion:** Die vorliegende Studie deutet darauf hin, dass Yoga eine positive Wirkung auf das Herz-Kreislauf-System haben kann. Obwohl die parametrischen Tests keine eindeutige Schlussfolgerung zuließen, ergab die getrennte Analyse der Gruppen einen positiven Effekt in der Yoga-Gruppe, aber keinen Unterschied in der Kontrollgruppe. Die vorliegenden Ergebnisse sind jedoch mit Vorsicht zu betrachten, da die statistische Aussagekraft gering war. Um genaue Aussagen über die Wirkung von Yoga auf das Herz-Kreislauf-System machen zu können, sind Studien mit einer größeren Probandenzahl erforderlich.

3 Abstract

Introduction: Cardiovascular disease is a major health threat worldwide. Many people recovering from acute myocardial infarction or invasive cardiac treatment benefit from rehabilitation programs.

Aims of the study: This study investigates the effect of yoga on the cardiovascular system in a rehabilitation program for people recovering from cardiovascular disease. This was a pilot study with a small number of participants to also investigate feasibility.

Methods: 20 participants aged between 43 and 79 years were recruited. All of them started a four-week rehabilitation program at the St. Radegund Rehabilitation Clinic near Graz, Austria, to recover from an acute myocardial infarction or invasive heart surgery. Ten of them were randomly selected for the yoga group and ten for the control group. Each participant in the control group completed the recommended and standardized rehabilitation program. The participants in the yoga group also participated in supervised yoga sessions for approximately 25 minutes in the morning and evening from Monday to Friday. On the day after arrival and the day before departure, the supine-to-stand test was performed with each participant. Cardiac index (CI), total peripheral resistance index (TPRI), heart rate (HR), systolic and diastolic blood pressure (sBP, dBP), mean arterial pressure (MAP), and stroke index (SI) were calculated and analyzed.

Results: 20 participants completed the entire study protocol. Applying a metric statistic revealed no significant effects for the hemodynamic parameters CI, TPRI, HR, MAP, sBP, dBP, and SI by the yoga intervention, however a trend towards an interaction was found for TRPI ($p=0.077$). When the groups were analyzed separately using the nonparametric Wilcoxon test, the yoga group showed more significance between pre- and post-measurements.

Discussion: The present study indicated that yoga may have a positive effect on the cardiovascular system. Although no clear conclusion was to be drawn by parametric tests, analyzing the groups separately revealed a positive effect in the yoga group, but no difference in the control group. However, the present results should be viewed with caution as the statistical power was low. Larger studies are needed to make accurate statements about the effect of yoga on the cardiovascular system.

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4 List of abbreviations

- ACS acute coronary syndrome
- BCE Before the Common Era
- BP blood pressure
- CAD coronary artery disease
- CI cardiac index
- CR cardiac rehabilitation
- CVD cardiovascular disease
- dBP diastolic blood pressure
- ECG electrocardiography
- EEG Electroencephalography
- EKG Elektrokardiogramm (German)
- HR heart rate
- HRV heart rate variability
- LDL low density lipoprotein
- LVEF left ventricular ejection fraction
- MAP mean arterial pressure
- MI myocardial infarction
- min minutes
- NSTEMI non-ST-Elevation myocardial infarction
- PAR population attributable risk
- sBP systolic blood pressure
- SD standard deviation
- SI stroke index
- STEMI ST-Elevation myocardial infarction
- TFM Task Force Monitor®
- TPR total peripheral resistance
- TPRI total peripheral resistance index
- US United States (of America)
- WHO World Health Organization

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Figure 25: TPRI for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 26: SBP for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 27: HR for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 28: MAP for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 29: DBP for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 30: CI for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data fof the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

Figure 31: SI for every epoch during the supine-to-stand test. On the right side the graph shows the data of the control group and on the left side the data of the yoga group. The blue line represents the pre-measurements, and the red line represents the post-measurements. Both axes have the same spacing.

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into account the difference between the pre- and post-measurements and the difference between the yoga and control groups.

6 Introduction

6.1 Cardiovascular disease

6.1.1 Terminology

Cardiovascular disease (CVD) is a pathological condition that affects the cardiovascular system, including the heart, blood vessels, or pericardium (a double-walled sac containing the heart and the roots of the major blood vessels) (1). CVD is a general term that encompasses several diseases of the heart and blood vessels. A detailed list is provided in the attachments. Various terms are used in the literature for the same or similar conditions, such as coronary artery disease, myocardial ischemia, and chronic coronary syndrome. Definitions of these terms can be found in the attachments.

6.1.2 Epidemiology and impact on society

CVDs are the leading cause of death worldwide. In 2016, approximately 17.9 million people died of CVDs (2). Myocardial ischemia is the most common cause of CVD-related deaths. Experts from the World Health Organization (WHO) estimate that the number of deaths will increase to about 23.4 million by 2030 (3). Therefore, they have an immense social and economic impact on society. Depending on the economic standard of the country, cardiovascular diseases account for 10% to 18% of disability-adjusted life years[1] (4). Incidence and mortality are higher in men than in women worldwide. Mortality rates vary widely from region to region. In Western Europe, the median age-adjusted mortality[2] rate is 324/100,000 for men and 234/100,000 for women. In Central Asian countries, the mortality rate due to CVD is 1,305/100,000 for men and 967/100,000 for women (5). Austria tops the list for age-adjusted incidence of cardiovascular disease in Europe. For every 100,000 inhabitants, there are 1,483 cases among women and 1,868 among men (5).

[1] Measure of the burden of a particular disease, defined as the sum of the number of Years of Life Lost (YLL) and the number of Years Lived with Disability (YLD) weighted by disease severity (50).
[2] Weighted average of age-specific mortality rates, where the weights are the proportions of persons in the corresponding age groups in the standard population (51).

6.1.3 Pathophysiology

6.1.3.1 Atherosclerosis

Atherosclerosis is the main cause of CVDs. Starting from a dysfunction of the vessel wall, an obstruction may develop, leading to poor oxygen supply to the heart muscle.

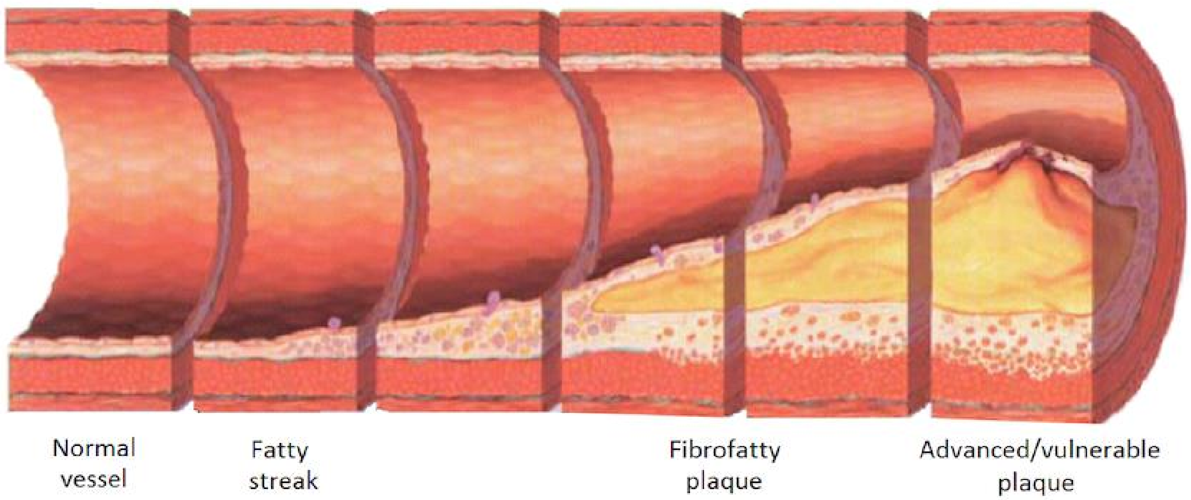


Figure 1: Development of atherosclerosis. Reproduced from: www.victorchang.edu.au/atherosclerosis

Atherosclerosis begins at a very young age, and almost everyone has atherosclerotic lesions in some vessels. In an autopsy study of 2876 individuals between the ages of 15 and 34 for whom the cause of death was not cardiac, the first lesions of atherosclerosis were found in the aortas of all of them (6). The pathogenesis of atherosclerosis is quite complex and still a subject of research. The mechanism is briefly explained here without claiming to be complete. The earliest phase of atherosclerosis is a local thickening of the arterial wall called fatty streaks. Characteristic of this fatty streak are lipid-laden macrophages in the intima, the second layer of the arterial wall from the inside. The more intracellular and extracellular lipids accumulate, the more smooth muscle cells also populate the intima. A fibrous cap forms around the fatty strip toward the arterial lumen to provide support for the lesion. This fibrous cap may consist of dense collagen or be rich in smooth muscle cells. As connective tissue, intracellular and extracellular lipids accumulate and more and more smooth muscle cells colonize, the lesion grows and a fibrous plaque forms. During this process, more and more macrophages die, leading to the release of messenger substances and other substances into the extracellular space. A cascade of biochemical communication triggers an immune response that leads to immigration of further immune cells. Inflammatory processes are important for the progression of atherosclerosis. Even at an early stage, inflammatory cells are found in the lesions (7). It is very likely that macrophages take up the oxidized low-density proteins to protect the endothelium from its toxic effect (8). When the macrophages are overloaded with lipids, they may die and release messenger molecules. This leads to even more inflammatory cells migrating into the vessel wall. In advanced lesions, a necrotic lipid-rich core and sometimes calcification are found. The coronary artery may respond to the growing lesion by positive remodeling, enlarging the artery at the site of the lesion. In this case, blood flow remains functional because clinical symptoms of poor oxygenation of the following muscles do not occur until more than 70 to 80 percent of the vessel lumen is occluded. On the other hand, the coronary artery may respond with negative regression by narrowing the lumen, resulting in earlier clinical manifestation. Dysfunction of the endothelium plays an important role in the development of atherosclerosis. The endothelium is the first layer of the artery wall from the inside. It forms a boundary between the blood and all other tissues. It interacts with the blood and regulates vascular tone, helps immune cells migrate into tissues, initiates the cascade of hemostasis when injured, and forms a barrier against toxic substances. Dysfunction of the endothelium makes the whole process of atherosclerosis possible. The clinical manifestation of an atherosclerotic lesion may be rapid or slow. If it develops slowly, the lesion grows and chronic narrowing of the lumen occurs. Rapid obstruction is by far the more likely event. One reason for rapid obstruction is erosion of an outer portion of the fibrous plaque, which is washed away by the blood and blocks a smaller vessel further down in the bloodstream. Plaque rupture also often results in hemorrhage from fragile micro vessels that grow in the atherosclerotic lesion when it reaches a certain size (7).

6.1.4 Risk factors

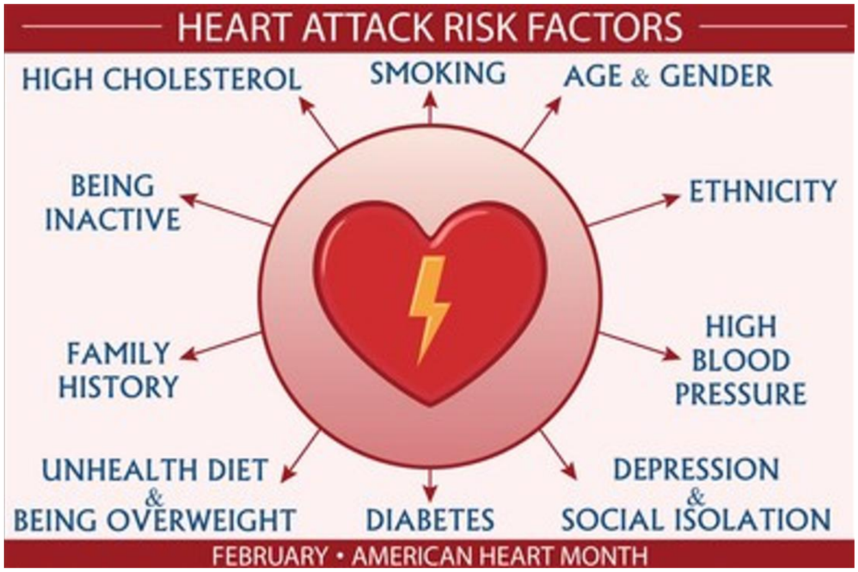


Figure 2: Risk factors for heart attack: Reproduced from: www.shutterstock.com/de/image-vector/heart-attack-risk-factors-infographic-vector-1632705589

In 2004, a large-scale case-control study of risk factors for myocardial infarction (MI) was published, also known as the "Interheart" study. The study involved 15152 cases and 14820 controls from 52 countries. They examined nine risk factors to which 90% of heart attacks in men and 94% in women are attributed. For each factor, they calculated the odds ratio. In this case, the odds ratio indicates how much more likely it is to have a heart attack with a risk factor than without. For example, the odds ratio for smoking in developing an MI is 2.87, so someone who smokes is 2.87 times more likely to have a heart attack than someone who does not smoke. An odds ratio of one would mean that the probability of having a heart attack with or without this risk factor is the same. If the odds ratio is less than one, it means that the probability of having a heart attack is lower with this factor (9). The nine risk factors and their odds ratios are as follows.

- smoking (odds ratio: 2.87)
- ApoB/ApoA1 ratio[3] (odds ratio: 3.25)
- history of hypertension (odds ratio: 1.91)
- diabetes (odds ratio: 2.37)

[3] The ApoB/ApoA1 ratio represents the balance of blood lipids, and if ApoB dominates, this accelerates the progression of atherosclerosis. Apo is an abbreviation for apolipoprotein. ApoB is a protein in very low or low to intermediate density proteins (VLDL, LDL, IDL). ApoA1 is a part of high density protein (HDL) (52).

- abdominal obesity (odds ratio: 1.12)
- psychosocial factors[4] (odds ratio: 2.67)
- regular alcohol consumption (odds ratio: 0.91)
- daily consumption of fruits and vegetables (odds ratio: 0.70)
- regular physical activity (odds ratio: 0,86)

(9)

Another large-scale study, such as the Framingham Heart Study, which began in 1948 with more than 5,000 participants and was in its third generation of participants by 2016, reached a similar conclusion (10).

6.1.5 Stress and CVD

Studies in animals and humans have shown a significant association between CVD and psychological factors such as depression and stress. A study in cynomolgus monkeys (Macaca fascicularis) has shown that monkeys with chronic stress are more likely to develop arteriosclerosis in their coronary arteries (11). In particular, anger responses to stress have been shown to be associated with CVD in young men. 1055 male medical students participated in a study in which anger responses to stress were documented in questionnaires. A follow-up 36 years later showed that the group with the highest anger levels had a significantly increased risk of CVD before the age of 55 compared with the others. (12). A Swedish study of 10,443 participants found a significantly increased risk of cardiovascular disease in people with depression (13). Large-scale studies have also demonstrated a significant association between anxiety and the prevalence of CVD (14–16). The pathophysiological mechanisms of psychological factors can be divided into two main categories. The first category is the behavioral mechanism. This means that people suffering from psychological problems are more likely to lead an unhealthier lifestyle with less physical activity, more smoking, and alcohol consumption. The second category is direct pathophysiological mechanisms. Here, the influence of stress has a direct, damaging effect on the

[4] The following psychosocial factors were included in the Interheart study: Depression, locus of control, perceived stress, and life events (9).

organism, such as neuroendocrine dysregulation, inflammatory processes and platelet activation (17).

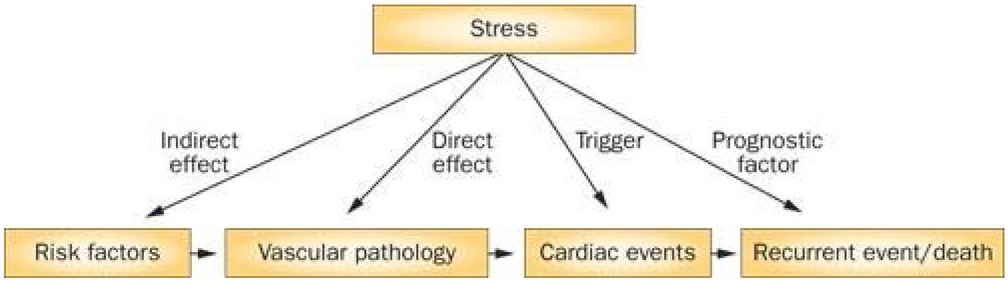


Figure 3: The influence of stress on cardiovascular disease: Reproduced from: www.nature.com/articles/nrcardio.2012.45.pdf?origin=ppub

6.2 Cardiac Rehabilitation

Cardiac rehabilitation programs are designed to accelerate recovery and improve long-term outcomes in patients recovering from acute cardiovascular events or procedures. Although the program varies from one clinic to another, the key components are as follows:

● Medical evaluation/baseline patient assessment

● Exercise training and physical activity counseling

● Coronary risk factor reduction/secondary prevention, including nutritional counseling and weight management

● Psychosocial support

● Advice regarding diet, weight management, purpose of medications, medication side effects, effects on exercise tolerance, and re-enforcement for medication adherence

(18)

Figure 4: The main components of a cardiac rehabilitation program: Reproduced from: www.aspenhospital.org/services/cardiopulmonary-rehab/

In numerous clinical trials, cardiac rehabilitation programs have been shown to reduce mortality and hospitalizations and improve physical performance and quality of life (19–22). Therefore, they are strongly recommended by the European Society of Cardiology, the American Heart Association and the WHO.

6.3 Yoga

Yoga is a spiritual discipline that originated in the Himalayan region. It focuses on the harmony between mind and body and includes a variety of physical, mental and spiritual practices. The word "yoga" comes from the Sanskrit root "yuj", which means "to join", "yoke" or "unite" (23). Discoveries of sculptures depicting yoga postures dating back to 3000 B.C. suggest how ancient the roots of yoga may be (24). For a long period of time yoga remained mainly in northern India and was practiced only by a relatively small number of male Brahmins[5]. At the end of the 19th century, T. Krishnamacharya, Swami Sivananda and other yogis[6] began to teach and spread yoga throughout India, including outside the Brahmin caste as well as to women. Around 1950, some of their students went to the U.S. to open yoga schools, and yoga became increasingly popular in

[5] a caste within Hindu society
[6] a person who practices yoga

the West (25). Over the centuries, yoga has evolved and many different styles of yoga have emerged. Each yoga style has a different focus, uses different techniques and practices. Many yogis speak of the six main branches of yoga, which are mentioned here to give an idea of the diversity of yoga (26).

Figure 5: The six branches of yoga: Reproduced from: www.twitter.com/bigbazaar/status/615852567235432448

- Hatha Yoga focuses on asanas[7], postures.
- In Raja Yoga, meditation is the main practice.
- Karma yoga is the act of doing good to others without expecting anything in return.
- Bhakti is the yoga of devotion. Rituals are often performed to worship Hindu gods. Dedicating one's life to a higher goal, as Mahatma Gandhi or Mother Teresa did, also corresponds to the idea of Bhakti Yoga.
- Jnana is the yoga of wisdom. The study of yogic philosophy is an important part of this tradition.
- Tantra Yoga is the most esoteric branch, where the practitioner tries to experience the divine in everything he does. Because there are traditions that include sexual practices, this branch of yoga is often misinterpreted and reduced to its sexual component. (26)

[7] A body posture as shown in figure 5.

The branches of yoga are far more complex and have only been briefly explained here to show how diverse yoga practice can be. Hatha yoga and other yoga styles that focus on asanas are the most commonly-practiced yoga styles in the world.

In this thesis, yoga focuses on the mental and physical practices that include postures (asanas), breathing techniques (pranayama), and meditation (dhyana). There are many other ways to understand yoga, and I do not have the expertise to give an authoritative definition of yoga.

In the last decades yoga has become more and more popular and has spread almost all over the world. It has become almost impossible to find anyone who has never heard of yoga. In terms of numbers, between 2016 and 2018, there were an estimated 300 million yoga practitioners worldwide, 36 million in the U.S., 4 million in Germany, and 350,000 in Austria, all of these numbers indicating an upward trend (27–29). Around 70% of yoga practitioners are female (27). In 2017, yoga was the most commonly-used complementary health practice among U.S. adults (30).

6.3.1 Health benefits of yoga

Figure 6: Yoga benefits. Reproduced from: https://www.getfitso.com/blog/health-benefits-of-yoga/

Yoga is called a science of health. Many yoga teachers, societies and magazines point to a markedly positive influence on health and well-being (24).

The following benefits of yoga are mentioned:

- improvement of flexibility
- help with lower back pain
- help with stress relief
- improvement of mental health
- reduction in inflammation
- increase in physical strength
- reduction in anxiety
- improvement of quality of life
- improvement of the immune system
- improvement of balance
- improvement of cardiovascular functions
- improvement of sleep
- improvement of self-esteem
- improvement of bone health
- promotion of better posture and body awareness
- improvement of brain functioning

(27,31,32)

6.4 Aims of the study

The central question of this work is: does an additional yoga intervention have an impact on cardiovascular response in a four-week cardiac rehabilitation program. This study was a pilot study with a small number of subjects to investigate feasibility.

Exercise-based cardiac rehabilitation programs have shown their beneficial effects in studies (33). In addition to physical exercises, subjects in the yoga group were also instructed in breathing exercises and body awareness and benevolence exercises. Whether this can be shown to have a benefit on the cardiovascular system compared to the normal cardiac rehabilitation program is the subject of this thesis. In order to objectify the effects on the cardiovascular system, the Supine-to-Stand test is performed before and after the four-week rehabilitation program.

The societal burden of cardiovascular disease is large and has an alarming upward trend. Therefore, improving cardiac rehabilitation programs may be beneficial for many patients. To date, few studies have examined the effect of yoga in patients just recovering from a serious cardiac event, and there is a need for more studies.

The assumption was that subjects who practice yoga in addition to the normal rehabilitation program will show greater improvements in the cardiovascular parameters studied than those who participate only in normal cardiac rehabilitation.

7 Methodology

7.1 Study design

The study took place at the cardiac rehabilitation center in St. Radegund in October and November 2019. 20 participants were randomly divided into two groups of ten. One group completed the normal rehabilitation program, while the other group participated in additional 25-minute yoga sessions every morning and afternoon from Monday to Friday. At the beginning and end of the four-week stay at the rehabilitation center, the supine-to-stand test (explained below) was administered. Blood pressure and the thoracic impedance was measured, and an ECG was written using the Task Force Monitor® (TFM). From these data, the following cardiovascular parameters were calculated: Heart Rate (HR), Systolic Blood Pressure (sBP), Diastolic Blood Pressure (dBP), Mean Arterial Pressure (MAP), Cardiac Index (CI), and Total Peripheral Resistance Index (TPRI). The results of the two groups were statistically analyzed. The original study design had included follow-up measurements six months and one year after the rehabilitation program. However, this did not occur because the participants did not continue the yoga intervention.

This work is part of a larger study with another intervention group of 10 participants practicing meditation. In addition to the parameters studied in this work, the following data were collected: ABI (ankle-brachial index), retinal image, EEG, hair sample (for cortisol analysis), stool sample (for microbiome analysis), 24-hour ECG, and questionnaires.

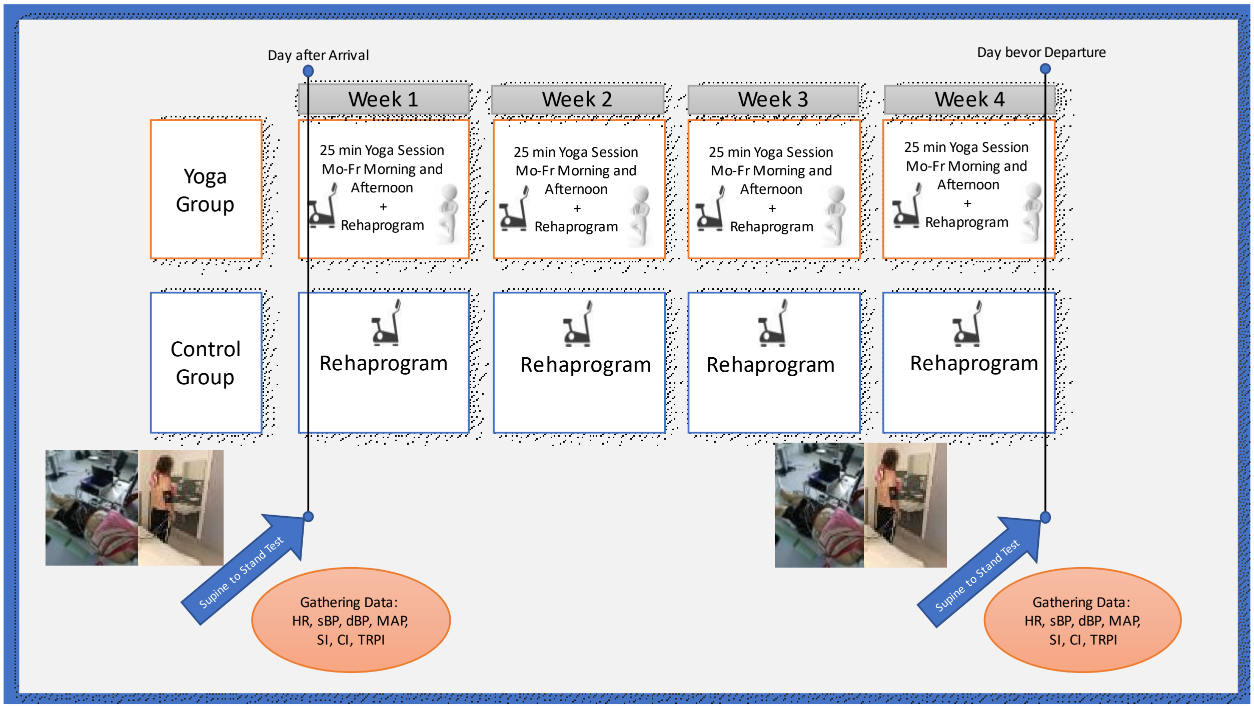


Figure 7: Overview of the study protocol.

7.1.1 Recruitment process

Patients participating in their rehabilitation program at the same time as this study were selected according to the following criteria.

7.1.1.1 Inclusion criteria:

- age range 40-80 years
- admitted to the cardiac rehabilitation center in St. Radegund for at least 4 weeks
- after myocardial infarction (MI)
- after ST-level myocardial infarction (STEMI)
- after non-ST-level myocardial infarction (NSTEMI)
- after acute coronary syndrome (ACS)
- coronary artery disease (CAD) with percutaneous coronary intervention
- after coronary artery bypass graft

7.1.1.2 Exclusion criteria

- patients who must be monitored because of clinical symptoms (subjects with NYHA III, mini mental score less than 26, or subjects who are not sufficiently mobile)
- subjects who already regularly practice yoga or meditation techniques

If a patient met the criteria, the study design was explained to them and they were asked if they were willing to participate in the study. All patients were informed of their right to withdraw from the study at any time without giving a reason.

Six women and 14 men, aged between 43 and 79 years, agreed to participate in the study. They were randomly assigned to two groups of ten participants each. An intervention group that completed the yoga intervention in addition to the rehabilitation program, and a control group that participated only in the rehabilitation program.

Table 1: Participants sorted by groups, sex and with age range.

Group	Female	Male	Age
Yoga	5	5	43-79
Control	1	9	51-75

7.2 The yoga intervention

An experienced yoga instructor designed and led the following intervention according to the physical abilities of patients participating in a cardiac rehabilitation program. The yoga session lasted approximately 25 minutes every morning and evening from Monday to Friday. Each session included the following components.

- Pranayama: Breathing exercises
- Asanas: Physical exercises
- Relaxation and Affirmations: Positive statements recited by the participants
- Meditation
- Metta: Practice of benevolence with positive thoughts towards yourself and/or others
- Homework: A little task for every day about consciousness, relaxation, or positive thinking

7.2.1 Timetable

Table 2: Overview of the yoga intervention

	Monday	**Tuesday**	**Wednesday**	**Tuesday**	**Friday**
Pranayama	Complete Breath/ Kumbhaka	Relaxation Breath	Ujjayi/ The ocean breath	Brahmari/ Humming Bee Breath	Anuloma/Alternate nostril breathing
Asanas	The same asana sequence (explained below)				
Relaxation	Body-scan Affirmations				
Meditation	Morning: Watching the breath Evening: Observing feelings				
Metta	Loving kindness towards yourself	Loving kindness towards a loved one	Loving kindness towards a random person	Loving kindness towards somebody difficult	Loving kindness to all
Homework	Inhale with a smile	Pause and watch your breath	Gratitude	In the same boat	Three times relaxation

7.2.2 Pranayama

Pranayama is performed in a comfortable seated position with the back straight and the spine and head erect. Participants begin by breathing naturally and noticing their state of mind. Each technique is practiced for a few minutes, after which participants have time to focus on their body sensations (34).

7.2.2.1 Full Breath Retention/ Kumbhaka

Participants begin with a deep breath and complete the inhalation by pulling the belly button inward and upward, then relax the abdomen and passively inhale. When the lungs are filled with air, the chest should be expanded in all directions. When exhaling, the chest is first relaxed and at the end of the exhalation the abdominal wall is gently pulled in (34).

7.2.2.2 Relaxation Breath

This breathing technique is about lengthening the exhalation. This is done by counting the length of inhalation and exhalation. After a few breaths, the exhalation should be slowly lengthened compared to the inhalation by exhaling more softly and slowly. This is always done in a comfortable space where there is no shortness of breath (34).

7.2.2.3 Humming Bee Breath/ Brahmari

In Brahmari, the inhalation is performed in a relaxed way through the nose. Throughout the exhalation through the nose, participants then emit a deep humming sound. The lips are gently closed and the vibration is felt throughout the body. Thoughts are also focused on the sound. It is possible to change the pitch of the sound (34).

7.2.2.4 The ocean breath/ Ujjayi

In this technique, inhalation and exhalation occur through the nose with the mouth firmly closed. In both, a sound is produced by partially closing the epiglottis. The sound is soft and sounds a bit like the ocean, which is why this breathing is also called "ocean breathing" (34).

7.2.2.5 Alternate nostril breathing/ Anuloma viloma

Anuloma viloma is performed by breathing alternately through the left and right nostrils. To do this, the middle and index fingers of the right hand are placed on the ball of the thumb. After exhalation, the thumb of the right hand closes the right nostril, and inhalation is done completely through the left nostril. Then the ring finger of the right hand closes the left nostril and the right nostril opens again. Exhalation occurs slowly through the right nostril. The next inhalation is through the still open right nostril. Then the right nostril is closed again with the right thumb, the left nostril opens again, and the exhalation is through the left nostril. This is the sequence of one round. It is repeated five times. After these five rounds, the right hand is lowered and breathing continues through both nostrils (34).

7.2.3 Asanas

7.2.3.1 Sitting on a chair

The next four exercises are performed sitting on a chair.

7.2.3.1.1 Awakening energy

Participants raise their arms sideways above their heads as they inhale and lower them as they exhale. This is repeated four times. Then the right arm is raised above the front of the body on inhalation and lowered again on exhalation. The head is turned to the left while doing this. This is repeated four times and then repeated with the left arm (34).

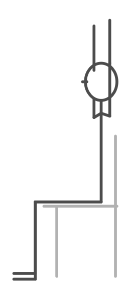


Figure 8: Asana: Awakening energy. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.1.2 Opening up

On inhalation, the arms are opened wide to the sides. Exhaling, one knee is brought up to the chest and the arms are closed around it. This is repeated twice, then the whole process is repeated with the other leg (34).

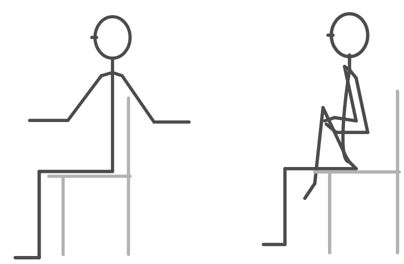


Figure 9: Asana: Opening up. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.1.3 Rotation of the shoulders

The shoulders are rotated four times in one direction and then four times in the other direction.

7.2.3.1.4 Leaning forward

The arms are folded behind the back, the right hand grips the left wrist. While inhaling, the back is kept straight and erect. On exhalation, the body bends forward, keeping the back straight. On the next inhalation, the body straightens again. This is repeated four times (34).

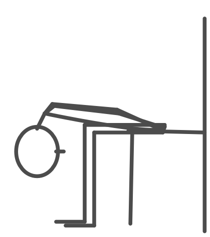


Figure 10: Asana: Leaning forward. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.2 Standing asanas

The next four exercises are performed while standing.

7.2.3.2.1 Center

On inhalation, the arms are spread out to the side of the body and raised above the head. On exhalation, they are brought into a prayer position in front of the chest (34).

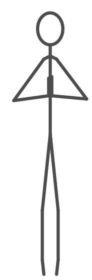


Figure 11: Asana: Center. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.2.2 The chair

On inhalation, the arms are held outstretched at the sides of the body with the palms facing inward. While exhaling, participants sit on an imaginary chair and hold this position for a few breaths (34).

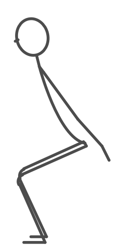


Figure 12: Asana: The chair. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.2.3 Half forward bend

During inhalation, the arms are brought to the sides of the body and stretched. On exhalation, participants bend forward, keeping the back straight. The hands are placed on the knees and the head hangs down (34).

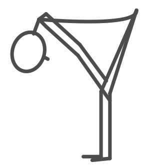


Figure 13: Asana: Half forward bend. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.2.4 Warrior two

The feet are placed 1.5 meters apart. The left knee is bent so that the knee is above the ankle. The arms are spread wide and parallel to the floor. The head is turned to look over the left arm. The position is held for four breaths and then repeated with the right leg (34).

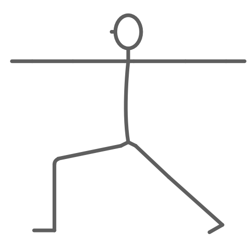


Figure 14: Asana: Warrior. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.3 Lying down

The next four exercises are performed lying down.

7.2.3.3.1 Stretching the legs

One leg is lifted and stretched. The foot is rotated four times in both directions. Then the leg is held with both hands for four breaths. Slowly the leg is placed straight or bent on the floor again. The process is repeated with the other leg (34).

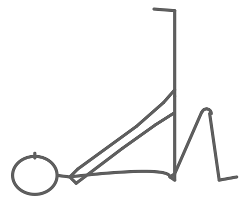


Figure 15: Asana: Stretching the legs. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.3.2 Crocodile

The legs are bent so that the feet touch the hips. Then the hips are raised and turned a little to the left. Now the knees are turned to the right. This position is held for four breaths. Then the knees are turned to the left, the position is held for four breaths as before (34).

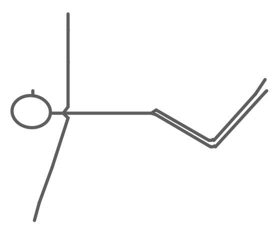


Figure 16: Asana: Crocodile. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.3.3 Shoulder supported bridge

The legs are bent and the feet touch the hips. The hips are raised on inhalation and lowered on exhalation. This is repeated four times and held for four breaths (34).

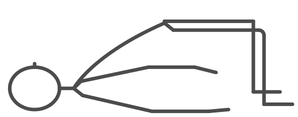


Figure 17: Asana: Shoulder supported bridge. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.3.3.4 Knees to the chest

The knees are bent, brought up to the chest and held with the arms. Then the body is swung from side to side (34).

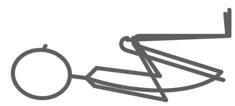


Figure 18: Asana: Knees to the chest. Reproduced from: Herzstudie genaue Beschreibung nach Studienende, Dr. Gilda Wüst, 11.2019

7.2.4 Relaxation

7.2.4.1 Body Scan

The Body Scan is performed in the supine position. It begins by focusing attention on the feet. The goal is to perceive the sensations in the body without judging. For a few breaths, the focus of attention remains on the feet. Then the attention shifts to the calves and remains there for the same amount of time. In this way, the scan explores sensations in other parts of the body, moving upward to the thighs, hips, back, shoulders, arms, hands, chest, and head. Finally, attention focuses on the whole body. At the end, one of the following affirmations is repeated internally (34).

"My blood vessels are wide and open, my heart beats calmly and regularly."

"I go through life with ease."

7.2.5 Metta-Meditation

The idea behind metta meditation is to feel loving kindness toward oneself and others. Participants are asked to assume a seated position with a straight back. If participants feel comfortable doing so, they can place their hands on their chest and feel the warmth of this touch. Then the following phrases are recited internally (34).

“May I be healthy”

“May I be safe”

“May I be peaceful and relaxed”

“May I be happy”

At the end of this meditation, the hands are folded in front of the chest and the participant bows. On Monday, loving-kindness is directed to the participants themselves, on Tuesday to a friend, on Wednesday to an acquaintance, on Thursday to a person with whom the participant has difficulties, and on Friday to all people. The above sentences are adjusted accordingly (34).

7.2.6 Meditation

The meditation is performed sitting upright on the front part of the seat of a chair with the spine straight.

7.2.6.1 Mindfulness of breathing

Attention is focused on the breath without manipulating it. One way is to focus a little more on the exhalation and the space after the exhalation. If thoughts wander, participants are asked to return to the breath without judgment or thought (34).

7.2.6.2 Observation of feelings

Participants ask themselves the question. "How do I feel at this moment?" And feel inside themselves to notice what sensations arise. The feelings should be observed without analyzing them, judging them, or trying to change them. To make this a little easier, it is possible to look at where in the body the feeling is located. Whenever the thoughts wander, participants are asked to repeat the question (34).

7.2.7 Homework

After each morning yoga class, participants are given a simple task to complete at their convenience throughout the day.

7.2.7.1 Smile breathing

Whenever participants remember, they should smile. The smile should be perceived intensely while taking a deep breath. On the next exhalation, participants are asked to visualize the smile and spread it throughout the body (34).

7.2.7.2 Watching the breath

During this meditation, participants breathe naturally and observe their breath flow without consciously inhaling and exhaling. It is possible to recite the following phrases internally while breathing.

"I am aware of my inhalation; I am aware of my exhalation"

or just

"in, out"

If the situation is suitable, the participants are asked to stop any activity for this exercise. If not, they can continue their activity (34).

7.2.7.3 Threefold relaxation

In this exercise, participants are asked to relax for the duration of three exhalations. On the first exhalation, participants should relax their breath itself. On the second exhalation, the body is relaxed so that it becomes wide and soft. With the third exhalation, participants let go of anything that is weighing them down and causing stress. Finally, a moment of silence should be enjoyed before returning to everyday life (34).

7.2.7.4 Say yes

Participants should say yes to this present moment. If the participants do not want to accept this moment, perhaps even with an inner voice presenting arguments why this moment is not acceptable, they are asked to smile to their ego and continue to embrace this present moment (34).

7.2.7.5 In the same boat

Whenever participants meet others, they should realize that these people only want to express their truth and rejoice in their existence. It is possible to recite the following sentences inwardly.

"Like me, this person wants to experience happiness."

"Like me, this person wants to be free from suffering."

(34)

7.2.7.6 Gratefulness

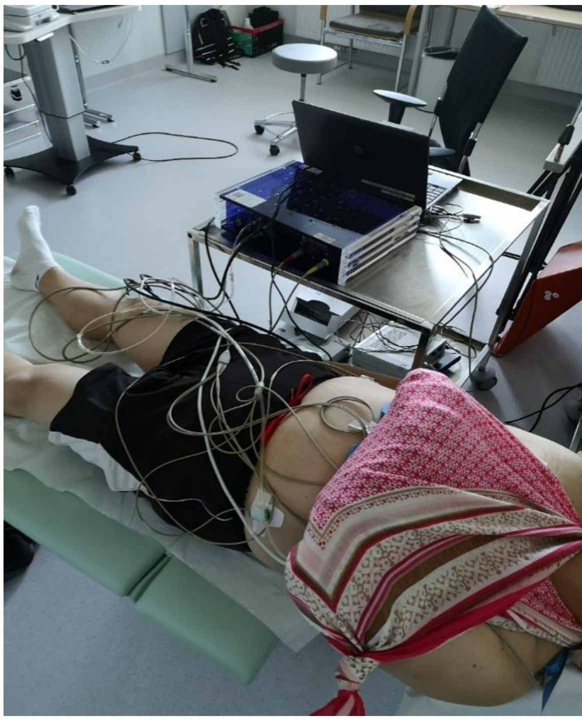
Participants should ask themselves what they can be grateful for in this moment. Once participants find something to be grateful for, they should let go of the issue and feel the sensation throughout their body (34).

7.3 Testing parameters

The supine-to-stand tests were conducted the day after the participants' arrival and on the day before their departure. All tests administered lasted 60 to 90 minutes and were conducted in one of the five following time slots: 9:00, 10:30, 13:00, 14:30, and 16:00. To the extent possible, each participant was tested in the same time slot on each of the test days. The supine-to-stand test lasted approximately 25 minutes, and the remaining time was used for the other tests mentioned in Section 8.1; these are not the subject of this thesis. During the supine test, all parameters were measured and calculated using the Task Force Monitor® (TFM). The parameters measured and achieved were: Heart Rate (HR), Systolic and Diastolic Blood Pressure (sBP, dBP), Mean Arterial Pressure (MAP), Stroke Index (SI), Cardiac Index (CI) and Total Peripheral Resistance Index (TPRI).

7.3.1 The supine-to-stand test

During the supine-to-stand test, the participant was asked to lie down for five minutes (basic phase), then stand for five minutes (standing phase), and lie down again for five minutes (recovery phase). The test took place in a quiet environment and the participant was asked to relax and not speak.



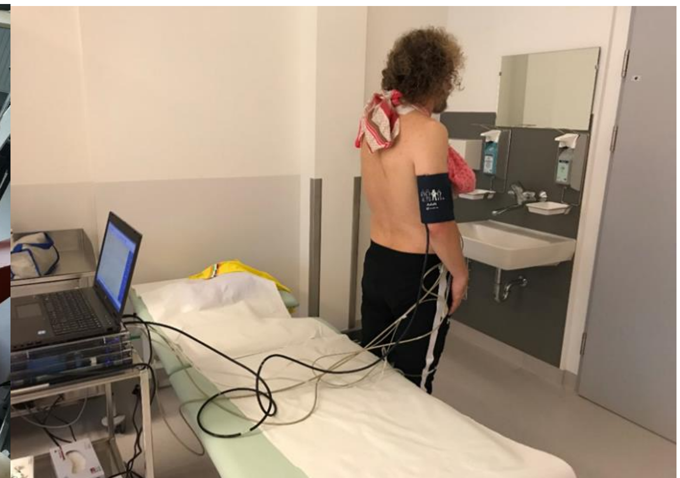
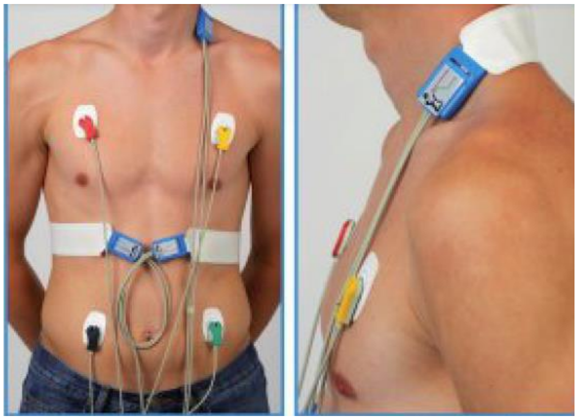


Figure 19 (left): A participant in supine position with all measuring devices attached. The arm rests in a sling to keep the finger cuff level with the heart when standing up. In the background is the TFM (the blue box) to which a laptop is attached.

Figure 20 (right): A participant in the standing position. The participant is asked to stand without support and look at a point on the door at eye level.

Prior to the test, all measuring devices were attached to the participant. These included a 3-lead ECG with 4 electrodes on the trunk, 3 impendency electrodes (2 in the middle of the trunk and one in the neck), a blood pressure arm cuff on the right arm, a finger cuff on the index and middle fingers of the left hand, and a recording unit on the left forearm. All devices were connected to the TFM, which recorded, processed, and visualized the data.



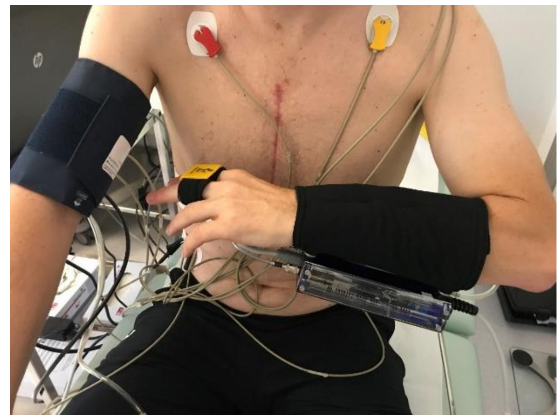


Figure 21 (left): image shows the 4 ECG electrodes and the 3 impendance electrodes placed on the chest. Reproduced from: Task Force Monitor Technical Specifications, CNsystems, 04.2019.

Figure 22 (right): A participant with the finger cuff and recording device on the left arm. A blood pressure cuff is attached to the left arm.

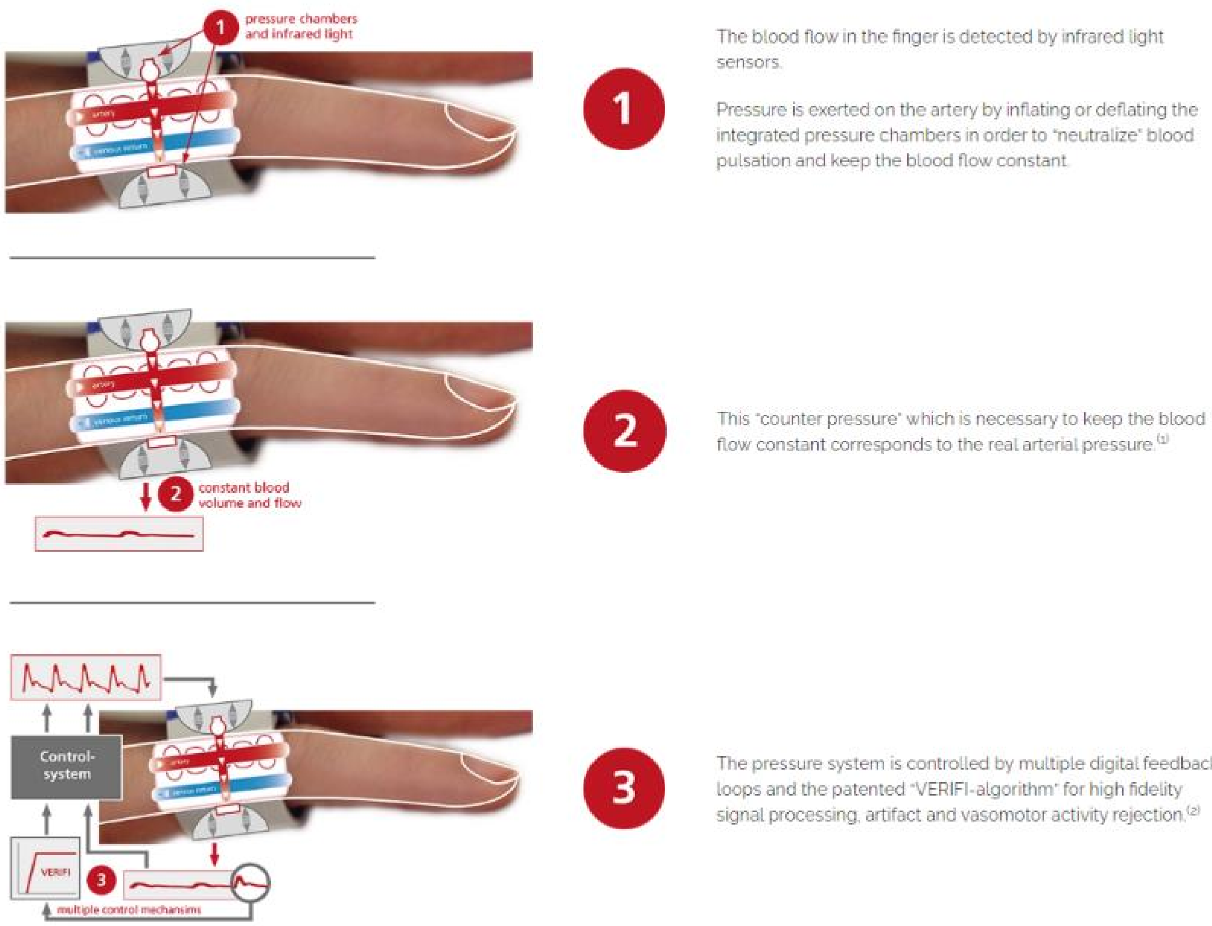


Figure 23: This illustration shows the operation of continuous blood pressure measurement with the CNsystems finger cuff. Reproduced from: www.cnsystems.com/technology/cnap-blood-pressure/

The TFM records the data in a period of 10 seconds, which is called an epoch.

The measurements took place at the following times.

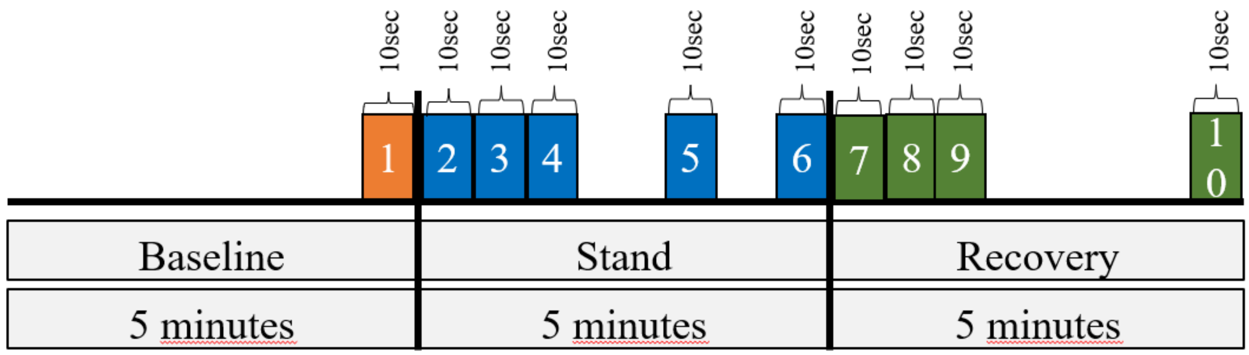


Figure 24: Visualization of the measurement times of every epoch.

Table 3: Measurement times of the individual epochs.

Baseline period	300 sec = 5 min
Baseline	second 290-300
Standing period	300 sec = 5 min
Stand 1	second 0-10
Stand 2	second 10-20
Stand 3	second 20-30
Stand 4	second 170-180
Stand 5	second 290-300
Recovery period	300 sec = 5 min
Recovery 1	second 0-10
Recovery 2	second 10-20
Recovery 3	second 20-30
Recovery 4	second 290-300

7.3.2 Parameters

The following parameters are analyzed in this thesis:

- Systolic Blood Pressure (sBP)
- Diastolic Blood Pressure (dBP)
- Mean Arterial Pressure (MAP)
- Cardiac Index (CI)
- Total Peripheral Resistance Index (TPRI)
- Stroke Index (SI)

7.3.2.1 Systolic blood pressure (sBP)

The pressure of the circulating blood against the vessel walls is the blood pressure. It occurs when the heart pumps blood through the body. When the heart muscle contracts, blood is forced out of the heart into the large arteries; this is called the systole of the cardiac cycle. During this contraction, blood pressure is at the peak of the cardiac cycle. The pressure at this peak is called the systolic blood pressure. It is measured in millimeters of mercury (mmHg) above the surrounding atmospheric pressure (35).

7.3.2.2 Diastolic blood pressure (dBP)

The part of the cardiac cycle that follows the contraction and emptying of the heart is called diastole. The blood pressure in the large arteries at this time is called diastolic blood pressure. It is measured in millimeters of mercury (mmHG) (35).

7.3.2.3 Mean arterial pressure (MAP)

Value to be calculated that indicates the magnitude of blood pressure as the driving force in the body's circulation. Mean blood pressure depends on cardiac output and peripheral resistance. It can be calculated using two methods. Planimetric: integration of the arterial pressure curve over time. Peripherally in the course of invasive blood pressure measurement. Centrally in the course of cardiac catheterization. Arithmetically approximately accurate: from systolic and diastolic blood pressure, in arteries close to the heart (central) arithmetic mean, in arteries far from the heart (peripheral) somewhat lower.

Central: $\frac{1}{2} \times (sBP + dBP)$

Peripheral: $dBP + 1/3 \times (sBP - dBP)$

(36)

7.3.2.4 Cardiac index (CI)

The CI is the cardiac output per minute in relation to the body surface area. Cardiac output is the volume of blood pumped from the left ventricle per unit time. Cardiac index is expressed in liters per minute per square meter ($l/min/m^2$) (35,37).

7.3.2.5 Total peripheral resistance index (TPRI)

The TPRI is the resistance offered by the systemic circulation that the heart must overcome to pump blood through the circulation in proportion to the body surface area. It is also referred to as the systemic vascular resistance index. The unit of measurement is $dyne*s*m^2/cm^5$ (35,38).

7.3.2.6 Stroke index (SI)

The SI is the volume of blood expelled by the left ventricle in a single beat relative to the body surface area. It is expressed in milliliters per square meter (ml/m^2) (39).

7.3.3 Data analysis and statistics

The anonymized data were analyzed by staff of the Institute of Physiology of the Medical University of Graz. The data evaluators were not involved in the planning process of the study nor in the data collection. This was helpful to keep the evaluation process as objective as possible. The normal distribution of the hemodynamic data was examined using the Shapiro-Wilks test, excluding values that deviated strongly from the mean. Repeated-measures analyses of variance (ANOVA) were performed with log-transformed data and means±standard deviations (SD) are reported in the tables and figures for comparison. Each of the hemodynamic parameters was analyzed separately using group as a between-subjects factor and pre-post and epochs as repeated-measures factors and tested at a significance level of $\alpha = 0.05$. In case of violation of the sphericity assumption, the results were corrected with Greenhouse-Geisser epsilon.

Because of the exploratory nature of this pilot study, changes within each group were tested separately and ranks were compared using the nonparametric Wilcoxon test to examine the effect of the intervention. All data were analyzed using SPSS (version 27.0, IBM Corp., Armonk, NY, USA).

Comparisons of the epochs are not reported due to the known changes during the transition from lying to standing.

7.3.3.1 Zero hypothesis

A statistical hypothesis is an assumption about the relationship between the data collected and the research question of the study. This can be demonstrated with statistical tests. The null hypothesis states that there is no significant difference in the data collected between the intervention group and the control group. In this study, the null hypothesis states that there is no significant difference in the measurement of cardiovascular parameters between the yoga intervention group and the control group.

7.3.3.2 Alternative hypothesis

The alternative hypothesis of the study is that the measured cardiovascular parameters improve significantly in the yoga intervention group compared to the control group.

7.3.3.3 The p-value

The p-value is the result of a statistical test and has a value from 0 to 1. It indicates how likely it is that the null hypothesis is true or not. A very high value makes it very likely that the null hypothesis is true, and a very low value makes it very likely that the alternative hypothesis is true. A commonly used cutoff point is a p-value of 0.05, below which one speaks of significance.

The p-value is much more complex, but this brief explanation is sufficient to understand the results. Detailed information on this topic can be found in the current literature.

8 Results

9 Discussion

The present study investigated the effect of yoga on cardiovascular parameters in a four-week cardiac rehabilitation program, comprising 20 participants equally randomized into a yoga and a control group. All participants underwent the standard rehabilitation program. The participants in the yoga group took part in an additional 25-minute yoga session twice a day for five days a week. At the beginning and the end of the four-week rehabilitation program the supine-to-stand test was performed. Heart rate (HR), middle arterial pressure (MAP), systolic blood pressure(sBP), diastolic blood pressure (dBP), total peripher resistance index (TPRI), stroke index (SI) and cardiac index (CI) were measured and compared using pre-and post-measurements. A significant improvement in sBP and MAP and a tendency for TRPI and HR in both groups was found. However, except for a tendency towards a group difference between the yoga and the control group in TPRI (p=0.077), none of the parameters revealed significant group effects applying metric statistics.

Since this was a pilot study, and the small groups showed high intra-individual variation, each of the two study groups was also analyzed individually by nonparametric tests. Significant improvements were found for TRPI, sBP, dBP, and MAP in the yoga group between pre-and post-measurements. The improvements were mainly found in the epochs during standing. No significant difference between the pre- and post-measurement was found in the control group (See Table 6-11). These results indicate that yoga in addition to the normal cardiac rehabilitation program may have a positive effect on some cardiac parameters.

Three other studies examined the effect of yoga in patients recovering from acute CVDs. One was performed in the UK in 2019 and two in India, both published in 2020 (40–42). In the UK-study, 60 participants (25 in the yoga group and 35 in the control group) in a cardiac rehabilitation program following an acute coronary syndrome, completed the study protocol. A certified yoga instructor led the approximately 75-minute yoga sessions, which were held twice a week for 12 weeks. A minimum of 18 yoga sessions had to be attended. All participants underwent the usual care which includes lifestyle education (physical activity, exercise, diet and weight management, smoking cessation), risk factor management, psychosocial, cardio- protective drug therapy and long- term management strategies. The main outcome measures were: estimated left ventricular filling pressure, distance walked, fatigue and breathlessness in a 6 min walk test, blood pressure, heart rate and estimated peak VO2 following a 3 min step- test. Effects on the hypothalamus–pituitary–adrenal axis, autonomic function, body fat, blood lipids and glucose, stress, and general health. None of the parameters investigated showed that yoga had a significant effect (41). Participants in the yoga group completed only two yoga sessions per week, which may be too few to see significant effects on the parameters studied, compared to an adequate rehabilitation program. In India, a large study was conducted in 24 medical centers, including 3959 patients after an acute myocardial infarction. Of those, 1970 participants practiced yoga, carried out in 13 supervised group sessions for approximately 75 min and spread over 12 weeks. These participants were encouraged to practice yoga at home. For this, they received a training video and a manual. The other 1989 participants received three sessions of educational advice and a leaflet during the same period of time. The outcome parameters were an occurrence of major adverse cardiovascular events and a self-rated health scale. An improvement of the self-rated health scale was found in the yoga intervention group. However, no difference in occurrence of major adverse cardiovascular events between the groups could be observed (40). A large part of the yoga intervention was performed by the participants themselves. As such, it is difficult to say how regularly and in what quality these yoga sessions were conducted. Another study in India compared 33 participants in a yoga group, who attend three yoga classes per week for 12 weeks and a control group of another 33 participants receiving the standard care included pharmacologic treatment and the instructions of a cardiologist. The main outcome measure was left ventricular ejection fraction (LVEF). However, no effect or benefit was found for yoga for LVEF. (42) The studies vary widely in terms of the size, duration, and intensity of the yoga intervention. None of these studies has demonstrated a substantial cardiovascular benefit of yoga compared with other interventions in patients recovering from acute CVD. However, there are several studies which showed a positive effect of yoga on the cardiovascular system. Khattab et al. found a significant increase in heart rate variability in 11 healthy adults after a five-week yoga intervention (43). Furthermore, a systematic review of 11 studies on the effect of yoga in patients with hypertension reported a significant decrease in sBP and dBP in nine studies (44).

Yoga encompasses a wide variety of different techniques so there are virtually no studies examining the same yoga intervention. Also, many studies done so far on yoga are of poor quality. Daniel B Fishbein found methodological weaknesses in many meta-analyses and randomized control studies, such as insufficient sample size, improper randomization, failure to compare yoga with well-established interventions and inappropriate control groups (45).

9.1 Limitations

This present study was a pilot study with the aim of investigating the effect of yoga in addition to a standard rehabilitation program and also of assessing the feasibility of the intervention within the clinical setting. Therefore, only a small study sample of 20 participants, ten in each group, was included. For the planned statistical analysis (ANOVA), including pre-and post-measurements and comparing several epochs, the given number of participants was too small. Therefore, the results should be viewed with caution as the number of participants was low. Future studies with larger number of participants are required, to confirm the above results.

The participants were randomly assigned to the groups before the pre-measurements. Several parameters, however, differed between the resulting groups already before the intervention, which makes it even more difficult to interpret the collected data. To avoid this problem, the participants could have been divided according to the pre-measurements, which was not possible in this study as there the yoga intervention started on the same day as the pre-measurements. Another limitation was the short time span of this study. There were only four weeks between the pre- and post-measurements. Follow-up measurements were scheduled six and 12 months later. These did not occur because none of the participants continued the yoga intervention at home. In future studies, perhaps a video of the yoga intervention and regular contact with participants could motivate participants to continue with the yoga intervention. In addition, all participants took part in the proven rehabilitation program, which includes physical exercise, healthy diet, and relaxation techniques. Therefore, the effect of additional yoga practice may not have been appropriately observed. During the time in the rehabilitation center, the participants' medication was adjusted, a factor not considered in this work. Also, there were no records of the consumption of coffee and nicotine before the measurements. Both have an influence on the cardiovascular system and the participants of the study were asked to abstain from coffee and nicotine. However, these factors could not be strictly controlled. The yoga intervention was added to an already tight schedule, and it was not possible to include the yoga intervention in the participants' digital schedule of daily activities. This may have created some stress for the yoga group participants. All participants came to the rehabilitation program in a relatively poor physical condition. They had recently had a serious event such as a heart attack or heart surgery. The time factor alone would have a positive effect on the cardiovascular system due to the normal regenerative capacity of the human body. To quantify the effect of an intervention, a control group without any intervention would be required. However, it would be unethical to exclude anyone from a rehabilitation program. One way to obtain these data could be to ask patients waiting for a place in a rehabilitation program if they would like to participate in a study.

9.2 Conclusions and future directions

In this study, parametric statistical tests failed to demonstrate a significant benefit of yoga on the cardiovascular system. This could be due to the pilot nature of this study and the limited sample size. Interestingly, when the groups were analyzed separately using a nonparametric test, differences were found in the groups for TRPI, sBP, dBP, and MAP. Considering all limitations, this could indicate that this yoga intervention had a beneficial effect on the cardiovascular system of the participants. There is a possibility that yoga may be beneficial for patients undergoing a cardiac rehabilitation program. Larger studies with bigger sample size are required to make accurate conclusions about the effect of yoga on the cardiovascular system.

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11 Attachment

11.1 Entities covered in the term CVD

Cardiovascular Abnormalities:

Heart Defects, Congenital, Vascular Malformations,

Cardiovascular Infections:

Endocarditis Bacterial, Syphilis, Cardiovascular, Tuberculosis, Cardiovascular Heart Diseases

Arrhythmias Cardiac, Carcinoid Heart Disease, Cardiac Conduction System Disease, Cardiac Output High/ Low, Cardiac Tamponade, Cardiomegaly, Cardiomyopathies, Cardiotoxicity, Endocarditis, Heart Aneurysm, Heart Arrest, Heart Defects Congenital, Heart Failure, Heart Neoplasms, Heart Rupture, Heart Valve Diseases, Myocardial Ischemia, Myocardial Stunning, Pericardial Effusion, Pericarditis, Pneumopericardium, Post-Cardiac Arrest Syndrome, Post-pericardiotomy Syndrome, Pulmonary Heart Disease, Rheumatic Heart Disease, Ventricular Dysfunction, Ventricular Outflow Obstruction

Pregnancy Complications Cardiovascular:

Embolism, Amniotic Fluid

Vascular Diseases:

Aneurysm, Angiodysplasia, Angioedema, Angiomatosis, Aortic Diseases, Arterial, Occlusive Diseases, Arteriovenous Malformations, Capillary Leak Syndrome

Cerebrovascular Disorders, Colitis Ischemic, Compartment Syndromes, Diabetic Angiopathies, Embolism and Thrombosis, Hand-Arm Vibration Syndrome, Hemorrhoids, Hemostatic Disorders, Hepatic Veno-Occlusive Disease, Hyperemia, Hypertension, Hypotension, Mesenteric Ischemia, Myocardial Ischemia, Optic Neuropathy, Ischemic, Peliosis Hepatis, Peripheral Vascular Diseases, Prehypertension, Pulmonary Veno-Occlusive Disease, Reperfusion Injury, Retinal Vein Occlusion, Scimitar Syndrome, Spinal Cord Vascular Diseases, Splenic Infarction, Stenosis, Pulmonary Vein, Superior Vena Cava Syndrome, Telangiectasis, Thoracic Outlet Syndrome, Varicocele, Varicose Veins, Vascular Fistula, Vascular Neoplasms, Vascular System Injuries, Vasculitis, Vasoplegia, Venous Insufficiency

(1)

11.2 Terminology definitions

11.2.1 Definition of Coronary Artery Disease (CAD)

Pathological processes of coronary arteries that may derive from a congenital abnormality, atherosclerotic, or non-atherosclerotic cause (46).

11.2.2 Definitions of Myocardial Ischemia

A disorder of cardiac function caused by insufficient blood flow to the muscle tissue of the heart. The decreased blood flow may be due to narrowing of the coronary arteries (CORONARY ARTERY DISEASE), to obstruction by a thrombus (CORONARY THROMBOSIS), or less commonly, to diffuse narrowing of arterioles and other small vessels within the heart. Severe interruption of the blood supply to the myocardial tissue may result in necrosis of cardiac muscle (MYOCARDIAL INFARCTION) (47).

11.2.3 Definition of coronary disease

An imbalance between myocardial functional requirements and the capacity of the coronary vessels to supply sufficient blood flow. It is a form of myocardial ischemia (insufficient blood supply to the heart muscle) caused by a decreased capacity of the coronary vessels (48).

11.2.4 Definition of chronic coronary syndrome

New term for stable coronary artery disease. Used for the first time in the 2019 European Society of Cardiology guidelines (49).