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Research Article

Effect of Brisk-Walk on Heart Sounds and Blood Pressure in Young Adults

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ABSTRACT

Background: Despite the potential significance of heart sounds in medical diagnoses, their integration into routine clinical assessment remains limited. **Objective**: This study aims to learn the effect of brisk walking on heart sound, focusing on intervals between S1 and S2, and S2 and S1, and blood pressure in healthy young adults. **Methods**: A convenience sampling method was used. Eight young adult subjects were asked to complete a brisk 30-minute walk on a treadmill. Heart sounds of each subject were recorded by using an electronic stethoscope, and a blood pressure monitor was used to record systolic and diastolic blood pressure before and after the 30-minute walk. The same activity was repeated two weeks after the initial study. **Results**: A varying degree of change in the S1-S2 interval and S2-S1 interval was found. Males exhibit an increase in SBP post-walk compared to the decrease observed in females. However, the diastolic blood pressure in both genders showed a reduction after walking, and it is consistent with the expected cardiovascular response to exercise. **Conclusion**: There were significant changes in S1-S2, S2-S1 interval, systolic and diastolic blood pressure after brisk walking among the subjects.

Keywords: blood pressure, brisk walk, exercise, heart sounds

1. Introduction

Brisk-walking is a low-risk and convenient type of physical activity for the majority of individuals. According to William L Haskell, all healthy individuals need moderate-intensity aerobic physical exercise for at least 30 minutes five days a week or vigorous-intensity aerobic physical activity for at least 20 minutes three days a week to promote and maintain health [1]. Cardiovascular health was critical for overall well-being, and monitoring key indicators like blood pressure played a vital role in preventive healthcare. Blood pressure measurements typically focus on systolic and diastolic values, indicating peak and minimum pressure during the cardiac cycle. However, these values alone might not have painted the complete picture of cardiovascular function.

Heart sounds were created from blood flowing through the four heart chambers as the cardiac valves opened and closed during the cardiac cycle. Audible sounds were created from the vibrations of these structures due to the blood flow. The first heart sounds (S1) comprised a mitral (M1) and tricuspid (T1) valve component, while the second heart sounds (S2) comprised an aortic (A2) and pulmonary (P2) valve component. Mitral valve closing was the louder component of S1, while in S2, the aortic valve closed sooner than the pulmonic valve, and it was the louder component of S2 due to the pressures in the aorta being higher than the pressures in the pulmonary artery [2, 3].

In short, heart sounds provide information about valve function, blood flow, and overall cardiac health. Despite the potential of heart sounds, their integration into routine clinical assessments remained limited. Hence, this study aimed to bridge the gap between heart sounds, specifically S1-S2 and S2-S1 heart sound intervals, and systolic and diastolic arterial blood pressure by conducting a type of exercise, which was brisk walking.

The problem statement of the research was that the relationship between heart sounds and blood pressure remains poorly understood. This research aimed to investigate heart sounds and blood pressure responses at rest and post-brisk walk in healthy young-adult individuals. Our research questions were divided into three points, which were how the heart sounds interval responded to brisk-walking, how blood pressure changed in response to brisk-walking, and how a combined analysis of heart sounds and blood pressure improved the accuracy of cardiovascular assessments.

There has been little data on heart sounds and diastolic and systolic blood pressure values in response to brisk walking. In contrast, most previous papers used other cardiovascular indicators such as heart rate variability (HRV), electrocardiography (ECG), and arterial stiffness. However, this study intends to determine the effectiveness of heart sounds as a marker for blood circulation. The significance of heart sounds in routine clinical assessment and examination remained limited in their use to recognize early stages of cardiovascular disease. By carrying out this research, the identification of specific heart sounds, especially the duration in response to being immobile (at rest) and being mobile (brisk walking), could be made. Another parameter, which was diastolic and systolic blood pressure, was also added. Blood pressure was one of the vital signs measurements that was often used by clinicians to see abnormal and normal conditions in patients, since high blood pressure was a common condition and often referred to as the "silent killer" because it might show no symptoms [4, 5].

The research objectives of this study consisted of a general objective, which was to learn the effect of heart sounds and diastolic and systolic blood pressure at rest and post-brisk walk in healthy young-adult individuals and to learn new skills of using electronic stethoscope and specific objectives which were to find the average duration of S1 and S2 interval and S2 and S1 intervals at rest and post-brisk walk, to find the average of systolic and diastolic blood pressure of the participants at rest and post-walk and to find average S1-S2, S2-S1 intervals, systolic and diastolic blood pressure in male and female. The hypothesis for this research was that brisk walking affects heart sounds and blood pressure values.

2. Methods

2.1. Overview of the Study

This is a quantitative study, where theory, hypothesis, and data are required to confirm the experimental research.

2.2. *Study Population and Target Population*

The study was conducted in eight young adults who voluntarily joined the study as subjects, aged from 19 to 22 years old.

2.3. Study Design and Study Duration

This experimental study that incorporated physical activity was conducted on young adult volunteers who do not smoke or drink alcoholic beverages and have no chronic diseases. The subjects' heart sound (S1 and S2) recording was taken using an electronic stethoscope, while their systolic and diastolic blood pressure were taken using a blood pressure monitor. Both the subject's heart sound and blood pressure were recorded at rest and immediately after the exercise, where each subject was required to walk for 30 minutes continuously on the treadmill at a speed of 3.2 km/h in a controlled environment at a lab.

2.4. Sample Size, Sampling Frame, Sampling Method, and Inclusion Criteria & Exclusion Criteria

A convenience sampling method was used in this study, while the sample size was obtained using a reference article by Takuro Matsuda et al. [12] and using the G power analysis method, which determined that 8 subjects were required for this study.

Inclusion Criteria
1. Respondents must be young adults
2. Respondents must be healthy (e.g, no fever, no injuries that may affect mobility like fractures)

Exclusion Criteria
1. Respondents with chronic diseases (e.g., cardiovascular disease, respiratory disease)
2. Respondents who are smokers
3. Respondents who are alcoholics

2.5. Variables Definition

Table 1. Operational Definition of Variables

Variables	Concept	Operational Definition	Measurement
Heart Sounds	Heart sounds are created from blood flowing through the heart chambers as the cardiac valves (atrioventricular valve and semilunar valve) open and close during the cardiac cycle. S1(lub) and S2(dub).	Measuring with an electronic stethoscope (Littmann MODEL 3200) before and after exercise	Scale
Blood Pressure	Systolic and diastolic blood pressures of the respondents	Measuring with a blood pressure monitor (OMRON MX3) before and after exercise	Scale

2.6. Method of Data Collection and Technique

To investigate the causal connection between heart sounds and systolic/diastolic blood pressure in healthy young adult individuals at rest and post-walk, this study was carried out in a laboratory situated in UniKL RCMP to ensure subject safety. Each participant was instructed to perform the study twice, first on the 1st of February and second on the 16th of February 2024, to ensure accuracy in data collection. During the study, the participants were first asked to sit and rest, during which baseline measurements were obtained by recording heart sounds using an electronic stethoscope at designated auscultatory areas (aortic, pulmonic, tricuspid, and mitral) and a blood pressure monitor were used to record systolic and diastolic blood pressure before immediately proceeding with a 30 minute walk on a treadmill at the speed of 3.2 km/h [13]. After the participants finished their 30-minute walk, their heart sounds and blood pressure were recorded immediately to get the best result. The same protocols and equipment were used in both sessions to ensure the best results were obtained. The equipment used in this study consisted of a treadmill, a timer, an electronic stethoscope (3M Littmann Digital Stethoscope), which was connected to the computer with the designated app (Stethassist), and a blood pressure monitor (Omron MX3). The analysis of the heart sounds interval (S1-S2 and S2-S1), along with systolic and diastolic blood pressure were examined based on the results obtained using the appropriate analysis method to find relevant changes and patterns.

2.7. Ethics approval

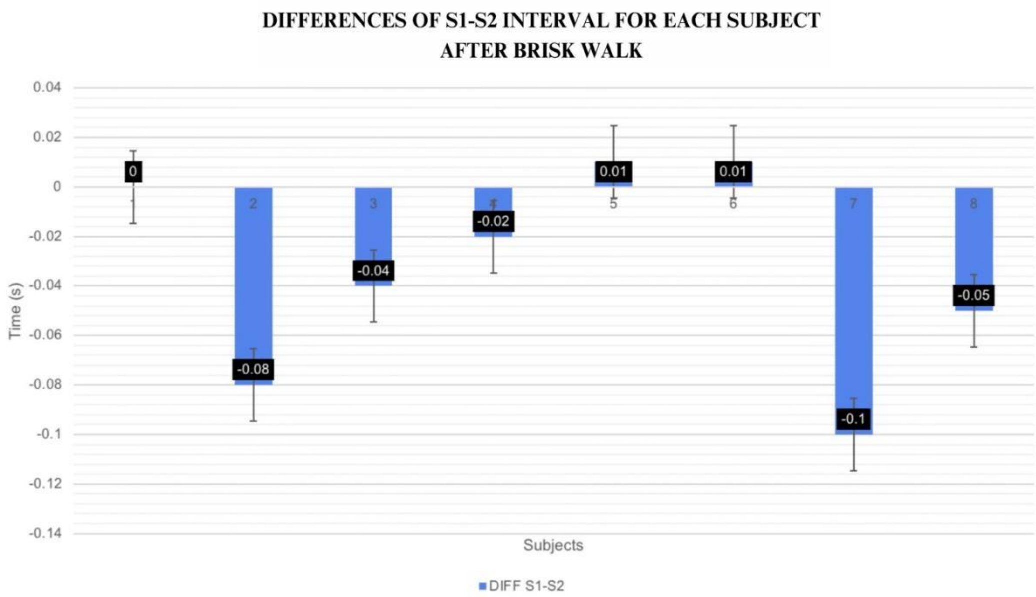
Participation was entirely voluntary, and informed consent was obtained from each participant. The identities and responses of respondents were treated confidentially and were not disclosed publicly. Data were only shared if explicitly requested by the participant and were used exclusively for educational purposes.

The research involved participants engaging in an experiment that required brisk walking. Additional precautions were implemented in the event of any health-related accidents, with a safety kit provided and transportation to nearby hospitals arranged for emergencies. Our supervisor was on standby during the experiment to offer Basic Life Support in case of emergency.

3. Results

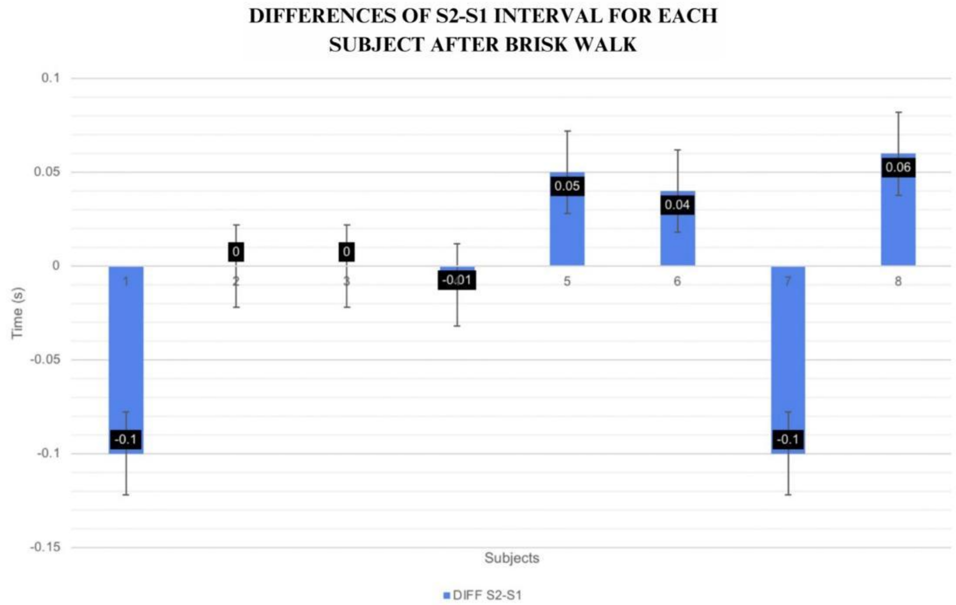
Heart sounds and blood pressure readings were gained from 8 respondents aged between 20 and 21 years old. Out of the 8 respondents, 5 of the respondents were male, and the other 3 respondents were female. The distribution according to gender was not equal. There were 5 male participants (62.5%) and 3 female participants (37.5%). Aside from that, all the respondents are non-alcoholic and non-smokers, with all but one respondent being overweight, and the rest have a normal weight.

Graph 1 presents the differences in S1-S2 intervals for each participant at rest and post-walk. For the S1-S2 interval, a varying degree of decrease can be seen in subjects 2,3,4,7 and 8 post-walk, while subject 1 does not show any change in S1-S2 interval after walking for 30 minutes. Subjects 5 and 6 show an increase in the S1-S2 interval.



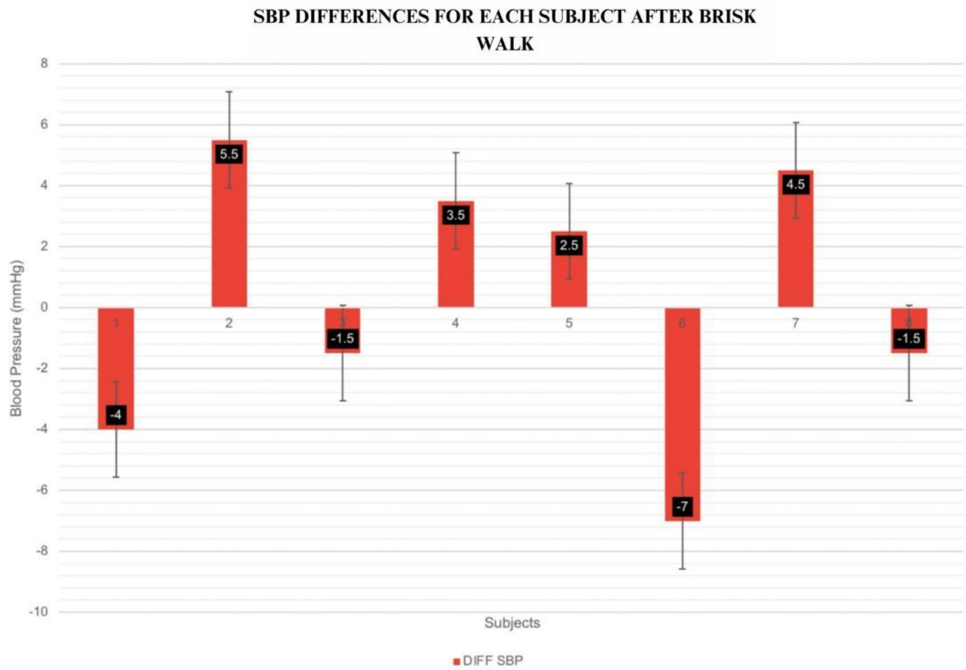
Graph 1. Differences in S1-S2 intervals of Each Participant

Graph 2 presents the differences of S2-S1 intervals for each participant at rest and post-walk. For the S2-S1 interval, subjects 1,4, and 7 showed a decrease in S2-S1 interval, whereas subjects 2 and 3 did not show any change after the 30-minute walk on the treadmill, and subjects 5,6 and 8 showed an increase in S2-S1 interval post walk.



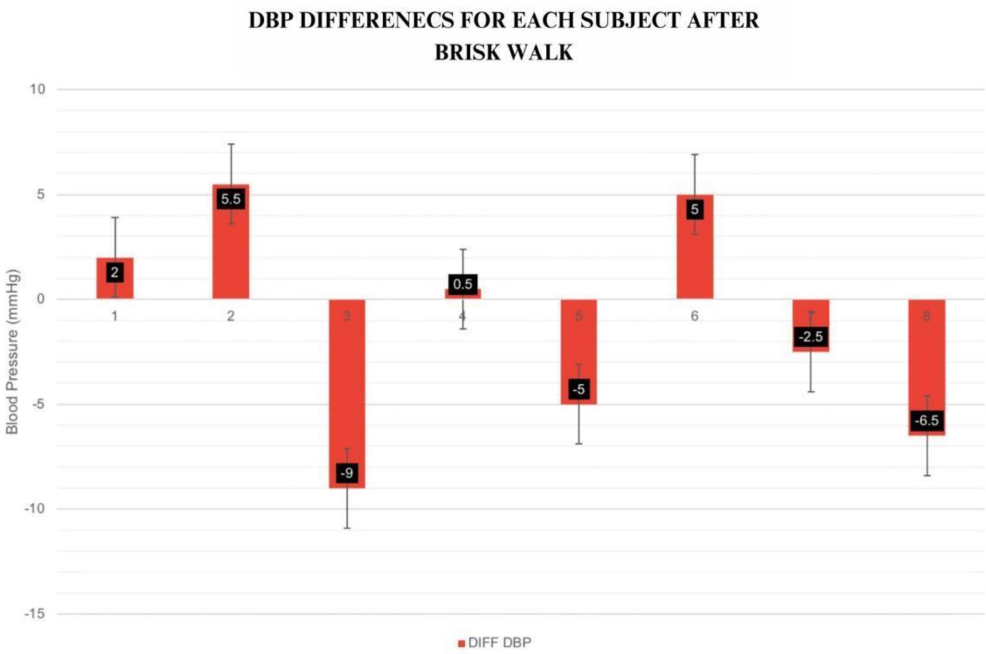
Graph 2. Differences S2-S1 intervals of Each Participant

Graph 3 presents the differences in systolic blood pressure of the participants at rest and post-walk. Each subject shows varying changes in systolic blood pressure. Main change from subject 6 shows abnormally low systolic blood pressure, which is 101 mmHg at rest and 94 mmHg post walk, which decreases by 7 mmHg. Meanwhile, other subjects showed varying changes in systolic blood pressure.



Graph 3. Differences in Systolic Blood Pressure for Each Participant

Graph 4 shows the differences in systolic blood pressure of the participants at rest and post-walk. Each subject shows varying changes in systolic blood pressure. Subject 3 shows a prominent decrease by 9 mmHg from 90.5 mmHg at rest to 81.5 mmHg post walk. Others show varying changes in systolic blood pressure.

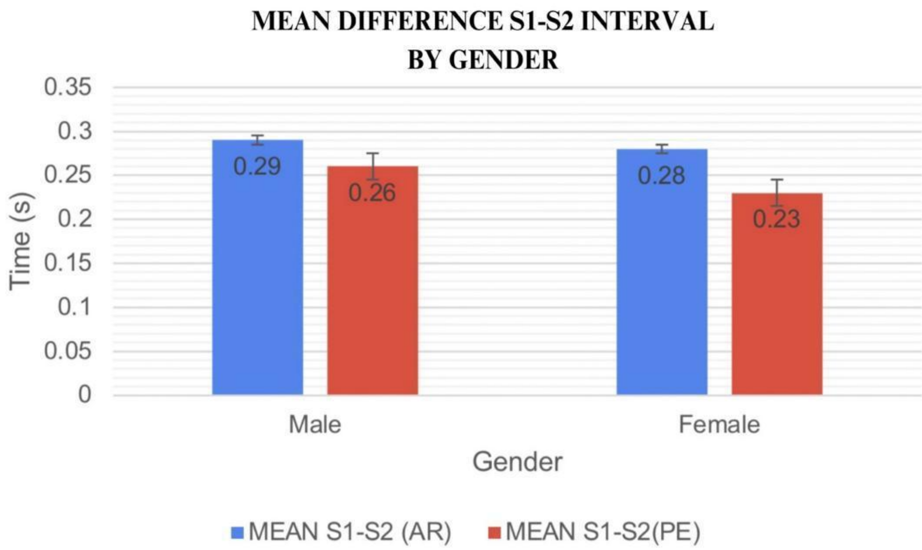


Graph 4. Differences in Diastolic Blood Pressure for Each Participant

Based on Graph 5, the data analysis of S2- S1 intervals reveals variation among male and female participants at rest and post-brisk walk conditions. Among the male participants, the S1-S2 interval at rest ranges from 0.24s to 0.31s, with an overall mean of 0.29s, while post-walk S1-S2 intervals range from 0.23s to 0.29s, with an overall mean of 0.26s. The mean difference between the S1-S2 interval at rest and post-walk is decreasing from 0.29s to 0.26s, a difference of 0.03s.

The female participants, on the other hand, showed S1-S2 intervals at rest ranging from 0.25s to 0.31s, with an overall mean of 0.28s, and post-walk S1-S2 intervals ranging from 0.18 to 0.26s, with an overall mean of 0.23s. The mean difference between the S2-S1 interval at rest and post-walk is decreasing from 0.28s to 0.23s, a difference of 0.05s.

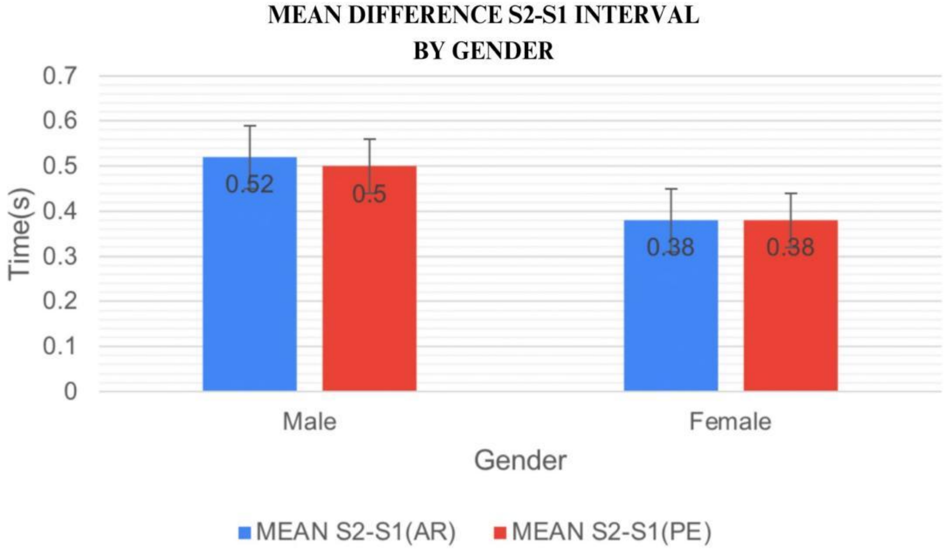
After comparison, we found that male participants seem to have a slightly higher mean for the S1-S2 interval compared to females (0.29s for males and 0.28s for females) at rest. On the other hand, after a 30-minute walk, both male and female participants exhibit a slight decrease in the mean of the S1-S2 interval compared to the resting state; however, the magnitude of this decrease varies, with the female participants having a slightly bigger mean decrease (17.86%) compared to the males (10.34%).



Graph 5. Mean Difference of S1-S2 Interval at Rest and Post-Walk of the participants by genders

The graph illustrates a decrease in the mean of the S2-S1 interval for males when comparing the data at rest and post-walk. The mean S2-S1 interval at rest ranges from 0.42s to 0.62s with an overall mean of 0.52s, whereas their post-walk S2-S1 intervals range from 0.42s to 0.57s, with an overall mean of 0.50s, a difference of 0.02s. Furthermore, the mean of the S2-S1 interval for females remains the same when comparing the data at rest and post-walk. Female participants showed mean S2-S1 intervals at rest ranging from 0.34s to 0.46s, with an overall mean of 0.38s, and their post-walk S2-S1 intervals ranged from 0.36s to 0.40s, with an overall mean of 0.38s

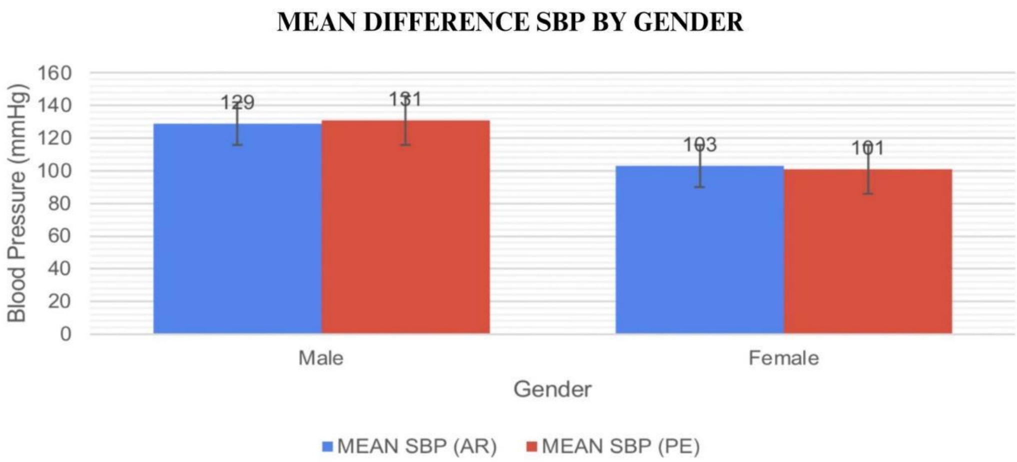
Interestingly, male participants generally have higher mean S2-S1 intervals compared to females, both at rest (0.52s for males compared to 0.38s for females) and post-walk (0.50s for males compared to 0.38s for females post-walk). The response to exercise among male participants appears to vary slightly, with some showing a decrease and others showing no significant change in the mean S2-S1 interval post-walk. Conversely, female participants generally exhibit minimal variation in the mean S2-S1 interval before and after the 30-minute walk.



Graph 6. Mean Difference of S2-S1 Interval at Rest and Post-Walk of the participants by gender

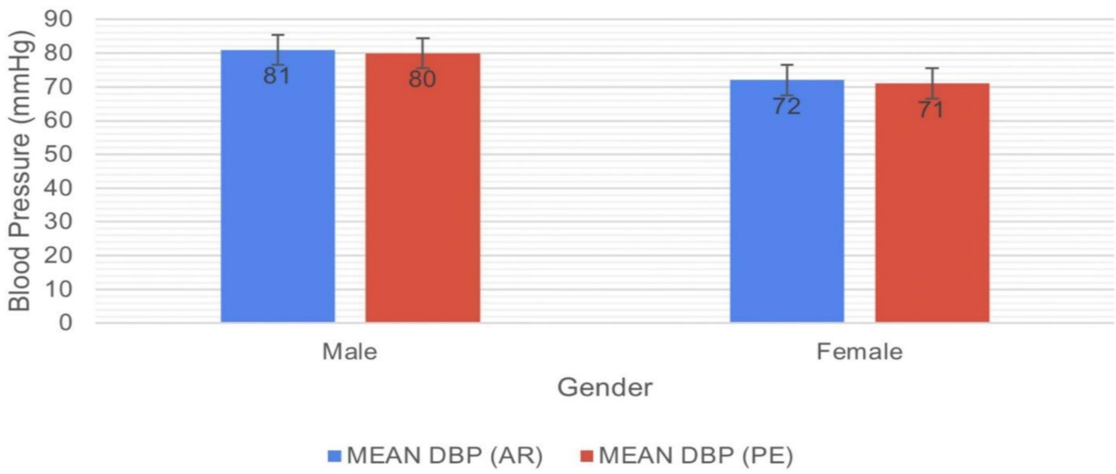
Graph 7 shows the mean systolic blood pressure for males and females at rest and post-walk. The mean difference between systolic blood pressure for males at rest and post-walk was 2 mmHg, with the data increasing from 129 mmHg to 131 mmHg. While the mean difference between systolic blood pressure for males at rest and post-walk was 2 mmHg, the data decreased from 103 mmHg to 101 mmHg.

Among the male participants, the mean SBP both at rest and post-walk was slightly higher than the overall female mean. This suggests that males generally exhibit higher SBP levels both at rest and after physical activity compared to females. However, the increase in SBP post-walk among males showed contrasts with the decrease observed in females.



Graph 7. Mean Difference in Systolic Blood Pressure of the participants by gender

The graph shows the mean diastolic blood pressure for males, which is decreased when comparing the data at rest and post-walk. The mean difference between diastolic blood pressure at rest and post-walk was decreasing from 81 mmHg to 80 mmHg, a difference of 1 mmHg. The mean diastolic blood pressure for females is decreased when comparing the data at rest and post-walk. The mean difference between diastolic blood pressure at rest and post-walk was decreasing from 72 mmHg to 71 mmHg, a difference of 1 mmHg. Here we can see that the overall male mean, both at rest, is slightly higher than the female mean.



Graph 8. Mean Difference in Diastolic Blood Pressure of the participants by genders

4. Discussion

Based on the results of this study, the data we would like to emphasize in this discussion, after analysis, include firstly, the time difference in the S1-S2 interval (graph 1) and S2-S1 interval (graph 2) for each participant at rest and post-walk. Secondly, the difference in systolic blood pressure for each individual at rest and post walk (graph 3) and the difference in diastolic blood pressure for each individual at rest and post walk (graph 4). Last but not least, we analyzed the data comparison between male and female participants for the mean S1-S2 interval (graph 5) and S2-S1 interval (graph 6), along with mean systolic blood pressure (graph 7) and diastolic blood pressure at rest and post walk.

For graphs 1 and 2, both S1-S2 and S2-S1 intervals are closely related to heart rate; thus, a decrease in both intervals after exercise is considered to be a response to increasing heart rate post-exercise. Interestingly, subjects 5 and 6 showed an increase in both heart sound S1-S2 and S2-S1 interval after walking for 30 minutes. Based on the information sheet that we gathered, we found that both subjects had a physically active lifestyle. The increase in S1-S2 interval is about 0.05s for subject 5 and 0.04s for subject 6, and the S2-S1 interval shows about 0.01s increase for both subject 5 and 6, meaning that the period of ventricular filling and ejection of the heart is longer compared to the rest of the subjects, who are physically less active. Physically active individuals often have larger and considerably stronger muscles than those of a normal person. This is due to the increase in metabolic demand of the myocardium by compensatory hypertrophy of the heart. This allows the individuals to pump a large stroke volume output per beat, even during periods of rest, resulting in a more efficient ejection and filling period.

According to a study by Morganroth, compared to non-athletes, athletes have 15–20% greater left ventricular wall thickness (LVWT) and 10–15% greater left ventricle (LV) size. In a landmark study of 1309 Italian athletes engaged in 38 sports, 45% had LV end-diastolic diameter ≥55 mm (≥60 mm in 14%). A markedly dilated LV was more common in athletes with a larger body surface area and in those participating in endurance sports (cycling, cross-country skiing, and rowing/canoeing). LV diastolic function can be enhanced by prolonged exercise training [14, 15]. The larger left ventricles of the individuals can eject a larger volume of blood into the arteries, enhancing oxygen delivery to muscles during exercise. These individuals also have enhanced filling capacity which means that more blood can be rapidly delivered to the ventricles during diastole.

For graph 3, subject 6 shows abnormally low systolic blood pressure, which is 101 mmHg at rest and 94 mmHg post walk, which decreases by 7 mmHg. The observed low systolic blood pressure at rest and post-walk in the subject can be attributed to the presence of anemia. Anemia, characterized by a reduced number of red blood cells or hemoglobin levels, can compromise the blood's oxygen-carrying capacity, potentially leading to decreased cardiac output and subsequent lower systolic blood pressure. This, in turn, might lead to a lower systolic blood pressure. Understanding these connections helps us see the broader picture of how health conditions can influence blood pressure, especially during activities like walking. Despite the low systolic blood pressure observed both at rest and after a 30-minute walk, the subject reported feeling normal and without any adverse symptoms following the physical activity. This resilience may be attributed to individual variations in blood pressure tolerance and adaptation to lower pressures during exercise.

For graph 4, diastolic blood pressure for each individual at rest and post walk, subject 3 showed a marked decrease in comparison with others, with a difference of about 9 mmHg. After subject 3 participated in the activity, the individual reported experiencing dizziness and tiredness. Probably, subject 3 shows symptoms of orthostatic hypotension, which was found to be associated with their dietary habits. The subject was reported to be on a single meal per day regimen due to their low metabolism. The observed symptoms of dizziness and nausea in the individual could be identified as indicative of orthostatic hypotension due to the prolonged 30-minute walk. This nutritional practice may contribute to the marked decrease in diastolic blood pressure response observed post-walk.

Based on the data comparison between male and female participants in the context of heart sound (graphs 5 and 6), these findings underscore potential gender differences in cardiovascular responses to physical activity, warranting further investigation. The observed differences in heart sound intervals between males and females could be attributed to several physiological and anatomical factors. Generally, females tend to have smaller hearts compared to males. The smaller size may affect the duration of cardiac cycles and subsequently influence heart sound intervals. Based on Ramaekers D. et al., the smaller female heart, pumping less blood with each beat, needs to beat at a faster rate to match the larger male heart's output [16]. Pelliccia et al. showed 23% lower LVWT and 11% smaller LV size in females compared to male athletes with similar age and training intensity. In this study, no female had LVWT >12 mm [17]. Sharma et al. showed similar findings in adolescent athletes (11% lower LVWT and 6% smaller LV size in females. Almost 5% of male athletes had LVWT ≥12 mm, but no females had LVWT >11 mm [18]. Further, women have a different intrinsic rhythmicity to the pacemaker of their hearts, which causes them to beat faster.

While in the context of blood pressure (graphs 7 and 8), this suggests that males generally exhibit higher SBP levels both at rest and after physical activity compared to females. However, the increase in SBP post-walk among males contrasts with the decrease observed in females, indicating potential differences in cardiovascular responses to exercise between genders. For DBP in both genders, it showed a decrease after physical activity, consistent with the expected cardiovascular response to exercise, where blood vessels dilate to accommodate increased blood flow, thereby reducing pressure on the arterial walls. However, it's noteworthy that males generally maintained higher DBP levels compared to females across both resting and post-walk conditions.

This study shows that females have lower blood pressure than males. Some of the reasons why this occurs are that it relates to their metabolism. Generally, females tend to have a slightly lower metabolic rate than males. A lower metabolism means that the body may expend energy at a slower pace, potentially leading to decreased heart rate and reduced vascular tone. These factors can contribute to lower blood pressure levels. Men often have higher RMR, meaning their bodies burn more calories at rest. This higher metabolic activity can lead to increased blood pressure as the heart works harder to circulate blood and deliver oxygen and nutrients to the body. This is because Nurshad Ali et al. found a positive association between BMR (a similar measure to RMR) and blood pressure, independent of factors like body size [19]. Also, based on Betty N Wu et al., men, on average, have a 10-15% higher resting metabolic rate (RMR) than women [20]. This means they burn more calories at rest, even when controlling for factors like body weight and composition.

Other than that, muscle mass can also be another factor why females have lower blood pressure compared to males. Based on Song Zhao et al., muscle mass positively impacts blood pressure for both genders. The study found that higher total muscle mass is associated with higher systolic blood pressure (SBP) in both men and women. But women generally have lower muscle mass than men [21]. This biological difference could explain why the study didn't observe a significant association between muscle mass and blood pressure in women. Since women inherently have less muscle, the potential impact on their blood pressure might be smaller compared to men.

Another reason the blood pressure in women tends to be lower than that of men is the higher levels of oestrogen in women compared to men. Oestrogen produces vasodilatory effects, essentially causing blood vessel walls to relax and allowing blood to flow easily. This means that less pressure is applied against these blood vessel walls. In contrast, men tend to have more testosterone than women, which can lead to vasoconstriction and, hence, higher blood pressure [22, 23].

As we compare graph 1 and graph 3, we cannot find any correlation between the S1-S2 interval and SBP

(P value = 0.795). For graphs 2 and 4, we also cannot find any correlation between the S2-S1 interval and DBP (P value=0.325). But previous research by N. Muhammad et al. found that the S1-S2 interval has a statistically significant correlation to SBP, and S2-S1 to DBP [8]. Even though heart sounds portray the activity of the heart during the cardiac cycle, the systolic and diastolic phases are also directly related to blood pressure [24].

Since heart sound and blood pressure are the basic indicators for heart condition, further studies with a bigger sample size need to be done. It is also preferable for further studies to ensure participants are of similar body mass index (BMI) to better rule out differences in cardiorespiratory and endurance ability [25, 26].

5. Conclusion

In conclusion, it can be seen that while there are indeed changes in the S1-S2 interval and S2-S1 interval, systolic blood pressure and diastolic blood pressure after walking for 30 minutes, the magnitude of changes differs from person to person, which could be attributed to several external factors like lifestyle and diet. Brisk walking, therefore, shows minimal impact on heart sound and blood pressure, as results differ too greatly among participants of this study. Lastly, we believe that further research must be done regarding the topic to reach more conclusive findings.

6. Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to privacy and ethical considerations, but are available from the corresponding author upon reasonable request.

7. Ethical Statement

Ethical clearance (UniKLRCMP/MREC/2023-2024/SSM-006) was obtained from the Medical Research and Ethics Committee (MREC) under UniKL Royal College of Medicine Perak. Participation was entirely voluntary, and informed consent was obtained from each participant. The identities and responses of respondents were treated confidentially and were not disclosed publicly. Data were only shared if explicitly requested by the participant and were used exclusively for educational purposes.

The research involved participants engaging in an experiment that required brisk walking. Additional precautions were implemented in the event of any health-related accidents, with a safety kit provided and transportation to nearby hospitals arranged for emergencies. Our supervisor was on standby during the experiment to offer Basic Life Support in case of emergency.

8. Author Contributions

Each author has made substantial contributions to this study, including conceptualization, study design, implementation, data collection, analysis, and interpretation. All authors have participated in drafting, revising, and critically reviewing the manuscript. They have provided final approval of the version to be published and have been involved in the decision regarding the journal for submission. Furthermore, all authors agree to take full responsibility for every aspect of the work.

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11. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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