FACULTY OF MEDICINE
AND HEALTH SCIENCES

The immediate effects of slow breathing exercises on blood pressure in older people

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Supervisor: Dr. Louise Poppe
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A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of Master of Science in Health Promotion by Bente Vandamme and Britt Van Lancker; Louise Poppe, Fien De Block and Andreai Pizarro

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The workload of this thesis was equally divided as we both contributed to every part and felt equally responsible for each section. We both wrote a similar portion of the literature study and also the methodology was evenly split, with Bente describing the data-analysis and Britt covering the patient recruitment and research design. For the results section, we collaboratively developed the analysis plan. Britt started to write the discussion. Bente added to it and revised it after the feedback. The conclusion was written together. The whole process was quite a journey, but we are pleased with the final outcome. It was a pleasant collaboration as we complemented each other, using our strengths and compensating for weaknesses.

List of abbreviations

Abbreviation	Definition
AHA	American Health Association
BE	Breathing Exercises
BMI	Body Mass Index
BP	Blood Pressure
DALYs	Disability-adjusted Life Years
DBE	Deep Breathing Exercises
DBP	Diastolic Blood Pressure
HBP	High Blood pressure
IC	Informed Consent
PA	Physical Activity
SBE	Slow Breathing Exercises
SBP	Systolic Blood Pressure
SD	Standard Deviation
WHO	World Health Organization

Abstract English version

Introduction: Hypertension is the number one preventable risk factor for cardiovascular diseases with an increasing incidence with advancing patient age. Breathing exercises have the potential to lower blood pressure. Therefore, they could be a useful intervention in the management of blood pressure in older adults. The aim of this study was to investigate the effect of slow breathing exercises on blood pressure control among the older Portuguese population.

Method: 31 older adults (mean age: 75,9) were recruited through the senior health program of Porto University to a two week crossover randomized controlled trial. All participants were randomly divided into two groups. Each group received the intervention and control measurements in a different order. Blood pressure was both measured at the beginning and the end of the sport class using the Collin BP 10 monitor.

Results: The analyzes showed that slow breathing exercises have no significant impact on both systolic and diastolic blood pressure. Furthermore, it also showed that there was also no order effect, meaning that the order of the measurements did not affect the results. There were no significant demographic differences between both groups.

Conclusion: Although the hypothesis predicted a significant reduction in blood pressure after a 10-minute session, the findings did not support this. Despite the results of this study and its limitations, the study highlights the need for further investigation on the immediate effects of breathing exercises in the older population to provide new recommendations for BP management.

“Number of words in article: 4317 (excluding preface, table of contents, introduction, abstract, appendices, tables, and reference list”

“Number of words in introduction: 2834”

Abstract Dutch version

Introductie: Hypertensie is de belangrijkste vermijdbare risicofactor voor hart- en vaatziekten, met een toenemende incidentie bij het ouder worden van de patiënt. Ademhalingsoefeningen hebben een bloeddrukverlagend effect. Hierdoor zouden ze een nuttige interventie kunnen vormen bij het beheersen van de bloeddruk bij oudere volwassen. Het doel van deze studie was om het effect van langzame diepe ademhalingsoefeningen op de bloeddrukregeling bij de oudere Portugese bevolking te onderzoeken.

Methode: 31 oudere volwassenen (gemiddelde leeftijd: 75,9) werden via het seniorengezondheidsprogramma van de Universiteit van Porto gerekruteerd voor een cross-over gerandomiseerd onderzoek met controlegroep van twee weken. Alle deelnemers werden willekeurig verdeeld in twee groepen. Elke groep kreeg de interventie- en controlemeting in een andere volgorde. De bloeddruk werd aan het begin en einde van de sportles gemeten met de Collin BP 10 monitor.

Resultaten: De analyses toonden aan dat trage diepe ademhalingsoefeningen geen significant effect hebben op zowel de systolische als diastolische bloeddruk. Bovendien bleek uit de analyse ook dat er geen volgorde-effect aanwezig was, wat betekent dat de volgorde waarin de metingen werden uitgevoerd de resultaten niet hebben beïnvloed. Er waren geen significante demografische verschillen tussen de twee groepen.

Conclusie: Hoewel de hypothese een significante verlaging van de bloeddruk na een sessie van 10 minuten voorspelde, ondersteunden de bevindingen dit niet. Desondanks benadrukt de studie de noodzaak van verder onderzoek naar de onmiddellijke effecten van ademhalingsoefeningen bij de oudere bevolking om nieuwe aanbevelingen voor bloeddruk behandelingen te kunnen doen.

“Aantal woorden artikel: 4317 (exclusief woord vooraf, inhoudstafel, inleiding, abstract, bijlagen, tabellen en referentielijst)”

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1. Introduction

Cardiovascular disease is reported to be the leading cause of death worldwide (Al-Makki et al., 2022). High blood pressure (HBP) or hypertension, is the number one preventable risk factor for cardiovascular diseases (Garg et al., 2024). A recent report of the World Health Organization (WHO) states that one in three adults faces hypertension. The number of people with hypertension even doubled between 1990 and 2019, from 650 million to 1,3 billion worldwide (World Health Organization, 2023).

Especially in the older population hypertension is a real global health challenge. The prevalence of hypertension increases with age, peaking among those in the 65 plus population group (Sutriyawan et al., 2022). Aging impacts the cardiovascular system, which includes the heart and blood vessels. This leads to narrower blood vessels and stiffened artery walls, resulting in an increased BP (Benetos et al., 2019; Sri Hari et al., 2021). According to a recent study 74,5 precent of the 65 plus population group suffers from hypertension compared to 22,4 percent of the adults aged 18-39 years (Ostchega & Nguyen, 2020). As this condition is linked to age, the prevalence and burden of disease are expected to rise with the ongoing population aging (Chang et al., 2019; Mills et al., 2016). Prince et al. (2015) even predicts that the number of disability-adjusted life years (DALYs) among individuals aged 60 and above will increase 40,6% between 2004 and 2030 due to cardiovascular disease (Prince et al., 2015). Therefore, its crucial to consider this group when tackling this health challenge and develop blood pressure (BP) control interventions for this population.

1.1. Definition and classification of blood pressure and hypertension

BP refers to the force of the blood flowing through the arteries and is defined as two numbers. The first number represents the systolic blood pressure (SBP), which is the pressure the blood exerts against the artery walls when the heart beats. The second number refers to the diastolic blood pressure (DBP), which is the pressure the blood exerts against the artery walls when the heart is resting between two beats (Balwan & Kour, 2021). In general, BP can be classified into different stages. The American Heart Association (AHA) recognizes five BP ranges (Balwan & Kour, 2021; Flack & Adekola, 2020). An overview of the different ranges can be found in Table 1.

Table 1

Classification of blood pressure according to AHA (Balwan & Kour, 2021)

Stage	Systolic Blood pressure	Diastolic blood pressure
Normal blood pressure	< 120 mmHg	< 80 mmHg
Elevated blood pressure	120-129 mmHg	< 80 mmHg
Hypertension stage 1	130-139 mmHg	80-89 mmHg
Hypertension stage 2	≥ 140 mmHg	≥ 90 mmHg
Hypertension crisis	180 mmHg	120 mmHg

HBP or hypertension, is when the pressure in your arteries is too high (World Health Organization: WHO, 2023a). Hypertension is defined as a SBP higher than 130 mmHg and/or a DBP higher than 80 mmHg (Flack & Adekola, 2020). The same classification is used in young, middle-aged, and aged populations. Although both elevated SBP and elevated DBP may be used to make a diagnosis of hypertension, more attention is given to SBP in general (Unger et al., 2020). This is because the SBP is a better predictor of hypertension and is also the main target of antihypertensive therapy (Strandberg & Pitkälä, 2003).

1.2. Risk factors and interventions for blood pressure control

Several risk factors contribute to a person's chances of developing hypertension. These risk factors can be divided into two different main groups. Firstly, there are the non-modifiable factors that are challenging to control, such as family history, gender, race, heredity, chronic kidney disease, and age (Flack & Adekola, 2020). Alongside the non-modifiable factors, there are also the modifiable risk factors that can be managed or altered. These include smoking, sleep apnea, cholesterol levels, diabetes, being overweight or obese, leading a sedentary lifestyle, lack of physical activity (PA), psychological stress, low fiber intake, and excessive alcohol consumption (Balwan & Kour, 2021; Islam et al., 2021; Sri Hari et al., 2021; Sutriyawan et al., 2022). It is reported that even a small BP reduction of 5 mmHg can lead to an approximate 25% decrease in cardiovascular complications (James et al., 2014). Therefore, it is essential to prioritize the management of hypertension focusing on modifiable factors, which can be addressed through various interventions. Generally, hypertension can be treated through pharmacological and non-pharmacological interventions, or a combination of both (Mahmood et al., 2019; Oliveros et al., 2020).

Pharmacological management

The American College of Physicians and the American Academy of Family Physicians recommend starting pharmacological treatment in adults aged 60 years and older with a persistent SBP of 150 mmHg or higher (Qaseem et al., 2017). This treatment typically involves the use of diuretics, renin-angiotensin, bèta blockers, and calcium channel blockers to lower morbidity and mortality among older adults with (pre)hypertension (Oliveros et al., 2020). Despite the effects of these medications on the BP, it is advised to be careful with prescribing them due to the several adverse effects such as hypotension, headache and dizziness (Qaseem et al., 2017). These effects could increase the risk of falls and hospitalization in the older population (Chiu et al., 2015; Costa-Dias et al., 2014; Oliveros et al., 2020). Moreover, it is reported that despite the presence of various pharmacological medications capable to effectively reduce BP, almost 70% of the hypertensive patients do not achieve the BP goal (Edwards et al., 2022; Naser et al., 2016). Additionally, it is also reported that there is a decreasing trend in antihypertensive medication adherence as age increases, especially from the age of 70 onwards (Burnier et al., 2020; Kim et al., 2019). Therefore, non-pharmacological interventions should be encouraged to miniate the risk of developing hypertension and keeping the BP under control. They can be utilized before starting the pharmacological therapy or in combination with it as an adjunctive therapy to reduce the need for medications (Islam et al., 2021; Mahmood et al., 2019; Oliveros et al., 2020).

Non-pharmacological management

Non-pharmacological management may impact modifiable risk factors such as cholesterol, diabetes, overweight, sedentary lifestyle, lack of PA, stress, smoking and alcohol consumption (Balwan & Kour, 2021; Mahmood et al., 2019; Sri Hari et al., 2021; Sutriyawan et al., 2022). The management could be categorized in different types of interventions such as dietary modifications, reducing alcohol intake, increasing PA, and relaxation/meditation with breathing exercises (BE) and reducing alcohol intake (Verma et al., 2021; Brook et al., 2013). Reducing alcohol intake, however, might not be a priority intervention, as research indicates that older adults generally consume less alcohol compared to younger individuals (Khamis et al., 2022; World Health Organization, 2018). Moreover, individuals aged 75 years old and above even have the lowest alcohol consumption (VAD, 2023). For the elderly there will be more focused on the following interventions:

First, there are the dietary modifications and weight loss. According to literature weight loss and healthy diets are effective ways to improve BP and its risk factors such as diabetes and cholesterol in older people (Kong et al., 2020; Verma et al., 2021). Therefore, a consistent diet of whole grains, vegetables, fruits, low-fat dairy products, nuts and less intake of sweets and red meat is recommended (Verma et al, 2021). Although the intended weight loss should primarily involve reducing fat mass, there is also a risk of unintentionally losing skeletal muscle mass (McCarthy & Berg, 2021), potentially resulting in nutrion-related sarcopenia (Cruz-Jentoft et al., 2010) which is an independent risk-factor for falling (Ca et al., 2014). Another potential dietary approach to manage BP involves limiting the salt intake to a maximum of 2400 mg per day (Mahmood et al., 2019; Verma et al., 2021). Despite its benefit on BP control, there is also an associated complication that should be kept in mind for the older population, called hyponatremia (Benetos et al., 2019; Powle et al., 2022). Hyponatremia can cause impaired perception and motor coordination, which lead into an increased risk of falls and femoral fractures (Adamczak et al., 2023). Due to these risks, dietary and weight loss strategies are not always so suitable for BP management in the older population or it needs to be followed up (McCarthy & Berg, 2021).

A second type of non-pharmacological intervention is increasing PA, one of the first recommended lifestyle treatments for lowering BP and improving cardiovascular health, physical function, and quality of life in older adults (Costello et al., 2011; Craighead et al., 2021; Mahmood et al., 2019). PA is defined as any bodily movement produced by the skeletal muscles (Garber et al., 2011). It includes exercise, sports and activities performed as part of daily living, work, spare time or active transport (Garber et al., 2011). Currently the PA recommendations for older adults consist of 30 minutes of moderate-intensity PA five days a week (150 min/week) and muscle-strengthening exercises at least 2 days a week (Craighead et al., 2021; Da Silva et al., 2019; Garber et al., 2011). Despite all the benefits of PA, most older people do not meet these current guidelines (Craighead et al., 2021; Moschny et al., 2011). This because of the various barriers they experience in regular PA such as frailty, fear of injury, invalidity, and lack of motivation (Craighead et al., 2021). Even simpler PA programs, like walking, can pose risks of falls, especially for frailer individuals who may encounter different types of obstacles (Okubo et al., 2016; Battaglia et al., 2020).

Finally there are stress reduction interventions, such as meditation, yoga, mindfulness and breathing control to reduce BP and improve cardiovascular health (Fu et al., 2020). The development of hypertension may be influenced by an imbalance in the autonomic nervous system, leading to stress and physical arousal (Herawati et al., 2023). The systematic review of Zaccaro et al. (2018) provides insight into the psychophysiological mechanisms underlying slow breathing techniques (<10 breaths/minute) and their effects on healthy subjects. Generally, SBE mainly affect the automatic and central nervous system (Zaccaro et al., 2018). Engaging in slow, deep breathing helps relax the body, restore autonomic nervous system balance, slow heart rate, alleviate stress, and even reduce blood pressure, offering a valuable intervention and alternative in blood pressure management (Mancia & Grassi, 2014; Moschny et al., 2011; Verma et al., 2021). According to the systematic review of Shao et al. (2023), relaxation techniques even ranked among the top interventions for reducing SBP and DBP in prehypertensive individuals and offers an easy and cost-effective approach (Reig-Ferrer et al., 2014; Shao et al., 2023). BE are often integrated in those relaxation interventions, but could possibly also stand alone as an approach (Clarke et al., 2015; Toussaint et al., 2021). They can be easily taught and performed independently in any setting (Hopper et al., 2019). Unlike previous discussed PA, BE require simpler techniques with less muscular effort (Herawati et al., 2023). Various type of BE exist in the literature, including guided, pursed lip, nostril, loaded, deep and slow breathing exercises (SBE) (Herawati et al., 2023). In addition to the benefits of BE, there are also some disadvantages or risks associated with them. Deep breathing exercises (DBE) prolong the contraction of the diaphragm, minimize the frequency of respiration, and increase the volume of the inspiration and expiration to maximize the amount of oxygen that enters the blood circulation while breathing. A good amount of oxygen in the vessels results in arteriolar dilatation (Herawati et al., 2023). Dilatation refers to the relaxation of the smooth muscle cells in the artery wall, which increases the diameter of the artery and lowers the BP (Cambridge Dictionary, 2024). DBE are typically performed at a rate of 6 to 10 breaths per minute, but the ideal rate of DBP to achieve optimal respiratory and cardiovascular outcomes appears to be 6 breaths per minute (Russo et al., 2017). However, achieving this rate may be easier for younger or well-trained persons compared to older adults. Therefore, it is important to customize the pace of the BE to the individual’s characteristics.

It's crucial to investigate whether BE, when employed as a standalone intervention, can effectively lower BP in older people. Within the literature there is mostly evidence of short term (<12 weeks) breathing interventions in adults. Yau & Loke's (2021) review specifically examined interventions lasting between ten days and twelve weeks, emphasizing BE at a rate of 6 breaths per minute or slower. These interventions resulted in significant reductions in both SBP and DBP, with decreases ranging from 2.2 to 15.3 mmHg in SBP and 3.1 to 11.4 mmHg in DBP among adults. Similarly, Herawati et al. conducted a systematic review with a broader population, reporting reductions in SBP from 4 to 54.22 mmHg and in DBP from 3 to 17 mmHg.

In contrast, there is limited literature focusing solely on the elderly population. Safarina et al.'s (2022) systematic review shifted its focus specifically to older populations. Investigating interventions lasting from four days to eight weeks, they found noteworthy decreases in SBP and DBP, averaging 13.12 mmHg and 6.78 mmHg, respectively. However, the quality of this review is limited by the small number of included studies and access limitations.

Within the literature, there is also noticeable gap regarding the immediate effects of BE on BP in older people. Exploring the immediate effects could also be interesting, especially in emergency scenarios. For instance, Mitsungnern et al., (2021) conducted a study investigating the efficacy of pursed-lip BE during hypertensive emergencies and reported significant reductions in BP. There is some evidence in the younger population, such as the study of Neto et al., (2024) which observed a reduction in SBP ranging from 4.3 to 4.8 mmHg following a 10-minute, 12 breaths-per-minute breathing exercise among individuals averaging 54 years old. Similarly, Telles et al., (2013) also found significant results in BP control after 10 minutes of BE in people with an average age of 49 years. However, Ghati et al., (2021) observed no significant BP changes in a 5-minute humming breathing exercise among individuals averaging 48 years old. This variation in results and methodologies, including different types of BE, durations, small sample sizes, and breathing frequencies, underscores the need for further trials to validate the effectiveness of singular breathing interventions and their potential role in hypertensive management (Brandani et al., 2017; Herawati et al., 2023).

2. Problem definition and research question

2.1. Problem definition

Given the research by Benetos et al. (2019), Craighead et al. (2021), McCarthy & Berg (2021), and Powle et al. (2022), it is necessary to prioritize hypertension management in the older population. These studies specifically highlight the distinctive challenges and barriers encountered by older individuals. Interventions suited for a broad age range or younger population might not always be appropriate for them. By focusing on this demographic, interventions and support systems can be tailored to address their specific needs, ultimately promoting enhanced well-being and quality of life among older adults. Older adults may for example benefit from more low-effort interventions, such as adjusting the breathing ratio and duration of the BE. Several studies use exercises lasting from 15, 30 to even 60 minutes, which could be challenging for older adults (Ghati et al., 2021; Mitsungnern et al., 2021; Neto et al., 2024).

During the review of literature most of the studies also seem to focus across a wide age range. Participants typically fall within the age range of 25 to 65 years old, with an average age of around 50 (Ghati et al., 2021; Neto et al., 2024; Telles et al., 2013). Due to the different age ranges and characteristics of the participants, the results and evidence of these studies cannot always be generalized to the older population. For instance, older people often experience more comorbidities and physiological factors that influence BP control. As a result, this age group is frequently excluded from the studies. Therefore, there seems to be a lack of evidence regarding BE in people aged 65 and older.

Further several studies describing the short- and long-term effects of BE on BP control were found. According to these findings there are different kinds of BE that seem to have a positive short and long-term effect on lowering BP (Fu et al., 2020; Ghati et al., 2021; Mitsungnern et al., 2021; Neto et al., 2024; Telles et al., 2013; Yau & Loke, 2021). However, conclusive evidence about the immediate effect of BE on BP control among older adults was lacking. Based on these discussed aspects, the general aim of this master's thesis is to investigate the effectiveness of BE in controlling BP in the older people. Specifically, the immediate impact of slow breathing exercises will be assessed, conducted at a rate of 10 breaths per minute during a 10-minute session, on the BP of individuals aged 65 and above.

2.2. Research question

Despite the research that already has been done during the past years, there seems to be a lack of evidence on the immediate effect of SBE on BP control in older people. This brings up the following research question:

"What is the immediate effect of slow breathing exercises of 10 minutes at a rate of 10 breaths per minute on the blood pressure of older adults?"

Table 2

Pico research question

Population	Older adults (>65 years)
Intervention	10 minutes slow breathing exercises (10 breaths/minute)
Control	No slow breathing exercises
Outcome	Systolic and diastolic blood pressure (mmHG)

Based on the prior examination of relevant literature and the defined problem, the following hypothesis was formulated below.

Hypothesis 1 (H1): Following 10 minutes of SBE leads to a greater reduction in BP between pre- and post-breathing exercise compared to following no breathing exercise intervention among older individuals.

3. Method

3.1. Recruitment participants

Participants for this study were recruited using a convenience sampling method, as they were available through the senior health program of the CIAFEL research unit (Centro de Investigação em Atividade Física, Saúde e Lazer) at the Faculty of Sport of the University of Porto. Two of the three existing sport classes from the senior health program were included in the trial, namely the Pilates and multicomponent class. The Pilates group had an average of 20 participants, while the multicomponent class consisted of more than 40 participants. Therefore, this group was further divided into two smaller groups of approximately 20 individuals. Based on this non-random sampling method and the following inclusion and exclusion criteria a total of 58 participants were recruited. The inclusion criteria of this study included the older Portuguese population of 65 years old and above, who were willing to attend the senior health program at the University of Porto faculty of sports during the academic year 2023-2024. Individuals with any health condition such as cardiovascular diseases, arterial arrhythmia, and respiratory problems, that could affect their breathing capacity and test procedures were excluded from the study. To ensure this, all participants were asked to fill in an anamnesis prior to the study (attachment 1). This questionnaire requested both socio-demographic information and diagnostic/health problems. When the required inclusion and exclusion criteria were met, all the selected participants were asked to fill in the informed consent (IC) to ensure that they fully understood the essential aspects of the study and what they were agreeing to.

3.2. Ethical aspects

This study was submitted and approved by the ethical committee of the University of Porto Faculty of Sports (attachment 2). By means of an IC all participants also received comprehensive information regarding the purpose, risks, and benefits of the intervention. Participants could withdraw from the study at any point.

3.3. Research design

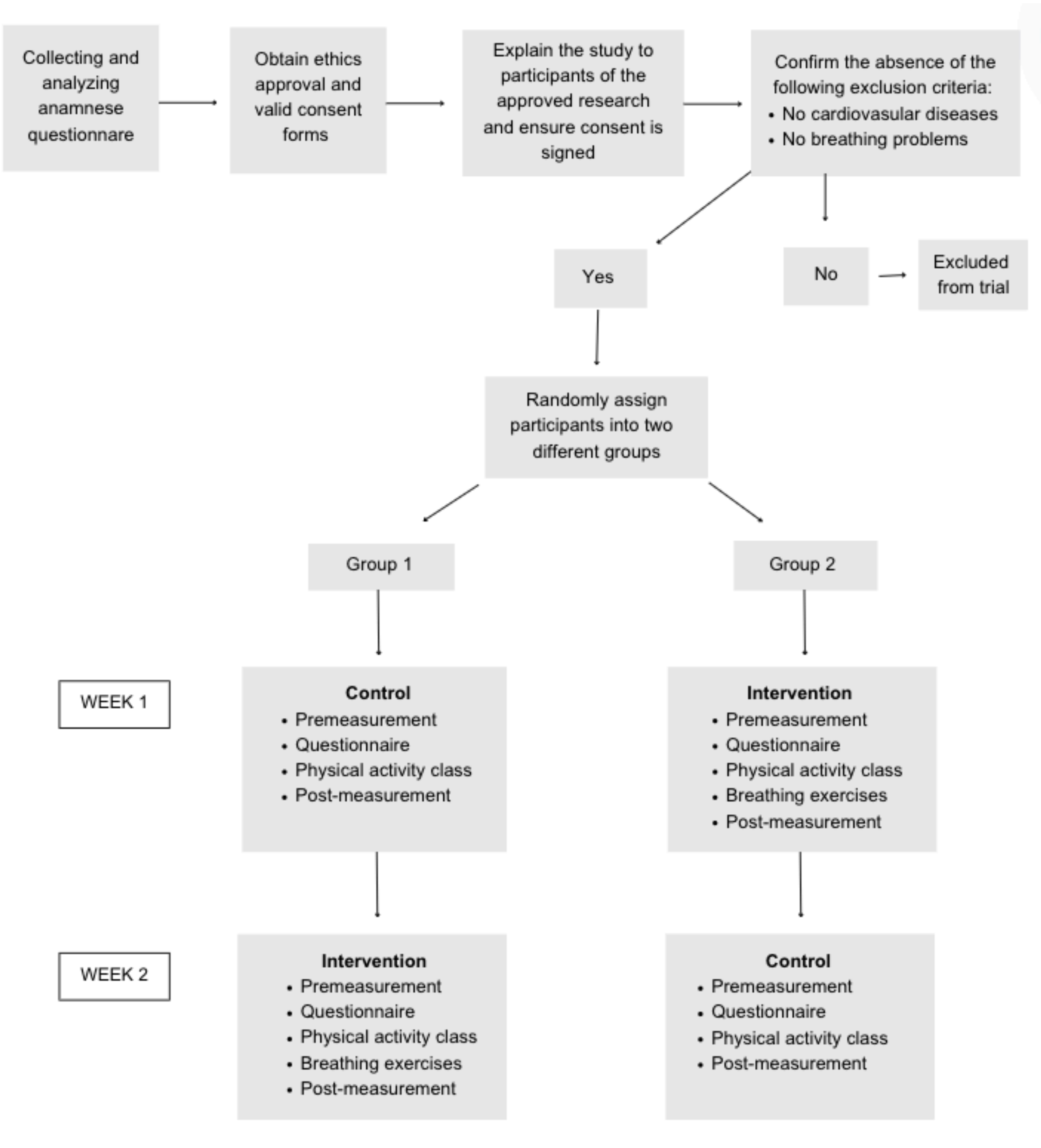
A cross-over randomized controlled trial was chosen within this study. Therefore, all participants were randomly assigned into two different groups. Both groups were exposed to both intervention and control measurement but in a different sequence, meaning that one group first received the control measurement followed by the intervention measurement (Group 1), while the other group first received the intervention measurement followed by the control measurement (Group 2). The BP measurements taken before and after the classes were carried out by the master's students themselves under guidance of a supervisor because of the language barrier towards the participants. Both multicomponent groups attended classes together on Monday but separately on Wednesday. Therefore, one measurement session was organized on Mondays and two on Wednesdays. For the Pilates group, the measurement session took place on Friday. So, in total there were four measurement sessions in a week over a two-week period. Resulting in at total of eight measurement sessions by the end of the data-collection.

At the beginning of the CIAFEL program, participants already filled in an anamnesis questionnaire developed by the research group (attachment 1). Prior to the measurements of this trial, the completed forms were screened to check the exclusion criteria and baseline characteristics of the participants. During these measurements, the following protocol was taken into account. First, the BP of each participant was measured before the start of the sport class. The BP was only measured once, but to verify the reliability of the measurements a second measurement was done in case the SBP during the first measurement was higher than 160 mmHg. During the measurements patients were not allowed to talk or use their cellphone. Finally, to complete the premeasurement, participants were asked to answer a short questionnaire that covers factors such as whether they had a coffee during breakfast, antihypertensive medication intake and mode of transportation before the sport class. These factors may have an influence on the performed measurement. After all this, the exercise class could start.

At the end of the exercise session, the intervention group additionally completed a 10-minute session of SBE. The control group, on the other hand, did not receive these exercises. Participants of the intervention group were asked to sit comfortably on a chair and were instructed to place one hand on their stomach and the other on their chest. The instructor led the participants through the rest of the BE, maintaining a pace of 10 breaths per minute. Inhalation and exhalation were performed at a rate of two seconds inhalation and four seconds exhalation. Finally, after the control group's exercise session and the intervention group's exercise session and SBE, a final BP measurement was taken in the same way as the premeasurement at the start of the session. Figure 1 visually illustrates the research design and protocol for clarification.

Figure 1

Research design and protocol



3.4. Measurement instruments

Anamnesis questionnaire

The anamnesis questionnaire is the questionnaire which was administered prior to the study (attachment 1). This questionnaire was drawn up by the researchers of the CIAFEL research group and consists of two main categories: socio-demographic variables and health problems and diagnoses. Both categories are further divided into more specific questions. The socio-demographic variables query data such as date of birth, nationality, civil status, and educational attainment. The other part of the questionnaire queries health data such as cardiovascular, respiratory, gastro-intestinal pathology, hearing problems, other medical diagnoses, the presence of a protheses and medication use.

Collin blood pressure 10 monitor

All BP measurements during this trial were carried out using the Collin (2010) BP monitor 10 provided by the CIAFEL research group itself. The Collin BP-10 monitor uses the oscillometric method. This is a method in which the cuff, which is placed on the upper arm, is first used to build up the pressure in the arteries and then reduce it again. This causes vibrations in the vessel wall which are detected by the device (Lewis & British, 2019). The Collin BP-10 monitor consists of a measurement unit and a manchet with a tube. The tube must be connected to the device. During the measurement a couple of significant points need to be considered to obtain the most reliable measurement results. First, the participants should rest about five minutes before measuring their BP. Furthermore, they have to sit on a chair in a relaxed upright position with their back supported against the back of the chair, both feet flat on the floor and their arm supported on a table at heart level. Tight clothing around the arm to be measured has to be removed. The cuff needs to be placed, snugly but not too tight, around the right upper-arm, approximately 2 cm above the elbow (Unger et al., 2020). The research by O'Brien et al. (2010) investigated the validity of different BP monitors and concluded that the Collin BP-10 monitor is proven to be accurate and suitable for clinics and research settings (O'Brien et al., 2010).

3.5. Data-analysis

To perform the statistical analyses the Statistical Package for the Social sciences (SPSS) software version 'SPSS 29' was used. During all the analyses, a 0.05 level of significance and a 0.10 level of borderline significance for alpha was used.

First, it was assessed whether the two groups, namely 'control-intervention' and 'intervention-control', differed from each other. The mean values of the demographic variables such as age, height, weight and Body Mass Index (BMI) and the baseline pretest measurements, namely SBP control, DBP control, SBP intervention and DBP intervention were compared between the two groups. An independent Student's t-test was employed for variables following a normal distribution while the Mann-Whitney U test was utilized for variables not following a normal distribution. Normality was evaluated using the Shapiro-Wilk test, and the Q-Q plots were analyzed accordingly. These results are further discussed in attachment 3.

To answer the research question a repeated measures ANOVA analysis was performed to check whether there was an effect off the 10-minute breathing exercise intervention on BP control of the study population. ANOVA analysis was notably employed to assess the absence of an interaction effect, to ensure that the order in which the measurements (control/intervention) were performed did not impact the results. Before analyzing the data, a cleaning process was conducted by checking the frequencies of all used variables. This cleaning specifically checked for possible outliers and missing values. There were no missing values or outliers detected in the dataset. Furthermore, before running the repeated measures ANOVA test, all required assumptions where checked. The Shapiro-Wilk normality Test was conducted to ensure that the data of the dependent variables (e.g. change in SBP and change in DBP) and demographic variables (e.g. age, weight and height) met the normality requirement of the analysis. All the dependent variables, as discussed in the following part, had no significant p-values (<0.05) on the test. Therefore, the null hypothesis could not be rejected, indicating that all the variables have a normal distribution. These results are further discussed in attachment 4.

For this research topic, the repeated measures ANOVA analysis was conducted separately for the SBP and the DBP. In this model two dependent variables were created analyzed per condition (control/intervention).

1. The first dependent variable is the change in SBP between the pre- and postmeasurement (Change in SBP).
2. The second dependent variable is the change in DBP between the pre- and postmeasurement (Change in DBP).

All these variables were calculated in SPSS as the difference between the absolute SBP and DBP values collected during the data collection. For the repeated measures ANOVA analysis, a within-subjects and between-subjects factor needed to be selected. The within-subjects factor was ‘Treatment’ (2 levels), indicating the different treatments (control/intervention) each participant received during the study period. The between-subjects factor was the ‘Order of measurement’ (2 levels), referring to the two groups. As already mentioned in the section ‘research design’, participants were randomly assigned into two groups based on the sequence in which they received treatments. In SPSS the order was represented by the variable ‘Order measurement’ and was dummy encoded in 0 ‘control-intervention’ and 1 ‘intervention-control’.

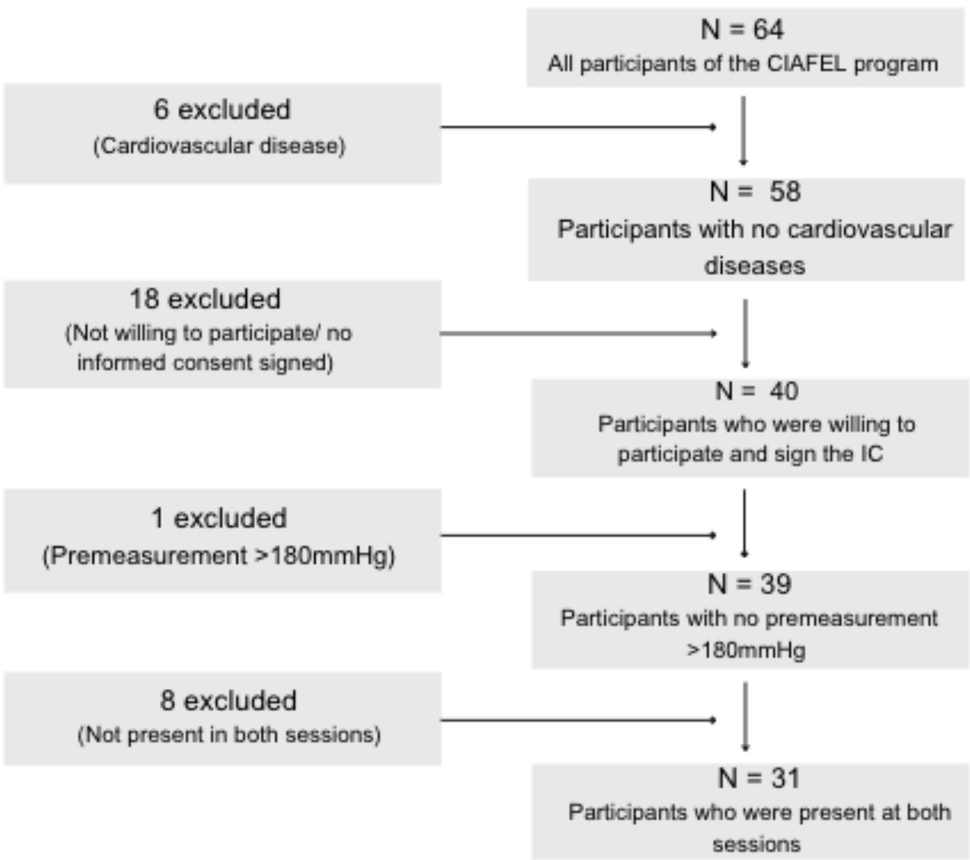
4. Results

4.1. Demographic characteristics

From the 58 eligible participants, 40 were willing to sign the IC and to participate in the study. Furthermore, some participants also dropped out during the measurements themselves. One of the participants had a SBP higher than 180 mmHg during the premeasurement. Therefore, this person was excluded from the study and was also not allowed to participate in the sports class that day because of his blood pressure which was located in 'crisis' stage of the hypertension classification. Finally, 8 participants dropped out of the study because they could not attend the second class for an unknown reason. This brought the study sample at a total of 31 participants who met the inclusion and exclusion criteria, were willing to sign the IC, did not have a SBP > 180 mmHG during the premeasurement and were present at both sessions. Figure 2 provides a schematic overview of the recruitment process.

Figure 2

Patient recruitment



The participants were randomly assigned into two different groups, which determined in what order they received the intervention and control condition. All the characteristics, namely average height, weight, BMI, sex, the presence of comorbidities (hypertension, diabetes, and high cholesterol) and baseline BP values are discussed in table 3 below. The summary of the queried comorbidities is included in this table to offer a more comprehensive understanding of the study population. The presence of certain comorbidities might also offer valuable insights during the result analysis.

Table 3

Additional demographic information participants

	Group 1 (n = 11)	**Group 2 (n = 20)**
Mean Age (SD)*	75.91 (5.68)	75.90 (3.81)
Sex		
Female (%)	7 (63.6)	11 (55.0)
Male (%)	4 (36.4)	9 (45.0)
Mean Height (SD)	160.82 (8.35)	157.80 (8.93)
Mean Weight (SD)	64.53 (15.83)	67.09 (12.09)
Mean BMI (SD)	24.70 (4.09)	26.78 (3.08)
Hypertension (%)	8 (72.7)	9 (45.0)
Diabetes (%)	3 (27.3)	3 (15.0)
Cholesterol (%)	2 (18.2)	7 (35.0)
Baseline pretest BP value		
Mean SBP control (SD)	135.91 (3.76)	141.93 (3.47)
Mean DBP control (SD)	76.32 (3.14)	73.05 (1.98)
Mean SBP intervention (SD)	130.68 (4.50)	141.78 (3.87)
Mean DBP intervention (SD)	75.77 (4.14)	72 (2.01)

“Abbreviations: SD = standard deviation“

To examine potential demographical difference between the two groups, an independent sample t-test was employed, and two-tailed testing was conducted at alpha = 0.05 for the continue variables with a normal distribution in both groups, namely age, weight, SBP control, DBP control and DBP intervention. Results indicated no significant differences in the means of age ($F(29)$= 3.826, p= 0;996), Weight ($F(29)$= 9.12, p= 0.617), SBP control

(*F*(29)= 1.129, *p*= 0.279), DBP control (*F*(29)= 0.559, *p*= 0.363), DBP intervention (*F*(29)= 0.301, *p*= 0.362). For the variables 'height, BMI and SBP intervention' with no normal distribution the Mann-Whitney U-test was used, and two tailed testing was conducted at alpha = 0.05. Results also indicated no significant difference between height (*U*= 96; *p*= 0.562), BMI (*U*= 69.500; *p*= 0.094) and SBP intervention (*U*= 66.500; *p*= 0.072). For the categorical variables the Fisher's Exact Test was used and two-tailed testing was conducted at alpha = 0.05. Results indicated no significant difference between gender (*p*= 0.718), diabetes (*p*= 0.638), cholesterol (*p*= 0.429) and hypertension (*p*= 0.258). These results suggest that there are no significant demographic and baseline measurement differences between the two groups in this study.

4.2. Effect of breathing exercises on blood pressure control

The descriptive statistics, mean and standard deviation (SD), for the SBP change during control and intervention measurement and the DBP change during control and intervention measurement were generated for the various groups, categorized according to the treatment order. The results are presented in Table 4.

Table 4

Descriptive statistics, mean (SD) for change in SBP and DBP between pre- and posttest per condition (control/intervention)

Group (n)	SBP control	SBP intervention	DBP control	DBP intervention
1 (11)	0.50 (13.32)	6.82 (11.86)	0.27 (10.71)	-0.50 (7.99)
2 (22)	7.40 (11.55)	5.65 (15.55)	-0.08 (7.34)	-1.70 (6.24)

The results of the repeated measures ANOVA analyses for both change in SBP and DBP are presented in table 5 and table 6, respectively.

Table 5

ANOVA-table of change in SBP between pre- and posttest

	df	F	p
Treatment	1	0.827	0.371
Order	1	0.438	0.513
Treatment x Order	1	2.581	0.119

Table 6

ANOVA-table change in DBP between pre- and posttest

	df	F	p
Treatment	1	0.378	0.543
Order	1	0.124	0.727
Treatment x Order	1	0.048	0.828

Based on the findings presented in Table 5, there is no significant interaction effect ‘Treatment x Order’ observed for SBP. This suggests that the order in which participants received their measurement type (control/ intervention) does not influence the obtained results in SBP. There is no carryover of benefits between the two different orders in which the measurements were carried out. Given the insignificance of the interaction effect, it was necessary to assess the main effect for ‘Treatment’. The analysis indicates that there is no significant main effect in the change of SBP between the intervention and control measurement. This specifically suggests that the BE did not affect participants’ SBP. The DBP results are outlined in Table 6. Similar to SBP, the analysis shows no significant interaction effect for DBP, indication that the order of measurement type does not affect the results in DBP. Assessing the main effect of ‘Treatment’, the analysis indicates that there is no significant main effect in the change of DBP between the intervention and control measurement. This specifically suggests that the BE did not affect participants’ DBP.

5. Discussion

5.1. Critical interpretation of results

Due to the need for more evidence regarding non-pharmacological interventions to control BP to prevent cardiovascular disease, this study aimed to investigate the effect of BE, a component of relaxation/meditation interventions in the elderly (Verma et al., 2021;Brook et al., 2013). The main objective of this study, which was carried out in context of a master's thesis, was to investigate the immediate effect of SBE on BP control among the older Portuguese population. Linked to this research question it was hypothesized that a 10-minutes session of SBE at a rate of 10 breaths per minute would lead to a greater reduction in BP compared to not performing BE.

In this study no evidence for an immediate effect of the SBE on the SBP and DBP was found. Existing literature already covers the short-term effects (less than 12 weeks) of BE on BP reduction in the broad population. Yau & Loke's (2021) review reported significant reductions in both SBP and diastolic DBP, ranging from 2.2 to 15.3 mmHg and 3.1 to 11.4 mmHg, respectively. Similarly, Herawati et al. (2023) reported reductions in SBP and DBP ranging from 4 to 54 mmHg and 3 to 17 mmHg, respectively. However, these systematic reviews focused on short-term effects, with interventions lasting from 10 days to 12 weeks. Since our study focuses on immediate effects, comparison with these studies may not be appropriate.

In the context of immediate effects of BE on BP among older people, there are limited available studies for comparison. Neto et al. (2024) conducted a study focusing on the immediate effects of 10-minute BE at rates of 12 and 20 breaths per minute, reporting a significant reduction in SBP ranging from 4.3 to 4.8 mmHg. This contradicts the observed results of this study. However, this study included a broader population aged between 20 and 75 years old and had strict inclusion and exclusion criteria. All participants had to be diagnosed with hypertension, taking antihypertensive medications for the last three months, and could not consume alcoholic or caffeinated beverages or engage in intensive PA 48 hours before the measurement. The notable disparity lies in the final condition. In the study by Neto et al. (2024), participants were required to avoid intense PA, whereas in this study, participants engaged in a 60-minute sports class between the pre- and postmeasurement. These discrepancies in study criteria may contribute to differences in the observed results.

Alongside the findings of this study, Ghati et al. (2021) also reported no significant results from a 5-minute bee-humming BE intervention at a breathing rate of 4-6 breaths per minute. Due to differing methodologies, it is challenging to compare the results directly or identify a common factor explaining the outcomes. However, both studies involved short intervention durations and participants who were unfamiliar with performing BE.

In general, the discrepancy in results may stem from the limited literature on the immediate effects of BE, particularly in older populations. Age-related physiological changes, such as decreased arterial compliance and reduced autonomic regulation, may influence the response to interventions for BP control (Benetos et al., 2019; Sri Hari et al., 2021; Xu et al., 2017). Most previous studies, such as those by Neto et al. (2024) and Ghati et al. (2021), involved younger participants, making it difficult to find research focused solely on older individuals. Additionally, existing studies employ varying methodologies, including different types of BE, rates, and durations. This variation makes it challenging to draw direct comparisons between our findings and existing literature. Given these inconsistencies, further trials, as suggested by Brandani et al. (2017) and Herawati et al. (2023), are necessary to better understand the immediate impact of BE on BP.

5.2. Limitations

Several limitations should be acknowledged while interpreting these results. The first limitation of this study design is the potential drop-out of participants. In total eight different participants dropped out the study during the measurements because they could not attend the second class for an unknown reason. The majority of participants, six out of eight, were assigned to the first group, 'control-intervention', resulting in a notable difference in group sizes. Group 1 ended up considerably smaller than Group 2, comprising of 11 participants compared to 22 participants in Group 2. Due the limited data collection time of two weeks, participants could not be replaced leading into a smaller sample size of only 31 participants and different group sizes, which may have reduced the statistical power of the study and influenced the results.

Second limitation of this study was the convenient sampling method which was used to recruit the participants. Due to this sampling method, there is selection and sampling bias because participants were recruited on a voluntary basis. All participants took part in the existing senior health program of the CIAFEL research group by whom they were selected for this study. It is possible that certain specific characteristics in this study may be more inclined in comparison to the general older population such as the physical fitness. These factors, combined with the study's small sample size and specific demographic traits such as age and comorbidities, may restrict the generalizability of the findings to the broader older population. Moreover, due to this sampling method, the study's design differs from typical studies on the immediate effects of BE. Typically, such studies involve a premeasurement, followed by the

BE, and finally, a postmeasurement (Ghati et al.,2021 ;Telles et al., 2013). However, in this study, a 60-minute sports class was incorporated into the design between the measurements, which could potentially impact the outcomes.

Additionally, the setting in which the measurements were carried out is also a limitation of this study. First, there was only one BP monitor available to carry out the measurements, only allowing for a single BP reading per participant due to time constraints before and after the sport class. However, it is recommended to conduct BP measurements two or three times with 1 minute rest between each reading to become a reliable estimate of BP and check the validity (Bello et al., 2018). Only participants with extremely high BP were measured twice to confirm the inclusion criteria of a BP less than 180 mmHg. Employing an extra BP monitor should have been more efficient to carry out the measurements. Furthermore, there was no separate room available to carry out the measurements and it had to be conducted in the same room of the sport lesson. This resulted in lot of noise and movements around the people during the BP measurements. This may have distracted the participants and induced stress, potentially impacting the accuracy of the BP readings, resulting in a potential higher blood pressure reading than normal. Future research should take this in into account and provide a quieter setting isolated from the other participants.

Another potential limitation could arise from participants' lack of familiarity with BE. In the study of Ghati et al. (2017) on the immediate effect of bee-humming BE, there were no significant results. Possibly due to a lack of experience with the exercises. Brandani et al. (2017) emphasized the crucial role of experience in the effectiveness of these exercises. They also noted that while experience enhances effectiveness, a lack of it could increase discomfort and tension during the exercises. In contrast, Telles et al. (2013) included participants with prior experience in yoga as a criterion and their study resulted in significant outcomes.

5.3. Relevance

Despite the lack of significant results and the identified limitations of this study it still has a value for the research of SBE as a non-pharmacological intervention for controlling the BP in the elderly. As highlighted earlier, existing literature employs different type of methods and highlighting the necessity for further research across different approaches (Herawati et al., 2023). This study aims to address this gap by providing additional insights into the efficacy of 10-minute SBE. Furthermore, it addressed the gap that there is more need to investigate the immediate effect interventions and not only the short- and long-term breathing interventions. An immediate reduction in BP could be crucial, especially in hypertensive emergencies. A subject that already was investigated by Mitsungnern et al. (2021) but requires more in-depth research. The final gap addressed by the study was the focus on the older population, which was not only a limitation to generalizability but also a strength of the study. Given the high prevalence of hypertension among this demographic group, there is a pressing need to develop targeted interventions tailored to their specific needs (Oliveros et al., 2020). The limitations identified in this study offer valuable insights and recommendations for further research about the same topic.

5.4. Recommendations

While this study has its methodological limitations, it indicates the importance of exploring non-pharmacological interventions for BP control in older adults and other age ranges. Future research could further investigate the immediate effect of SBE as standing alone intervention on BP control in older people. First of all, this research could benefit from another even more complex research design. Therefore, a longitudinal study design is recommended to not only investigate the immediate effects but also the long-term effects of interventions and to delve deeper into the enduring impacts of BE on BP regulation. Employing repeated measurements over time would afford researchers a nuanced understanding of the persistent effects of the intervention and how they develop over time. This would also increase the reliability and accuracy of the obtained results. Furthermore, to reinforce the external validity of the research outcomes, it is necessary to expand the sample size and recruit a diverse and representative participant population. By covering a wider population with more differing characteristics and demographics, studies can ensure the generalizability of the results to the broader elderly population and reduce the risk of selection bias.

Moreover, to ensure the fidelity and accuracy of the measurements standardized protocols and validated measurement instruments are necessary. Minimizing environmental variables, noise disruptions, and standardized measurement procedures would increase the reliability and validity of study outcomes. To ensure that the lack of experience in performing BE does not affect the outcomes, it is advisable to also conduct a few trial sessions where participants can become familiar with the exercises. Finally, future research should also explore the effectiveness of SBE across a wider age spectrum to gain deeper insights into potential age-related variations in responses to the breathing intervention. In this way, more personal interventions can be created to reduce high BP. At the end of this discussion, it is important to briefly emphasize that if BE prove to be effective, other BP management techniques such as medication, diets and physical should certainly not be written off. This study mainly wanted to shed more light on BE as a possible BP management intervention which also can be used in combination with other effective techniques to have a greater effect in BP control.

6. Conclusion

This interventional study aimed to explore the effectiveness SBE as a non-pharmacological intervention for BP control among the elderly population. A crossover randomized controlled trial was conducted with 31 older aged participants to investigate the immediate effects of SBE on BP.

Contrary to our hypothesis, which proposed that a 10-minute session of SBE would result in a significant reduction in BP, our findings did not support this expectation. The study revealed no significant changes in SBP and DBP after SBE compared to the control measurement. Despite the absence of significant results and the limitations identified, our study contributes valuable insights to the broader research on SBE. It underscores the need for further exploration of the immediate effects of BE in the elderly population and provides recommendations to inform future investigations.

In conclusion, determining whether SBE have an immediate impact on BP reduction necessitates additional research to deepen our understanding of their potential benefits. This study sets the stage for further investigation into the role of SBE in BP management among older adults.

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8. Attachments

Attachment 1: Anamnesis questionnaire

ANAMNESE

Identificação Sociodemográfica

1. ID:_______________
2. Ano de nascimento: _____________
3. Residência: ____
4. Nacionalidade:____
5. Estado civil: Solteira_( ) Viúva_( ) Separada/ Divorciada_( ) União de facto_( )
6. Nível de Escolaridade (Número total de anos que frequentou a escola): ______________________
7. Principal função desempenhada na vida: ____

Diagnósticos e questões de saúde

8. Já recebeu diagnóstico de demência? Não_( ) Sim_( )
9. Necessita de auxílio para caminhar? Não_( ) Sim_( )

9.1 Caso necessite de ajuda para caminhar, qual tipo de auxílio costuma usar?

Bengala_( ) Muleta_( ) Andarilho_( ) Pessoa_( ) Outra? Qual?______________

10. Teve alguma queda nos últimos 6 meses? Não_( ) Sim_( )

10.1 Se sim, quantas vezes nos últimos 6 meses?

1 vez_( ) 2-3 vezes_( ) 4-6 vezes_( ) 6 vezes ou mais_( )

11. Já recebeu diagnóstico de alguma patologia respiratória? Não_( ) Sim_( )

11.1 Se sim, qual? ____

12. Já recebeu diagnóstico de alguma patologia cardiovascular? Não_( ) Sim_( )

12.1 Se sim, qual? ____

13. Já recebeu diagnóstico de alguma patologia musculo-esquelética? Não_( ) Sim_( )

13.1 Se sim, qual? ____

14. Já recebeu diagnóstico de alguma patologia gastrointestinal? Não_( ) Sim_( )

14.1 Se sim, qual? ____

15. Possui alguma prótese? Não_( ) Sim_( )

15.1 Se sim, especifique o local?

____

16. Algum outro diagnóstico médico? Não_( ) Sim_( )

16.1 Se sim, qual? ____

____

____

17. Faz uso de alguma medicação? Não_( ) Sim_( )

17.1 Se sim, especifique quais medicações, bem como as respectivas dosagens e horários?

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Attachment 2: Approval of the ethical committee University of Porto

U.PORTO
FACULDADE DE DESPORTO
UNIVERSIDADE DO PORTO

ETHICS COMMITTEE

Statement

For the intended purposes it is declared that the project CEFADE 20_2024 "*Acute effects of slow breathing exercises on blood pressure of older adults involved in an exercise program*", submitted to the Ethics Committee of the Faculty of Sports of the University of Porto was approved for taking into account the recommended ethical requirements.

Porto, may 29th , 2024

The President of the Ethics
Committee

Isabel Maria Ribeiro Mesquita
(Full Professor)

Attachment 3: Demographics

To determine whether the continuous demographic variables ‘age, weight, height, and BMI’ and the baseline variables for each condition (control/intervention) ‘pretest SBP control, pretest SBP intervention, pretest DBP control, and pretest DBP intervention’ differ significantly between the two groups, namely group 1 (control-intervention) and group 2 (intervention-control), an independent Student's t-test was employed. Prior to conducting the t-test, the assumption of normality for both groups was assessed using the Shapiro-Wilk Test at a 5% significance level. If the null hypothesis, that the data originates from a normal distribution, is rejected, the normal Q-Q plots of those variables were further analyzed for confirmation. The results of the Shapiro-Wilk Test are summarized in Table 8 and Table 9.

Table 8

Results of the Shapiro-Wilk test for change in SBP and DBP per condition (intervention/control)

Dataset	Shapiro-Wilk Test		
	Statistics	df	P
Age	0.915	11	0.282
Weight	0.865	11	0.066
Height	0.839	11	0.031
BMI	0.940	11	0.541
Pretest SBP control	0.928	11	0.393
Pretest DBP control	0.926	11	0.376
Pretest SBP intervention	0.818	11	0.016
Pretest DBP intervention	0.855	11	0.049

Table 9

Results of the Shapiro-Wilk test for change in SBP and DBP per condition (intervention/control)

Dataset	Shapiro-Wilk Test		
	Statistics	df	P
Age	0.969	20	0.730
Weight	0.963	20	0.609
Height	0.976	20	0.875
BMI	0.862	20	0.009
Pretest SBP control	0.952	20	0.394
Pretest DBP control	0.931	20	0.161
Pretest SBP intervention	0.930	20	0.156
Pretest DBP intervention	0.907	20	0.057

The results of the Shapiro-Wilk test are not significant for all variables, except for height and pretest SBP intervention in the first group and BMI in the second group. This means that for these variables, the null hypothesis that the data originates from a normal distribution needs to be rejected at the 5% significance level. The normal Q-Q plots for these variables will be further analyzed and are presented in Figure 3, 4 and 5 below.

Figure 3

Normal Q-Q plots of Height participant for group 1

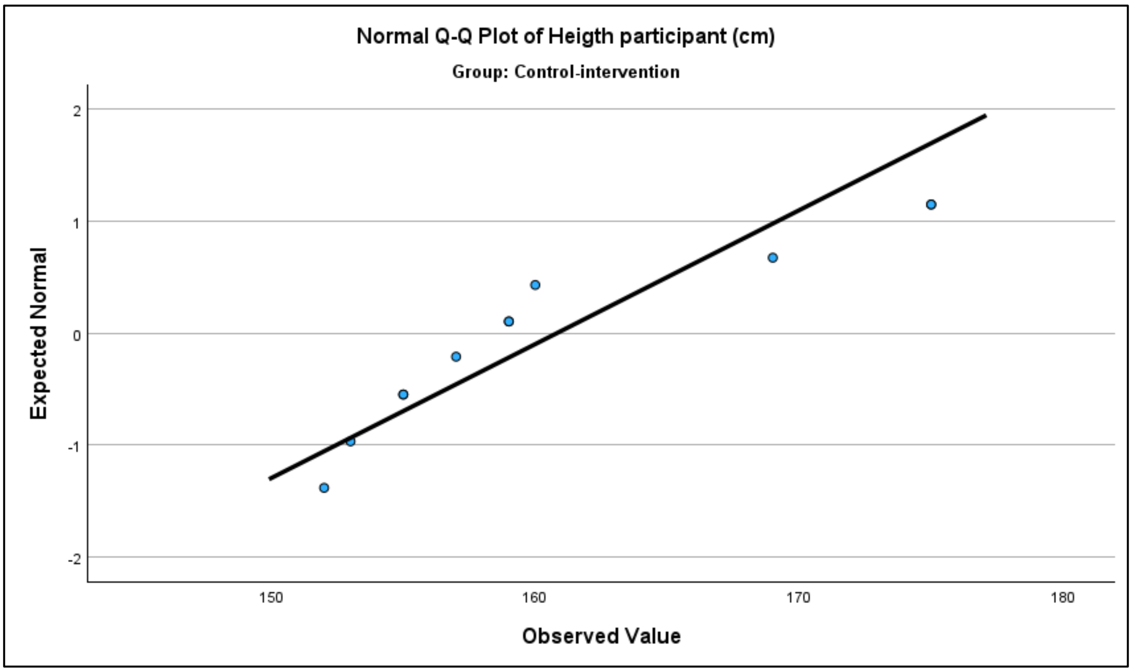


Figure 4

Normal Q-Q plot of BMI for group 2

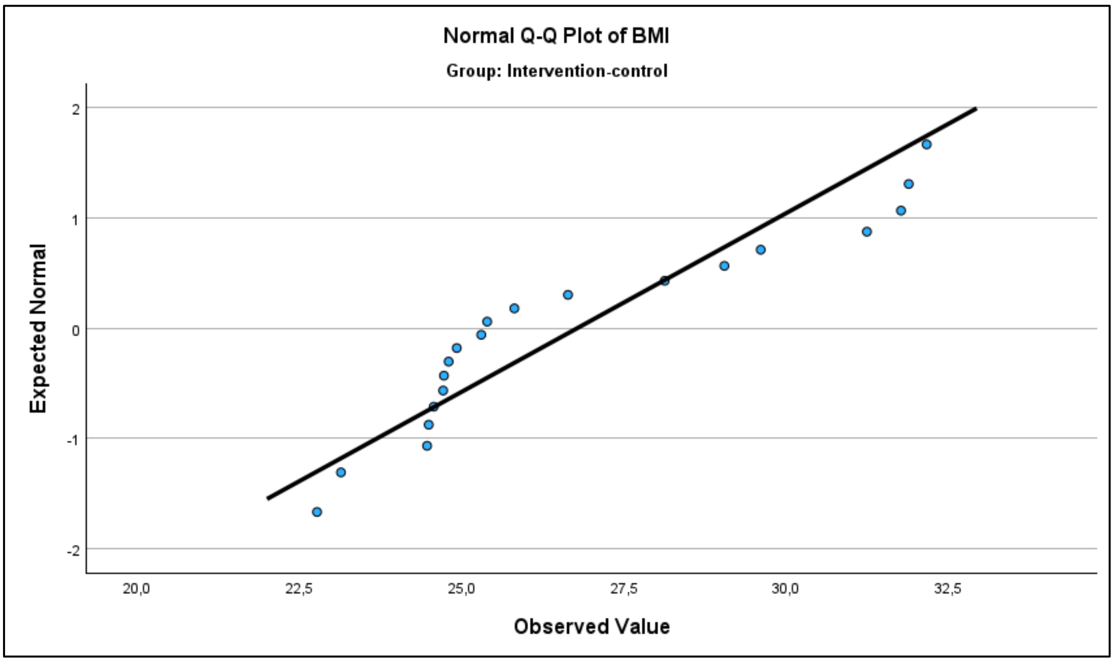
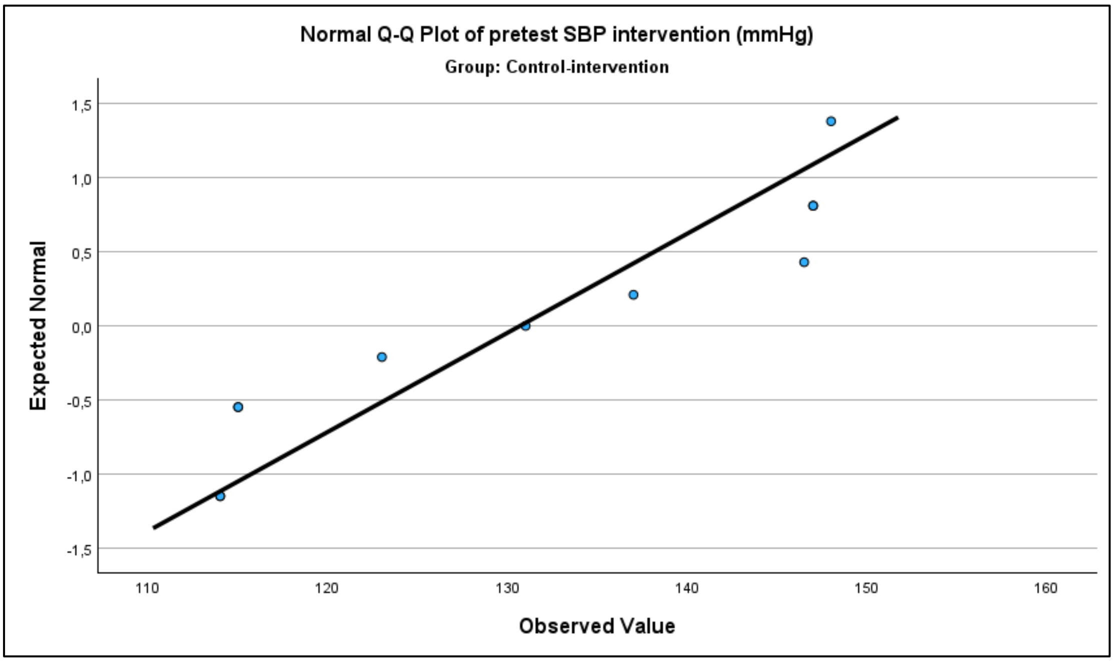


Figure 5

Normal Q-Q plot of pretest SBP intervention for group 1



The normal Q-Q plots do not align with what is expected from a Q-Q plot of a normal distribution. In a normal distribution, the points in the Q-Q plots should lie along the straight reference line with minimal deviation. This confirms that the null hypothesis needs to be rejected and these variables do not follow a normal distribution. Therefore, for these variables, a Mann-Whitney U test needs to be used in place of the independent Student's t-test.

Attachment 4: Assumptions ANOVA

To assess the ANOVA repeated measures, two assumptions need to be checked. First, the assumption of normality of the dependent variables must be verified. Second, it is important to ensure that there are no extreme outliers in the data.

Normality test

The normality assumption of the data was assessed using the Shapiro-Wilk test. The test was conducted to examine the normality of the SBP change during control and intervention measurement and DBP change during control and intervention measurement. If the null hypothesis, that the data originates from a normal distribution, is rejected, the normal Q-Q plots of those variables were further analyzed for confirmation. Table 10 presents the results of the Shapiro-Wilk test, the Skewness, and the Kurtosis.

Table 10

Results of the Shapiro-Wilk test, Skewness and Kurtosis for change in SBP and DBP per condition (intervention/control)

Dataset	Shapiro-Wilk Test		
	Statistics	**df**	**P**
Change SBP, control	0.956	31	0.224
Change SBP, intervention	0.976	31	0.698
Change DBP, control	0.952	31	0.181
Change DBP, intervention	0.979	31	0.786

The results of the Shapiro-Wilk test are not significant for SBP change during control measurement and intervention measurement and for DBP change during control measurement and intervention measurement. Based on this analysis, the null hypothesis that states that the data originates from a normal distribution cannot be rejected at the 5% significance level.

Outliers

Outliers are checked by running the descriptives and analyzing the boxplots per dependent variable, namely the change in SBP and change in DBP per condition (control/intervention). The boxplots are presented in Figure 6, 7, 8 and 9 below.

Figure 6

Boxplots of change in SBP control measurement

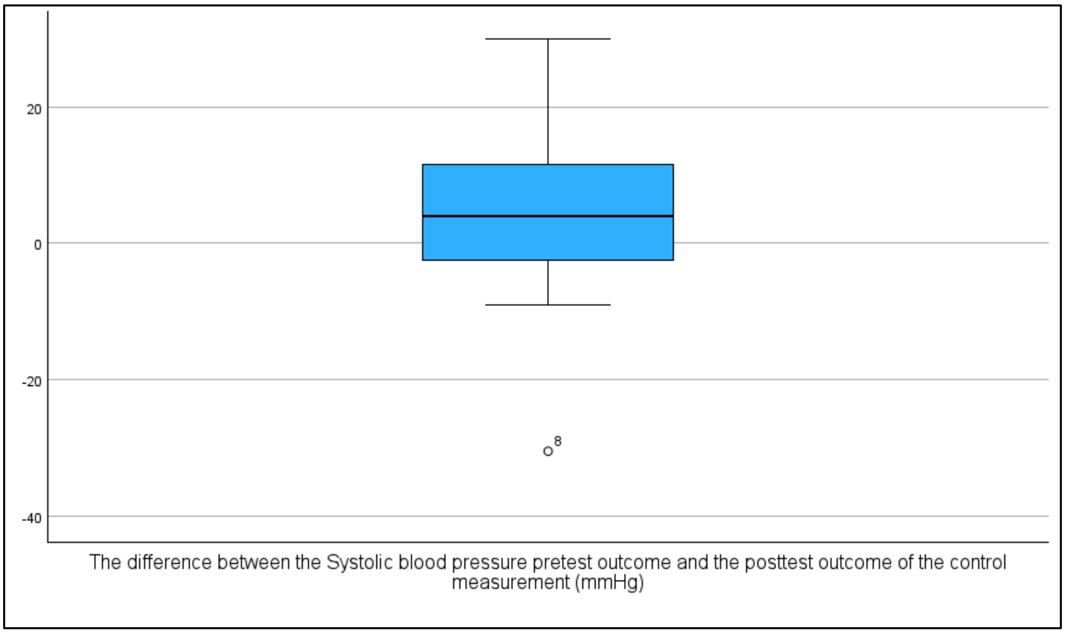


Figure 7

Boxplot of change in SBP intervention measurement

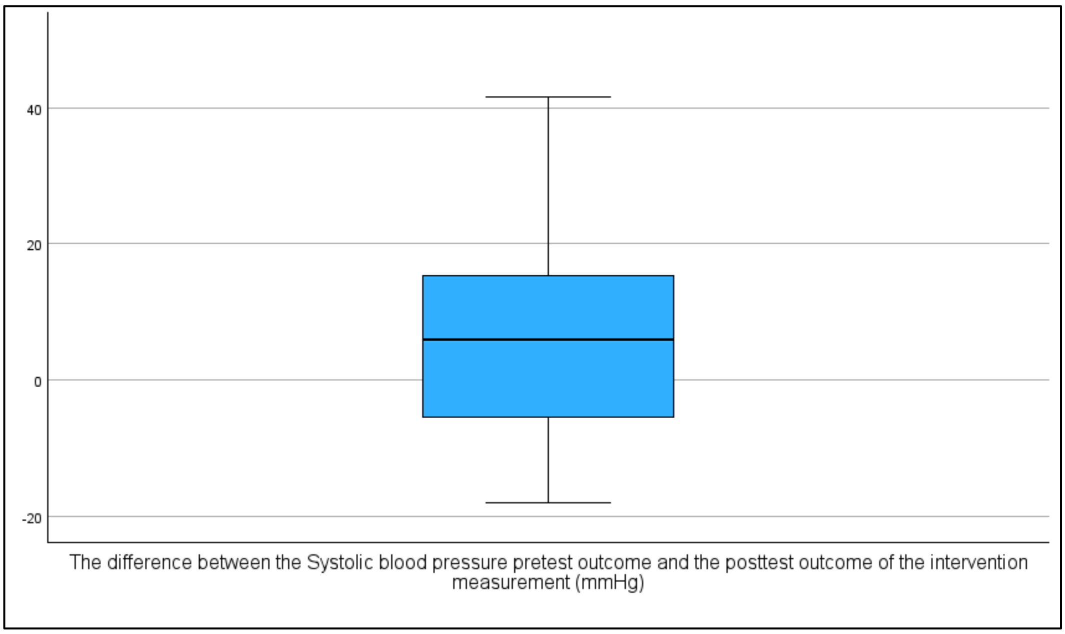


Figure 8

Boxplot of change in DBP for control measurement

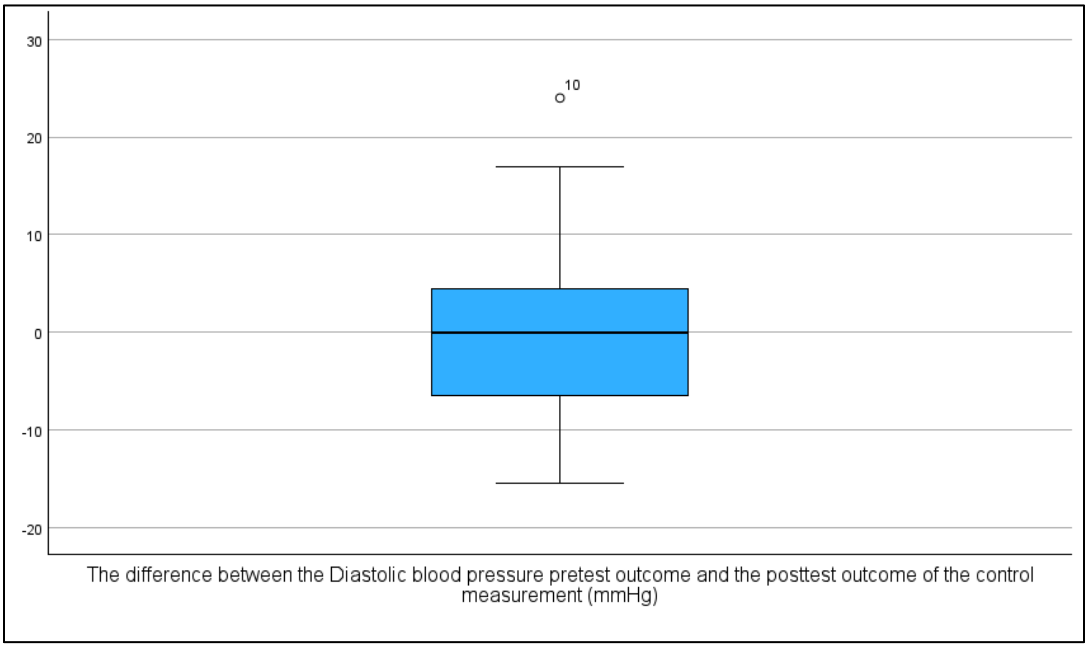
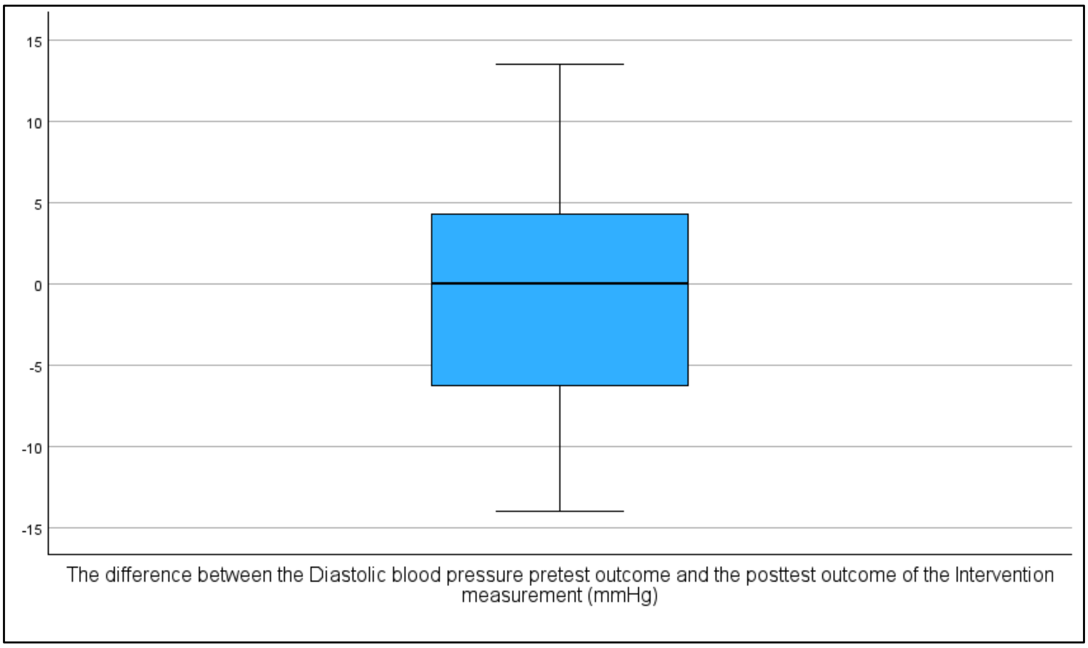


Figure 9

Boxplot of change in DBP for intervention measurement



There are no extreme outliers (greater than 3 SD) found for the change in SBP and change in DBP per condition (control/intervention), which means the assumption is met for the ANOVA repeated measures analysis.

Attachment 5: Logbook fieldwork

UNIVERSITEIT GENT

FACULTEIT GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN

Logboek veldwerk

Duid in vet aan tot welke categorie uw onderzoek behoort:

- **Veldwerk in kader van eigen onderzoek uitgevoerd door de student**
- Veldwerk in kader van eigen onderzoek, maar waarbij student meedraait in lopend project
- Veldwerk in kader van ander onderzoek: Indien de student kan verder werken op reeds verzamelde gegevens (reeds beschikbare data), is elke student verplicht om bijkomend 50 uur veldwerk te doen waarbij data verzameld worden in het kader van een ander onderzoek.

Beschrijving veldwerk	Plaats (UGent of naam externe locatie)	Duur (X aantal uur of minuten)
Preparation for data-collection (Testing and controlling the equipment (Blood pressure monitor) for the measurements and creating paper version.	UPorto – Faculty of sports	+/- 4h
Data-collection for own research (2h/ session) (1/03; 4/03; 8/03; 11/03; 15/03; 18/03; 22/03)	UPorto – Faculty of sports	+/- 14h
Data-collection for own research (3u/ session) (13/03; 20/03)	UPorto – Faculty of sports	+/- 6h
Data organization (From paper questionnaire to excel and later to SPSS)	UPorto – Faculty of sports	+/- 10h
		Totaal aantal uren: 34h

Signature (co)-supervisor:

9. List of illustrations

Figures

Tables

10. Social outreach

Hart- en vaatziekten zijn wereldwijd een van de belangrijkste oorzaken van overlijden, met jaarlijks bijna 17,9 miljoen sterfgevallen. Vooral hoge bloeddruk, ook bekend als hypertensie, speelt hierbij een cruciale rol als belangrijkste risicofactor die te beïnvloeden is. Ouderen worden vaak zwaar getroffen door hypertensie, waarbij de prevalentie stijgt met de leeftijd en een piek bereikt bij 65 jaar en ouder.Naast traditionele medicatie zijn er alternatieve niet-medicinale methoden om hypertensie aan te pakken, zoals meer bewegen, dieet en relaxatietechnieken, waaronder ademhalingsoefeningen. Deze eenvoudige oefeningen kunnen overal worden uitgevoerd, vragen weinig inspanning en kunnen meer gepast zijn voor ouderen. Maar hoe effectief zijn ze echt in het verlagen van de bloeddruk?

Om dit te onderzoeken, werd in samenwerking met de Universiteit van Porto een studie opgezet naar het directe effect van langzame diepe ademhalingsoefeningen op de bloeddruk van ouderen. 31 deelnemers van een sportles van gemiddeld 75 jaar werden verdeeld in twee groepen. Eén groep onderging eerst een controlemeting en daarna een interventiemeting, terwijl de volgorde voor de andere groep werd omgekeerd. Voor en na de sportles ondergingen de deelnemers bloeddrukmetingen. Bij de interventiemeting voerden ze 10 minuten ademhalingsoefeningen uit na de sportles, terwijl bij de controlemeting de bloeddruk direct na de sportles werd gemeten zonder oefeningen. Een groter verschil tussen de begin- en eindmetingen werd verwacht bij de interventiemeting, maar de resultaten toonden geen significant verschil tussen de interventie- en controlemetingen aan. De ademhalingsoefeningen hadden dus geen invloed op de bloeddruk.

Hoewel deze resultaten niet significant zijn, benadrukken ze het belang van verder onderzoek naar dit onderwerp. Het is cruciaal om meer inzicht te krijgen in de effecten van ademhalingsoefeningen op de bloeddruk, vooral bij oudere volwassenen, om uiteindelijk beter te begrijpen hoe hypertensie het beste kan worden aangepakt.