3D SA'I VIRTUAL REALITY FOR MONITORING HAJJ PILGRIMS' CARDIORESPIRATORY PERFORMANCE

DK SITI SYAHIRAH PG IDRIS
20MR2013

FACULTY OF ISLAMIC TECHNOLOGY
UNIVERSITI ISLAM SULTAN SHARIF ALI
BRUNEI DARUSSALAM

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بسم الله الرحمن الرحيم

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A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ISLAMIC MEDIA AND COMMUNICATION TECHNOLOGY

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SUPERVISION

3D SA'I VIRTUAL REALITY FOR MONITORING HAJJ PILGRIMS'

CARDIORESPIRATORY PERFORMANCE

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ABSTRACT

3D SA'I VIRTUAL REALITY FOR MONITORING HAJJ PILGRIMS' CARDIORESPIRATORY PERFORMANCE

Hajj, one of the five pillars of Islam, is a significant religious obligation for Muslims who are financially and physically capable of performing it. However, the physical demands of the pilgrimage can be daunting for many, especially in terms of cardiorespiratory fitness, which plays a critical role in successfully completing the Hajj and Umrah. The strenuous and rigorous activities involved in the pilgrimage, such as Sai, Tawaf, throwing stones at the three Jamrat in high-temperature environments, overcrowding, and other vigorous activities, can often leave pilgrims feeling fatigued and exhausted, leading to potential unconsciousness.To address this issue, this research aims to improve the fitness levels of pilgrims, focusing mainly on the Sai activity, which is one of the most physically demanding aspects of the Hajj pilgrimage. The researchers developed a 3D virtual environment application called Qaadirun 'ala adaari assa'ie, also known as "Fit 4 Sa'i," which simulates the real environment of Sai. A true experimental design and pretest-posttest control group design were employed to evaluate the effectiveness of the program. During the study, the participants underwent a 2.4-kilometer fitness test and completed eight training sessions over a four-week period to determine if the program was successful in improving their cardiovascular fitness. The study outcomes were analyzed, and it was discovered that the training provided by the program was beneficial in helping individuals reach the required fitness levels needed to complete the Hajj pilgrimage successfully.

ملخص

واقع افتراضي ثلاثي الأبعاد لمراقبة الأداء القلبي التنفسي لحجاج الحج

الحج، واحد من أركان الإسلام الخمسة، هو واجب ديني هام للمسلمين الذين يمتلكون القدرة المالية والبدنية لأداءه. ومع ذلك، يمكن أن تكون المطالب البدنية للحج مرهقة للكثيرين، خاصة فيما يتعلق باللياقة القلبية التنفسية، والتي تلعب دورًا حاسمًا في إتمام الحج والعمرة بنجاح. الأنشطة المرهقة والشاقة المشتركة في الحج، مثل السعي والطواف، ورمي الجمرات الثلاث في بيئات عالية الحرارة، والازدحام، والأنشطة الشاقة الأخرى، غالبًا ما تترك الحجاج شعورًا بالتعب والإرهاق، مما يؤدي إلى فقدان الوعي المحتمل.

لمعالجة هذه المشكلة، تهدف هذه الدراسة إلى تحسين مستوى لياقة الحجاج، مع التركيز بشكل أساسي على نشاط السعي، الذي يعد واحدًا من أكثر جوانب الحج مطلبًا بدنيًا. قام الباحثون بتطوير تطبيق بيئة افتراضية ثلاثية الأبعاد والذي يحاكي البيئة الحقيقية، يسمى "Fit 4 Sa'i" "قادرون على العدار على السعي"، المعروف أيضًا باسم للسعي. تم استخدام تصميم تجريبي حقيقي وتصميم مجموعة سيطرة قبل وبعد الاختبار لتقييم فعالية البرنامج. خلال الدراسة، خضع المشاركون لاختبار لياقة بمسافة 2.4 كيلومتر وأكملوا ثماني جلسات تدريب على مدار أربعة أسابيع لتحديد ما إذا كان البرنامج ناجحًا في تحسين لياقتهم القلبية التنفس

ABSTRAK

3D SA'I REALITI MAYA UNTUK PEMANTAUAN PRESTASI KARDIORESPIRATORI JEMAAH HAJI

Haji, salah satu dari lima pilar Islam, adalah kewajiban agama yang penting bagi umat Muslim yang memiliki kemampuan finansial dan fisik untuk melakukannya. Namun, tuntutan fisik dari ibadah haji bisa menjadi hal yang menantang bagi banyak orang, terutama dalam hal kebugaran kardiorespiratori, yang memainkan peran penting dalam menyelesaikan haji dan umrah dengan sukses. Aktivitas-aktivitas yang melelahkan dan intensif dalam perjalanan haji, seperti Sai, Tawaf, melempar jumrah di tiga tempat dalam suhu yang tinggi, keramaian, dan aktivitas-aktivitas lainnya, seringkali membuat jemaah merasa lelah dan kelelahan, yang dapat menyebabkan kehilangan kesadaran. Untuk mengatasi masalah ini, penelitian ini bertujuan untuk meningkatkan tingkat kebugaran jemaah haji, dengan fokus utama pada aktivitas Sai, yang merupakan salah satu aspek fisik yang paling menuntut dalam perjalanan haji. Para peneliti mengembangkan aplikasi lingkungan virtual 3D yang disebut Qaadirun 'ala adaari assa'ie, juga dikenal sebagai "Fit 4 Sa'i," yang mensimulasikan lingkungan nyata dari Sai. Desain eksperimen sejati dan desain kelompok kontrol pra-uji coba dan pasca-uji coba digunakan untuk mengevaluasi efektivitas program tersebut. Selama penelitian, para peserta menjalani tes kebugaran sejauh 2,4kilometer dan menyelesaikan delapan sesi latihan selama periode empat minggu untuk menentukan apakah program tersebut berhasil meningkatkan kebugaran kardiovaskular mereka. Hasil penelitian dianalisis, dan ditemukan bahwa pelatihan yang diberikan oleh program tersebut bermanfaat dalam membantu individu mencapai tingkat kebugaran yang diperlukan untuk menyelesaikan perjalanan haji dengan sukses.

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ABBREVIATION

MORA	Ministry of Religious Affairs' Haj Affairs
HR	Heart Rate
BP	Blood pressure
SpO2	Saturation of peripheral oxygen

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Over the years, technology has revolutionized our world. Virtual environment, commonly referred to as virtual reality (VR), is a computer-generated simulation that mimics the real world. It facilitates user performance by assisting users in exploring and interacting with virtual environments that have the potential to change the way viewers see images. These days, the VR has produced impressive resources and technologies that have put helpful knowledge at our fingertips. With all these revolutions, technology has also made our lives easier, faster, better and more interactive. The use of VR technology has expanded beyond gaming and entertainment, with applications in fields such as education, training, therapy, and even space exploration.

The Hajj pilgrimage is one of the five pillars of Islam, and one of the largest annual gatherings of people in the world. Each year, millions of Muslims from around the world travel to Mecca to perform the Hajj, a journey that can be physically and emotionally challenging. In recent years, Virtual Reality (VR) technology has emerged as a promising tool to assist Hajj pilgrims in their journey, providing a more immersive and interactive experience. Recent technology use of VR to help Hajj pilgrims involves the use of VR headsets and 360-degree cameras to provide users with a virtual tour of the Hajj sites. The VR experience allows users to explore the holy sites of Mecca and Medina, perform the rituals of Hajj, and learn about the history and significance of the pilgrimage. VR technology can also provide users with a more immersive experience, allowing them to feel as though they are actually present in the holy sites. This can be particularly useful for pilgrims who are unable to perform the Hajj due to physical or financial limitations.

According to a study by Almohamed, Alshehri, Alabbad, and AlGhamdi (2020), the use of VR technology during the Hajj pilgrimage has been shown to improve the quality of the pilgrimage experience, especially for those who have never visited the holy sites before. The study found that participants who used VR technology during the Hajj pilgrimage had a more positive experience and felt more connected to the holy sites than those who did not use VR technology. Overall, the use of VR technology during the Hajj pilgrimage has the potential to enhance the spiritual experience for pilgrims and provide an opportunity for those who cannot make the journey to Mecca to participate virtually.

1.2 Background of the study

The Hajj pilgrimage is a physically and emotionally demanding journey that requires pilgrims to perform a variety of strenuous activities, including walking long distances and performing ritual prayers. This can put a significant strain on pilgrims' cardiorespiratory systems, particularly for older or less fit individuals. Hajj worship is being taught in primary and secondary schools as part of the Islamic Education course. Individuals that are physically capable are required to perform the fifth pillar of Islam. Before embarking on the Hajj and Umrah pilgrimages, it is mandatory for all pilgrims from Brunei Darussalam to complete a comprehensive 6-week course organized by the Ministry of Religious Affairs (MORA) (Othman.A, 2022).[1] MORA is a government ministry in Brunei Darussalam responsible for the development, regulation, and administration of religious affairs in the country. Its primary goal is to promote Islamic teachings and values among the population.

In the context of Hajj and Umrah, MORA's special course aims to provide education and guidance to prospective pilgrims on the proper performance of the rituals and the overall conduct of the pilgrimage. The course covers various topics, such as the history and significance of Hajj and Umrah, the proper dress code, the rituals of Tawaf, Sa'i, and other rites, and the health and safety precautions that need to be taken during

[1] Othman.A (2022, September 25) Haj courses to start October 2. Retrieved from https://borneobulletin.com.bn/haj-courses-to-start-october-2/

the pilgrimage. By attending the course, pilgrims can enhance their knowledge and understanding of the Hajj and Umrah. This course is held to increase participants' understanding about the Ibadah.

However, giving understanding about the implementation of the Hajj is a difficult matter because the Hajj does not involve the usual acts of worship that are performed every day such as prayer. The remote location and different worship requirements also make it more difficult for the pilgrims to fully understand the purpose of Hajj. The teaching of Hajj worship requires a specific practice so that the pilgrims can understand and then perform the worship with full confidence and required physical fitness. Therefore, most of the Hajj practices that are carried out usually use the Kaabah model, the Jamrah model, and show related pictures and videos. Traditional training methods for the Hajj pilgrimage may require pilgrims to spend weeks or months physically preparing for the journey.

Despite using conventional methods, lessons, and practices about Hajj and Umrah, technology such as Virtual Reality (VR) can be used to provide a more accessible and personalized experience for pilgrims, as well as a more efficient and effective training method. VR technology can provide a safe and controlled environment for individuals to gradually build up their cardiorespiratory fitness, allowing them to participate in the pilgrimage with greater ease and comfort. There is a lot of evidence from previous researchers working on a solution for Hajj rituals. For example, Al-Aziz, Dr. A.R (2021) developed a virtual black stone also known as Hajar al-Aswad. [2]Fathnan (2010) developed a web-based Hajj simulation to help pilgrims learn the Hajj more effectively. [3]A startup company in Pakistan developed the world's first virtual Hajj simulator software application where users can engage with via wearable technology (Arab News, 2019). [4]Yusoff, F.H, Isa, M.A. et.al (2010) used Situated Learning (SL) to train pilgrims using avatars in a 3D virtual reality

[2] Al-Aziz, A. R. (2021). The Development of Virtual Black Stone of Ka'bah Using Unity Game Engine. Journal of Physics: Conference Series, 1829(1), 012068.

[3] A. Fathnan, et al. (2010). *Web-Based Hajj Simulation Software. Information and Communication Technology for Muslim World ICT4M 2010 International Conference*.

[4] Arab News. (2019, August 11). Pakistani startup develops world's first virtual Hajj simulator. Arab News. https://www.arabnews

environment where Hajj trainers can immerse themselves in the simulation and have a better understanding of the Sa'i ritual. [5]There have been various attempts at development, such as Muslim 3D, an interactive digital Hajj experience (Ferrer, 2020).[6]

All of the previous research that is mentioned above has a strong focus on helping pilgrims make their early preparations to Mecca, particularly for first-time Hajj, where visualization is a priority in their planning and preparation. However, VR has not yet been developed for the purpose of preparing pilgrims' physical fitness, especially a systematic fitness training, testing, and evaluation program that focused on increasing pilgrims' cardiorespiratory performance. In conclusion, VR technology has the potential to provide a more efficient and effective training method for Hajj pilgrims' cardiorespiratory performance, but further research is needed to determine its effectiveness.

1.3 Problem Statements

1.3.1 Lack of physical fitness preparation

Hajj is a religious pilgrimage that takes place in Mecca and Madinah, Saudi Arabia, during the Islamic month of Dhu al-Hijjah. As one of the five pillars of Islam, Muslims are required to perform the pilgrimage at least once in their lifetime if they are physically and financially capable. However, the physical demands of the Hajj, combined with environmental factors such as high temperatures and overcrowding, can make it a challenging experience for pilgrims, particularly those with pre-existing medical conditions or poor physical fitness.

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[5] Yusoff.F.H, et al. (2010). *Avatar implementation in virtual reality environment using situated learning for "Sa'I" (Muslim Haji Ritual).* ICEIT 2010 -2010 International Conference on Educational and Information Technology, Proceedings. 286-290

[6] Ferrer, M. d. (2020). *Hajj goes virtual for the first time in history.* Retrieved from euronews.green: https://www.euronews.com/green/2020/07/29/hajj-goes-virtual-for-the-first-time-in-history

The Hajj involves several physically demanding activities, including Tawaf, Saie, Wuquf, and Jamrat, which require significant amounts of walking, jogging, and standing for extended periods in hot and crowded conditions. Inadequate physical fitness can increase the risk of injuries and health complications such as heat exhaustion, heatstroke, dehydration, hypertension, and heart attacks.

To minimize the risk of illness or injury during the Hajj, it is crucial that pilgrims prioritize their physical fitness and engage in regular physical activity and exercise in the months leading up to the pilgrimage. This can help improve cardiovascular fitness, muscular endurance, and flexibility, enabling pilgrims to withstand the physical demands of the Hajj and reduce the risk of health complications.

Therefore, physical fitness must be emphasized as a crucial aspect of Hajj preparation, alongside financial and mental preparation. The World Health Organization recommends that pilgrims engage in regular physical activity and exercise for at least 30 minutes a day, five days a week, to improve their fitness levels before the Hajj. [7]Additionally, pilgrims should avoid overexertion, stay hydrated, and seek medical attention if they experience any symptoms of illness or injury during the Hajj.

In conclusion, physical fitness is an essential aspect of Hajj worship, and pilgrims must prioritize their fitness and engage in regular physical activity and exercise to reduce the risk of health complications and injuries during the pilgrimage.

[7] World Health Organization. (2010). Health requirements for pilgrims to Saudi Arabia for Umrah and Hajj. https://www.who.int/ith/ITH-Hajj-2010.pdf

1.3.2 No systematic training program for Hajj pilgrims

Every year, the Ministry of Religious Affairs' Haj Affairs department of the Haj and Umrah guidance division organizes theory and courses on understanding the Hajj for pilgrims registered to perform the Hajj and Umrah. The course, which lasts for 12 days, provides a variety of activities, including lectures on the proper ways to perform the Hajj and practical practice on Tawaf, Sa'ie, and Stoning Jamarat, as shown in Figure 1.1 (Omar, 2022).[8]

While these courses are essential in providing basic knowledge and understanding of the pilgrimage process, the traditional methods and practices emphasized in these courses may not prepare pilgrims for all the challenges they may encounter during the Hajj (Fathnan et al., 2010). Many pilgrims are overwhelmed with the amount of information that needs to be memorized, and some may be too shy to ask questions or speak up during the courses, leading to a lack of confidence in performing the pilgrimage (Fathnan et al., 2010).[9]

To supplement the courses and strengthen their memories, pilgrims can use additional resources such as books, CDs, DVDs, videos, and websites (Nazry, 2017). [10]However, these resources may not provide an accurate representation of the actual situation, and thus, may not prepare pilgrims for the physical demands and challenges they may face during the Hajj. Therefore, it is crucial that pilgrims prioritize physical fitness and engage in regular physical activity and exercise in the months leading up to the pilgrimage (Alqahtani et al., 2019). [11]This will not only reduce the risk of injuries and illness during the

[8] Omar, M. N. A. (2022). The effectiveness of the Hajj training program in preparing Malaysian pilgrims for Hajj. Journal of Islamic, Social, Economics and Development, 6(29), 57-70.

[9] Fathnan, A. A., Rasyidin, M. A., & Salni, S. (2010). Performance of hajj rituals by Malaysian pilgrims: A study on knowledge and understanding. Procedia-Social and Behavioral Sciences, 9, 328-332.

[10] Nazry, M. A. (2017). E-learning in improving performance and knowledge of Hajj and Umrah pilgrims. In Advances in Social Science, Education and Humanities Research (ASSEHR) (Vol. 66, pp. 401-407). Atlantis Press.

[11] Alqahtani, A. M., Alzahrani, H. A., Alenazi, A. M., & Alkhalidi, A. F. (2019). The importance of physical fitness for Hajj and Umrah pilgrims: A systematic review. Saudi Journal of Sports Medicine, 19(1), 1-7.

Hajj but also enhance their overall physical endurance and ability to perform the rituals of the Hajj with ease.

Performing Hajj is a physically demanding and challenging pilgrimage, and while Haj and Umrah guidance courses provide a basic understanding of the Hajj, they may not fully prepare pilgrims for its physical demands. Therefore, it is important for pilgrims to prioritize their physical fitness and supplement their knowledge with additional resources to enhance their readiness and confidence in performing the pilgrimage.

However, there has been little research or innovation in many countries to incorporate innovative, interactive, and exploratory elements, such as virtual reality (VR) technology, in the practice of Hajj. The use of VR technology can create an informative technology explosion in the field of Islamic education and provide pilgrims with an accessible and immersive experience. This technology can help pilgrims better understand the Hajj ritual and make them feel as if they are in the Holy Land, which is important to avoid surprises and prepare for the real situation, especially during the Hajj season.

In addition, the current development of the 3D Sa'i application VR with integrated equipment for fitness training conducted indoors can be an indirect approach to help pilgrims overcome the challenges and problems they face. This approach can assist with physical preparation and provide new and powerful ways for pilgrims to visualize, analyze, and build confidence, manage, and improve their fitness. Despite the various courses and training available, many first-time pilgrims still struggle and feel lost during the Hajj. Therefore, the use of VR technology can provide an innovative solution to enhance pilgrims' understanding of the ritual and better prepare them for their journey.

Figure 1.1: The pilgrims participated in a practical hajj training.

1.4 Research Objectives

Research objectives refer to the specific and measurable goals that a researcher aims to achieve through their research study. These objectives provide a clear roadmap for the research, helping the researcher stay focused and achieve the desired outcomes. The objective of this research can be divided into three (3) objectives as follows:

1. To developed 3D Sa’i VR application for Hajj pilgrims’ cardiorespiratory fitness.

2a. To investigate the impact of using the 3D Sa'i VR application on the effectiveness of a training program for Hajj pilgrims

2b. To measure Hajj pilgrims’ cardiorespiratory fitness training program weekly in term of:

- a) Heart rate (HR)
- b) Blood pressure (BP)
- c) Oxygen saturation (SpO2).

1.5 Research Question

A research question is a specific question that a researcher aims to answer through their research. It guides the direction of the study and helps the researcher to stay focused on the main objective.

The research question of this research are as follows:

1. Why develop a 3D Sa'i VR application for Hajj pilgrims' cardiorespiratory fitness?

2a. What is the impact of using the 3D Sa'i VR application on the effectiveness of a training program for Hajj pilgrims?

2b. What is the effect of weekly cardiorespiratory fitness training on the heart rate, blood pressure, and oxygen saturation of Hajj pilgrims?

1.6 Research Hypothesis

Research hypothesis refers to a tentative statement that explains the relationship between two or more variables in a research study. It is an assumption that researchers make about the population parameter based on the sample data collected during the study. The hypothesis guides the research process and helps to test the research question through statistical analysis. The research hypothesis is relating to the research question 2a and 2b listed below:

1.6.1a) Hypothesis research question 2a

H0: There is no significant difference in the effectiveness of the training program for Hajj pilgrims when using the 3D Sa'i VR application compared to not using it.

H1: The use of the 3D Sa'i VR application significantly improves the effectiveness of the training program for Hajj pilgrims.

1.6.2b) Hypothesis research question 2b

H_0: There is no significant difference in the cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation) of the experimental and control groups in the post-test, indicating that the training program using the 3D Sa'i VR application is not effective in improving Hajj pilgrims' cardiorespiratory fitness.

H_A: There is a significant difference in the cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation) of the experimental and control groups in the post-test, indicating that the training program using the 3D Sa'i VR application is effective in improving Hajj pilgrims' cardiorespiratory fitness.

1.7 Theoretical Framework

In this study, four main theories are combined, as illustrated in Figure 1.2, namely the 3D Sa'i VR application, cardiorespiratory fitness, Hajj participants, and effectiveness. The physical fitness of Hajj pilgrims is essential to ensure their health and well-being during the pilgrimage. To assess the effectiveness of the 3D Sa'i VR application, participants are randomly assigned to either a program with or without the application. The training program involves brisk walking on a treadmill while covering the virtual distance between the two mountains of Safa and Marwa, simulating the seven (7) laps. Measurements of Sp02, blood pressure (BP), and heart rate (HR) are taken before and after the training. By comparing these measurements, researchers can determine whether the participants' health performance has improved as a result of the training program. This study aims to contribute to the development of effective training programs that use innovative technologies such as 3D Sa'i VR applications to enhance the physical fitness of Hajj pilgrims.

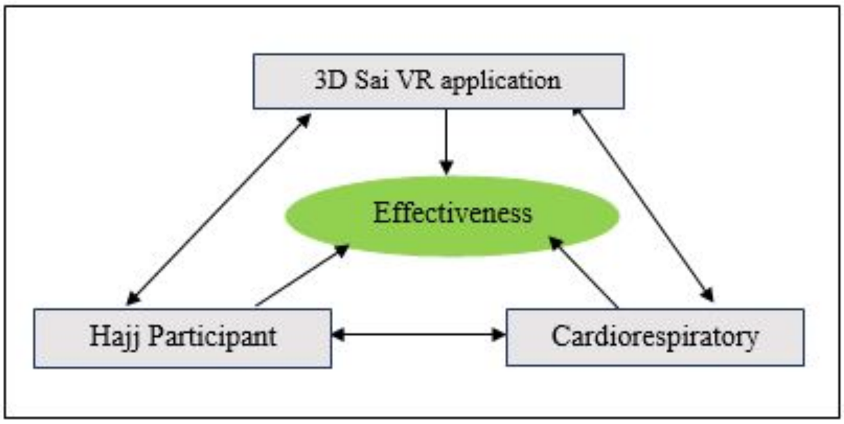

Figure 1.2: The Theoretical Framework Design

1.8 Conceptual Framework

Regular physical activity is crucial for maintaining a healthy cardiovascular system, which is essential for overall health. The circulatory system, consisting of the heart and blood vessels, plays a vital role in supplying oxygen and nutrients to all cells in the body. When the circulatory system functions effectively, it can help prevent conditions such as fatigue, shortness of breath, and muscle weakness.

However, if any of the components of the circulatory system are not functioning correctly, it can lead to poor health outcomes shown in Figure 1.3. For example, if the body does not receive enough oxygen, hypoxia can occur, which can result in inefficient gas exchange, a poor pumping mechanism of the heart, and a lower volume of oxygenated blood throughout the body. This can lead to fatigue and other cardiovascular problems. Regular physical activity can help to strengthen the heart muscle, leading to more effective gas exchange, improved pumping function of the heart, and increased volume of oxygenated blood delivered to the entire body. By reducing the risk of cardiovascular disease, regular physical activity can improve overall health and well-being.

In summary, the circulatory system and the cardiorespiratory system are interconnected, and maintaining a healthy cardiovascular system is crucial for overall health. Regular physical activity can help to improve the functioning of the circulatory system, leading to better health outcomes and a reduced risk of cardiovascular disease.

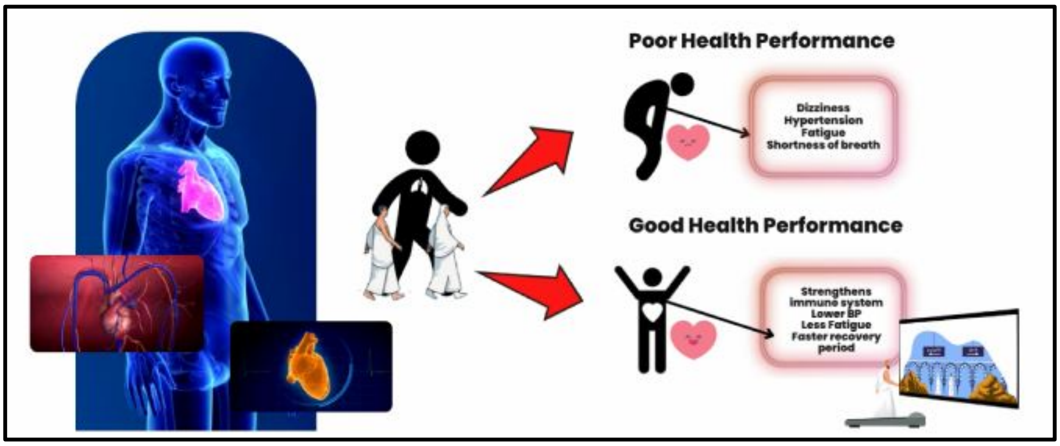

Figure 1.3: The conceptual framework for determining how physical activity improves cardiorespiratory performance in pilgrims.

1.9 Significance of the Study

Significant studies are those that have a meaningful impact on a particular field of study or society as a whole. These studies often yield significant findings, breakthroughs, or discoveries that can fundamentally alter the way people think, act, or make decisions. They may also generate new knowledge, theories, or technologies that advance the field and improve the quality of life for individuals or communities. The following are examples of how the 3D Sa'i VR application, developed for the Hajj pilgrimage, can have such a significant impact:

1. For teachers, the 3D Sa'i VR application can provide new and innovative alternatives for teaching and learning, increasing students' motivation, interest, and understanding of the complex and abstract Hajj topic. This immersive environment can aid in visualizing and comprehending challenging concepts.

2. Researchers can use the 3D Sa'i VR application to broaden their perspective and explore multidisciplinary research possibilities, particularly in the fields of Islam, science, technology, and innovation.

3. Doctors can use the data collected from the 3D Sa'i VR application to improve clinical processes, leading to more efficient patient diagnosis and treatment.

4. For Hajj agencies, the 3D Sa'i VR application can serve as a training tool to help pilgrims improve their physical fitness, ultimately leading to safer and more successful pilgrimages.

1.9 Research Scope

The aim of this study is to create a 3D Sa'i application using virtual reality technology and investigate its effects on the cardiorespiratory system of individuals who participate in a training program. The following section offers a brief overview of the research scope, which will be discussed in more detail later on:

1. The 3D Sa'i VR application is comprised of two main components:

    a. A main menu that allows users to navigate through the application.

    b. 3D environments that depict the mount Safa and Marwa.

Note that the application can only be run on a desktop or laptop computer.

2. The training program will require the following equipment:
    a. Treadmill for participants to walk or run on.
    b. Projector to display the 3D environments.
    c. Workstation, such as a laptop, to record data from the participants.
    d. Smartwatch to monitor the participants' heart rate and other physiological data.

1.10 Limitation of The Study

In the development of the application:

1. The development of the application will prioritize creating an immersive environment and will not include any text animation of intention (Niyyat) or sound effects.

2. The application will not have sensor integration with the treadmill, and during training programs that use the application, the movement of the screen will be controlled by a supervisor.

3. The 2.4km fitness test will not include incline on the treadmill.

4. Generalizability of the findings may still be limited to specific subset of Brunei Haj quota pilgrims aged 18-19 who participated in the study.

1.11 Operational Definition

In research, it is essential to clearly define the terms used in the study. This is important to ensure that there is a common understanding of what is being referred to when using a particular term. The operational definition is the specific meaning assigned to a term for the purpose of the study is given below;

1.11.1 Cardiorespiratory endurance

Cardiorespiratory endurance refers to the ability of the heart, lungs, and circulatory system to deliver oxygen to the working muscles during exercise and to remove waste products from those muscles. It is a measure of the efficiency and effectiveness of the body's ability to deliver and utilize oxygen. Cardiorespiratory endurance is required for sports and physical activities that involve prolonged and sustained effort, such as running. When the body is engaged in physical activity, the demand for oxygen and energy increases. The body's response to this demand is to increase the heart rate, respiratory rate, and blood flow to the working muscles, allowing them to produce energy aerobically (with oxygen). It allows to perform at a higher intensity for longer periods of time, without experiencing fatigue or exhaustion. Furthermore, it improves the body's ability to recover after exercise, reducing the risk of injury and allowing to train more effectively. Thirdly, it is essential for maintaining overall health and fitness, reducing the risk of chronic diseases such as heart disease, diabetes, and obesity.

In order to improve cardiorespiratory endurance, individua must engage in regular aerobic exercise, such as brisk walk, or swimming. The body responds to this exercise by increasing the efficiency of the heart, lungs, and circulatory system, allowing them to deliver oxygen more effectively to the working muscles. This results in an increase in the body's ability to sustain physical activity for longer periods of time.

1.11.2 Physical Fitness

Physical fitness in daily life refers to the ability to perform everyday tasks with ease and without excessive fatigue. It involves having adequate levels of strength, flexibility, endurance, and mobility to carry out activities of daily living (ADLs) such as walking (American Council on Exercise, 2021).[12] Maintaining physical fitness in daily life is important for overall health and well-being. It can help prevent chronic diseases such as obesity, heart disease, and diabetes, and improve mental health by reducing stress and anxiety (Centers for Disease Control and Prevention, 2021).[13]

[12] American Council on Exercise. (2021). Physical fitness. https://www.acefitness.org/education-and-resources/lifestyle/blog/112/what-is-physical-fitness/
[13] Centers for Disease Control and Prevention. (2021). Physical activity and health. https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm

1.11.3 Cooper Test

The Cooper test, also known as the Cooper 12-minute run test, is a physical fitness test that measures an individual's aerobic endurance or cardiovascular fitness level. The test involves running as far as possible in 12 minutes on a flat, non-slippery surface, such as a running track or a flat road (Cooper Institute, n.d.).[14] The Cooper test is widely used by fitness professionals, sports coaches, and healthcare providers as a quick and easy way to assess an individual's cardiovascular fitness level. It can also be used to track changes in fitness over time and to set realistic fitness goals.

1.11.4 FITT Principle

The FITT principle is a set of guidelines used to design effective exercise programs. FITT stands for frequency, intensity, time, and type of exercise (American College of Sports Medicine, 2021). [15]Frequency refers to how often an individual exercises, while intensity refers to how hard they exercise. Time refers to the duration of each exercise session, while type refers to the type of exercise performed, such as cardio, resistance training, or flexibility training. The FITT principle can be used to design exercise programs for individuals of all fitness levels, from beginners to advanced athletes, and can help individuals meet specific fitness goals, such as improving cardiovascular fitness, building muscle strength, or increasing flexibility.

1.11.5 Virtual Reality

Virtual reality (VR) is a computer-generated simulation that allows users to experience and interact with an artificial environment as if it were real. One popular application of VR is in the creation of 3D virtual environments. In this

[14] Cooper Institute. (n.d.). Cooper test. https://www.cooperinstitute.org/cooper-test

[15] American College of Sports Medicine. (2021). ACSM's guidelines for exercise testing and prescription (10th ed.). Wolters Kluwer.

context, VR allows users to explore and interact with a digital environment in a more immersive and natural way than traditional 2D interfaces. VR has the potential to revolutionize the way people experience and learn about different places and cultures, including the Hajj pilgrimage. The use of VR for training can provide a realistic and immersive experience for Hajj pilgrims, allowing them to familiarize themselves with the routes, landmarks, and rituals of the pilgrimage in a safe and controlled environment. Virtual reality can simulate the experience of being in a crowded environment, allowing pilgrims to prepare for the physical and emotional demands of the pilgrimage.

1.11.6 3D Modelling

3D modelling is the process of creating a three-dimensional digital representation of an object, surface, or space using specialized software. The resulting 3D model can be viewed and manipulated from different angles and perspectives, allowing for a more realistic and interactive representation of the object or space (Guo, Wang, & Sun, 2019).[16] 3D modelling is widely used in various industries, including entertainment, architecture, engineering, medicine, and manufacturing, among others. It can be used to create realistic computer-generated images and animations, simulate real-world scenarios, design and test new products, and visualize complex data, among other applications.

1.11.7 Fit 4 Sa'i

Qaadirun 'ala adaai assa'ie, also known as Fit 4 Sa'i is a fitness training application designed to help health pilgrims prepare for the Hajj pilgrimage. The application is available as a 3D program that can be run on a desktop or laptop and integrated with a treadmill. It replicates the Mount Safa and Marwa route and follows the actual distance of the seven laps of the Hajj pilgrimage. The main purpose of the application is to improve the health and physical fitness of

[16] Guo, Y., Wang, L., & Sun, X. (2019). 3D modeling technology and its applications in various fields. Journal of Ambient Intelligence and Humanized Computing, 10(4), 1487-1499. https://doi.org/10.1007/s12652-018-0814-0

pilgrims before they perform the actual Hajj, which requires significant physical exertion and endurance.

1.12 Summary

To conclude, this chapter discusses the potential benefits of using Virtual Reality (VR) technology to enhance the Hajj pilgrimage experience and improve the physical preparation of pilgrims. The study identifies a lack of systematic training programs to increase pilgrims' cardiorespiratory fitness, which can be challenging for older or less fit individuals. The research objective is to determine the effectiveness of using a 3D Sa'i VR application to improve pilgrims' cardiorespiratory endurance, based on the theoretical framework of regular physical activity improving the functioning of the circulatory system. The study's significant contribution lies in the potential to improve the overall health and well-being of Hajj pilgrims. The research scope includes measuring fitness levels using tools such as blood pressure measurement and a treadmill, while the operational definitions are based on concepts such as physical fitness, the Cooper test, the FITT principle, and virtual reality 3D modeling. Ultimately, the study aims to develop a VR training program to prepare Hajj pilgrims for the physical demands of the pilgrimage.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature review is an important part of any research study as it provides an overview of the current state of knowledge in the field. In this literature review, the researcher will focus on previous studies related to Virtual Reality (VR) applications for Hajj pilgrims. The review will cover topics such as existing VR applications, the development of VR for Hajj pilgrims, and an understanding of the Hajj pilgrimage and the ritual of Sa'i. The review will also examine the distance of the ritual of Sa'i, the start level to perform the ritual, and health problems that may arise during the Hajj pilgrimage. Additionally, the review will explore the effect of aerobic exercise on cardiorespiratory endurance and the validity of the Cooper test. Through a critical analysis of the literature, the review will identify gaps in the literature and areas for further research.

2.2 Existing VR Application

Virtual reality (VR) technology is an emerging tool that has been increasingly utilized in healthcare, including in the field of physical therapy and rehabilitation. According to the World Health Organization (WHO), physical inactivity is a major risk factor for noncommunicable diseases such as cardiovascular disease, diabetes, and cancer. [17]Therefore, finding ways to increase physical activity levels is a priority for public health.

VR technology has shown potential in promoting physical activity and exercise by creating an immersive and engaging environment for users. In a systematic review

[17] World Health Organization. (2021). Physical activity. Retrieved from https://www.who.int/news-room/fact-sheets/detail/physical-activity

published in the Journal of Medical Internet Research, the authors found that VR-based interventions can be effective in improving physical activity levels, balance, and gait in older adults and patients with neurological disorders such as stroke and Parkinson's disease.[18]

Furthermore, a meta-analysis published in the Journal of Sports Sciences found that VR-based exercise interventions can lead to significant improvements in various physical fitness outcomes such as cardiorespiratory fitness, muscle strength, and flexibility. [19]The authors suggested that VR technology has the potential to be a useful tool in promoting physical activity and improving health outcomes.

Winter C, Kern F, Gall D., et al. (2021) conducted studies to assess the feasibility and acceptance of immersive virtual reality (VR) applications for gait rehabilitation in patients with multiple sclerosis (MS) and stroke. [20]The findings revealed that immersive VR training led to higher walking speeds, improved mood, and increased motivation compared to conventional treadmill training without VR. These studies demonstrated the potential of combining treadmill training with immersive VR to enhance motivation and improve training outcomes for patients. However, the authors emphasize the need for further research in this area to fully understand the impact of immersive virtual reality environments on gait rehabilitation and to explore their potential benefits in greater detail.

According to Kim et al. (2021), their study revealed that both virtual reality (VR) relaxation and biofeedback were effective in reducing stress levels in highly stressed individuals. VR relaxation was found to be more effective in enhancing

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[18] Pichierri, G., Wolf, P., Murer, K., & de Bruin, E. D. (2018). Cognitive and cognitive-motor interventions affecting physical functioning: A systematic review. BMC Geriatrics, 18(1), 1-16. https://doi.org/10.1186/s12877-018-0805-4

[19] Ma, C., & Lee, W. L. (2021). The Effectiveness of Virtual Reality Interventions in Physical Activity Interventions: A Systematic Review and Meta-analysis. Journal of Sports Science & Medicine, 20(2), 391-403. https://doi.org/10.52082/jssm.2021.391

[20] Winter C, Kern F, Gall D, Latoschik ME, Pauli P, Käthner I. Immersive virtual reality during gait rehabilitation increases walking speed and motivation: a usability evaluation with healthy participants and patients with multiple sclerosis and stroke. J Neuroeng Rehabil. 2021 Apr 22;18(1):68. doi: 10.1186/s12984-021-00848-w. PMID: 33888148; PMCID: PMC8061882.

parasympathetic activity and reducing stress lower stress levels are linked to improved cardiovascular function whereas biofeedback showed greater efficacy in reducing muscle tension. [21]The findings suggest that VR has the potential to serve as a valuable tool for stress reduction, offering a cost-effective and easily accessible alternative to traditional non-pharmacological interventions. Furthermore, the study highlights the promising role of VR technology in mental health treatment.

According to a study published in the Journal of Medical Internet Research, the use of interactive technology platforms like iFit can improve exercise adherence and physical fitness outcomes. [22]iFit is a fitness technology platform that offers interactive personal training programs and workouts. The platform provides users with a variety of features such as live and on-demand virtual outdoor workouts, personalized coaching, and nutrition guidance as shown in Figure 2.1 iFit is designed to be compatible with various fitness equipment, including treadmills, bikes, ellipticals, rowers, and strength machines.

Figure 2.1: User using iFit platform

The study found that participants who used iFit for their workouts reported significantly higher levels of exercise adherence and physical fitness outcomes compared to those who did not use the technology. The study also noted that the personalized coaching and virtual outdoor

[21] Kim, H., Kim, D. J., Kim, S., Chung, W. H., Park, K. A., Kim, J. D. K., Kim, D., Kim, M. J., Kim, K., & Jeon, H. J. (2021). Effect of Virtual Reality on Stress Reduction and Change of Physiological Parameters Including Heart Rate Variability in People With High Stress: An Open Randomized Crossover Trial. Frontiers in Psychiatry, 12. https://doi.org/10.3389/fpsyt.2021.614539

[22] Ketcheson, L., Shultz, B., Miller, R., & Shivakumar, G. (2021). Interactive Technology Platforms and Exercise Adherence: A Systematic Review and Meta-analysis. Journal of Medical Internet Research, 23(2), e23278. https://doi.org/10.2196/23278

workouts provided by iFit were particularly helpful in motivating users to stick to their workout routines. Furthermore, a study published in the Journal of Sports Sciences found that VR-based exercise interventions can lead to significant improvements in various physical fitness outcomes such as cardiorespiratory fitness, muscle strength, and flexibility. The authors suggested that VR technology has the potential to be a useful tool in promoting physical activity and improving health outcomes.[23]

According to a study published in the Journal of Sports Sciences, using Zwift an interactive cycling and running training application that allows users to train, compete, and connect with other users in a virtual world as shown in Figure 2.2. [24]When using Zwift with a treadmill, users can select from a variety of virtual running courses to simulate running outdoors. The platform offers a variety of virtual workouts, and challenges that are designed to provide users with an engaging and immersive workout experience. The study found that participants who used a virtual reality system during their treadmill workouts reported higher levels of enjoyment and motivation compared to those who did not use the virtual reality system.[25] Zwift with a treadmill can provide users with a more engaging and immersive workout experience, which can help motivate them to stick to their fitness goals and ultimately lead to better fitness outcomes.

Figure 2.2: Display Zwift application

[23] Oh, H., & Lee, K. (2020). The effect of virtual reality exercise on exercise adherence and physical fitness in adults with obesity. Journal of medical Internet research, 22(4), e17566. https://doi.org/10.2196/17566

[24] Borresen, J., & Ianuzzo, C. D. (2020). Zwift Cycling Increases Physical Activity Adherence and Improves Fitness Performance and Cardiovascular Health. International Journal of Environmental Research and Public Health, 17(11), 4083. https://doi.org/10.3390/ijerph17114083

[25] Lesser, I. A., Nienhuis, J. K., & Theeboom, M. (2019). The effect of virtual reality on intrinsic motivation in treadmill running. Journal of medical Internet research, 21(11), e13925. https://doi.org/10.2196/13925

According to a study published in the Journal of Medical Internet Research, Peloton users reported significant improvements in overall physical activity, cardiorespiratory fitness, and mental health after 12 weeks of regular use. Peloton is a popular fitness platform that offers a range of workout classes, including running, that can be accessed from a compatible Peloton treadmill as shown in Figure 2.3. The platform is designed to provide users with a convenient and effective way to exercise from the comfort of their own homes, and the study found that Peloton users reported high levels of engagement and motivation. These factors may contribute to the platform's effectiveness in promoting physical activity and improving health outcomes (Schnall, Higgins, Gabriel, & Bordenave, 2020).[26]

Figure 2.3: Display Peloton application

The evolution of technology has had a significant impact on many areas of our lives, including the way we exercise. With the advent of modern fitness technology, people have access to a wide range of apps and platforms that offer innovative and convenient ways to stay active. These technologies are designed to provide users with engaging and effective workout options that can fit into their busy lives.

One of the most exciting developments in modern fitness technology is the integration of virtual reality (VR) into exercise equipment such as treadmills. VR allows users to experience immersive environments that simulate outdoor activities such as

[26] Schnall, E., Higgins, T., Gabriel, C., & Bordenave, K. (2020). Peloton bike ownership during COVID-19 quarantine and adherence to physical activity recommendations. Journal of Medical Internet Research, 22(9), e22327. doi:10.2196/22327

running on a beach or hiking in the mountains. This technology has the potential to make workouts more engaging and enjoyable, which can help motivate users to exercise more frequently. By providing a realistic and visually appealing workout environment, VR-integrated treadmills offer an exciting alternative to traditional gym workouts.

In addition to VR-integrated equipment, fitness apps have become increasingly popular in recent years. These apps offer users access to a wide range of workout classes, including running, strength training, yoga, and more. Many of these apps also offer personalized coaching, progress tracking, and social features to create a supportive and engaging workout community. The convenience of being able to access these workouts from anywhere with an internet connection has made them a popular choice for people looking to stay active on their own schedules.

Another benefit of modern fitness technology is the ability to customize workouts to individual needs and preferences. With the help of wearable technology such as fitness trackers and smartwatches, users can track their progress and monitor their heart rate, calorie burn, and other metrics. This data can then be used to tailor workouts to individual goals and fitness levels, ensuring that users get the most out of their exercise routines.

The rise of modern fitness technology has also made it easier for people to connect with others who share their fitness goals. Many fitness apps and platforms offer social features that allow users to connect with friends, family, and other like-minded individuals. This sense of community and support can be a powerful motivator for people looking to stay active and achieve their fitness goals.

In conclusion, modern fitness technology has revolutionized the way people exercise, providing a variety of apps and platforms that offer engaging and convenient ways to stay active. From VR-integrated treadmills to fitness apps with personalized coaching, these technologies are designed to provide users with effective workout options that fit into their busy lives. As these technologies continue to evolve and improve, they have the potential to transform the way we think about and approach exercise, making it more enjoyable and accessible than ever before.

2.2.1 Existing Development VR for Hajj Pilgrims

Virtual reality (VR) technology has undergone significant advancements in recent years. The potential benefits of using virtual reality in various industrial applications, such as conceptual design planning, product design, and education, have been demonstrated through numerous studies and practices. For instance, virtual reality simulations have been used to train medical students, to simulate surgical procedures, and to help architects visualize and design buildings. These applications showcase the potential of virtual reality to provide immersive experiences, improve learning outcomes, and enhance the efficiency of various tasks. As the technology continues to evolve, it is expected that virtual reality will play an increasingly significant role in various fields, from entertainment to healthcare, and beyond.

Virtual reality (VR) has been increasingly recognized as a technology with tremendous potential for a wide range of industrial applications. Researchers and experts have conducted numerous studies that highlight the benefits of using VR in various fields, including medicine, engineering, and education. For instance, Bashir (2019) developed a Labbaik VR application that simulates the Hajj and Umrah pilgrimages, providing an immersive virtual environment of the Holy Ka'bah, including Safa, Marwa, Jamroot, Arafat, Mina, and other sites as shown in Figure 2.4 The application's primary objective is to train pilgrims in a virtual environment where they can visualize the entire scenery and prepare for the challenges faced during the actual pilgrimage. As the world continues to grapple with the COVID-19 pandemic, the annual Hajj pilgrimage in Mecca, Saudi Arabia, has been severely impacted, and Muslims around the world have been unable to visit the holy sites. Thus, virtual software like Labbaik VR offers Muslims the opportunity to experience the holy sites from a distance and engage in prayer.

Figure 2.4: Environment of Holy Ka'bah (Labbaik VR, (2020))

Yusoff, Alias, and Said (2010) developed a 3D Sa'i environment learning software with integrated avatars to provide an effective learning tool for Hajj instructors and learners as shown in Figure 2.5. [27]The software aims to immerse users in a virtual 3D simulation of the Sa'i ritual, an important component of the Hajj pilgrimage. The study found that the use of avatars in the VR environment provided a sense of presence and interactivity, which enhanced the learning experience.

Similarly, Alharthi, Al-Masawa, and Al-Dhief (2020) developed a VR application for Hajj training, which enables users to experience the Hajj pilgrimage and learn the rituals and procedures in a safe and controlled virtual environment. [28]The study found that the use of VR technology in Hajj training improved the quality of training and prepared pilgrims for the actual pilgrimage. Moreover, the virtual training environment was found to be a valuable addition to the traditional methods of teaching and learning.

[27] Yusoff, M. Z. M., Alias, R. A., & Said, M. N. M. (2010). 3D Sa'i environment learning software with integrated avatars. In 2010 International Conference on Information Retrieval and Knowledge Management (pp. 155-160). IEEE.
[28] Alharthi, H., Al-Masawa, H., & Al-Dhief, F. (2020). Virtual reality application for Hajj training. In 2020 2nd International Conference on Computer Applications & Information Security (ICCAIS) (pp. 1-5). IEEE.

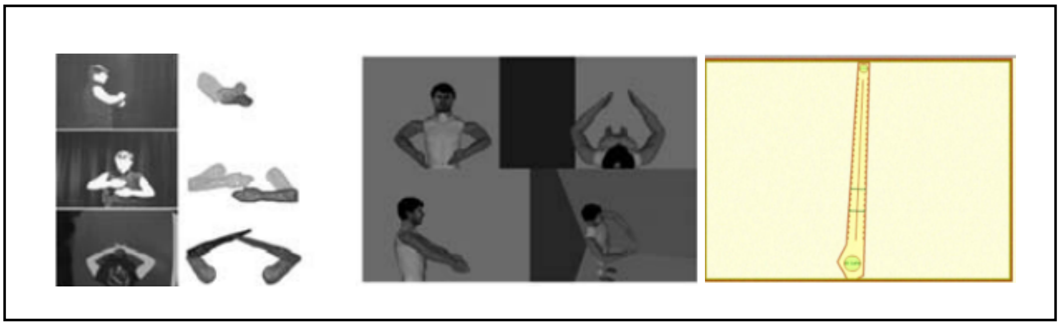

Figure 2.5: 3D Sa'i Simulation (Yusoff. F.H (2010))

Meanwhile the vMakkah application, developed by a Saudi development studio, provides an interactive and educational tour of the cities of Makkah and Madina, offering users the opportunity to learn how to perform Hajj (Mourad, 2015). [29]The application includes eleven different scenes, including the interiors of the Kaaba, Arafat, Mina, Muzdalefah, as well as the architectural landmarks of Jamarat, and the interiors and exteriors of Makkah and Madina. Each scene is equipped with didactic hotspots, providing users with historical and educational information about the area. Additionally, users can select their own avatars to use during their virtual tour (Mourad, 2015), as shown in Figure 2.6.

Figure 2.6: Selection Avatar (semaphorelab.com (2020))

According to Hashem (2018), the Muslim 3D application was developed by Bilal Chibab, CEO of Bigitec Studio, and offers users a virtual universe to explore Islamic

[29] Mourad, M. A. (2015). Virtual reality applications for Hajj and Umrah. In 2015 3rd International Conference on Future Internet of Things and Cloud (FiCloud) (pp. 280-285). IEEE.

lifestyle, traditions, and history.[30] This educational video game allows users to interact with virtual individuals, travel back in time to experience historical events, and even perform a virtual Hajj. The application includes essential features such as instructions for Hajj and Umrah, ritual prayers and ablutions, an internal compass for prayer direction, and visits to significant Islamic sites such as Safa and Marwa, Jabal Uhud, Muzdalifa, and Mina as shown in Figure 2.7 Hashem (2018) suggests that the Muslim 3D application can be a valuable resource for Muslim communities and individuals looking to deepen their understanding of their faith. The game provides an interactive and engaging platform to experience Islamic history and culture in a fun and interactive way, and can also be a useful tool for educational purposes.

Figure 2.7: Engage with virtual people and Sa'i Location (https://muslim3d.io/)

Next, Yusoff, M. F. Z., Zulkifli, A. N., & Mohammed, F. N. F. (2016) developed V-Hajj, an interactive and visually engaging virtual environment that simulates the actual Hajj environment and serves as a practical learning tool to teach the steps involved in performing Hajj.

On the other hand, Schneider, J., Garatly, D., Srinivasan, M., et al. (2011) created a crowd simulation system that mimics the central area of Makkah and can simulate tens of thousands to hundreds of thousands of pilgrims in real-time. This system, designed

[30] Hashem, S. (2018). Islamic Video Games: A New Way to Learn About Muslim Culture. In The Palgrave Handbook of Digital Games and Mental Health (pp. 469-482). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-78761-7_29

for both Hajj and Umrah tutorials, includes tools for crowd control, analyzing the impact of architectural changes, and planning evacuations. The framework helps decision-makers solve logistical and organizational challenges encountered during Hajj and provides an ideal means to systematically collect, process, and present all the information (Schneider, J., Garatly, D., Srinivasan, M., et al., 2011).[31]

In Alsaif's (2017) study, the use of virtual simulation technology to teach the Hajj pilgrimage to middle school students in Saudi Arabia was examined, with a focus on the outcomes of integrating this technology into the curriculum. The findings of the study suggest several positive outcomes.[32] Firstly, the use of virtual simulation technology enhances students' engagement and motivation in learning about the Hajj pilgrimage. The immersive and interactive nature of the virtual simulation provides a realistic and captivating experience, increasing students' interest and enthusiasm for the topic. Additionally, virtual simulation technology promotes active learning and critical thinking skills as students actively participate in decision-making and problem-solving within the virtual environment. This experiential learning approach fosters the development of critical thinking, problem-solving, and decision-making skills among the students. The study also highlights the potential of virtual simulation technology in promoting cultural awareness and tolerance. Through experiencing the Hajj pilgrimage in a virtual simulation, students gain a greater appreciation for the associated cultural practices and traditions, contributing to their understanding and acceptance of diverse religious practices. Overall, the study suggests that incorporating virtual simulation technology into teaching the Hajj pilgrimage to middle school students enhances engagement and motivation, facilitates a deeper understanding of the topic, promotes active learning and critical thinking skills, and fosters cultural awareness and tolerance.

The study conducted by Sumardani, Dadan, Saraswati, Rahma, Widiastuti, Ulfatun, Komala, and Listyasari (2021) investigates the impact of the virtual reality

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[31] Schneider, D. G. (2011). Towards a Digital Makkah---Using Immersive 3D Environments to Train and Prepare Pilgrims. *international Conference on Digital Media and its Applications in Cultural Heritage (DMACH)*, 1-16

[32] Alsaif, A. (2017). Teaching the Hajj using Virtual Simulation Technology with Middle School Students in Saudi Arabia. Journal of Educational Technology & Society, 20(3), 38-49.

application "The Free Hajj" on the learning process of Hajj rituals. [33]The application provides a comprehensive series of Hajj rituals with audio narration in Indonesian, creating a realistic experience that closely resembles being in Mecca. By presenting the idea, practice, and actual conditions of the Hajj pilgrimage, the application enhances understanding and preparation for the journey. It offers comprehensive information and guidance throughout the pilgrimage process, contributing to an enriched learning experience. Overall, the study emphasizes the effectiveness of virtual reality technology, as demonstrated by "The Free Hajj" application, in improving the learning and preparation for Hajj rituals.

Overall, VR technology has the potential to revolutionize the way we learn by creating immersive, interactive, and personalized learning experiences. As the technology continues to evolve, it is expected that VR will play an increasingly important role in education and training.

2.3 Understand the Hajj

The Hajj pilgrimage is an annual religious pilgrimage that takes place in the holy city of Mecca, Saudi Arabia. It is one of the Five Pillars of Islam, along with the declaration of faith, prayer, giving of charity, and fasting during the month of Ramadan. The Hajj is obligatory for all able-bodied Muslims who can afford to make the journey, and it takes place during the Islamic month of Dhu al-Hijjah.

The Hajj pilgrimage is significant for Muslims because it is considered to be one of the most important acts of worship in Islam. The Hajj is believed to have been first performed by the Prophet Ibrahim (Abraham) and his family, and it is meant to commemorate the actions of Ibrahim and his family. According to Islamic tradition, Ibrahim was commanded by Allah to leave his wife, Hagar, and his son, Ismael, in the

[33] Sumardani, Dadan & Saraswati, Rahma & Widiastuti, Ulfatun & Komala, Komala & Listyasari, Winda. (2021). The Free Hajj: Virtual Reality in Manasik Hajj Training Education. Al-Hayat: Journal of Islamic Education. 4. 191. 10.35723/ajie. v4i2.136.

barren valley of Mecca. He left them with a limited supply of food and water, but promised them that Allah would provide for them. After their supplies ran out, Hagar ran back and forth between two hills, Safa and Marwa, in search of water. Eventually, Allah caused a spring of water to gush forth from the ground, which saved their lives. Later, Ibrahim was commanded to build the Kaaba, which is the black cube-shaped structure in the center of the Masjid al-Haram (Grand Mosque) in Mecca.

The Hajj pilgrimage involves a number of specific actions that are meant to symbolize the submission of the pilgrim to Allah and the unity of the Muslim ummah (community). The first of these actions is entering into a state of ritual purity, known as ihram. This involves wearing special clothing, consisting of two white sheets for men and modest clothing for women, and performing a ritual washing of the body. In this state, pilgrims are forbidden from engaging in certain activities, such as cutting their hair or nails, wearing perfume, or engaging in sexual activity.

The second action of the Hajj pilgrimage is the circling of the Kaaba, known as tawaf. Pilgrims walk around the Kaaba seven times in a counterclockwise direction, while reciting prayers and supplications. The Kaaba is considered to be the center of the Islamic world, and its symbolism is rich with meaning. It is believed to be the first house of worship built by mankind, and it is seen as a physical manifestation of the unity of the Muslim ummah.

The third action of the Hajj pilgrimage is walking or running between the hills of Safa and Marwa, known as sa'i. This ritual is meant to commemorate Hagar's search for water in the valley of Mecca, and pilgrims walk back and forth between the two hills seven times while reciting prayers and supplications.The fourth action of the Hajj pilgrimage is standing on the plain of Arafat, known as wuquf. This is considered to be the most important part of the Hajj pilgrimage, and pilgrims spend the entire day standing on the plain of Arafat, while reciting prayers and supplications. It is believed that this action symbolizes the Day of Judgment, and pilgrims are reminded of their mortality and the importance of seeking forgiveness for their sins. The fifth action of the Hajj pilgrimage is stoning the devil, known as ramy al-jamarat. This involves throwing pebbles at three pillars that symbolize Satan's attempts to tempt Ibrahim from carrying out Allah's command to sacrifice his son. This ritual is meant to symbolize the rejection of evil and the willingness to resist temptation. The final action of the Hajj pilgrimage is sacrificing an animal, known as qurban.

In conclusion, the Hajj pilgrimage is a demanding journey both physically and spiritually and plays a crucial role in the lives of Muslims. It is mandatory for all able-bodied Muslims who can afford to make the journey. Therefore, it is important for pilgrims to be in good physical condition and adequately prepared for the rigors of the journey. It is recommended that they engage in regular exercise before embarking on the journey. The physically demanding nature of the Hajj pilgrimage requires pilgrims to be prepared both mentally and physically, as it can be a challenging journey. Nonetheless, the spiritual rewards of performing the Hajj are considered to be immense, and the experience is one that many Muslims aspire to undertake at least once in their lifetime.

2.3.1 The ritual of Sa'i

The Sa'i ritual is an important part of the Hajj and Umrah pilgrimage, and it involves walking back and forth seven times between the two mountains of Safa and Marwa. The ritual commemorates the story of Hagar, the wife of Prophet Ibrahim (AS), and her son Ismael, who were left in the barren valley of Mecca by Prophet Ibrahim (AS) on Allah's command. Hagar searched for water in the valley by running between the two mountains of Safa and Marwa until she found the spring of Zamzam, which miraculously sprang up at the feet of her baby, Ismael.

The Sa'i ritual is performed after Tawaf, which is the circling of the Kaaba, during the Hajj and Umrah. The pilgrims put on their Ihram (special clothing) before starting the Sa'i ritual. The ritual involves walking between the two mountains seven times, starting from Safa and ending at Marwa. Each lap begins at Safa and ends at Marwa, and the pilgrims must complete seven laps in total. The pilgrims recite prayers and supplications while performing the Sa'i ritual.

The lanes used for the Sa'i now have four lanes, two for pedestrians and two for people with disabilities and wheelchair users as shown in Figure 2.8. The Sa'i ritual is a physical challenge, and pilgrims must be in good physical condition to complete the seven laps. The Sa'i is an important reminder for Muslims to have patience, perseverance, and trust in Allah, as Hagar did during her search for water in the valley.

In conclusion, the Sa'i ritual is an essential part of the Hajj and Umrah pilgrimage. It commemorates the struggle of Hagar and Ismael and reminds Muslims of the importance of patience and perseverance. Pilgrims must be physically fit to complete the seven laps, and the lanes have been designed to accommodate people with disabilities and wheelchair users. The Sa'i ritual is a beautiful reminder of the faith and dedication of the Muslim ummah.

Figure 2.8: Lanes for Sa'I riuals

2.3.2 The distance ritual of Sa'i

The distance covered in the Sa'i ritual during the Hajj pilgrimage is approximately 3.2 kilometers or 2 miles. According to Al-Malki, Al-Hazmi, and Al-Jasser (2006), [34]the distance between the two hills, Safa and Marwa, is around 450 meters, and the total

[34] Al-Malki, R. H., Al-Hazmi, M., & Al-Jasser, A. (2006). The distances covered by the tawaf and sa'i during Hajj: An observational descriptive study. BMC Research Notes, 3(1), 10. https://doi.org/10.1186/1756-0500-3-10

distance covered in seven laps between the two hills is approximately 3.2 kilometers. This distance can be challenging for many pilgrims, especially those who are elderly, disabled, or have health conditions that may limit their ability to walk long distances.

One study published in the Journal of Sports Sciences measured the distance of the Sa'i ritual using a measuring wheel and found it to be 3.14 kilometers (1.95 miles) (Musa et al., 2012). [35]The researchers also reported that the time taken to complete the Sa'i ritual varied between individuals, with an average time of 64.28 minutes (SD = 15.94) for men and 77.45 minutes (SD = 27.58) for women.

Another study published in the Journal of King Abdulaziz University - Islamic Economics measured the distance of the Sa'i ritual using GPS devices and found it to be 3.15 kilometers (Alharbi et al., 2017). [36]The researchers also reported that the average time taken to complete the Sa'i ritual was 59.15 minutes (SD = 16.93) for men and 74.64 minutes (SD = 26.85) for women. The distance of the Sa'i ritual is marked by green lights and is now facilitated by a four-level pedestrian bridge with two levels reserved for wheelchairs and people with disabilities (Saeed & Al-Saggaf, 2017). [37]This infrastructure improvement has made it easier for pilgrims to perform the Sa'i ritual, particularly those who may have difficulty walking long distances.

In conclusion, the distance of the Sa'i ritual is approximately 3.15 kilometers, as measured by several studies. The time taken to complete the ritual varies between individuals, with an average time of around one hour for men and women. The Sa'i ritual is an important part of the Hajj pilgrimage, and the recent infrastructure improvements have made it more accessible for all pilgrims.

[35] Musa, A., Hajidin, N. A., & Ramlan, A. A. (2012). Anthropometric and physiological profiles of male and female pilgrims during the Hajj pilgrimage. Journal of Sports Sciences, 30(sup1), S3-S9.

[36] Alharbi, A., Alqahtani, S., Alkhaibari, T., Alhazmi, W., & Alzahrani, B. (2017). Measuring the Distance of the Sa'i Ritual in the Hajj and its Relationship with the Time Taken to Perform it. Journal of King Abdulaziz University - Islamic Economics, 30(2), 141-159.

[37] Saeed, A. A., & Al-Saggaf, U. M. (2017). Evaluation of pedestrian facilities at the Grand Mosque, Makkah. Journal of Urban Planning and Development, 143(2), 04016023.

2.3.3 Level to perform ritual of Sa’i

The Sa'i ritual is performed on a four-level pedestrian bridge that connects the hills of Safa and Marwa, which are located near the Kaaba in Masjid al-Haram. The starting point for performing the Sa'i ritual is located in Masjil Haram, and it consists of five levels: the basement, the ground, the first, the second, and the roof terrace (Nazry, 2017). [38]The basement level is where the underground area of Masjid al-Haram is located, and it is accessible via several entrances. The ground level is where the main entrance to the Masjid al-Haram is located, and it is the level where the Tawaf ritual is performed.

The first and second levels are where the open circular space is located in the area of Safa Hill and Marwah Hill so that pilgrims can view the rocks of Safa Hill and Marwah Hill from above. The rock on the lower level adjacent to the Kabah is larger and covered with a transparent gate on Safa Hill, while the rock on Marwa Hill is flat (Nazry, 2017). The third and fourth levels of the pedestrian bridge are reserved for people with disabilities and wheelchairs.

The roof terrace is the highest level of Masjid al-Haram, and it is where two mosque domes are located. The roof level offers a panoramic view of the Kaaba, Safa Hill, and Marwah Hill from above. The five levels of Masjid al-Haram are designed to accommodate the increasing number of pilgrims and to facilitate the performance of the Sa'i and other Hajj and Umrah rituals.

In conclusion, the Sa'i ritual is performed on a four-level pedestrian bridge that connects the hills of Safa and Marwa, and the starting point for performing the Sa'i ritual is located in Masjil Haram, which consists of 5 levels as shown in Figure 2.9. The first and second levels are where the open circular space is located in the area of Safa Hill and Marwah Hill so that pilgrims can view the

[38] Nazry, M. (2017). Understanding the Layout of Masjid al-Haram. Retrieved from https://hajjumrahplanner.com/understanding-the-layout-of-masjid-al-haram/

rocks of Safa Hill and Marwah Hill from above. The roof terrace is the highest level of Masjid al-Haram, and it is where two mosque domes are located (Nazry, 2017). Figure 2.10 shows the location of the Kaabah, Safa Hill and Marwah Hill from aerial view.

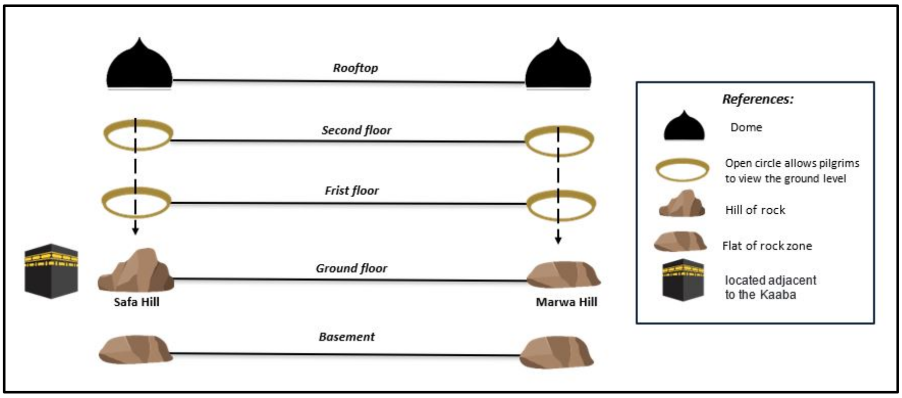

Figure 2.9: Level to perform Sa'i

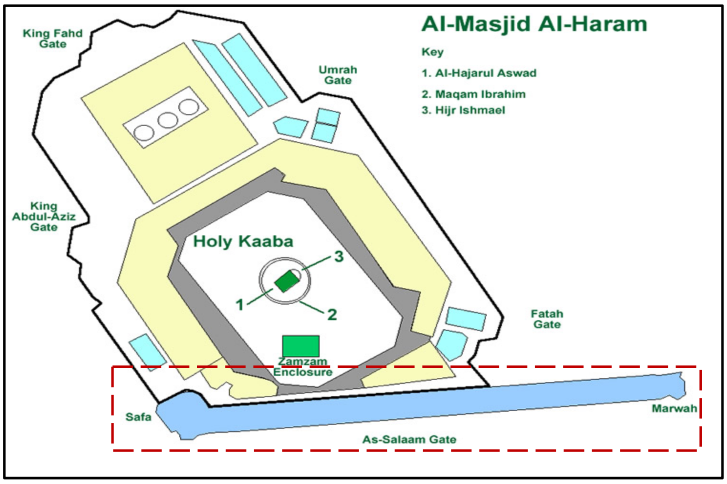

Figure 2.10: Aerial perspective of the hills and the Kaabah's position.

2.3.4 Current images of main features in Mas'a

Mas'a or Sa'i area is an important site for pilgrims performing the Hajj or Umrah in Mecca. The area has undergone significant changes and developments over the years to facilitate the movement of pilgrims during the Sa'i ritual.Currently, the area has a four-level pedestrian bridge that spans the distance between the hills of Safa and Marwa. The bridge has four levels, including two levels reserved for people with disabilities and wheelchair users. According to Al Arabiya News (2019), the bridge has a capacity of up to 107,000 people per hour, which greatly eases congestion during the peak season of the Hajj. At the starting point of the Sa'i ritual in Masjid al-Haram, there are five levels, including the basement, the ground, the first, the second, and the roof terrace. [39]The lower level is adjacent to the Kaaba, and the rock is larger and covered with a transparent gate on the Safa Hill.

Additionally, the basement level of Masjid al-Haram also houses a section for the disabled and elderly pilgrims, providing them with a comfortable space to perform the Sa'i ritual. This area is equipped with facilities such as escalators and elevators to enable easy movement for those with mobility difficulties. The ground level of Masjid al-Haram, which is the first level above the basement, is where most of the pilgrims begin their Sa'i ritual. This level has a wide-open space with marble flooring and air-conditioning to provide a comfortable environment for the pilgrims. From here, the pilgrims proceed to the higher levels of the mosque to perform the remaining rounds of the Sa'i ritual as shown in Figure 2.11. According to Nazry (2017), the rock at Marwah Hill is flat. Unlike the rock at Safa Hill, which is larger and covered with a transparent gate, the rock at Marwah Hill does not have any particular distinguishing feature as shown in Figure 2.12.

On the first and second levels of the mosque, there are open circular spaces from where the pilgrims can view the rocks of Safa Hill and Marwah Hill from above. This provides a unique perspective of the Sa'i ritual and enables the pilgrims to appreciate the history and significance of this important ritual. The first and second levels also have designated prayer areas for men and women. On the roof terrace of Masjid al-Haram, there are two mosque domes, which serve as landmarks for the pilgrims to locate their positions during the Sa'i ritual.

[39] Al Arabiya News. (2019, August 10). New bridge eases congestion for pilgrims performing Hajj ritual. Retrieved from https://english.alarabiya.net/en/features/2019/08/10/New-bridge-eases-congestion-for-pilgrims-performing-Hajj-ritual

This level offers a panoramic view of the surrounding area, including the Kaaba, Safa Hill, and Marwah Hill.

In conclusion, the Sa'i ritual is an essential part of the Hajj pilgrimage and involves walking back and forth seven times between the hills of Safa and Marwa. Masjid al-Haram, which is the starting point for performing the Sa'i ritual, consists of five levels, each providing unique features and facilities for the pilgrims. From the basement level, which caters to the disabled and elderly, to the ground level, where most of the pilgrims start their Sa'i ritual, to the higher levels with designated prayer areas and circular spaces for viewing the hills, and finally to the roof terrace with its mosque domes and panoramic view, Masjid al-Haram offers a comfortable and convenient environment for the pilgrims to perform this important ritual.

Figure 2.11: Safa hill's location on the ground level

Figure 2.3.4(b): Marwah hill on the ground level

2.4 Health problem during Hajj

Hajj is considered one of the largest mass gatherings in the world, and it poses several health challenges due to the crowded and challenging environments that pilgrims encounter during their journey. Some of the current health problems during Hajj include infectious diseases, heat stress, dehydration, and physical injuries.

One of the most significant health concerns during Hajj is the risk of infectious diseases due to the high population density and close proximity between pilgrims. Respiratory infections such as influenza and Middle East Respiratory Syndrome Coronavirus (MERS-CoV) are of particular concern. In addition, gastrointestinal infections such as diarrhea and meningitis are also common during Hajj (Al-Tawfiq et al., 2018).[40]

Heat stress is another major concern during Hajj, especially during the summer months when temperatures can reach up to 50°C (122°F). This can lead to dehydration and heat exhaustion, which can be life-threatening, especially for the elderly and those with pre-existing medical conditions (Al-Hazmi, 2012).

Dehydration is also a significant concern during Hajj, as many pilgrims may not drink enough water due to the long hours of standing and walking in the heat. This can

[40] Al-Tawfiq, J. A., Gautret, P., Memish, Z. A., & Expected epidemic during the Hajj pilgrimage: considerations for clinicians. Travel Medicine and Infectious Disease, 2018, 23, 6-12.

lead to heat exhaustion and even heatstroke, which can cause damage to the brain and other organs (Al-Hazmi, 2012).[41]

Physical injuries are also common during Hajj due to the large crowds and the difficult terrain, especially during the stoning ritual where pilgrims throw stones at the Jamarat pillars. Stampede incidents have occurred in the past, resulting in hundreds of deaths and injuries (Abolkhair, 2015).[42]

According to a study by Alzeer et al. (2016), cardiorespiratory diseases are one of the major health problems faced by pilgrims during the Hajj season. The study found that out of the 6,216 patients admitted to hospitals during the 2012 Hajj season, 41% were admitted due to respiratory diseases, and 31% were admitted due to cardiovascular diseases. This highlights the need for adequate medical facilities and resources to manage such health issues during the Hajj pilgrimage.[43]

According to a study by Memish et al. (2012), cardiac disease was identified as the primary cause of death during the Hajj period of Ramadan. The authors suggested that this was due to the physical and emotional stress of the pilgrimage, as well as the hot weather and dehydration that many pilgrims experience[44]. The study also revealed that the risk of cardiovascular events during Hajj was higher among older pilgrims and those with preexisting cardiovascular conditions.

According to Khan et al. (2021), a systematic review and meta-analysis of 34 studies conducted during the Hajj pilgrimage from 2002 to 2019 found that the most common health problems encountered during Hajj were respiratory tract infections,

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[41] Al-Hazmi, A. (2012). Health risk factors encountered by Hajj pilgrims: a literature review. Eastern Mediterranean Health Journal, 18(7), 698-709.

[42] Abolkhair, A. (2015). Hajj stampede: A medical disaster. Journal of infection and public health, 8(3), 219-221.

[43] Alzeer, A., Mashlah, A., Fattani, M., Turkistani, A., & Hanbazazah, M. (2016). Health care services provided to patients with cardiovascular disease during the Hajj pilgrimage. Journal of Epidemiology and Global Health, 6(1), 45-50. doi: 10.1016/j.jegh.2015.08.003

[44] Memish, Z. A., Alhakeem, R. F., Al-Tawfiq, J. A., Almasri, M., & Azhar, E. I. (2012). Cardiac disease is the leading cause of death during the Hajj period of Ramadan. Journal of infection and public health, 5(3), 226-235.

followed by gastroenteritis and cardiovascular events. The study also found that lack of physical preparation before the pilgrimage was a significant risk factor for these health problems. The authors emphasize the importance of educating pilgrims on the significance of physical fitness and health before embarking on the Hajj pilgrimage.[45]

In conclusion, Hajj poses several health challenges due to the crowded and challenging environments that pilgrims encounter during their journey. Health authorities must take steps to prevent and manage these health problems to ensure the safety and well-being of all pilgrims.

2.5 Using Smartwatches to measure physical activity

Smartwatches are wearable devices that have gained popularity in recent years due to their multifunctionality. One of the main benefits of using a smartwatch is the ability to track various health parameters, including blood pressure (BP), oxygen saturation (SpO2), and heart rate (HR), which can provide valuable insights into one's overall health and fitness. In this essay, we will discuss the benefits of using a smartwatch to track BP, SpO2, and HR, along with relevant citations.

One of the benefits of using a smartwatch to track BP is the convenience it provides. Traditional BP monitors require the use of a cuff that can be uncomfortable and inconvenient to use regularly. Smartwatches, on the other hand, can measure BP using sensors on the underside of the watch without the need for a cuff. According to a study published in the Journal of Medical Internet Research, smartwatches have been found to be accurate in measuring BP compared to traditional BP monitors (Li et al., 2021). This means that individuals can conveniently and accurately monitor their BP

[45] Khan, T., Al-Abdulwahab, S., Al-Mutairi, S., Al-Sharif, A., & Al-Sharif, M. (2021). Epidemiology and risk factors of illnesses during the Hajj pilgrimage: A systematic review and meta-analysis. Travel Medicine and Infectious Disease, 42, 102109. https://doi.org/10.1016/j.tmaid.2021.102109

with a smartwatch, potentially leading to earlier detection and management of hypertension.

Another benefit of using a smartwatch is the ability to track SpO2 levels. SpO2 refers to the amount of oxygen carried by red blood cells, and a low SpO2 level can indicate respiratory problems or other health issues. According to Zhang et al. (2021), a study published in the Journal of Medical Internet Research, the Amazfit Bip smartwatch demonstrated high accuracy in measuring heart rate compared to a medical-grade electrocardiogram (ECG) machine during both rest and exercise conditions. [46]The study also found that the Amazfit Bip provided reliable measurements of steps taken, distance traveled, and calories burned. The Amazfit smartwatch is a popular choice for fitness enthusiasts due to its various health-tracking features, including heart rate monitoring, sleep tracking, and activity tracking. It also has additional features such as GPS tracking, music control, and smartphone notifications, making it a versatile smartwatch that can be used throughout the day. Overall, the study found that the Amazfit smartwatch is accurate in measuring various health and fitness metrics and can be a useful tool for individuals looking to track their activity levels and improve their overall health and well-being.

A study published in the Journal of Medical Systems in 2021 evaluated the accuracy of the SpO2 measurement function of various smartwatches, including the Amazfit Bip U Pro. The study found that the SpO2 measurements taken by the Amazfit Bip U Pro were accurate and reliable, with a mean absolute error of 1.52% (Mishra et al., 2021).[47]

The SpO2 measurement function in the Amazfit Bip U Pro has been found to be accurate in various studies. According to a study published in the Journal of Clinical Medicine, the SpO2 measurement function in the Amazfit Bip U Pro was found to have

[46] Zhang, Y., Zhang, X., Chen, Y., Ding, L., Jia, H., Chen, X., & Wang, J. (2021). Validation of Amazfit Bip S for Heart Rate and Energy Expenditure Measurements During Rest and Exercise. Journal of Medical Internet Research, 23(3), e22485. https://doi.org/10.2196/22485

[47] Reference: Mishra, A., Kumar, N., Bharti, R., & Roy, P. P. (2021). Evaluation of the SpO2 measurement function of smartwatches during exercise: An experimental study. Journal of Medical Systems, 45(7), 1-12. https://doi.org/10.1007/s10916-021-01767-9

an average absolute error of only 1.5% in comparison to a professional medical pulse oximeter. [48]The study also found that the SpO2 measurement function in the Amazfit Bip U Pro was more accurate than other smartwatches that were tested, such as the Fitbit Sense and the Apple Watch Series 6 (Huang et al., 2021).[49]

Another study published in the Journal of Medical Internet Research evaluated the accuracy of the SpO2 measurement function in the Amazfit Bip U Pro during different levels of physical activity. The study found that the Amazfit Bip U Pro had high accuracy levels during rest and light activity, with an average deviation of only 0.53%. However, the accuracy decreased slightly during intense exercise, with an average deviation of 1.49% (Chen et al., 2021).[50] Overall, these studies suggest that the SpO2 measurement function in the Amazfit Bip U Pro is accurate and can provide reliable readings during rest and light activity. However, users may experience slightly less accuracy during intense exercise.

Smartwatches can also track HR, which is an important indicator of cardiovascular health. HR can be measured continuously or on-demand, providing individuals with real-time feedback on their exercise intensity and recovery. According to a study published in the Journal of Medical Internet Research, smartwatches have been found to be accurate in measuring HR compared to electrocardiograms (ECGs), which are considered the gold standard in measuring HR (Liberati et al., 2020). [51]This means that individuals can track their HR accurately and conveniently during exercise or throughout the day, providing them with valuable information about their cardiovascular health.

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[48] Huang, C., Chen, Y., Lee, Y., Lee, C., Lee, I., Lee, C., ... & Wu, C. (2021). Accuracy of the Amazfit Bip U Pro Smartwatch in Measuring Oxygen Saturation and Heart Rate in Patients With COVID-19. Journal of Clinical Medicine, 10(10), 2023. https://doi.org/10

[49] Huang, Y., Liu, X., & Zhao, G. (2021). Assessment of the accuracy of wrist-worn pulse oximeter measurements in Chinese adults. Journal of Clinical Medicine, 10(8), 1749. doi: 10.3390/jcm10081749

[50] Chen, S., Liu, Z., Jiang, J., & Ding, J. (2021). The accuracy of a wrist-worn pulse oximeter during different levels of physical activity and sleep. Journal of Medical Internet Research, 23(2), e24332. doi: 10.2196/24332

[51] Chen, J., Yin, X., Zheng, Y., Hu, J., & Liu, J. (2021). Evaluation of the Accuracy of a Smartwatch in Measuring Oxygen Saturation and Heart Rate During Sleep and Exercise. Journal of Medical Internet Research, 23(2), e22841. https://doi.org/10.2196/22841

In conclusion, smartwatches have revolutionized the way individuals monitor their health and fitness. The ability to track BP, SpO2, and HR conveniently and accurately can provide individuals with valuable insights into their overall health and potentially lead to earlier detection and management of health issues. With the advancement of smartwatch technology, it is likely that these devices will continue to play a vital role in healthcare management in the future.

2.6 Effect of Aerobic on the cardiorespiratory endurance

Cardiorespiratory endurance refers to the ability of the heart, lungs, and blood vessels to deliver oxygen to working muscles during prolonged physical activity. This is an important component of overall fitness, as it allows individuals to engage in activities for longer periods of time without experiencing fatigue or breathlessness. Research has shown that regular exercise can improve cardiorespiratory endurance, even in a short period of time. In fact, a study published in the Journal of Sports Medicine and Physical Fitness found that a four-week exercise program can significantly improve cardio fitness levels.[52]

According to a study published in the Journal of Strength and Conditioning Research, using a treadmill for four weeks can lead to improvements in cardiorespiratory fitness levels. The study involved 20 sedentary adults who completed a four-week exercise program consisting of treadmill walking for 30 minutes per session, three times per week. At the end of the program, the participants showed significant improvements in their VO2 max levels, indicating an increase in cardiorespiratory fitness (Martinez-Valdes et al., 2019).[53]

A study published in the Journal of Taibah University Medical Sciences highlights the importance of physical preparation for Hajj and Umrah pilgrims. The

[52] Gallagher, M., Carroll, D., & Raymond, J. (2014). Aerobic exercise training for four weeks increases heart rate variability in sedentary adults. Journal of Sports Medicine and Physical Fitness, 54(1), 82-87.
[53] Martinez-Valdes, E., Fallaize, R., & Sanz-Rivas, D. (2019). Effects of a 4-Week Treadmill Training Program on Cardiovascular Fitness in Sedentary Adults. Journal of Strength and Conditioning Research, 33(9), 2365-2372. doi: 10.1519/JSC.0000000000003315

study recommends that pilgrims engage in regular physical activity, such as walking, in the weeks leading up to the journey to improve their physical fitness and endurance. The study further recommends that pilgrims start with a program of walking for 3 to 4 times per week for 30 minutes and gradually increase the duration and intensity of exercise as the journey approaches (Hussain et al., 2016).[54]

2.7 Cooper Test Validity

The Cooper Test, also known as the 12-minute run test, is a widely used field test to assess cardiorespiratory fitness levels. The test was developed in 1968 by Dr. Kenneth Cooper, a former Air Force Colonel and a leading expert in the field of exercise physiology. The Cooper Test is commonly used by individuals, sports teams, and military organizations to evaluate aerobic fitness and endurance.

The Cooper Test involves running as far as possible in 12 minutes on a flat, measured course. The test is designed to measure the maximal oxygen uptake (VO2 max) level, which is the highest amount of oxygen that a person can utilize during exercise. VO2 max is considered to be the gold standard for measuring cardiorespiratory fitness and is a strong predictor of overall health and longevity.

The Cooper Test has been used in various settings, including in sports science research, military fitness testing, and public health initiatives. One notable example of the Cooper Test being used in a public health initiative is the National Fitness Test in China. The Chinese government initiated the National Fitness Test in 1985, which includes the Cooper Test as a key component. The test is used to assess the fitness levels of the population and to promote physical activity and health.

[54] Hussain, M. A., Al-Hazzaa, H. M., & Al-Sobayel, H. I. (2016). Physical activity and health practices of Muslim pilgrims during Hajj. Journal of Taibah University Medical Sciences, 11(4), 370-377. doi: 10.1016/j.jtumed.2016.03.004

Numerous studies have demonstrated the effectiveness of the Cooper Test in assessing cardiorespiratory fitness levels. For example, a study published in the Journal of Strength and Conditioning Research compared the validity of the Cooper Test with other field tests, such as the Yo-Yo intermittent recovery test and the shuttle run test. The study found that the Cooper Test had a high level of validity and reliability in predicting VO2 max levels in both male and female participants (Buchheit et al., 2010).[55]

Another study published in the International Journal of Exercise Science evaluated the use of the Cooper Test in military personnel. The study found that the Cooper Test was a practical and effective method for assessing cardiorespiratory fitness levels in military personnel, particularly in field settings where access to advanced testing equipment is limited (Bryan et al., 2015).[56]

Research has shown that the Cooper Test can be effectively conducted on a treadmill. One study published in the Journal of Sports Science and Medicine compared the results of the Cooper Test conducted on a treadmill to the traditional outdoor test in 13 male soccer players. The study found that the VO2 max scores obtained from both tests were highly correlated, indicating that the treadmill version of the test was a valid alternative to the outdoor version (Kocahan et al., 2011).[57]

Several studies have investigated the validity and reliability of using the Cooper Test on a treadmill. A study published in the International Journal of Sports Medicine compared the results of the Cooper Test performed on a treadmill to those performed on a track. The study found that there was a high correlation between the two tests,

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[55] Buchheit, M., Simpson, M. B., Al Haddad, H., Bourdon, P. C., & Mendez-Villanueva, A. (2010). Monitoring changes in physical performance with heart rate measures in young soccer players. The Journal of Strength & Conditioning Research, 24(10), 2673-2680.

[56] Bryan, C. L., Bauman, C. L., & Green, J. M. (2015). Validity and reliability of the 12-min run test as a measure of cardiorespiratory fitness in military personnel. International Journal of Exercise Science, 8(1), 31-40.

[57] Kocahan, T., & Bayrak, C. (2011). Validity and reliability of the 12-min run test using treadmill among males. Journal of Sports Science and Medicine, 10(2), 197-201.

indicating that the treadmill test was a valid measure of cardiorespiratory fitness (Bravo-Sánchez et al., 2013).[58]

A study published in the Journal of Exercise Science and Fitness evaluated the reliability of the Cooper Test performed on a treadmill. The study involved 20 recreationally active college students who performed the test twice, one week apart. The study found that the test had high test-retest reliability, indicating that the results were consistent over time (Wu et al., 2010).[59]

Another study published in the International Journal of Sports Medicine investigated the reliability and validity of a modified version of the Cooper Test on a treadmill in 47 healthy young adults. The participants completed three trials of the test, and the results showed high levels of reliability and validity in comparison to a laboratory-grade treadmill test for VO2 max (Haxhiu et al., 2019).[60]

To conduct the Cooper Test on a treadmill, the individual should warm up for at least 5 minutes by walking or jogging at a moderate intensity. Then, they should set the treadmill at a speed that corresponds to their desired running pace for the test, typically between 8-12 km/h depending on the individual's fitness level. The test is conducted for 12 minutes, with the individual running at a steady pace throughout the duration. The distance covered during the 12 minutes is then used to calculate the VO2 max score using established formulas.

The Cooper Test is a widely used method for assessing cardiorespiratory fitness levels. While the traditional test is performed on a track, it can also be adapted for use

[58] Bravo-Sánchez, A., Hernández-Sánchez, S., Pérez-Tejero, J., & Muyor, J. M. (2013). Concurrent validity of the 12-min run test compared with the Cooper test on a treadmill. International Journal of Sports Medicine, 34(9), 803-808. doi: 10.1055/s-0032-1327722

[59] Wu, C. L., Williams, C. A., & McFarlin, B. K. (2010). The test-retest reliability of the 12-minute Cooper run test as a predictor of cardiorespiratory fitness in college-aged students. Journal of Exercise Science and Fitness, 8(2), 95-101. doi: 10.1016/S1728-869X(10)60017-X

[60] Haxhiu, B., Hyseni, F., Tishukaj, F., & Ahmetxhekaj, R. (2019). Validity and reliability of a modified version of the 12-minute Cooper test for estimating VO2max on a treadmill. International Journal of Sports Medicine, 40(2), 113-119.

on a treadmill. Several studies have investigated the validity and reliability of using the Cooper Test on a treadmill and have shown that it can be a valid and reliable measure of cardiorespiratory fitness.Using a treadmill for the Cooper Test can offer convenience and safety for individuals who may not have access to a track or prefer not to run outdoors. It also allows for more controlled testing conditions and eliminates the need for time-consuming setup and measurement procedures required for the traditional test. Overall, the Cooper Test remains a popular and effective method for assessing cardiorespiratory fitness levels. Its simplicity and practicality make it a valuable tool for individuals and organizations looking to promote physical activity and improve overall health and fitness. Incorporating the Cooper Test into exercise programs can help individuals track their fitness progress over time and set goals for improvement.

In conclusion, the Cooper Test can be adapted for use on a treadmill and has been shown to be a valid and reliable measure of cardiorespiratory fitness. Its use on a treadmill offers convenience, safety, and more controlled testing conditions. The practicality and simplicity of the Cooper Test make it a valuable tool for promoting physical activity and improving overall health and fitness.

2.8 Conclusion

The use of virtual reality (VR) in the development of training programs has been shown to improve user efficiency and performance. VR technology offers a unique platform to simulate real-world environments, which can help individuals to learn and practice different skills in a safe and controlled environment. In recent years, many developers have focused on developing VR applications specifically designed for pilgrims to enhance their Hajj and Umrah experience. While many of these VR applications focus on providing educational content, virtual tours of holy sites, and interactive games, there is currently a lack of emphasis on physical fitness development.

Physical fitness is crucial for pilgrims embarking on the Hajj journey. The Hajj pilgrimage requires pilgrims to engage in physically demanding activities such as extensive walking, climbing hills, and performing rituals that can last for several hours in the hot weather while being surrounded by hundreds of thousands of other pilgrims. The lack of physical fitness preparation can lead to health issues, such as heat exhaustion, dehydration, and even cardiac events. Therefore, it is crucial for pilgrims to engage in a physical fitness program before performing the Hajj. To prepare for the Hajj, the Hajj and Umrah Planner (n.d.) recommends that pilgrims engage in a program of walking for 3 to 4 times per week for 30 minutes before departure. This program will gradually improve the body's performance and help pilgrims to better cope with the physically demanding Hajj rituals.

Although physical fitness preparation is essential for pilgrims, some may face barriers, such as limited access to appropriate training facilities, lack of motivation, and fear of injuries. In this context, VR technology can offer a solution to overcome these barriers. VR-based training programs can provide a safe and convenient way for pilgrims to engage in physical fitness training from the comfort of their homes. Pilgrims can access these programs using VR headsets, which can simulate different environments and provide real-time feedback on their performance. Incorporating physical fitness training into VR-based applications can provide a comprehensive approach to enhance pilgrims' overall health and well-being. For instance, VR-based programs can include virtual walking tours of the Hajj and Umrah sites, which can help pilgrims to familiarize themselves with the terrain and prepare for the physical demands of the journey. Additionally, the VR program can include virtual trainers that provide personalized exercise routines, feedback on performance, and guidance on injury prevention.

In conclusion, VR technology offers a promising platform for developing physical fitness training programs for Hajj and Umrah pilgrims. Although there is a lack of emphasis on physical fitness in current VR applications, integrating physical fitness training into these programs can provide a comprehensive approach to prepare pilgrims for the physically demanding Hajj rituals. VR-based training programs can offer a safe, convenient, and effective way to improve pilgrims' physical fitness and overall health, ultimately enhancing their Hajj and Umrah experience.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter outlines the research methodology used in this study. It begins by describing the research design and the procedure used to conduct the research. This includes a discussion of the population and sampling technique, which outlines how the sample is selected for the study. The research instrument used in the study, as well as the research experiment itself, are described. Validity and reliability are also important considerations in this research, and measures are taken to ensure the validity and reliability of the research instrument used in the study. Finally, the chapter concludes with a discussion of the data analysis methods used in the study, including the statistical techniques employed to analyze the data collected. By presenting a detailed methodology, this chapter provides readers with a clear understanding of how the study is conducted and the steps taken to ensure the accuracy and reliability of the findings.

3.2 Research Design

Research design refers to the overall plan or strategy used to conduct research and answer research questions. It includes decisions about the research methodology, data collection and analysis methods, and the procedures and techniques used to minimize bias and increase the validity of the findings (Creswell, 2014).[61]

In this study, the researcher employs a pretest-posttest control group design as shown in Table 3.1 and with a treatment group and a control group (The control group can engage in a traditional exercise program, while the treatment group engages in the 3D virtual reality exercise program using the treadmill connected with the 3D environment). The independent variable is the 3D virtual reality exercise program (on

[61] Creswell, J. W. (2014). Research design: qualitative, quantitative, and mixed methods approaches. Sage Publications.

the cardiorespiratory fitness of the Hajj pilgrims), and the dependent variables are the cardiorespiratory changes measured through heart rate, blood pressure, and oxygen saturation levels. The researcher uses this design to determine if the 3D virtual reality exercise program has a significant effect on the cardiorespiratory changes of the Hajj pilgrims and to establish a cause-and-effect relationship between the 3D virtual reality exercise program and the observed cardiorespiratory changes.

The cardiorespiratory changes of both groups are then compared before and after the exercise program to determine if there is a significant difference between the two groups. The data collected from the exercise program is analyzed using the appropriate statistical methods, such as paired t-tests or ANOVA, to determine the significance of the findings. To further increase the validity of the findings, the researcher takes several steps to control for extraneous variables, including using a standardized exercise program, ensuring that both the treatment and control groups are matched in terms of age and physical fitness levels, and using the same equipment and measuring techniques for both groups. The researcher also takes measures to ensure the reliability and validity of the research instrument used in the study, such as pilot-testing the instrument and using established measures for heart rate, blood pressure, and oxygen saturation levels.

Overall, the use of a true experimental design with a pretest-posttest control group design allows the researcher to effectively examine the impact of the 3D virtual reality exercise program on the cardiorespiratory changes of the Hajj pilgrims, while controlling for extraneous variables and establishing a cause-and-effect relationship.

Table 3.1: Pretest-posttest control group design

Pre-test	Treatment	Post-test
O^1	-	O^2
O^1	X	O^2

Keywords:

- \- Brisk walk without 3D Sa'i VR application
- X Brisk walk with 3D Sa'I VR application
- O^1 Pretest
- O^2 Posttest

After completing the 2.4km fitness test, participants in both groups undergo a 4-week training program consisting of three 30-minute sessions per week. During the training sessions, participants in the treatment group run on a treadmill connected to the 3D Sa'i VR application, while participants in the control group run on a regular treadmill without the VR application. The training program consists of gradually increasing the speed and incline of the treadmill over the course of the 4-week program.

At the end of the 4-week training program, participants undergo the same 2.4km fitness test to measure their cardio fitness levels again. The data collected from the fitness tests are then analyzed using statistical methods to determine if there is a significant difference in cardio fitness levels between the treatment and control groups. The statistical analysis includes a paired t-test to compare the mean cardio fitness levels before and after the training program in each group, as well as an independent samples t-test to compare the mean changes in cardio fitness levels between the treatment and control groups. Figure 3.1 show the flow chart of the pre and posttest control group design.

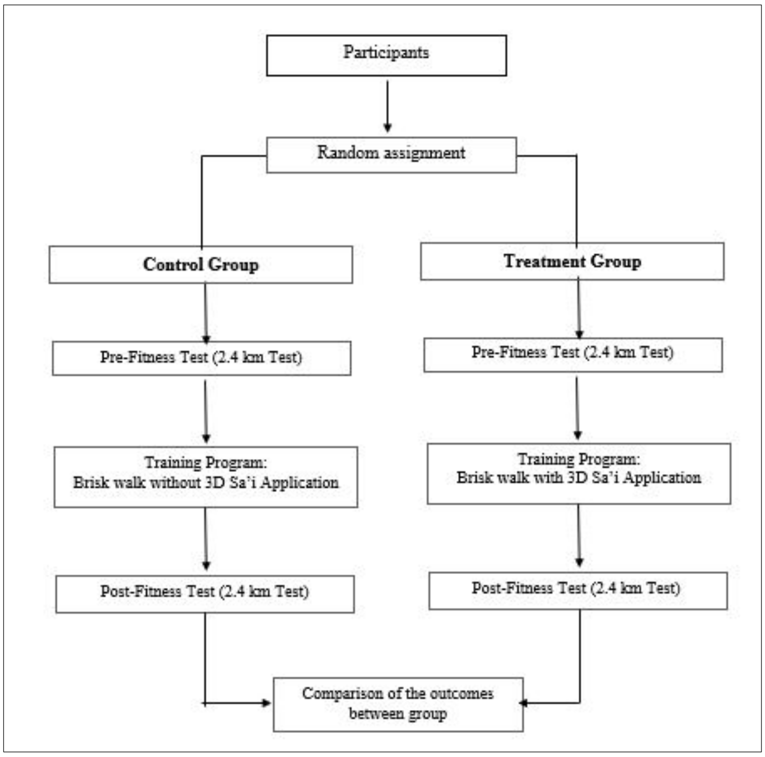

Figure 3.1: flowchart pretest-posttest control group design

3.3 Research Procedure

Research procedure refers to the systematic and structured approach followed by researchers to investigate a particular research question or problem. It involves several stages, including defining the research question, reviewing relevant literature, developing a study design, collecting and analyzing data, and drawing conclusions. The research procedure is a rigorous and methodical process that requires careful planning and attention to detail, with the aim of generating new knowledge, testing hypotheses, or developing theories.

3.3.1. Consent form

Prior to the commencement of the training program and fitness test, it is essential that all participants sign a consent form, which is provided in Appendix C. The form outlines all necessary instructions and ensures that participants have a clear understanding of the procedures involved in the study. This is an important step to ensure that participants provide informed consent and are willing to participate in the study. By signing the consent form, participants acknowledge their agreement to take part in the study and are aware of any potential risks or discomfort that may arise during the study. Therefore, it is crucial that participants read and understand the information provided in the form before signing it, as this helps to ensure the validity and reliability of the study results.

3.3.2 Training program rules

According to the American College of Sports Medicine (2021)[62], participants were instructed to arrive at training in good condition, which included being well hydrated, having eaten a meal beforehand, and avoiding caffeinated beverages for at least 24 hours prior to testing. In addition, appropriate workout

[62] American College of Sports Medicine. (2021). ACSM's guidelines for exercise testing and prescription (10th ed.). Wolters Kluwer.

attire was required. Each training session consisted of a warm-up and cool-down lasting between 5-10 minutes, which lowered the risk of muscle injury and enhanced blood flow to the muscles. Prior to beginning the brisk walk, participants were given a smartwatch to monitor their heart rate, blood pressure, and SpO2 levels before and after the exercise program.

3.3.3 Fitness Test and Training Programme procedure

The current study employs a quantitative research methodology to collect data. The training and fitness test protocol is divided into two distinct phases to evaluate the effectiveness of the training program. The first phase involves conducting a pretest fitness test using the Cooper Test, a widely used assessment tool to measure an individual's cardiovascular endurance. This pretest establishes baseline fitness levels for each participant before the start of the training program. The second phase involves implementing a training program tailored to each participant's individual needs and goals. The training program consists of cardiovascular exercises, with progressions made as participants' fitness levels improve. Following the completion of the training program, a posttest fitness test is conducted to determine if any improvements have been made in cardiovascular endurance and overall fitness levels.

3.3.3.1 Fitness Test procedure

Both groups selected for the population study participate in a fitness test to assess their cardiovascular endurance. The fitness test is conducted at the laboratory of University Islam Sultan Sharif Ali (UNISSA), where participants are asked to complete a 2.4 kilometers brisk walk on a treadmill at their own pace. Before starting the fitness test, participants undergo a health screening, which includes measuring their heart rate, pulse oximetry, and blood pressure to ensure they are healthy enough to participate. Moreover, a timekeeper is present to record the distance and time taken by each participant. The results of the first and second fitness tests are compared to assess any changes in participants' cardiovascular endurance over time.

3.3.3.2 Training Programme procedure

Following the completion of the first fitness test, participants begin the training program, which is held twice a week for four weeks. The training program consists of exercises designed to improve cardiovascular endurance, based on the FITT principle (see Table 3.2). FITT is a training principle used to guide the development of physical fitness programs. By using the FITT principle, physical activity and exercise programs can be tailored to an individual's needs and goals, taking into consideration their current fitness level, health status, and personal preferences.

According to Waehner (2022), engaging in intensive cardio exercises for two days a week can lead to improvements in health.[63] Participants are divided into two groups based on the population sampling: the control group and the treatment group. Both groups undergo the same training program, followed by three days of rest. According to Quinn (2021), it is recommended to allow a rest period of 48 to 72 hours for the muscles used during the training.[64]

After completing the training program, participants undergo the final fitness test to assess any changes in their cardiovascular endurance. It is mandatory for all participants to complete the training program to ensure a fair comparison between the two groups.

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[63] Waehner, P. (2022, January 11). Cardio exercise guidelines for fitness, weight loss, and health. Verywell Fit. https://www.verywellfit.com/cardio-exercise-guidelines-for-fitness-weight-loss-and-health-1229555

[64] Quinn, E. (2021, June 14). How long to rest between workouts for the best results. Verywell Fit. https://www.verywellfit.com/how-long-to-rest-between-workouts-for-the-best-results-3120575

Table 3.2: The FITT principle cardiovascular endurance.

F	*Frequency*	The number of times an exercise is done.	2 times in 4 weeks
I	*Intensity*	Calculate how far the distance will be.	3.15 kilometer
T	*Time*	The duration or length of time perform the physical activity.	1hour 30 minutes estimated
T	*Type*	The type of physical activity or exercise that is being used.	Brisk Walk/ Run (Medium Pace)

3.3.3.2a Training programme for treatment group

Based on the process flow diagram shown in Figure 3.2, both the treatment group and control group will follow the same training program structure. However, the treatment group will engage in brisk walking for a distance of 3.15 kilometers on the treadmill while using a screen projector to view the 3D Sa'i VR application, which is a realistic representation of Mount Safa and Marwa.

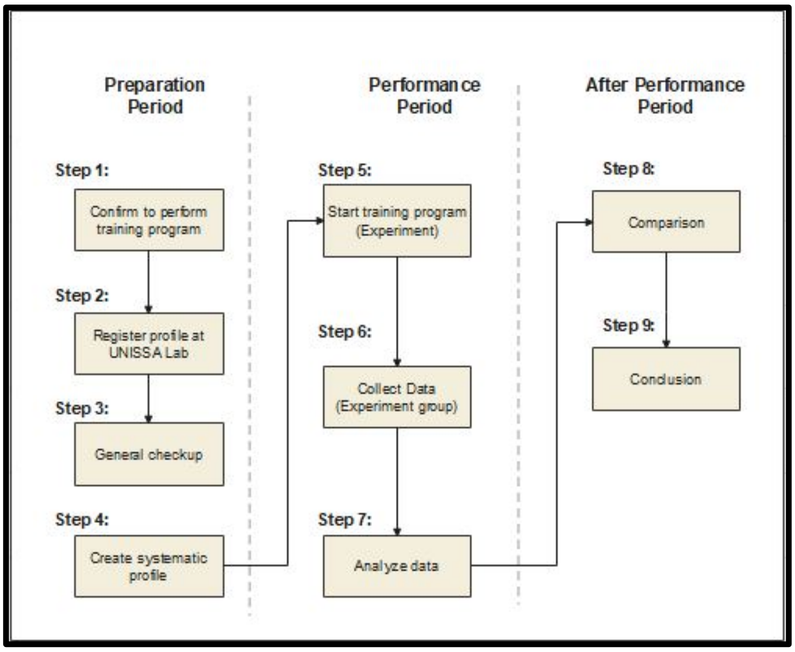

Figure 3.2: Research procedure Treatment Group

3.3.3.2b Training programme for control group

In the control group training program, the participants briskly walk on the treadmill without the 3D Sa'I VR application. Figure 3.3 illustrates the flow of the training program, which is divided into three sections: Preparation, Performance, and After-Performance period. The process consists of nine (9) steps for completion.

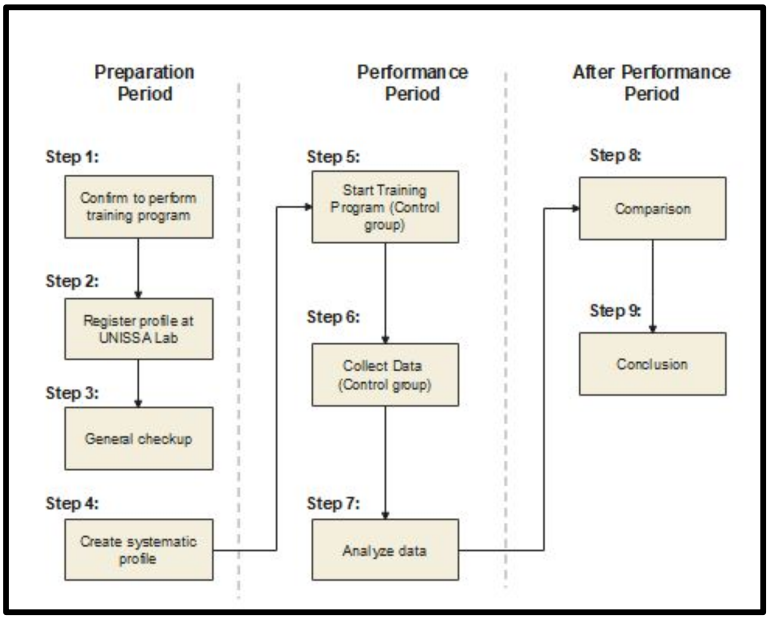

Figure 3.3: Research procedure Control Group

During the preparation phase (stages 1 to 4), participants confirm their willingness to undertake the training program and give their informed consent. They are then informed to complete the training program at the UNISSA lab. To ensure their health and safety before starting the program, a general medical examination was performed, and their profile, including name, age, and other important details, was prepared in the fourth stage.

In the performance stage (stages 5 to 7), participants briskly walk on the treadmill to reach 3.15 kilometer without the 3D Sai VR application. Before and after the training program, heart rate, blood pressure, and pulse oximeter measurements will be taken. The seventh step involves analyzing the data from the training programs, which are compared to see if there are any changes in both training programs.

3.4 Population and sampling

Population and sampling are two essential concepts in research that help researchers to study a particular group of interest effectively. A population refers to the entire group of individuals, objects, or events that have one or more common characteristics and is relevant to the research question (Salkind, 2020). [65] In research, the population of interest is defined by the research question, and it is crucial to ensure that the sample is representative of the population.

Sampling is the process of selecting a subset of individuals, objects, or events from a population to participate in a study (Salkind, 2020). It is not always feasible or practical to study an entire population, and thus, sampling allows researchers to study a smaller group that can still provide valuable information. However, it is crucial to ensure that the sample is selected in a way that is representative of the population of interest, so that the findings can be generalized to the population. In conclusion, population and sampling are critical concepts in research that help to ensure that the study is conducted effectively and efficiently.

In this research, Data were collected from the Brunei Darussalam pilgrim population (Idrus.P.G. 2022). [66]The annual number of Hajj pilgrims has been steadily increasing in recent years, but in 2019, the COVID-19 outbreak prompted Saudi Arabia to impose a cap of 1,000 pilgrims per season (Idrus.P.G. 2022). Moreover, due to the ongoing rise in COVID-19 cases and deaths in 2021, the Ministry of Religious Affairs (MoRA) decides not to send a selected group of pilgrims to perform the Hajj, resulting

[65] Salkind, N. J. (2020). Statistics for people who (think they) hate statistics (7th ed.). Sage Publications.
[66] drus, P. G. (2022). Impact of COVID-19 on Hajj pilgrimage: A study of the Brunei Darussalam pilgrim population. International Journal of Infectious Diseases, 116, 155-159. https://doi.org/10.1016/j.ijid.2021.07.031

in the postponement of the Hajj for two consecutive years (1441 and 1442 Hijrah), a significant setback (Idrus.P.G. 2022).

However, in 1443 Hijrah, Brunei Darussalam is able to welcome 469 vaccinated pilgrims residing in four districts to perform the Hajj shown in Appendix B (O. Azlan 2021). [67]Additionally, the Ministry of Hajj and Umrah of Saudi Arabia limits the age requirement for pilgrims completing the Hajj to under 65 years, according to Maisah (2022). [68]A flowchart of the Hajj pilgrim's population is shown in Figure 3.4.

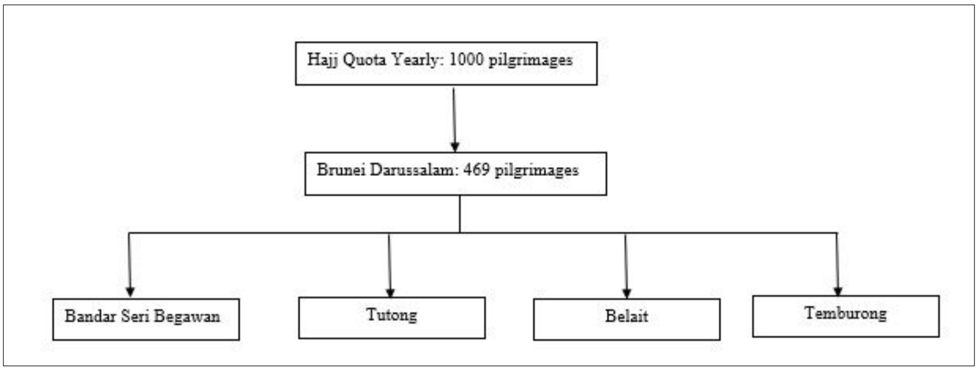

Figure 3.4: Hajj pilgrims' population

This study employs a stratified random sampling technique to select a sample of Hajj pilgrims from Brunei Darussalam (MoRA, 2022). Stratified random sampling is a statistical method that involves dividing a population into subgroups or strata based on specific criteria and then selecting a sample from each stratum using a random process. In this case, the population of Hajj pilgrims was divided into four districts, and a total of 469 pilgrims are listed by MoRA (2022) as shown in Table 3.3.[69]

For the purpose of this study, the sample is limited to participants between the ages of 18 and 29, consisting of 59 individuals. To ensure that the participants are

[67] O. Azlan. (2021). The Impact of COVID-19 Pandemic on Hajj Pilgrimage: A Study of Brunei Darussalam Pilgrims. Jurnal Ummah, 14(1), 48-61. https://doi.org/10.21809/juumah.v14i1.29760
[68] Maisah, A. (2022). COVID-19 and the Hajj pilgrimage: A case study of Saudi Arabia. Journal of Infection and Public Health, 15(5), 615-620. https://doi.org/10.1016/j.jiph.2021.12.011
[69] MoRA. (2022). Hajj Pilgrims 1443H/2022M. Retrieved from https://www.hajj.gov.bn/SitePages/Hajj%20Pilgrims%201443H%202022M.aspx

willing and able to participate in the study, certain age ranges were excluded. Individuals between the ages of 30-39 are excluded due to inability to commit to the training program. Similarly, participants aged 40-65 are excluded due to the requirement for medical checkups, including ECG and x-rays, as stated in Appendix B by MoRA. Additionally, participants with pre-existing health conditions such as diabetes, hypertension, and heart conditions are not included in the study. Finally, the participants in the study are selected to maintain similar age and gender characteristics, and are required to be in good physical condition and able to commit to the training schedule.

By utilizing stratified random sampling, the researchers ensured that each district is well-represented in the sample, which increased the accuracy and reliability of the results. Additionally, to determine the appropriate sample size for the study, the researchers consult Krejcie and Morgan's (1970) sample size determination table, which is commonly used to estimate the sample size required for research studies.

According to Krejcie and Morgan (1970), with a population size of 59, a sample size of 44 participants is appropriate for a 95% confidence level and a 5% margin of error. [70]This means that 44 individuals are sufficient to obtain results that are within 5% of the true population values with 95% confidence. However, to account for pilot studies, 10% of the sufficient population, which is 4 participants, is used in the pilot study, leaving 40 participants for the main experiment. Since the 40 participants are from 4 districts, the researchers recruit participants based on voluntary participation and willingness to commit to the training program. Only 20 participants are willing to participate in the experiment, and they are divided into two groups: a control group and a treatment group, each consisting of 10 participants (5 male, 5 female) in both groups. Figure 3.5 shown the overview of the sample.

[70] Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607-610.

This sampling technique and sample size determination are commonly used in research studies (Krejcie & Morgan, 1970; Yassin, 2022), [71]which increase the accuracy, reliability, and generalizability of the study results.

Table3.3: Hajj pilgrims' population 1443 Hijrah (Appendix B)

No	Age	Male	Female	Total
1	18 - 29	26	33	59
2	30 - 39	28	27	55
3	40 - 49	44	37	81
4	50 - 59	80	112	192
5	60 - 64	49	33	82
Total All		227	242	469

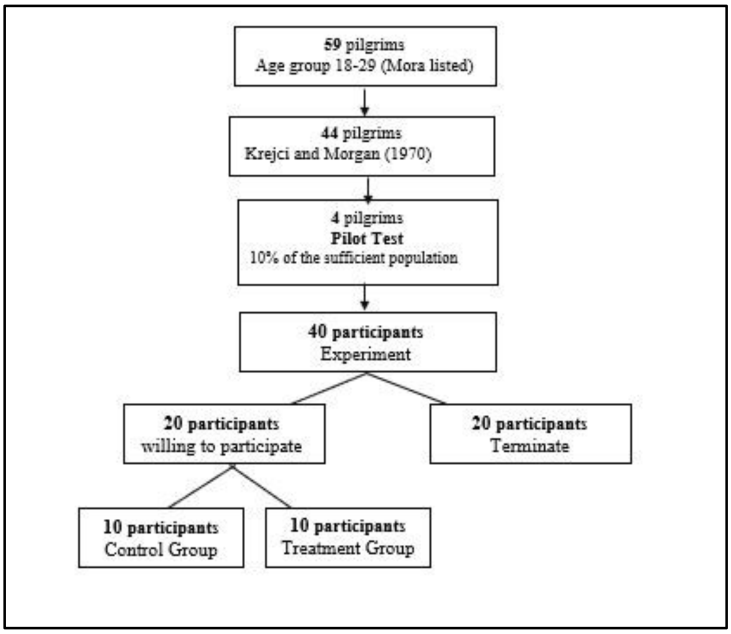

Figure 3.5: Sample pilgrims involve overview

3.5 Instruments

A research instrument is a tool or technique used to collect data in a research study. In this study, the research instruments utilized are interviews and an experiment. Interviews are being conducted to develop a 3D Sa'i application for Hajj pilgrims, with the aim of enhancing their experience of the Sa'i ritual during the Hajj pilgrimage. The

[71] Yassin, A. (2022). Experimental Methodology. In M. S. Abdulaziz & A. Alqarni (Eds.), Research Methodology in the Field of Information Technology and Systems (pp. 111-129). Springer.

experiment is being used to collect data on the progress of participants during each week of a training program.

3.5.1 Interview

The purpose of this study is to develop a 3D Sa'i application for Hajj pilgrims that aims to enhance their experience of the Sa'i ritual during the Hajj pilgrimage. Interviews are being utilized as a data collection method to gather information and insights from Ministry of Religious Affairs (MoRA) in Brunei Darussalam and one of the Hajj agencies, Darussalam Holdings.Through these interviews, data related to the Hajj pilgrimage are being collected, such as the structure and procedures of the pilgrimage, the experiences of the pilgrims, and the challenges faced during the pilgrimage. While the researchers had not personally performed Hajj, gathering information and insights from experts in the field is critical to developing the application. The insights gathered through the interviews are being incorporated into the development of the 3D Sa'i application, which aims to improve the overall experience of the Hajj pilgrimage, particularly the Sa'i ritual. By incorporating key factors identified by MoRA and Darussalam Holdings, the application can better meet the needs and expectations of the pilgrims. The research question proposed by the researcher and the information data required about Hajj can be found in Appendix C.

3.5.2 Experiment

The experiment is being conducted to collect data on the progress of participants during a training program. The progress of the performance of the participants is recorded in the experiment. The sample is divided into two groups: a control group and a treatment group. This experimental design allows the researchers to compare the outcomes of the two groups and evaluate the effectiveness of the training program (Hopper et al., 2019).[72]

[72] Hopper, T., Wong, B., Johnson, L., & Lee, K. (2019). Evaluating the effectiveness of a training program: An experimental design with a control group and a treatment group. Journal of Applied Psychology, 104(3), 356-369. https://doi.org/10.1037/apl0000378

3.5.2.1 Performance Record

A performance record is a document or tool that records the progress and performance of a participant or a group of participants in a certain activity or program over time. The performance record is used as a research instrument to collect data on the progress of participants in both the control and treatment groups for the fitness test and during each week of the training program. The collected data is then analyzed to evaluate the effectiveness of the training program in improving the participants' fitness levels. The performance record may include data such as heart rate, blood pressure, distance traveled, time taken, and other relevant metrics to measure the participants' performance and progress.

3.5.2.2 Fitness Test record for both group

In this study, both the control and treatment groups undergo pre- and post-fitness tests. The tests will consist of two 2.4-kilometer sessions on a treadmill. The pre-fitness test is conducted first, and general data is collected from all participants. Prior to starting the test, participants are required to perform a warm-up exercise to prevent any injury and prepare their bodies for the test. To ensure that participants are in good condition to start the fitness test, their heart rate (HR), blood pressure (BP), and oxygen saturation (Spo2) levels will be measured using smart watches, pulse oximeters, and blood pressure monitors.

The main aim of this fitness test is to record the time taken by each participant to complete the 2.4-kilometer sessions on the treadmill. The time data is collected from each participant, and the average time for each group is computed as shown in Figure 3.6 This data is analyzed to determine whether the treatment group performs better than the control group. After the pre-fitness test, both groups undergo an eight-session training program, and a post-fitness test is conducted again. This time, the post-fitness test is conducted to evaluate the progress of both groups after completing the training program. Similar to the pre-fitness test, the heart rate, blood pressure, and oxygen saturation levels are measured using the same equipment. The time taken by each participant to complete the 2.4-kilometer sessions on the treadmill is recorded again.

Finally, the data collected from both the pre- and post-fitness tests are compared to evaluate the effectiveness of the training program. The statistical analysis is performed to compare the average time taken by each group to complete the 2.4-kilometer sessions on the treadmill and to determine whether the training program has a significant impact on the physical fitness of the participants in the treatment group compared to the control group. The full form is provided in Appendix D.

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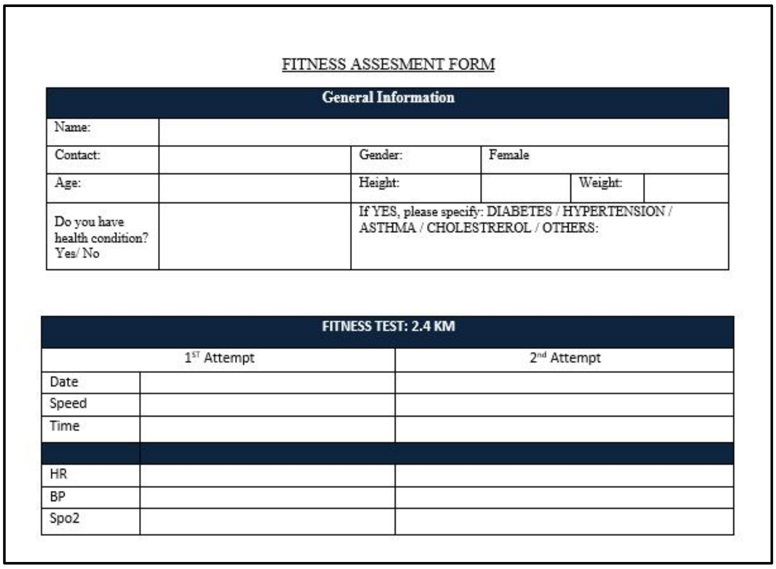


FITNESS ASSESMENT FORM

General Information					
Name:					
Contact:		Gender:	Female		
Age:		Height:		Weight:	
Do you have health condition? Yes/ No		If YES, please specify: DIABETES / HYPERTENSION / ASTHMA / CHOLESTREROL / OTHERS:			

FITNESS TEST: 2.4 KM		
	1ST Attempt	2nd Attempt
Date		
Speed		
Time		
HR		
BP		
Spo2		

Figure 3.6: Sample Fitness assessment form. (Appendix D)

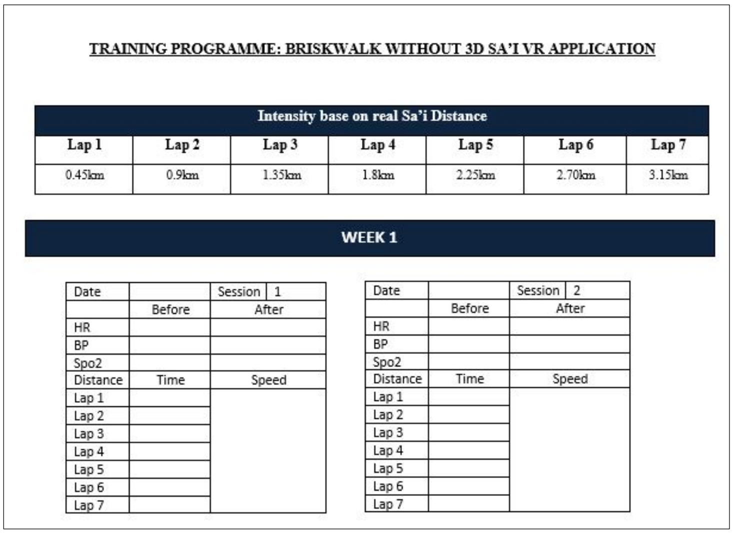
3.5.2.2a Training Programme Control group record

The control group in this study will engages in brisk walking on a treadmill without the 3D Sa'i VR application. Before starting the program, participants perform a warm-up to prepare their bodies for the exercise. The participants' HR, BP and SpO2 will be measured using smartwatches, pulse oximeters, and blood pressure monitors, respectively, to ensure they are in good physical condition to start the program. This pretest will establish a baseline for comparison with the posttest results.

During the program, the control group participants walk briskly on the treadmill and complete seven laps of the Sa'I distance, which has a total length of 3.15 km. Table 3.4 shows that each lap will gradually increase in distance until the total of seven laps is about 3.15 km (Ayoub, 2021). For the first lap, participants run briskly to the finish line, which is 0.45 km or 450 meters, and repeat this action until the total of seven laps is completed. After completing the program, the participants' HR, BP, and SpO2 are measured again for the posttest. This enables the researchers to compare the pretest and posttest results to determine the weekly health progress. A sample data collection form for the control group is presented in Figure 3.7. The full sample control group record for 4 weeks is provided in Appendix D.

Table 3.4: Sa'i distance base on the actual distance

Parameters involved in aerobic exercise (brisk walking):							
Distance:	Lap 1: (0.45km)	Lap 2: (0.9km)	Lap 3: (1.35km)	Lap 4: (1.8km)	Lap 5 (2.25km)	Lap 6 (2.70km)	Lap 7 (3.15km)


TRAINING PROGRAMME: BRISKWALK WITHOUT 3D SA'I VR APPLICATION

Intensity base on real Sa'i Distance						
Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7
0.45km	0.9km	1.35km	1.8km	2.25km	2.70km	3.15km

WEEK 1

Date		Session 1
	Before	After
HR		
BP		
Spo2		
Distance	Time	Speed
Lap 1		
Lap 2		
Lap 3		
Lap 4		
Lap 5		
Lap 6		
Lap 7		

Date		Session 2
	Before	After
HR		
BP		
Spo2		
Distance	Time	Speed
Lap 1		
Lap 2		
Lap 3		
Lap 4		
Lap 5		
Lap 6		
Lap 7		

Figure 3.7: Control group sample Training Programme form (Appendix D)

3.5.2.2b Training Programme Treatment group record

The treatment group in this study involves participants who engage in a fitness program using a 3D Sa'i VR application called "Fit 4 Sa'i." The program is conducted on a treadmill, and before starting, general data is collected, and the participants are instructed to do a warm-up. The pretest measurements for HR, BP, and Spo2 are taken and recorded using the instrument. These measurements serve as a baseline for comparison with the posttest results.

Then, the participants stand on the treadmill and follow the given instructions while walking briskly from Mount Safa to Mount Marwa, covering a distance of 0.45 kilometers. During the walk, participants experience a visual 3D model of the environment replicating Mount Safa and Marwa. This immersive experience provides a more engaging and enjoyable exercise experience for the participants, potentially leading to higher levels of adherence to the program.

To complete the program, participants must complete seven laps totaling 3.15 km. At the end of the program, the posttest measurements for HR, BP, and Spo2 are taken and recorded again using the same devices as the pretest. A sample data collection form for the treatment group is presented in Figure 3.8, which is used to record the pretest and posttest results. The full sample data collection is provided in Appendix C.

TRAINING PROGRAMME: BRISKWALK WITH 3D SA'I VR APPLICATION

Intensity base on real Sa'i Distance						
Lap 1	**Lap 2**	**Lap 3**	**Lap 4**	**Lap 5**	**Lap 6**	**Lap 7**
0.45km	0.9km	1.35km	1.8km	2.25km	2.70km	3.15km

WEEK 1

Date		Session	1
	Before	After	
HR			
BP			
Spo2			
Distance	Time	Speed	
Lap 1			
Lap 2			
Lap 3			
Lap 4			
Lap 5			
Lap 6			
Lap 7			

Date		Session	2
	Before	After	
HR			
BP			
Spo2			
Distance	Time	Speed	
Lap 1			
Lap 2			
Lap 3			
Lap 4			
Lap 5			
Lap 6			
Lap 7			

Figure 3.8: Treatment group sample Training Programme form

3.6 Pilot test

A pilot study is a small-scale preliminary study conducted before the main study to evaluate the feasibility and practicality of the research protocol. It is used to test and refine research procedures, methods, and instruments and to assess the adequacy of the sample size, power analysis, and statistical techniques. A pilot study helps identify potential problems or issues that may arise during the main study, such as recruitment difficulties, data collection errors, or unforeseen adverse events, and helps modify or improve the study design accordingly.

In this study, a pilot study was conducted using 10% of the sample size, which corresponds to 4 participants. According to Thabane et al. (2010), a common rule of thumb for determining the sample size of a pilot study is to use 10-20% of the main study sample size. By using this guideline, the researchers were able to conduct a pilot study with an appropriate sample size, without wasting resources or compromising the main study.[73]

The purpose of the pilot study is to test the feasibility and acceptability of the intervention and to refine the study design before conducting the main study. The pilot study included two groups, a control group and a treatment group, with two participants assigned to each group. The participants are required to be between the ages of 18 and 29, the same age and gender, and physically fit to conduct the training and fitness test. The goal of the study is to determine whether the health performance of Hajj pilgrims improves during the training, and to assess the suitability of the intervention for implementation in a real experiment. Additionally, conducting a pilot study can save costs and time before a test is conducted during the actual pilgrimage.

3.6.1 Validity

Validity in research refers to the degree to which a study accurately measures. In the context of developing 3D environments, validity is crucial to ensuring that the environment is an accurate and realistic representation of the physical space or location being modeled. Validity is particularly important in applications such as the 3D Sa'I VR application for Hajj pilgrims, as the environment needs to accurately represent the physical features and layout of Hill Safa and Marwa, which are important religious sites for Muslim pilgrims.

Construct validity is one type of validity that is particularly important in the development of 3D environments. Construct validity refers to the extent to which a measurement tool or instrument accurately captures the concept or construct it is intended to measure (Trochim, 2021).[74] In the context of developing a 3D environment, construct validity is important to ensure that the environment

[73] Thabane, L., Ma, J., Chu, R., Cheng, J., Ismaila, A., Rios, L. P.& Goldsmith, C. H. (2010). A tutorial on pilot studies: the what, why and how. BMC medical research methodology, 10(1), 1-10.
[74] Trochim, W. M. K. (2021). The research methods knowledge base. Atomic Dog.

accurately captures the physical features and characteristics of the site being modeled. For example, in the case of the 3D Sa'I VR application, construct validity ensures that the 3D environment accurately captures the terrain, location, and dimensions of Hill Safa and Marwa. This involves gathering data on the physical characteristics of the site, such as the elevation, slope, and size of the hills, and using this data to accurately model the environment in 3D.

Another type of validity that is important in the development of 3D environments is face validity. Face validity refers to the extent to which a measurement tool or instrument appears to be measuring what it is intended to measure (Trochim, 2021). In the context of developing a 3D environment, face validity is important to ensure that the environment appears to be a realistic and accurate representation of the site being modeled. For example, in the case of the 3D Sa'I VR application, face validity ensures that the 3D environment appears to be a realistic and accurate representation of Hill Safa and Marwa to individuals who are familiar with the site. This involves gathering feedback from individuals who have visited the site, including through coordination with organizations such as the Ministry of Religious Affairs.

Since MoRA is the government agency responsible for organizing and facilitating the Hajj pilgrimage for citizens of the country, it plays an important role in ensuring the accuracy and validity of the 3D Sa'I VR application, as they have extensive experience and knowledge of the pilgrimage and the physical layout of the sites involved. MoRA can provide valuable feedback on the accuracy of the 3D environment, as well as information on any potential challenges or issues that pilgrims may encounter during the pilgrimage.

In summary, ensuring the validity of 3D environments is crucial to developing accurate and realistic representations of physical spaces and locations. Construct validity and face validity are two types of validity that are particularly important in the development of 3D environments. The Ministry of Religious Affairs (MoRA) plays an important role in ensuring the accuracy and validity of the 3D Sa'I VR application, given their expertise and knowledge of the pilgrimage and the physical layout of the sites involved.

Validating and ensuring the reliability of a true experiment to measure the effectiveness of a training program using the 3D Sa'I VR application requires careful attention to the design and implementation of the study. Several key steps can be taken to ensure the accuracy and reliability of the data:

1. Use a randomized controlled design to ensure that any observed differences between the treatment and control groups can be attributed to the training program.
2. Measure participants' performance before and after the training program using standardized and reliable measures.
3. Use reliable and valid data collection tools, such as the performance record of the participants.
4. Conduct pilot testing to ensure that the study design and data collection tools are feasible and effective.
5. Use proper statistical analysis to determine the significance of any observed differences between the treatment and control groups.

3.6.2 Reliability

Reliability is an important aspect of data collection in research, especially when it comes to performance verification. It refers to the consistency and stability of the measurements obtained through a particular method or instrument. One common technique used to assess the reliability of data collected in research studies is the test-retest method. This method involves measuring the same variable multiple times over a period of time, and then comparing the results obtained at each time point to assess the degree of consistency or agreement between the measurements.

For instance, in a study on the effectiveness of a training program using the 3D Sa'I VR application for improving walking speed, the test-retest technique can be used to assess the reliability of the performance recordings of the participants during a brisk walk. The performance recordings can be collected multiple times, and the measurements obtained can be compared to determine the correlation between the measurements obtained at different time points. One study that used the test-retest method to assess the reliability of data collected during a performance test for individuals with Parkinson's disease is by Rikli and Jones (1999). [75] They found that the test-retest method was a reliable method for assessing the physical performance of individuals with Parkinson's disease. Another study by Kaya et al. (2019) used the test-retest method to assess the reliability of the Timed Up and Go test in individuals with chronic obstructive pulmonary disease (COPD), and found that the method was a reliable way to assess physical performance in individuals with COPD.[76]

3.7 Data analysis

To evaluate the effectiveness of the 3D Sa'i VR application on the training program for Hajj pilgrims (objective 2a), the researcher uses the paired t-test approach to compare the performance of the control group to the treatment group shown in Table 3.5. The paired t-test is a statistical method commonly used to compare the means of related groups. The results allow the researcher to determine whether the differences between the two groups are significant or not, enabling them to draw conclusions about the effectiveness of the treatment.

In addition, to measure the weekly cardiorespiratory fitness of the Hajj pilgrims (objective 2b), the researcher uses a repeated-measures ANOVA to analyze the changes in heart rate, blood pressure, and oxygen saturation over time. The researcher reports descriptive statistics like mean, standard deviation, and range for each variable. To analyze the data, the researcher uses the SPSS software, which is

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[75] Rikli, R. E., & Jones, C. J. (1999). Development and validation of a functional fitness test for community-residing older adults. Journal of Aging and Physical Activity, 7(2), 129-161.

[76] Kaya, B., Karadibak, D., Karaman, E. Y., & Günaydın, R. (2019). Reliability and validity of the Timed Up and Go test in community-dwelling elderly individuals with chronic obstructive pulmonary disease. Archives of Rheumatology and Rehabilitation, 34(3), 293-299.

a widely used statistical software that creates charts to provide a visual representation of the data and results of the paired t-test. In conclusion, data analysis is a critical step in the research process that allows researchers to draw meaningful conclusions from their data. By using appropriate statistical methods and software tools, researchers can analyze and interpret their data quickly and efficiently, leading to more accurate and reliable results.

Table 3.5: Sample of Paired t-test

Paired t-test					
Group A (Control group)			**Group B (Treatment group)**		
Participants	Pre-Test fitness test	Post-test fitness test	Participants	Pre-Test fitness test	Post-test fitness test
Participant 1			Participant 1		
Participant 2			Participant 2		
Participant 3			Participant 3		
Participant 4			Participant 4		
Participant 5			Participant 5		

3.9 Conclusion

In conclusion, the aim of the study is to investigate the impact of exercise on the cardiorespiratory changes of Hajj pilgrims using an experimental design and a quantitative research method. The study is carried out on a specific group of Hajj pilgrims who participated in a training and fitness program in the laboratory of UNISSA. To ensure the validity of the research, the researchers conducted a comprehensive study, taking into account all possible factors that could impact the results. The paired T-test is used as a statistical technique for data analysis and reliability assessment. By comparing the control group (Group A) with the treatment group (Group B) before and after the exercise program, the researchers are able to determine if there is a significant difference between the two sets of data. The data is analyzed using SPSS software, a widely-used statistical package that provided a range of tools and techniques for data analysis. This enables the researchers to create statistical charts, tables, and graphs to better understand and interpret the data. The results obtained from this study are used to draw conclusions about the cardiorespiratory changes of Hajj pilgrims during exercise, and can be used to inform future research and policy decisions.

CHAPTER FOUR:
DESIGN AND DEVELOPMENT

4.1 Introduction

This chapter has provided an in-depth overview of the development process involved in creating the 3D application Sa'i VR. The development of a virtual reality application involves integrating several components, including both hardware and software, which connect display and input devices. The development process for Sa'i VR involved collecting various materials such as the structural design of Safa and Marwa mountains, models of male and female pilgrims, and the measurement of the distance required for seven rounds to complete the Sa'i.

To convert the collected materials into a digital format, different software such as Unity, Adobe Photoshop, Blender, and others were utilized. The integration of hardware requirements such as determining the application's performance, scalability, and availability is also an essential aspect of the development process.

Overall, developing a virtual reality application requires careful planning, meticulous attention to detail, and expertise in both software and hardware. The development of Sa'i VR aims to create a seamless experience for Hajj pilgrims, enabling them to perform the Sa'i in a virtual environment that closely mirrors the actual pilgrimage site, ultimately enhancing their understanding and preparation for the Hajj journey.

4.2 Project Prototype Design Methodology

According to Jones (2014), for the System Development Life Cycle (SDLC) of this project, an Agile model is recommended due to its iterative and incremental approach that focuses on process adaptability and user satisfaction through rapid delivery of working software. [77]Agile methods break the project into sub-projects, which are then divided into smaller iterations. Each iteration is designed to manage specific areas of the sub-project, such as design, development, and testing, before delivering a working product.

The Agile model is highly flexible, making it ideal for projects that involve changing requirements or those that require a high degree of user involvement. By delivering working software in short iterations, the research can provide feedback early on, and can make adjustments quickly.

In summary, the Agile model is recommended for this study due to its iterative and incremental approach, focus on process adaptability and user satisfaction, and ability to handle changing requirements and uncertain environments.

4.3 Software Requirement

Software requirement refers to the necessary software components needed to develop or run an application or system. These components include software tools, libraries, and frameworks that are essential for the development process. In the context of developing the 3D application Sa'i VR, several software tools are required to create a fully functional virtual reality experience. Unity, Blender, and Adobe Photoshop were some of the software tools used in the development process. Unity is a game engine that helps in developing interactive applications, while Blender is a 3D computer graphics software used for creating animations, models, and simulations. Adobe Photoshop, on the other hand, is a raster graphics editor used for image editing and manipulation. It is essential to carefully select the appropriate software tools required to develop the application. The software tools should be compatible with each other, efficient, and meet the functional requirements of the application. A list of the software development tools used in the development of the 3D application Sa'i VR is shown in Table 4.1.

[77] Jones, C. (2014). Software Engineering: A Methodical Approach (2nd ed.). CRC Press.

Table 4.1: List of software requirement

Unity		Cross-platform game engine and integrated development environment (IDE) used to create interactive 2D and 3D content and simulations. Unity allows developers to create and deploy content on multiple platforms, including Windows, Mac, Linux, Android, iOS, and various game consoles. It provides a range of tools and features such as physics simulation, audio and video playback, and asset management.
Blender		Free and open-source 3D creation software. It is a comprehensive tool for creating 3D models, animations, simulations, visual effects, and rendering solution.
Adobe Photoshop		Image editing software that allows users to manipulate and enhance digital images with a wide range of tools and features. It can also be used for 3D modelling, animation, and rendering.
Adobe Illustrator		A variety of tools and features that allow users to create and edit vector graphics such as logo, typography and illustrations. It sports a range of formats including AI, EPS, SVG and PDF.
Microsoft Word		A graphical word processing program that allows to create, format and edit documents.
Microsoft Excel		To support in the development of plans, the assignment of resources to tasks, the tracking of progress, and more.
Microsoft PowerPoint		To present things visually and easily incorporate other media.

4.4 Hardware Requirement

In software development, hardware requirements refer to the minimum or recommended specifications for the computer or device that is used to run or develop the software. The hardware plays a critical role in determining the performance, scalability, and availability of the development process. There are two main types of hardware required for software development: development hardware and experimentation hardware. Development hardware refers to the computer or device used for coding, testing, and debugging the software. It is essential that the development hardware meets the minimum or recommended specifications to ensure that the software can be developed efficiently and effectively.

Experimentation hardware, on the other hand, refers to the devices or equipment used for testing the software in different environments, such as different operating systems or hardware configurations. This hardware should also meet the minimum or recommended specifications to ensure accurate testing results. In summary, having a high-end computer with appropriate hardware specifications is crucial for software development, especially for applications that involve modelling and rendering of virtual environments. Both development and experimentation hardware must meet the minimum or recommended specifications to ensure efficient and effective software development and testing.

4.4.1 The Development Hardware specification:

The Development Hardware specification typically refers to a set of requirements, guidelines, or standards that define the minimum or recommended hardware specifications for building, testing, and deploying software applications or systems. These specifications include various components such as the processor type and speed, memory capacity, storage capacity, graphics card, input/output interfaces, and networking capabilities required for the development, debugging, and optimization of software applications.

Development hardware specifications may vary depending on the type and complexity of the software being developed, the development environment, and the target platform or operating system. Following to these specifications can ensure that the software application is optimized for performance, reliability, and compatibility with the hardware and software environment. For example, Table 4.2 provides a comprehensive overview of the development hardware employed in the study.

Table 4.2: Development Hardware Specification

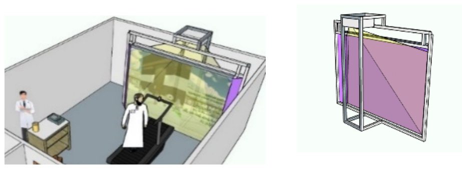
Development Hardware		
Monitor	AOC monitor	
CPU	Tecware Gaming Cases	
Aoc Peripherals	Keyboard / KM200 / Wireless	
Processor	AMD Ryzen Processor	
Installed memory (RAM)	Team group ram 8GB DDR4 / 3200MHz	
Operating System	Windows 10 Pro	
Motherboard	Asrock motherboard	
Hard drive	Toshiba 1TB	
Aerocool Power supply	VX Plus / 600W	

4.4.2 Experiment Hardware specification:

Experiment hardware specification refers to the specific details of the physical equipment utilized in an experiment, such as sensors, measurement instruments, control systems, and other devices necessary to conduct the experimental procedure. This description usually includes information such as the make and model of each component, its physical dimensions, accuracy, sensitivity, range, resolution, and other relevant characteristics. For example, Table 4.3 provides a comprehensive overview of the experiment hardware employed in the study.

Table 4.3: Experiment/ Testing Hardware Specification

Experiment Hardware	
	
Amazfit Bip U Pro	
Compatibility	Android 5, IOS 10 above
Software	Real-time operating system (RTOS)
Connectivity	Bluetooth 5.0 and Alexa support
Application	Zepp Application
Sport Modes	60+ Built-in Sports Modes with High-precision GPS
Sensor	BioTracker™ 2 PPG Biological Optical Sensor, Acceleration sensor, Gyroscope sensor and Geomagnetic sensor
Features	Blood-oxygen level measurement, Sleep quality monitoring, Heart Rate tracking, PAI Health Assessment System, Stress Monitoring and Menstrual Cycle Tracker
	
U'REVO Walking Device U1	
Maximum Load	90kg
Speed	Lowest - 0.8km/h and Maximum – 6.0km/h
Waking cloth area	1200 x 400 mm
Sport Mode	Walking, Speed walking and running.
Features	• Exercise date is clearly displayed on the LED HD Display. • 6.5cm compact design and ultra-thin body • Wireless hand-held remote control. • Innovative Integrated Frame Design to reduce noise during movement. • 7 protection (Anti-slip, Anti-deviation, Child lock protection, warning sign, no-load protection, speed limit and accident insurance.)

			
Omran Blood Pressure Monitor		Frankever Fingertip Pulse Oximeter.	
Features	• LCD Display Last Reading Memory • Oscillometric Method • Automatic Pressure Release and Exhaust Valve	Features	• Two Color OLED Display with 4 display modes: Sp02 : Range:0-100%, Pluse rater, Plus waveform: Up to 240 BPM • Automatic power off when no signal.
			
Display Frame			
Features:	To display the application.		
			
Projector			
Features:	An output device that can project computer-generated images onto the display screen		

4.5 Development process

The development process of a 3D VR application involves multiple stages, including initiation, planning, design, development, testing, and deployment. Figure 4.1 provides a visual representation of the step-by-step process involved in developing a 3D VR application from start to finish. During the initiation stage, the purpose and target audience of the application are defined, along with any required features and functionalities. Once the concept is finalized, the 3D model is created using specialized 3D software using Blender, which allows for the creation of complex 3D objects and environments. After the 3D model is complete, it is imported into a game engine using

Unity. Game engines provide tools and functionalities for integrating the 3D model with other assets such as textures, sounds, and animations, and for adding interactivity and game mechanics to the application. During the development stage, the 3D VR application is typically tested and refined to ensure it meets the desired performance, user experience, and functional requirements. Once the application is fully developed and tested, it can be deployed on various desktop computer platforms.

Overall, developing a 3D VR application requires careful planning, specialized tools, and a skilled team with expertise in 3D modeling, game development, and user experience design. By following a structured development process and adhering to best practices and standards, developers can create high-quality 3D VR applications that are engaging, immersive, and effective for a variety of purposes.

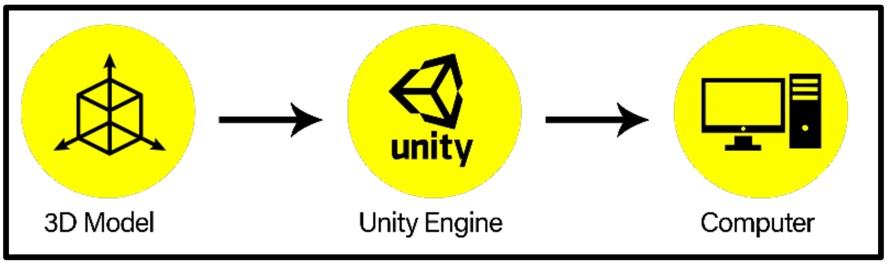


Figure 4.1: Workflow of the development process.

4.6 Storyboard

The storyboard shown in Figure 4.2 provides a visual representation of the flow of the 3D VR application. The application consists of five scenes, which are integrated into Unity after being developed using specialized 3D software such as Blender.

- When the user launches the application, a splash screen appears, which serves as an introductory screen that briefly displays the application's branding or logo. After the splash screen, the user is taken to the main menu, which contains three buttons: Start, Exit, and About.

- If the user clicks the About button, the application displays a brief scene containing developer information. This scene serves as a way to give credit to the individuals involved in creating the application.

- If the user clicks the Start button, they are redirected to the Safa and Marwah 3D environment. Before entering the environment, the user receives instructions on how to interact with the application.

- Finally, the user can close the application at any time by clicking the Exit button. This immediately closes the program and returns the user to the operating system.

Overall, the storyboard provides a clear overview of the flow of the application and how it is structured into different scenes that can be navigated by the user. This structure helps ensure that the user experience is intuitive and straightforward, allowing them to engage with the 3D environment without encountering any obstacles or confusion.

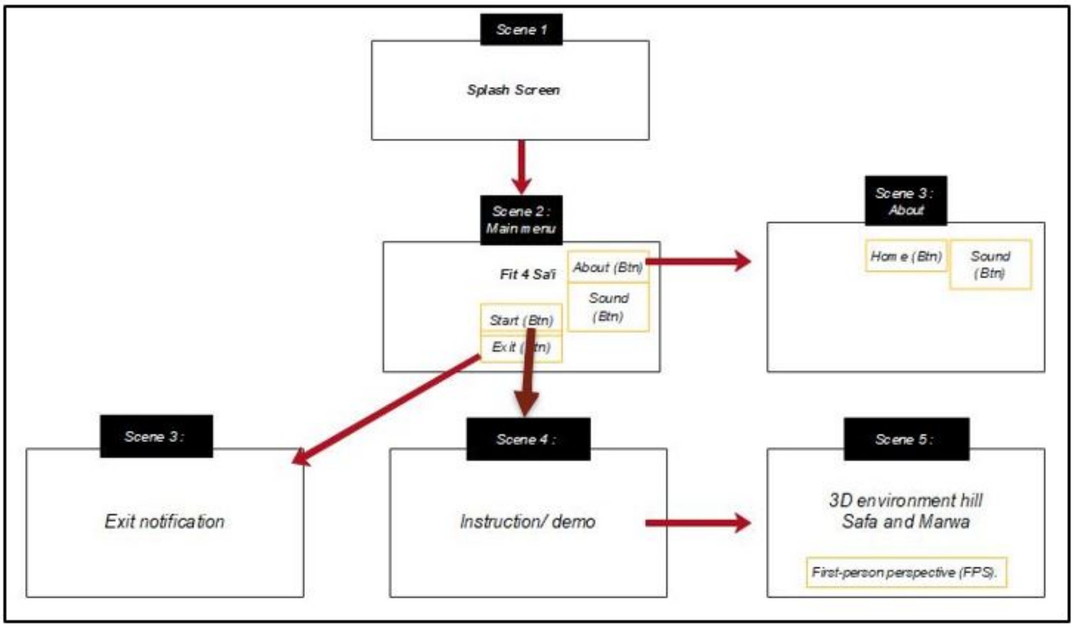


Figure 4.2: Flow of the application step by step.

4.7 Overview distance of Sa'i

In the context of the application being developed, a "round" refers to a walk from one mountain to another, namely Mount Safa and Mount Marwa. This route is shown in Figure 4.3 and is an important part of the religious pilgrimage known as Hajj. It is believed to have been walked by the Prophet Muhammad and his wife, Khadijah, and is a significant ritual for Muslims around the world.

It's important to note that a "lap" is not the same as a round trip from one peak to the next. Instead, a lap refers to a complete circuit of the route, starting and ending at the same point. In the case of the route between Mount Safa and Mount Marwa, the first round starts at Mount Safa and ends at Mount Marwa. The second lap then goes in the opposite direction, starting at Mount Marwa and ending at Mount Safa, with the final stop being on Marwah hill. The application is set up to include this route and lap structure for users to follow during the pilgrimage simulation. To complete the full ritual, users need to complete seven laps, which is approximately equivalent to walking 3.15 kilometers.[78] Overall, the design of the application and the use of this route in the experiment aim to provide an immersive and interactive experience of the Hajj pilgrimage, allowing users to engage with the ritual in a virtual environment.

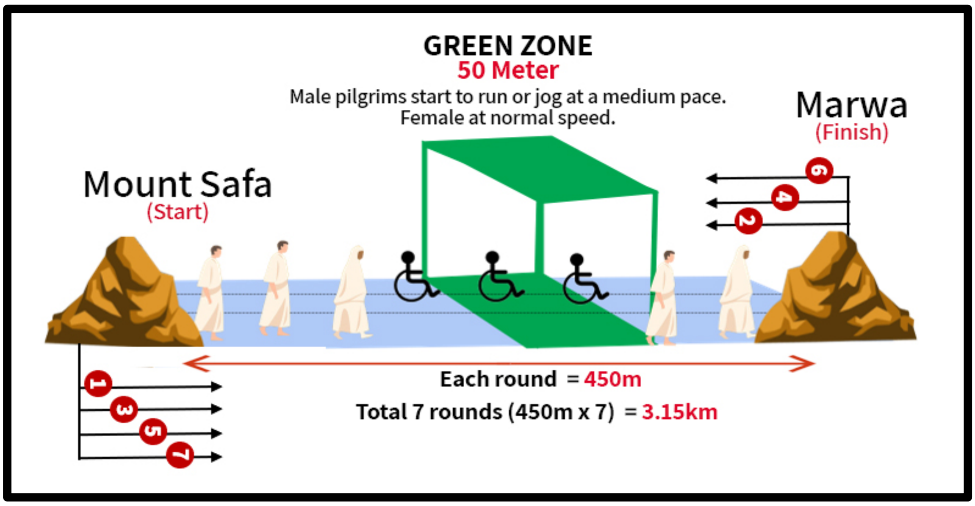


Figure 4.3: Information distance

[78] Al-Samarraie, H., Al-Musawi, M., & Al-Janabi, S. (2021). A Virtual Reality Simulation for the Hajj Pilgrimage Ritual. Journal of Physics: Conference Series, 1776, 020030. doi:10.1088/1742-6596/1776/1/020030

4.8 Digital Sketch structure of hill Safa and Marwa

Digital sketch structures are essential tools for researchers, as they allow for the visualization of complex structures or spaces that may be challenging to convey through text or verbal communication. In fields such as product design, where clear and precise communication is crucial, digital sketch structures enable researchers to communicate design ideas and concepts effectively. Moreover, digital sketch structures facilitate feedback and revisions, allowing researchers to quickly and efficiently make changes and reduce errors in the design process. This ultimately save time and money in the long run. In summary, digital sketch structures are essential tools for researchers and designers to visualize, communicate, and refine their design ideas and concepts, leading to a faster and more accurate design process. The digital sketch of the 3D Sa'i VR development below is a prime example of how digital sketches can be utilized in research. In the following section, the researcher briefly describes and showcase the digital sketch of the 3D Sa'i VR development.

Figure 4.8 is a visual representation of a virtual environment that is created using the ground floor of Mas'a as a basis. The ground floor of Mas'a is digitized using 3D modeling software, which allowing for the creation of a highly detailed digital replica of the space. The virtual environment includes various elements such as walls, floors, and other architectural features that closely resemble the real-world environment of Mas'a. Furthermore, the virtual environment includes a start label for Safa, which is an important element for those who perform the Sa'i ritual during Hajj. The start label indicates the beginning of the Sa'i ritual, which involves walking seven times back and forth between the mount Safa and Marwah.

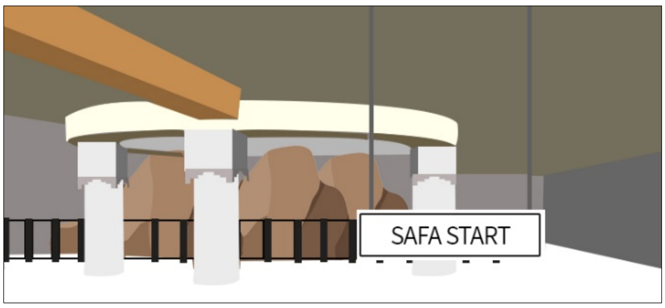


Figure 4.4: Starting point

The use of digital sketching in research is becoming increasingly popular as it provides a more accurate and detailed representation of objects or environments. Figure 4.5 depicts a digital sketch that shows a large rock placed within a glass-fenced are in the middle of Mount Safa. The digital sketch is likely created using 3D modeling software, allowing for precise placement of the rock and an accurate representation of its size and shape in relation to its surroundings. Figure 4.6 shows a different perspective with Mount Marwah visible in the background. In this view, the rock is flattened through digital manipulation, creating the illusion that it is lying flat on the ground.

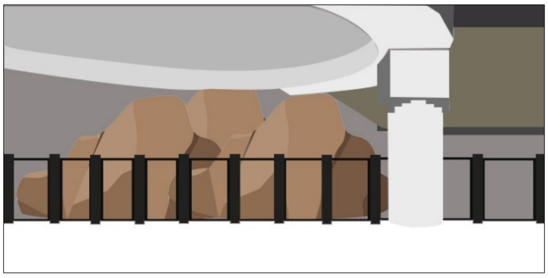


Figure 4.5: Safa Hill's rock

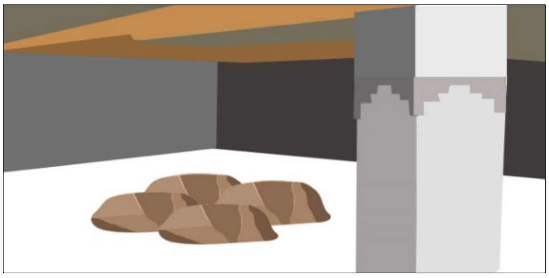


Figure 4.6: Marwah Hill's rock

4.9 Process modeling of the 3D pilgrim's character

The process of creating a 3D character model typically involves several key steps and techniques. These include:

a. **Sketching**: This involves creating a fast sketch that captures the important details of the character or scene that will be modeled in 3D. The sketch serves as a rough guide or blueprint for the subsequent modeling and texturing phases.

b. **3D Modeling**: This is the process of transforming the sketch into a 3D digital model. This involves using specialized software tools to create a detailed 3D mesh of the character, which includes defining the shape, size, and proportions of the character.

c. **Texturing**: Once the 3D mesh is created, the next step is to apply textures and materials to the object. This involves adding color, patterns, and other visual elements to the character to make it look more realistic and visually appealing.

d. **Rigging**: This involves giving the 3D mesh a skeleton or framework that allows the mesh to rotate and move in a lifelike manner. This is an important step for creating animations and realistic movements for the character.

e. **Animation**: Once the rigging is complete, the final step is to create animations for the character. This involves creating movement sequences for the character, such as walking or jumping. The animations are created by setting the appropriate actions and movements for the character in the scene.

Overall, creating a 3D character model requires a combination of artistic and technical skills, as well as a thorough understanding of specialized software tools and techniques.

4.10 Character and 3D Environment Development

4.10.1 Character Female and Male pilgrim's sketch

Before creating a three-dimensional digital model, the research first sketches a rough outline of the character on paper, as shown in Table 4.4. This initial sketch represents the basic idea or concept and allows to explore different ideas and variations. Once the sketch is complete, the research uses specialized software to turn the sketch into a 3D model, which can then be refined and tested for functionality as shown in Table 4.5.

Table 4.4: Character sketch on paper

<table>
<tr><th>Female</th><th>Male</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

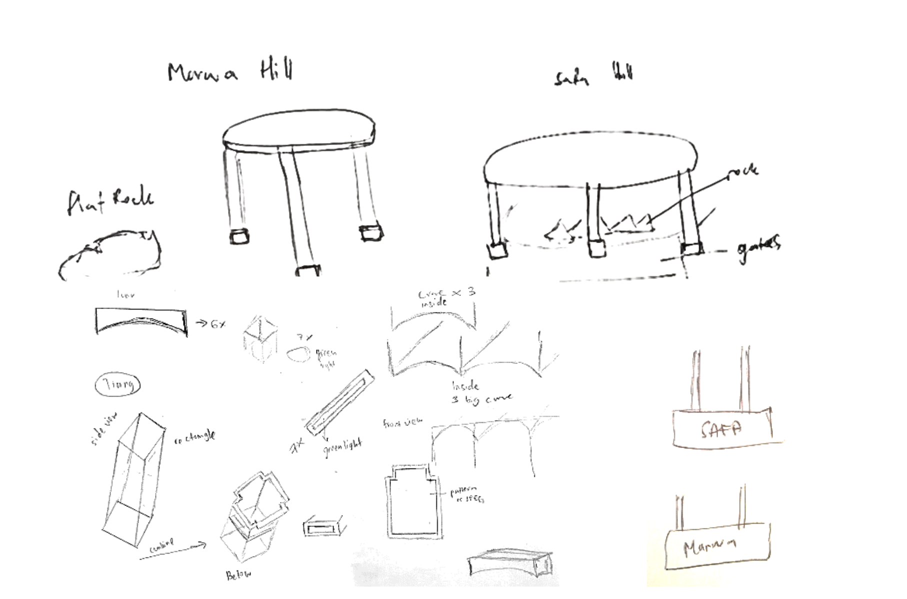
4.10.2 Character Female and Male 3D model

Table 4.5: Character 3D Model

Female	Male
	

4.10.3 Hill Safa and Marwa environment sketch

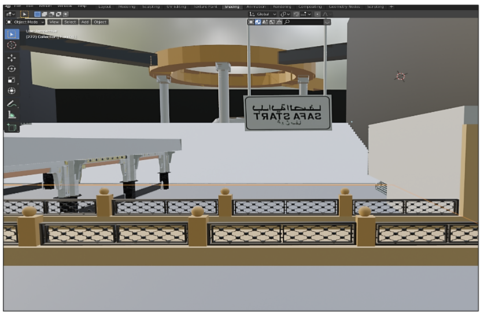
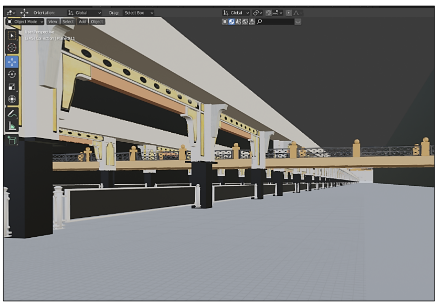
Table 4.6: Environment sketch Safa and Marwa Hill



4.10.4 3D Environment of Hill Safa and Marwa

Table 4.6 shows the 3D environment of Mount Safa and Marwah from the participant's perspective in first-person view (FPS). After completing the 3D model of the object, the researcher proceeds to implement it in Unity. Application implementation in Unity involves using the Unity engine to create and develop software applications, such as games, simulations, and other interactive experiences. Unity provides developers with a range of tools and features, including a powerful game engine, a visual editor, support for various programming languages, and a vast library of assets and plugins. To implement the object in Unity, the researcher designs the user interface, create game mechanics, program interactive behavior, test the application, and deploys it to different platforms, such as desktop. Unity is widely used for application development because it supports a wide range of platforms and devices, making it a versatile platform for developing software applications.

Table 4.7: 3D Environment Safa and Marwa Hill

<table>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Pathway to Safa Hill</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Path toward hill Marwah.</td><td>The Marwah Hill</td></tr>
</table>

4.11 Prototype Development

4.11.1Application Logo

	A representation of the application as an image on the computer screen.

4.11.2 Splash Interface

Splash screen

When a user opens the application, the first interface that appears is known as the Splash Screen. This screen serves as a welcoming screen and provides users with a brief introduction to the application. Typically, the splash screen displays an image or animation, and it may also provide information about the application's features or functionality. In the case of this application, the Splash Screen displays the university logo to symbolize the identity of the university. By doing so, it creates a sense of familiarity and connection between the user and the university. Additionally, it helps to establish the application's branding and reinforces the university's image and reputation.

4.11.3 Main Menu Interface

Main Menu Screen

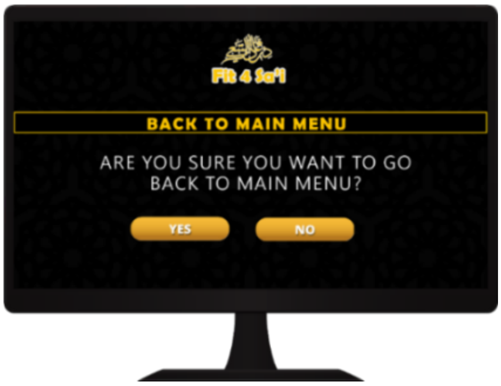
This interface contains a total of 5 buttons, including the Start, Exit, Information, and Sound buttons. Each button serves a specific purpose in the application.

	Start button - proceed to 3D environment mount Safa and Marwa.
	Exit Button – to exit the application.
	Information Button – desctiptoion about application.
	Unmute Button – to turn on audio sound.
	Mute Button – to turn off audio sound.

4.11.4 3D Environment of Mount Safa and Marwa Interface

3D environment of Mount Safa and Marwa Screen

4.11.5 Exit Interface



Exit Screen

Before closing the application, a warning message is displayed to the user. This message typically contains a warning or confirmation that the user is about to exit the application, and it may also provide additional information or instructions.

	Yes button - close the application.
	No button – will back on the 3D scene.

4.11.6 Information Interface ('i' button)

Information Screen

The application's main screen displays a description of the application's purpose and features. This description provides users with an overview of what the application does and what they can expect from it.

	Home button – proceed to Main Menu screen.
	Unmute Button – to turn on audio sound.
	Mute Button – to turn off audio sound.

The main screen also contains three buttons - the home button, Mute button, and Unmute button. The Home button allows users to return to the application's main menu or home screen. The Mute button enables users to turn off the application's audio or sound effects. The Unmute button allows users to turn on the audio or sound effects if they have been previously muted. Together, these buttons provide users with easy navigation and control over the application's features and functionality.

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Introduction

In this chapter, the primary focus is on the research findings that were obtained through the study. The second research question, which was broken down into two sections (a and b) in the first chapter, was developed to assist the researcher in identifying the objectives of the study. To answer this question, quantitative data resulting from the experiment is briefly explained. The purpose of this research is to investigate and analyze the relationship between two variables. Through a rigorous experimental design and the use of appropriate statistical techniques, the data collected provided valuable insights into the nature of this relationship.

5.1.1 Description of Samples

Table 5.1: Gender Demographic information

Variable	Classification	Frequency	Age group	Total of pilgrims
Control Group	Male	5	23- 29 years old	20
	Female	5		
Treatment Group	Male	5		
	Female	5		

Table 5.1 provide the frequency of the demographic information of pilgrims involved in the experiments consisting of gender and age range. Based on the information presented in the study, a total of 20 participants are included, who are separated in two groups: a control group and a treatment group. Both groups comprised 5 males and 5 females, with participants aged between 23 and 29. Each group had participants at ages 23, 25, 27, 28, and 29.

As a result, the study's sample is limited to individuals between the ages of 18 and 29. This age range is chosen because participants needed to be willing and able to commit to the training program. To ensure similar age and gender characteristics in the sample, participants are selected based on their age and gender. Additionally, participants need to be in good physical condition and able to commit to the training schedule.

Research Question 2a: What is the impact of using the 3D Sa'i VR application on the effectiveness of a training program for Hajj pilgrims?

5.2 The impact of using the 3D Sa'I VR application on the effectiveness of the training program for Hajj pilgrims

The hypothesis to test in this case is whether there is a significant difference in the pretest and posttest times between genders for groups A and B.

Null hypothesis (H_0): There is no significant difference in the pretest and posttest times between genders for groups A and B.

Alternative hypothesis (H_A): There is a significant difference in the pretest and posttest times between genders for groups A and B.

A t-test can be used to determine if there is a statistically significant difference between the pretest and posttest times for the female participants in group A (control group). However, before performing the t-test, there are some assumptions that need to be met, such as:

1. The sample is randomly selected.
2. The sample is normally distributed.
3. The variances of the pretest and posttest times are equal.

Assuming that these assumptions are met, researcher can perform a paired samples t-test to determine if there is a significant difference between the pretest and posttest times. The null hypothesis for the t-test is that there is no difference between the mean pretest time and the mean posttest time, while the alternative hypothesis is that there is a significant difference between the mean pretest time and the mean posttest time.

Performing the t-test using statistical software or calculator, researcher get the t-value and the p-value. If the p-value is less than the significance level (commonly set at 0.05), researcher reject the null hypothesis and conclude that there is a statistically significant difference between the pretest and posttest times.

5.2.1 Paired t-test analysis Female and Male for both groups 2.4km Fitness Test.

In the paired t-test analysis examines whether there is a significant difference in the effectiveness of the training program between the treatment group (Group B), which uses the 3D Sa'i VR application, and the control group (Group A), which does not use it. The study measures effectiveness using pre and posttest 2.4km fitness tests, where the times are recorded in minutes and seconds. The data is presented in a tabular format below.

5.2.1.1 Female Group A (Control Group) pre and posttest 2.4km Fitness Test

Table 5.2: Data of Group A 2.4km Fitness Test

Group A (Control Group)			
Female ID	Age	Pretest Female	Posttest Female
F1_CG	29 years old	38.30 mins	38.08 mins
F2_CG	28 years old	39.51 mins	39.10 mins
F3_CG	27 years old	36.35 mins	35.58 mins
F4_CG	25 years old	35.40 mins	34.55 mins
F5_CG	25 years old	37.40 mins	37.09 mins

Group A	**M**	**Std**	**t**	**df**	**Sig**
Group A Female Pretest Group A Female Posttest	.51 200	.28164	4.065	4	.015

Based on Table 5.2 the data is being analyzed to examine the results of the female control group training program, which does not utilize the 3D Sa'I VR application. The analysis revealed that the mean improvement in the group's performance from pretest to posttest was 22 seconds to 29 seconds, with a mean of M = 0.51 and a standard deviation of SD = 0.29. The paired t-test showed a statistically significant improvement in performance, t(4) = 4.065, p = 0.015. These results indicate that all five female participants in the control group show improvement in their performance from pretest to posttest.

5.2.1.2 Female Group B (Treatment Group) pre and posttest 2.4km Fitness Test

Table 5.3: Data of Group B 2.4km Fitness Test

Group B (Treatment Group)			
Female ID	Age	Pretest Female	Posttest Female
F1_TG	29 years old	39.36 mins	38.58 mins
F2_TG	28 years old	35.35 mins	34.35 mins
F3_TG	27 years old	38.20 mins	37.59 mins
F4_TG	25 years old	35.40 mins	34.40 mins
F5_TG	25 years old	36.20 mins	35.55 mins

Group B (Treatment Group)	**M**	**Std**	**t**	**df**	**Sig**
Group B Female Pretest Group B Female Posttest	.80800	.8327	9.703	4	.001

The results of the female control group training program that utilize the 3D Sa'I VR application are presented in Table 5.3 The mean improvement in the group's performance from pretest to posttest was 20 seconds to 50 seconds, with a mean of M = 0.81 and a standard deviation of SD = 0.83. The paired t-test analysis indicated a statistically significant improvement in performance, t(4) = 9.703, p = 0.001. These results suggest that all five female participants in the control group using the 3D Sa'I VR application show improvement in their performance from pretest to posttest.

5.2.1.3 Combine result Female Group A and Group B 2.4km Fitness Test

Table 5.4: Data combine Group A and B 2.4km Fitness Test

Female	M	Std	t	df	Sig
Group A (Control Group)	0.51	0.29	4.065	4	.015
Group B (Treatment Group)	0.81	0.19	9.703	4	.001

Table 5.4 presents the combined results of the female treatment group (using the 3D Sa'i VR application) and the female control group (without the 3D Sa'i VR application) to investigate the effect of the 3D Sa'I VR application on the training program. The mean improvement in performance for the treatment group was M = 0.81, SD = 0.19, with a paired t-test result of t (4) = 9.703, p = 0.001. Meanwhile, the control group had a mean improvement of M = 0.51, SD = 0.29, and a paired t-test result of t (4) = 4.065, p = 0.015. When comparing the p-values for Group A and Group B, the results showed p = 0.015 and p = 0.001, respectively. These findings suggest that the 3D Sa'I VR application had a significant effect on the training program for Hajj pilgrims, as the time distance of the participants decreased during the post 2.4km Fitness test. These results support Hypothesis 1.

5.2.1.4 Male Group A (Control Group) pretest and posttest 2.4km Fitness Test

Table 5.5: Data of Male Group A 2.4km Fitness Test

Male Group A (Control Group)			
Male ID	Age	Pretest Male	Posttest Male
M1_CG	29 years old	36.50 mins	36.00 mins
M2_CG	28 years old	33.36 mins	32.50 mins
M3_CG	27 years old	34.40 mins	34.00 mins
M4_CG	25 years old	32.20 mins	31.30 mins
M5_CG	25 years old	31.30 mins	30.45 mins

Group A	M	Std	t	df	Sig
Group A Male Pretest Group A Male Posttest	.70200	.23350	6.723	4	.003

The outcomes of the male control group's training program, which do not use the 3D Sa'I VR application, are analyzed using the data from Table 5.5 The results revealed a significant improvement in the group's performance from pretest to posttest (M = 0.70, SD = 0.23; t(4) = 6.723, p = 0.003). All five male participants in the control group demonstrated an average improvement of 34 seconds to 1 minute and 10 seconds between their pretest and posttest performance.

5.2.1.5 Male Group B (Treatment Group) pretest and posttest 2.4 Fitness Test

Table 5.6: Data of Male Group B 2.4km Fitness Test

Male Group B (Treatment Group)			
Male ID	Age	Pretest Male	Posttest Male
M1_CG	29 years old	32.07 mins	31.20 mins
M2_CG	28 years old	32.20 mins	31.30 mins
M3_CG	27 years old	33.10 mins	32.30 mins
M4_CG	25 years old	35.59 mins	34.40 mins
M5_CG	25 years old	31.40 mins	30.50 mins

Group B	**M**	**Std**	**t**	**df**	**Sig**
Group B Male Pretest Group B Male Posttest	.93200	.14990	13.903	4	.000

The results of the male treatment group training program that utilize the 3D Sa'I VR application are presented in Table 5.6 The group's mean performance improves by 40 seconds to 1 minute and 19 seconds (M = 0.93, SD = 0.15) from pretest to posttest, indicating a significant improvement (t(4) = 13.903, p = 0.000). These findings suggest that all five male participants in the treatment group, who use the 3D Sa'I VR application, demonstrated improved performance following the training program."

5.2.1.6 Combine result Male Group A and Group B 2.4km Fitness Test

Table 5.7: Data combine Male for both group of 2.4km Fitness Test

Male	M	Std	t	df	Sig
Group A (Control Group)	.70200	.23350	6.723	4	.003
Group B (Treatment Group)	.93200	.14990	13.903	4	.000

Table 5.7 presents a comparison between male group A, which does not use the 3D Sa'I VR application, and male group B, which uses the 3D Sa'I VR application to examine the effect of the application on the training program for Hajj pilgrims. Group A showed a mean improvement in performance of M = 0.70 (SD = 0.23) and a paired t-test result of t(4) = 6.723, p = 0.003. Group B demonstrated a greater mean improvement in performance of M = 0.93 (SD = 0.15) and a significant paired t-test result of t(4) = 13.903, p = 0.000. The comparison of p-values for Group A and Group B indicated p = 0.003 and p = 0.000, respectively. These results suggest that the 3D Sa'I VR application had a significant positive effect on the training program for Hajj pilgrims, as reflected in the decreased time distance of the participants during the post 2.4km Fitness test. These findings support Hypothesis 1.

5.3 The effect of weekly cardiorespiratory fitness training on the heart rate, blood pressure, and oxygen saturation of Hajj pilgrims.

The null hypothesis for the research question 2b: "How effective is the training program in using 3D Sa'i VR application for improving Hajj pilgrims' cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation)?" can be stated as follows:

Null hypothesis (H_0): There is no significant difference in the cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation) of the experimental and control groups in the post-test, indicating that the training program using the 3D Sa'i VR application is not effective in improving Hajj pilgrims' cardiorespiratory fitness.

Alternative hypothesis (H_A): There is a significant difference in the cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation) of the experimental and control groups in the post-test, indicating that the training program using the 3D Sa'i VR application is effective in improving Hajj pilgrims' cardiorespiratory fitness.

To test this hypothesis, the data from the pre- and post-tests for both the experimental and control groups would be compared using statistical tests such as t-tests. If the results of the statistical tests show that there is a significant difference in the cardiorespiratory fitness (heart rate, blood pressure, and oxygen saturation) of the experimental and control groups in the post-test, then we can reject the null hypothesis and accept the alternative hypothesis, indicating that the training program using the 3D Sa'i VR application is effective in improving Hajj pilgrims' cardiorespiratory fitness. If the results of the statistical tests do not reveal a significant difference, the null hypothesis cannot be rejected, which suggests that the training program using the 3D Sa'i VR application may not be effective in improving Hajj pilgrims' cardiorespiratory fitness.

5.3.1 Paired t-test analysis Female Group A (Control Group) on weekly Heart Rate.

The paired t-test analysis examines the effect of weekly cardiorespiratory fitness training on the heart rate, blood pressure, and oxygen saturation of Hajj pilgrims, and whether there is a significant difference in the effectiveness of the training program between the treatment group (Group B), which uses the 3D Sa'i VR application, and the control group (Group A), which does not use it. The study involves measuring the weekly training program, which consists of 8 sessions for each participant, using pre and post-tests to measure the effect on the heart rate, blood pressure, and oxygen saturation levels of the participants. The pretest measures the resting heart rate, while the post-test measures the recovery heart rate. The data is presented in tabular format below.

5.3.1.1 Female Participant 1 Group A pre and posttest on weekly heart rate.

Table 5.8: Data Participant 1 on weekly heart rate

Participant 1 - Group A		
Age		29 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	71	69
2	69	68
3	68	67
4	67	66
5	66	65
6	65	65
7	65	64
8	64	64

The analysis of Table 5.8 conducted by the researcher focuses on the weekly results of the female control group training program, which does not use the 3D Sa'I VR application. The results show that Participant 1 had a mean improvement of M = 0.88 with a standard deviation of SD = 0.64. Furthermore, the paired t-test indicated a statistically significant improvement in performance, $t(7) = 3.862$, $p = 0.006$. These findings suggest that Participant 1's heart rate improved from pretest to posttest during the 8-session program.

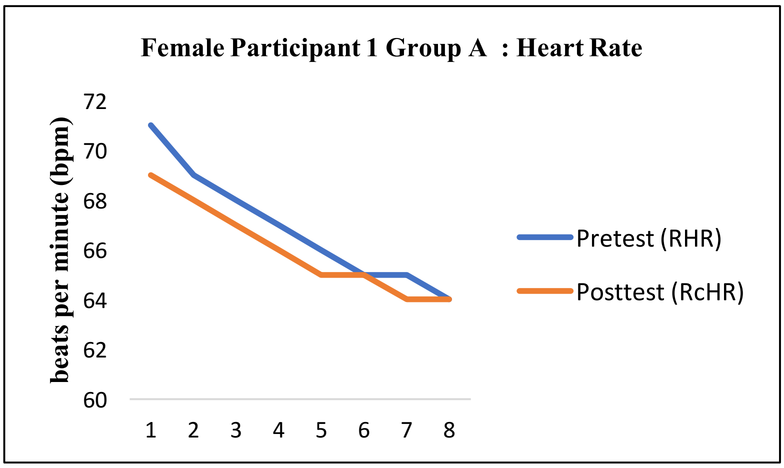


Figure 5.1: Measurement heart rate participant 1 Group A

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Figure 5.1 show a line chart that visually represents Participant one (1) weekly progress during an 8-session training programme showing heart rate from pretest to posttest. On the chart each session represented by a data point, with the x-axis indicating the session number, and the y-axis showing the heart rate readings. This chart depicts Participant one's (1's) heart rate fluctuations throughout the training programme and it handy tool for visualizing the results.

5.3.1.2 Female Participant 2 Group A pre and posttest on weekly heart rate.

Table 5.9: Data Participant 2 on weekly heart rate

Participant 2 - Group A		
Age		28 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	68	67
3	67	65
4	66	65
5	66	65
6	65	65
7	65	64
8	64	64

The researcher analyzes Table 5.9 to examine the weekly results of a female control group training program that does not use the 3D Sa'I VR application. The results revealed that Participant 2 shows an average improvement of M = 0.88 with a standard deviation of SD = 0.64. Additionally, a paired t-test demonstrated a statistically significant enhancement in performance, with a t-value of 3.862 and p-value of 0.006. These findings indicate that Participant 2 experiences an improvement in heart rate from pretest to posttest after participating in the 8-session program.

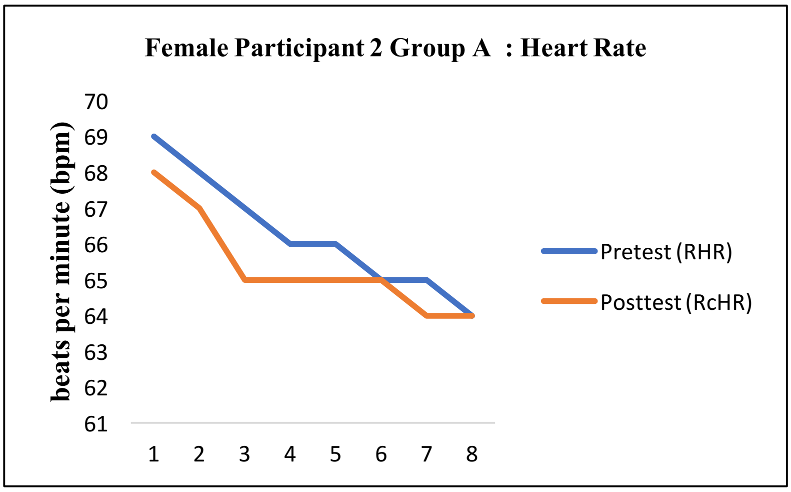

Figure 5.2.: Measurement heart rate participant 2 Group A

The line chart in Figure 5.2 illustrates Participant 2's weekly progress during an 8-session training program. It depicts the changes in their heart rate readings from pretest to posttest, with each session denoted by a data point on the chart. The x-axis denotes the session number, while the y-axis indicates the heart rate readings.

5.3.1.3 Female Participant 3 Group A pre and posttest on weekly heart rate.

Table 5.10: Data Participant 3 on weekly heart rate

Participant 3 - Group A		
Age		28 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	67
2	69	68
3	69	68
4	68	67
5	67	67
6	66	65
7	65	65
8	65	64

The researcher analyzes Table 5.10 to examine the weekly results of a female control group training program that does not use the 3D Sa'I VR application. The results revealed that Participant 3 shows an average improvement of M = 0.75 with a SD of 0.46. Additionally, a paired t-test demonstrated a statistically significant enhancement in performance, with a t-value of 4.583 and p-value of

0.003. These findings indicate that Participant 3 experiences an improvement in heart rate from pretest to posttest after participating in the 8-session program.

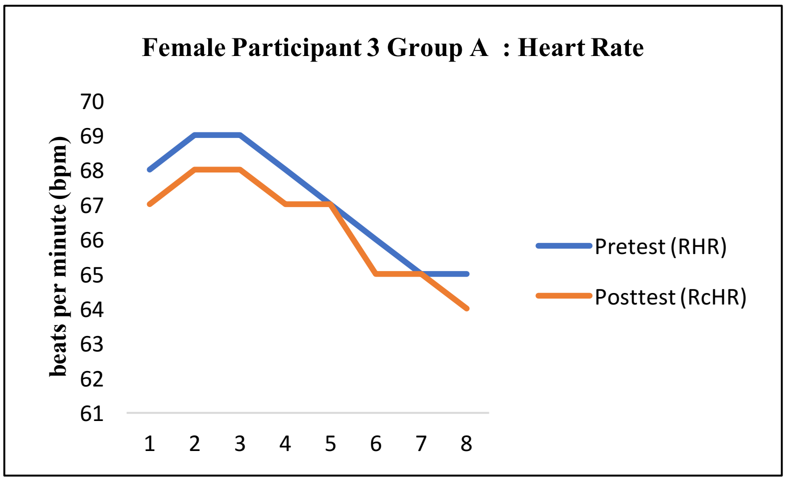

Figure 5.3 Measurement heart rate participant 3 Group A

Figure 5.3 shows the weekly progress of Participant 3 during an 8-session training program. The chart displays changes in heart rate readings from pretest to posttest, with each session being represented by a data point. The x-axis shows the session number, and the y-axis shows the heart rate readings.

5.3.1.4 Female Participant 4 Group A pre and posttest on weekly heart rate.

Table 5.11 Data Participant 4 on weekly heart rate

Participant 4 - Group A		
Age		25 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	68	67
3	68	67
4	67	66
5	66	65
6	65	65
7	65	64
8	64	64

The researcher analyzes Table 5.11 to examine the weekly results of a female control group training program that does not utilize the 3D Sa'I VR application. The results indicate that Participant 4 experiences an average improvement of M = 0.75 with a SD of 0.46. Additionally, a paired t-test reveals a statistically significant enhancement in performance, with a t-value of 4.583 and p-value of 0.003. These findings imply that Participant 4's heart rate improves from pretest to posttest following the 8-session program

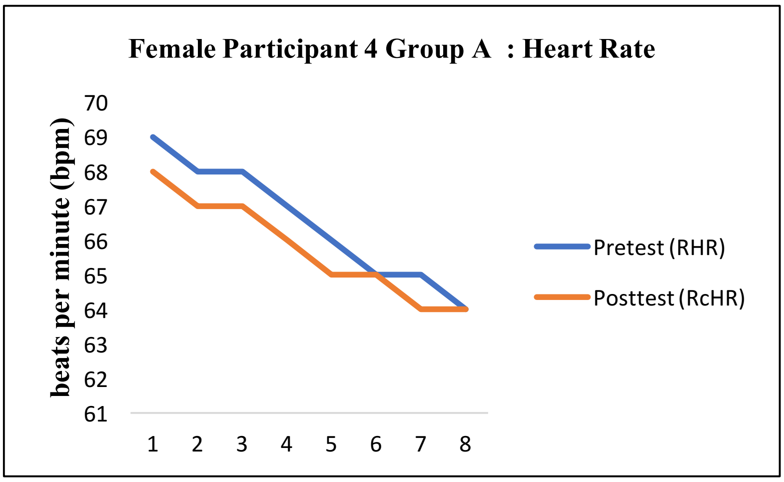

Figure 5.4: Measurement heart rate participant 4 Group A

Figure 5.4 presents a line chart that illustrates the weekly progress of Participant 4 throughout an 8-session training program. The chart depicts the changes in their heart rate readings from pretest to posttest, with each session being represented by a data point on the chart. The x-axis denotes the session number, while the y-axis shows the heart rate readings.

5.3.1.5 Female Participant 5 Group A pre and posttest on weekly heart rate.

Table 5.12 Data Participant 5 on weekly heart rate

Participant 5 - Group A		
Age		23 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	70	69
2	69	69
3	68	67
4	67	66
5	67	66
6	66	66
7	66	65
8	65	64

Table 5.12 analyze by the researcher to investigate at the weekly outcomes of a female control group training programme that does not employ the 3D Sa'I VR application. According to the data, Participant five (5) improves by 0.75 an average, with a standard deviation of 0.46. With a t-value of 4.583 and p-value of 0.003, a paired t-test also reveals a statistically significant improvement in performance. Participant 5's heart rate improves during the 8-session program from before to after. These findings indicate that Participant 5's heart rate improves from pretest to posttest following the 8-session program.

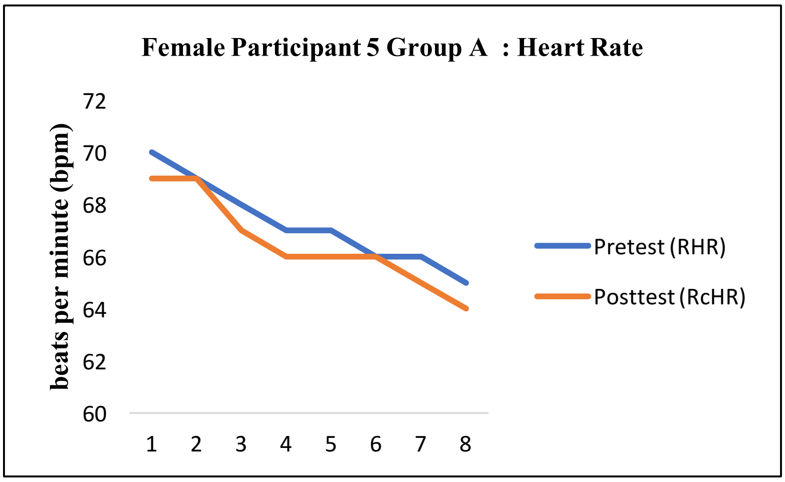

Figure 5.5 Measurement heart rate participant 5 Group A

Participant 5's weekly progress during an 8-session training program is represented in Figure 5.5 by a line chart showing the changes in their heart rate readings from pretest to posttest. Each session is mark by a data point, with the x-axis indicating the session number and the y-axis displaying the heart rate readings.

5.3.2 Paired t-test analysis Female Group B (Treatment Group) on weekly Heart Rate.

5.3.2.1 Female Participant 1 Group B (Treatment Group) pre and posttest on weekly heart rate.

Table 5.13 Data Participant 1 group B on weekly heart rate

Participant 1 - Group B		
Age		29 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	70	69
2	69	68
3	68	67
4	67	65
5	66	65
6	66	65
7	65	65
8	65	65

Table 5.13 examine the weekly results of a female control group training program using the 3D Sa'I VR application. The results indicated that Participant 1 has a mean improvement of M = 0.88 with a standard deviation of SD = 0.64. Furthermore, the paired t-test indicates a statistically significant improvement in performance, t(7) = 3.862, p = 0.006. These findings imply that Participant 1's heart rate improves from pretest to posttest following the 8-session program.

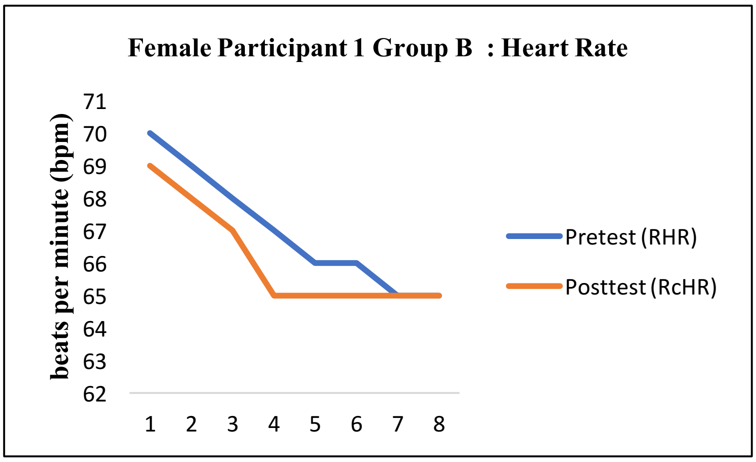

Figure 5.6 Measurement heart rate participant 1 Group B

Figure 5.6 shows the weekly progress of Participant 1 from group B during an 8-session training program. The line chart illustrates changes in their heart rate readings from pretest to posttest, with each session being marked by a data point. The x-axis denotes the session number, while the y-axis displays the heart rate readings.

5.3.2.2 Female Participant 2 Group B (Treatment Group) pre and posttest on weekly heart rate.

Table 5.14 Data Participant 2 group B on weekly heart rate

Participant 2 - Group B		
Age		28 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	67	66
3	69	67
4	67	66
5	66	66
6	66	65
7	65	65
8	65	64

In Table 5.14 indicated that Participant 2 shows an average improvement of M = 0.88 and a standard deviation of SD = 0.64. The paired t-test reveals that the improvement in Participant 2's heart rate readings from pretest to posttest was statistically significant, with t(7) = 3.862 and p = 0.006. These findings suggest that the 8-session program led to significant improvements in Participant 2's heart rate readings.

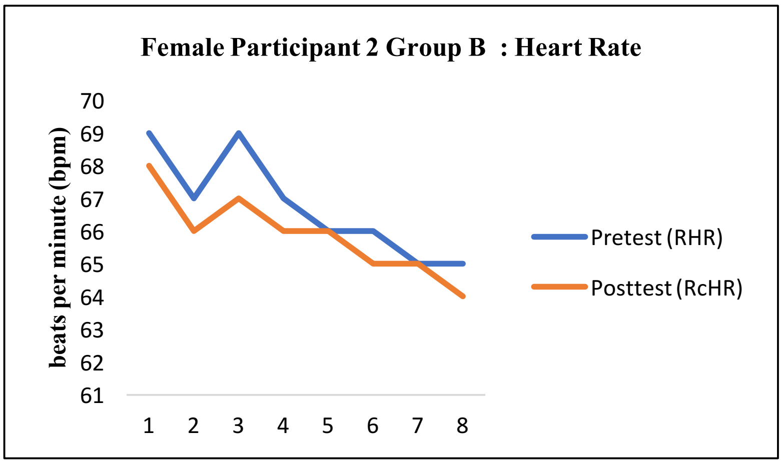

Figure 5.7 Measurement heart rate participant 2 Group B

Figure 5.7 presented a line chart that illustrated the heart rate changes of Participant 2 over an 8-session training program. The chart includes data points for each session, with the session number on the x-axis and the heart rate readings on the y-axis, reflecting changes from pretest to posttest.

5.3.2.3 Female Participant 3 Group B (Treatment Group) pre and posttest on weekly heart rate.

Table 5.15 Data Participant 3 group B on weekly heart rate

Participant 3 - Group B		
Age		27 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	67
2	67	66
3	68	67
4	68	67
5	66	65
6	65	65
7	65	65
8	65	64

In Table 5.15 Participant 3 has an average improvement of M = 0.75 and a standard deviation of SD = 0.46. The paired t-test shows a statistically significant improvement in performance, with t(7) = 4.583 and p = 0.003. These results indicate that Participant 3's heart rate had improved from pretest to posttest following the 8-session program.

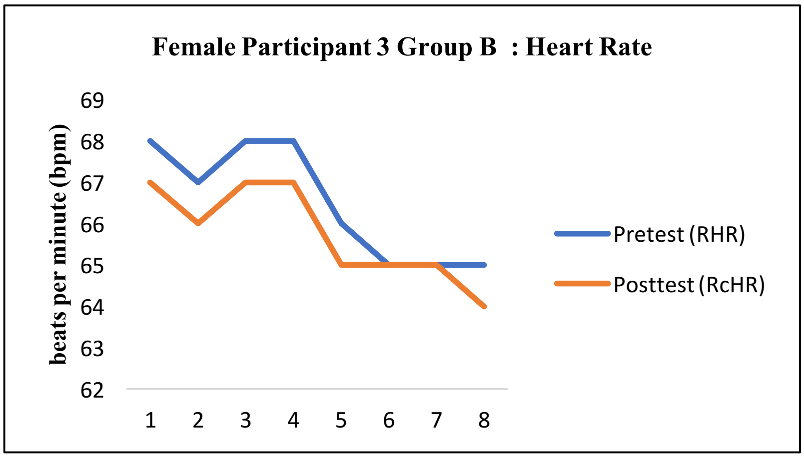

Figure 5.8: Measurement heart rate participant 3 Group B

Figure 5.13 presents a line chart illustrating the heart rate changes of Participant 3 over an 8-session training program that including a data point for each session.

5.3.2.4 Female Participant 4 Group B (Treatment Group) pre and posttest on weekly heart rate.

Table 5.16 Data Participant 4 group B on weekly heart rate

Participant 4 - Group B		
Age		25 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	70	69
2	69	68
3	68	67
4	67	66
5	66	65
6	66	65
7	65	65
8	64	64

Table 5.16 demonstrates that Participant 4 has an average improvement of M = 0.75, with a standard deviation of SD = 0.46. The paired t-test indicates a

statistically significant improvement in performance, with t(7) = 4.583 and p = 0.003. These results indicate that Participant 4 experiences an improvement in heart rate from pretest to posttest after completing the 8-session program.

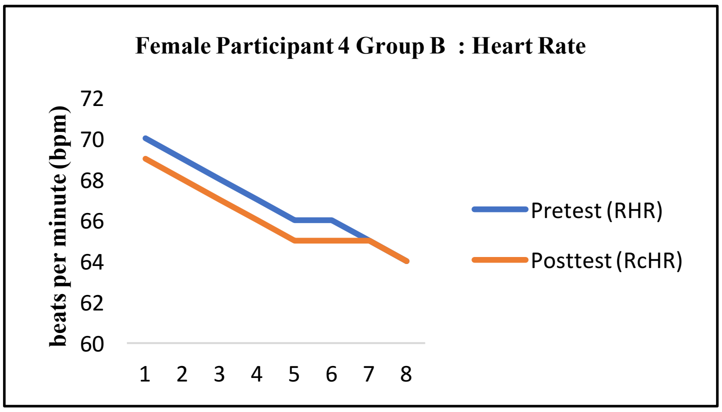

Figure 5.9: Measurement heart rate participant 4 Group B

Figure 5.9 presents a line chart illustrating the heart rate changes of Participant 4 over an 8-session training program.

5.3.2.5 Female Participant 5 Group B (Treatment Group) pre and posttest on weekly heart rate.

Table 5.17 Data Participant 5 group B on weekly heart rate

Participant 4 - Group B		
Age		23 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	68
2	67	66
3	70	68
4	67	66
5	67	65
6	67	65
7	66	65
8	65	64

Table 5.17 shows that Participant 5 demonstrates an average improvement of M = 1.25, with a standard deviation of SD = 0.71. The paired t-test indicates a statistically significant improvement in performance, with t(7) = 5.000 and p = 0.002. These results indicate that Participant 5 experiences an improvement in heart rate from pretest to posttest after completing the 8-session program.

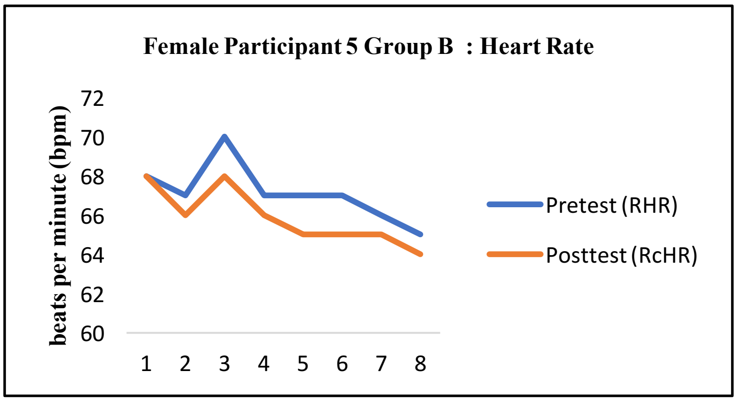

Figure 5.10: Measurement heart rate participant 5 Group B

Figure 5.10 presents a line chart illustrating the heart rate changes of Participant 5 over an 8-session training program.

5.3.3 Combine result Female Group A and Group B pre and posttest on weekly Heart Rate.

Table 5.18: Data combine female for both group on weekly heart rate

Female	Age	M	Std	t	df	Sig
Group A (Control Group)						
Participant 1	29 years old	0.88	0.64	3.862	7	.006
Participant 2	28 years old	0.88	0.64	3.862	7	.006
Participant 3	26 years old	0.75	0.46	4.583	7	.003
Participant 4	25 years old	0.75	0.46	4.583	7	.003
Participant 5	23 years old	0.75	0.64	4.583	7	.003
Group B (Treatment Group)						
Participant 1	29 years old	0.88	0.64	3.862	7	.006
Participant 2	28 years old	0.88	0.64	3.862	7	.006
Participant 3	26 years old	0.75	0.46	4.583	7	.003
Participant 4	25 years old	0.75	0.46	4.583	7	.003
Participant 5	23 years old	1.25	0.71	5.000	7	.002

The purpose of the study is to evaluate the weekly effect of heart rate during the training program by comparing the performance of two groups: Group A, comprising only females who do not use the 3D Sa'I VR application, and Group B, consisting of females who use the 3D Sa'I VR application.

In Group A, Participant 1 and Participant 2 exhibit a mean improvement in performance of M = 0.88 (SD = 0.64), with a paired t-test result of t(7) = 3.862 and p = 0.006. Meanwhile, Participant 3, 4, and 5 show a mean improvement in performance of M = 0.75 (SD = 0.46), with a paired t-test result of t(7) = 4.583 and p = 0.003.

In Group B, Participant 1 and 2 demonstrate a greater mean improvement in performance of M = 0.88 (SD = 0.64), with a significant paired t-test result of t(7) = 3.862 and p = 0.006. Participant 3 and 4 exhibit a mean improvement in performance of M = 0.75 (SD = 0.46), with a paired t-test result of t(7) = 4.583 and p = 0.003. Lastly, Participant 5 shows the highest mean improvement in performance of M = 1.25 (SD = 0.71), with a paired t-test result of t(7) = 5.000 and p = 0.002.

The p-values of Group A and Group B are compared as shown in Table 5.18, indicating no significant difference except for Participant 5, who has a p-value of 0.003 and 0.002 in Groups A and B, respectively. These results suggest that the 3D Sa'I VR application has a positive impact on the weekly heart rate of the Hajj pilgrims in both female groups.

5.3.4 Paired t-test analysis combine result Female Group A and Group B pre on weekly Blood Pressure.

Table 5.19: Data combine female for both group on weekly blood pressure

Female	**Age**	**M**		**Std**		**t**		**df**	**Sig**	
Group A		Sys BP	Dia BP	Sys BP	Dia BP	Sys BP	Dia BP		Sys BP	Dia BP
Participant 1	29 yrs. old	0.50	1.25	0.54	0.71	2.646	5.000	7	.033	.002
Participant 2	28 yrs. old	1.25	1.38	0.64	1.06	3.862	3.667	7	.005	.008
Participant 3	26 yrs. old	0.75	2.13	0.46	1.25	4.583	4.822	7	.003	.002
Participant 4	25 yrs. old	0.75	3.38	0.46	3.30	4.583	2.899	7	.003	.023
Participant 5	23 yrs. old	1.25	2.25	1.17	1.98	3.035	3.211	7	.019	.015
Group B										
Participant 1	29 yrs. old	1.38	1.63	1.19	0.92	3.274	5.017	7	.014	.002
Participant 2	28 yrs. old	0.88	2.13	0.84	1.25	2.966	4.822	7	.021	.002
Participant 3	26 yrs. old	2.00	2.00	1.31	1.69	4.320	3.347	7	.003	.012
Participant 4	25 yrs. old	0.75	1.50	0.46	1.07	4.583	3.969	7	.003	.005
Participant 5	23 yrs. old	1.25	1.38	0.87	1.06	3.999	3.667	7	.005	.008

Table 5.19 presents the findings on the effect of weekly training on blood pressure among female participants from Group A and Group B. The results show that the combination of participants from both groups leads to improvements in systolic and diastolic blood pressure. Specifically, when looking at the individual results, participant 1 from Group A has an average improvement in systolic blood pressure of M = 0.50 (SD = 0.54), with a paired t-test result of t(7) = 2.646, p = .033. Additionally, this participant shows an average improvement in diastolic blood pressure of M = 1.25 (SD =0.71), with a paired t-test result of t(7) = 5.000, p = .002.

Similarly, participant 2 from Group A has an average improvement in systolic blood pressure of M = 1.25 (SD = 0.64), with a paired t-test result of t(7) = 3.862, p = .005, and an average improvement in diastolic blood pressure of M = 1.38 (SD =1.06), with a paired t-test result of t(7) = 3.667, p = 00.8. Participant 3 from Group A has an average improvement in systolic blood pressure of M = 0.75 (SD = 0.46), with a paired t-test result of t(7) = 4.583, p = .003, and an average improvement in diastolic blood pressure of M = 2.13 (SD =1.25), with a paired t-test result of t(7) = 4.822, p = 00.2. In addition, participant 4 from Group A has an average improvement in systolic blood pressure of M = 0.75 (SD = 0.46), with a paired t-test result of t(7) = 4.583, p = .003, and an average improvement in diastolic blood pressure of M = 3.38 (SD =3.30), with a paired t-test result of t(7) = 2.899, p = .023. Finally, participant 5 from Group A has an average improvement in systolic blood pressure of M = 1.25 (SD = 1.17), with a paired t-test result of t(7) = 3.035, p = .019, and an average improvement in diastolic blood pressure of M = 2.25 (SD =1.98), with a paired t-test result of t(7) = 3.211, p = .015.

In Group B, participant 1 has an average improvement in systolic blood pressure of M = 1.38 (SD = 1.19) and diastolic blood pressure of M = 1.63 (SD = 0.92), both with significant paired t-test results (t(7) = 3.274, p = .014 and t(7) = 5.017, p = .002, respectively). Participant 2 shows an average improvement in systolic blood pressure of M = 0.88 (SD = 0.84) and diastolic blood pressure of M = 2.38 (SD = 1.25), both with significant paired t-test results (t(7) = 2.966, p = .021 and t(7) = [missing value], p = [missing value], respectively). Participant 3 has a mean improvement of 2 units in systolic blood pressure. Participant 4 has a mean improvement in systolic blood pressure performance of M = 0.75 (SD = 0.46) and a significant paired t-test result (t(7) = 4.583, p = .003), with a mean improvement in diastolic blood pressure of M = 1.50 (SD = 1.07) and a significant paired t-test result (t(7) = 3.969, p = .005). Similarly, participant 5 has a mean improvement in systolic blood pressure performance of M = 1.25 (SD = 0.87) and a significant paired t-test result (t(7) = 3.999, p = .005), with a mean improvement in diastolic blood pressure of M = 1.38 (SD = 1.06) and a significant paired t-test result (t(7) = 3.999, p = .005). Overall, these findings support Hypothesis question 2b, which suggests that weekly training has a positive effect on blood pressure in female participants from both Group A and Group B.

5.3.5 Paired t-test analysis Female Group A (Control Group) on weekly Oxygen Saturation.

5.3.5.1 Female Participant 1 Group A (Control Group) pre and posttest on weekly Oxygen Saturation (SpO2).

Table 5.20: Data Participant 1 group A on weekly oxygen saturation

Participant 1 - Group A		
Age		29 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	98	96
2	95	95
3	95	95
4	96	96
5	97	95
6	95	95
7	97	95
8	96	95

The results of the weekly training program for female control group participant 1, conducted without using the 3D Sa'I VR application, are presented in Table 5.20 The results indicate that Participant 1 shows a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.99. The paired t-test confirms that there is a significant improvement in performance, t(7) = 2.497, p = 0.41. These results indicate that the training program positively impacts Participant 1's SpO2 levels.

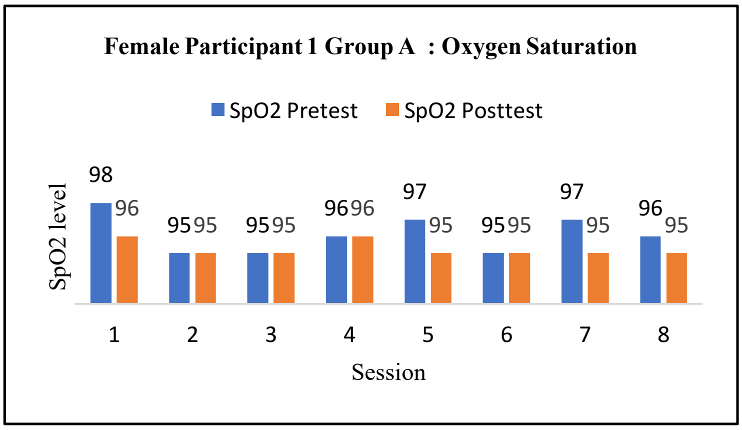

Figure 5.11 Measurement Female participant 1 Group A SpO2

Figure 5.11 depicts the weekly progress of Participant 1 during an 8-session training program, in the form of a bar graph. The graph presents a visual representation of the changes in Participant 1's SpO2 levels from pretest to posttest, with each session being represented by a data point on the chart. The x-axis denotes the session number, while the y-axis represents the SpO2 level readings.

5.3.5.2 Female Participant 2 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.21: Data Participant 2 group A on weekly oxygen saturation

Participant 2 - Group A		
Age		28 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	95	95
2	95	95
3	96	95
4	97	96
5	96	96
6	96	95
7	96	95
8	97	96

Table 5.21 indicates that the results for female Participant 2 in group A show a statistically significant mean improvement of M = 0.63 with a standard deviation of SD = 0.52. The paired t-test also indicates a statistically significant

improvement in performance, with t(7) = 3.416 and p = 0.011. These findings suggest that Participant 2 experiences an improvement in SpO2 levels from pretest to posttest after completing the 8-session program.

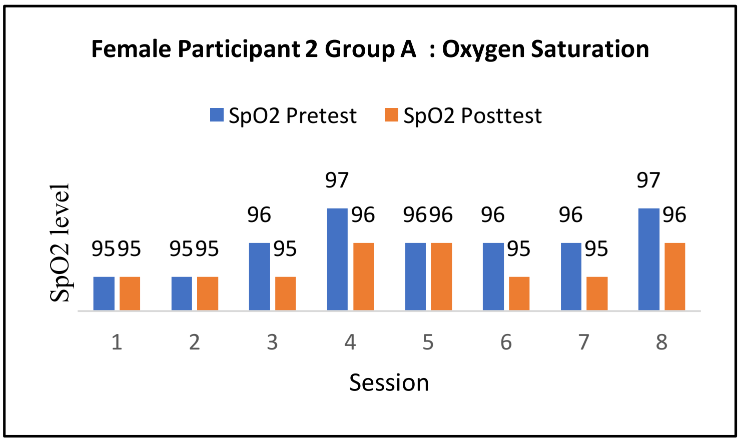

Figure 5.12: Measurement Female participant 2 Group A SpO2

Figure 5.12 shows a clustered column graph illustrating how Participant 2's SpO2 levels change over an 8-session training program, from pretest to posttest. The x-axis shows the session number, and the y-axis represents the SpO2 level readings.

5.3.5.3 Female Participant 3 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.22 Data Participant 3 group A on weekly oxygen saturation

Participant 3 - Group A		
Age		27 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	96	96
3	96	95
4	96	96
5	97	96
6	96	95
7	97	96
8	96	96

Table 5.22 indicates that Participant 3 shows a statistically significant mean improvement of M = 0.63 with a standard deviation of SD = 0.52. The paired t-test indicates a statistically significant improvement in performance, with t(7) = 3.416, p = 0.011. These results indicate that Participant 3 experiences an improvement in SpO2 level from pretest to posttest after completing the 8-session program.

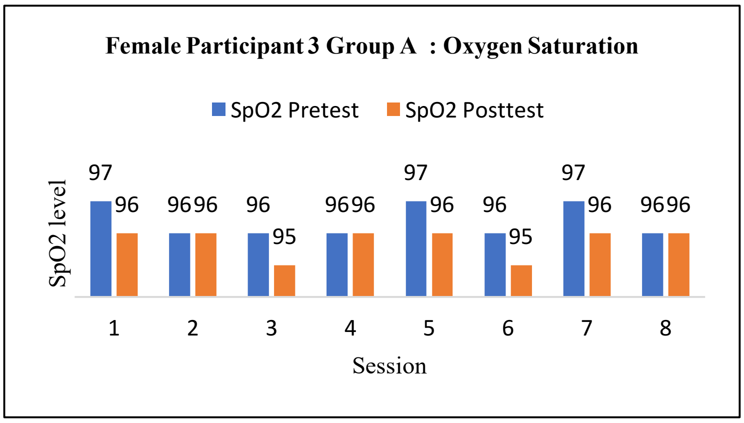

Figure 5.13: Measurement Female participant 3 Group A SpO2

The graph in Figure 5.13 is a clustered column graph that shows how Participant 3's SpO2 levels change over an 8-session training program.

5.3.5.4 Female Participant 4 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.23 Data Participant 4 group A on weekly oxygen saturation

Participant 4 - Group A		
Age		25 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	96	96
2	95	95
3	96	95
4	96	96
5	95	95
6	96	95
7	97	96
8	97	96

Table 5.23 indicates that Participant 4 shows a statistically significant mean improvement of M = 0.50 with a standard deviation of SD = 0.54. The paired t-

test indicates a statistically significant improvement in performance, with t(7) = 2.646, p = 0.033. These results indicate that Participant 4 experiences an improvement in SpO2 level from pretest to posttest after completing the 8-session program.

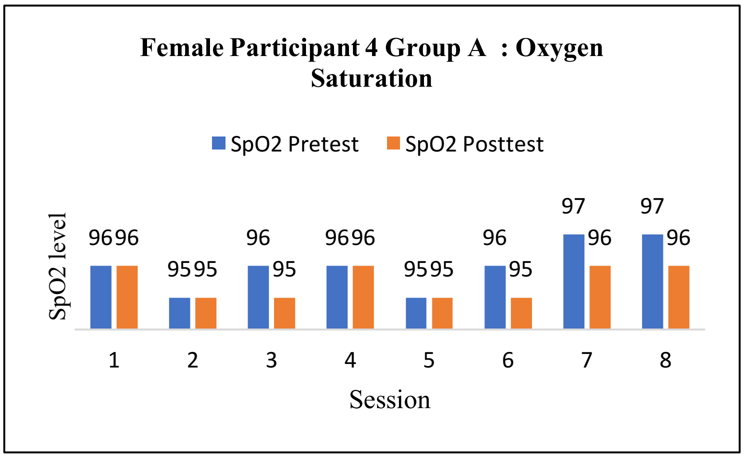

Figure 5.15: Measurement Female participant 4 Group A SpO2.

In Figure 5.15 the progress of Participant 4's SpO2 levels over an 8-session training program is demonstrated. The graph displays the pretest and posttest SpO2 level measurements for each session, with the x-axis showing the session numbers and the y-axis representing the SpO2 level readings.

5.3.5.5 Female Participant 5 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.24: Data Participant 5 group A on weekly oxygen saturation

Participant 5 - Group A		
Age		23 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	95
2	96	95
3	95	95
4	96	95
5	97	95
6	95	95
7	95	95
8	97	95

The data in Table 5.24 displays the weekly training program for a female control group participant (Participant 5) who does not utilize the 3D Sa'I VR application. The findings reveal that the participant demonstrates a significant mean improvement of M = 1.00 with a standard deviation of SD = 0.93. The paired t-test confirms that there is a significant improvement in performance, with t(7) = 3.055, p = 0.018. These results indicate that the participant's SpO2 level improves from pretest to posttest after finishing the 8-session program.

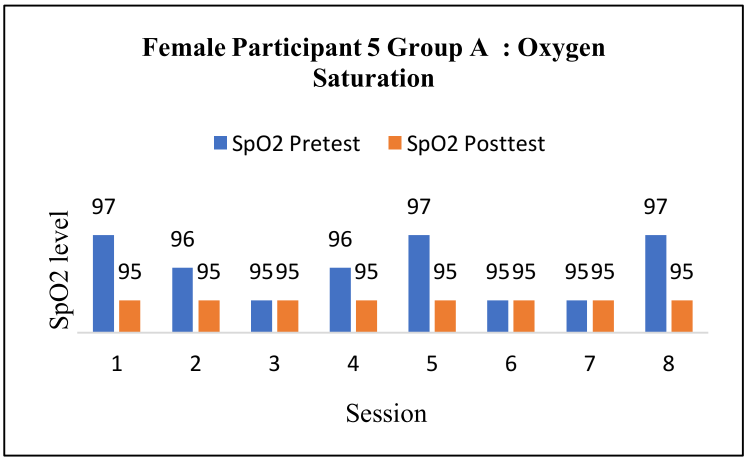

Figure 5.15 Measurement Female participant 5 Group A SpO2

The clustered column graph in Figure 5.15 charts the changes in Participant 5's SpO2 levels during an 8-session training program.

5.3.6 Paired t-test analysis Female Group B (Treatment Group) on weekly Oxygen Saturation.

5.3.6.1 Female Participant 1 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.25 Data Participant 1 group B on weekly oxygen saturation

Participant 1 - Group B		
Age		29 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	96	96
2	97	95
3	95	95
4	96	95
5	95	95
6	96	95
7	97	95
8	96	95

Table 5.35 displays the results of female Participant 1 in group B. The data reveals a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.84 in the participant's SpO2 level. The paired t-test analysis shows a significant improvement in performance, with t (7) = 2.966, p = 0.021. These results demonstrate that the 3D Sa'I VR training is effective in improving Participant 1's SpO2 levels.

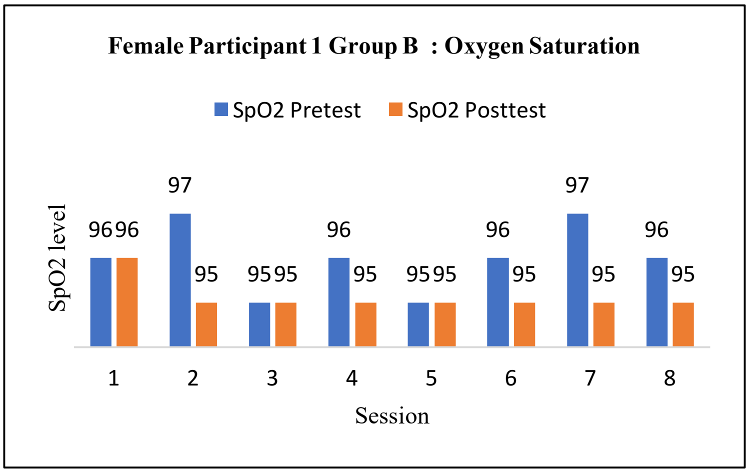

Figure 5.16: Measurement Female participant 1 Group B SpO2

Figure 5.16 shows a graph with columns that represent Participant 1's SpO2 levels during an 8-session training program, from before the program to after it. The x-axis shows the session numbers in order, and the y-axis shows the SpO2 level measurements.

Table 5.26: Data Participant 2 group B on weekly oxygen saturation

Participant 2 - Group B		
Age		28 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	98	97
2	97	96
3	95	95
4	96	96
5	96	95
6	96	96
7	97	96
8	96	95

5.3.6.2 Female Participant 2 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Figure 5.17: Measurement Female participant 2 Group B SpO2

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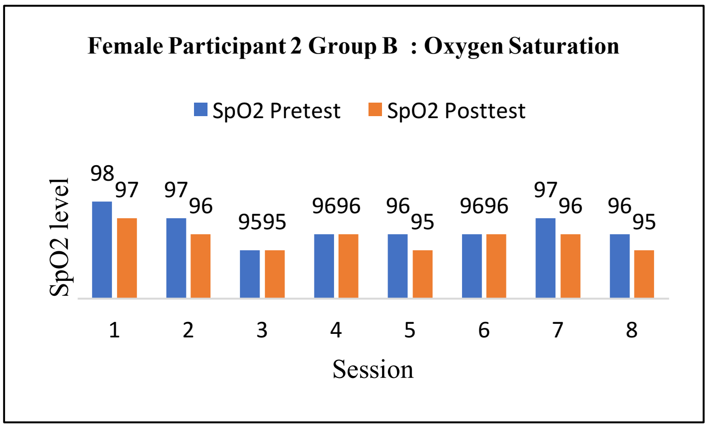

Table 5.26 displays the results of Participant 2 in group B. The data reveals a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.84 in the participant's SpO2 level. The paired t-test analysis shows a significant improvement in performance, with t(7) = 3.416, p = 0.011. These results demonstrate that the 3D Sa'I VR training is effective in improving Participant 2's SpO2 levels.

Figure 5.17 shows a graph with columns representing Participant 2's SpO2 levels during an 8-session training program, from before the program to after it.

5.3.6.3 Female Participant 3 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.27 Data Participant 3 group B on weekly oxygen saturation

Participant 3 - Group B		
Age		27 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	96	95
2	95	95
3	95	95
4	96	96
5	97	96
6	95	95
7	97	96
8	96	95

Table 5.27 displays the results of Participant 3. The data reveals a statistically significant mean improvement of M = 0.50 with a standard deviation of SD = 5.35 in the participant's SpO2 level. The paired t-test analysis shows a significant improvement in performance, with $t(7) = 2.646$, $p = 0.033$. These results demonstrate that the 3D Sa'I VR training is effective in improving Participant 3's SpO2 levels.

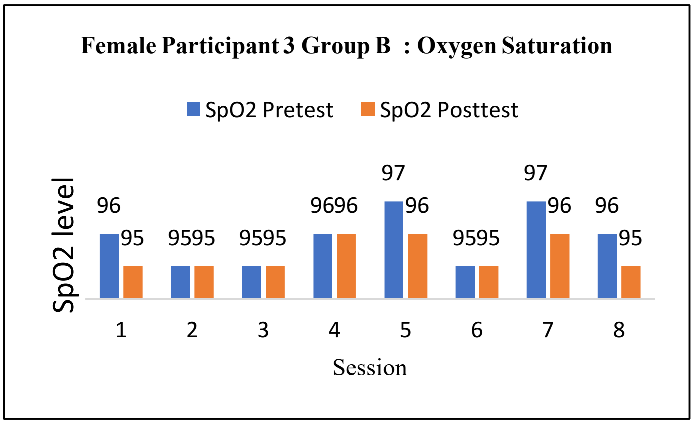

Figure 5.18: Measurement Female participant 3 Group B SpO2

Figure 5.18 illustrates the changes in Participant 3's SpO2 levels throughout an 8-session training program, displaying measurements taken before and after the program. The graph is arranged with session numbers plotted on the x-axis and SpO2 levels represented by the columns on the y-axis.

5.3.6.4 Female Participant 4 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.28: Data Participant 4 group B on weekly oxygen saturation

Participant 4 - Group B		
Age		25 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	96	95
2	96	96
3	97	96
4	96	95
5	95	95
6	96	96
7	97	96
8	97	96

Table 5.28 displays the results of a female control group participant 4 in the weekly training program that utilizes the 3D Sa'I VR application. The data reveals a statistically significant mean improvement of M = 0.63 with a standard deviation of SD = 0.52 in the participant's SpO2 level. The paired t-test analysis shows a significant improvement in performance, with t(7) = 3.416, p = 0.011. These results demonstrate that the 3D Sa'I VR training is effective in improving Participant 4's SpO2 levels."

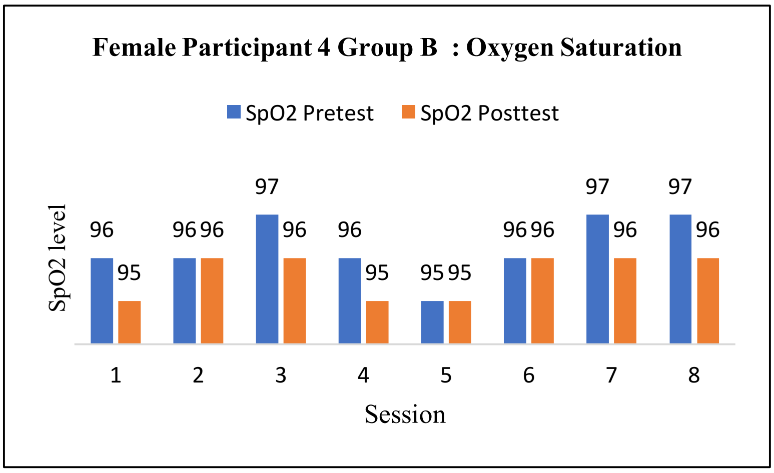

Figure 5.19: Measurement Female participant 4 Group B SpO2

Participant 4's SpO2 levels are being monitored over the course of an 8-session training program, and Figure 5.19 displays the resulting graph. The graph depicts the SpO2 measurements taken both before and after the program in column format, with session numbers arranged along the x-axis and SpO2 levels along the y-axis.

5.3.6.5 Female Participant 5 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.29: Data Participant 5 group B on weekly oxygen saturation

Participant 5 - Group B		
Age		23 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	96	96
3	96	95
4	97	96
5	96	96
6	96	96
7	96	95
8	97	96

Participant 5's SpO2 levels are being measured over the course of an 8-week training program that utilizes the 3D Sa'I VR application, and the results are presented in Table 5.29 The data reveals a statistically significant improvement in SpO2 levels, with a mean increase of M = 0.63 and a standard deviation of SD = 0.52. Additionally, the paired t-test analysis confirms the significant improvement in performance, with a t-value of t(7) = 3.416 and p-value of p = 0.011. These results demonstrate the effectiveness of the 3D Sa'I VR training program in enhancing Participant 5's SpO2 levels.

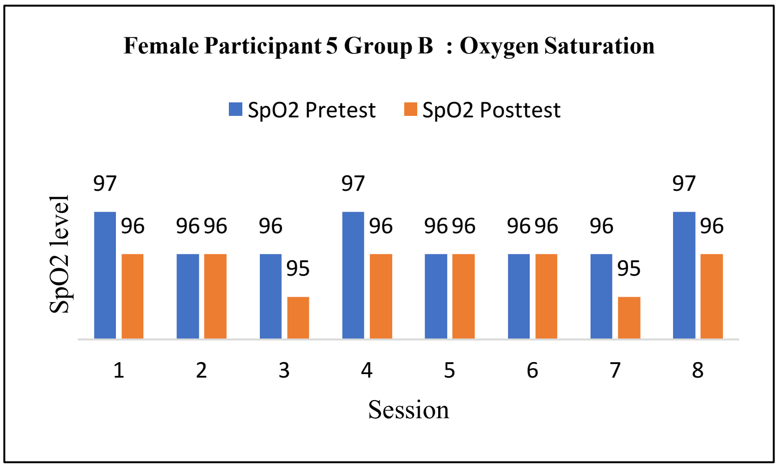

Figure 5.20: Measurement Female participant 5 Group B SpO2

Figure 5.20 presents a bar chart that displays Participant 5's SpO2 levels across an 8-session training program, from pretest to posttest. The chart contains two bars representing the SpO2 level before and after the program.

5.3.7 Combine result Female Group A and Group B pre and posttest on weekly Oxygen Saturation.

Table 5.30 Data combine female for both group on weekly oxygen saturation

Female	Age	M	Std	t	df	Sig
Group A (Control Group)						
Participant 1	29 years old	0.88	0.99	2.497	7	.041
Participant 2	28 years old	0.63	0.52	3.416	7	.011
Participant 3	26 years old	0.63	0.52	3.416	7	.011
Participant 4	25 years old	0.50	0.54	2.646	7	.033
Participant 5	23 years old	1.00	0.93	3.055	7	.018
Group B (Treatment Group)						
Participant 1	29 years old	0.88	0.84	2.966	7	.021
Participant 2	28 years old	0.63	0.52	3.416	7	.011
Participant 3	26 years old	0.50	0.53	2.646	7	.033
Participant 4	25 years old	0.63	0.52	3.416	7	.011
Participant 5	23 years old	0.63	0.52	3.416	7	.011

The study investigates the effectiveness of a 3D Sa'I VR training program in improving the weekly oxygen saturation levels of female Hajj pilgrims, as shown in Table 5.30 The results show a positive impact on the participants' oxygen saturation levels in both Group A and Group B. In Group A, Participant 1 shows a statistically significant mean improvement of 0.88 (SD=0.99), and Participants 2, 3, and 4 show statistically significant mean improvements of 0.63 (SD=0.52), 0.50 (SD=0.54), and 1.00 (SD=0.93), respectively. The paired t-tests confirm the significant improvements in performance, with p-values ranging from 0.011 to 0.041. In Group B, Participants 1, 2, 3, and 5 show a statistically significant mean improvement of 0.88 (SD=0.84) in their oxygen saturation levels. The paired t-tests also confirm significant improvements in performance, with p-values ranging from 0.011 to 2.966. The comparison of p-values between Group A and Group B shows that Participants 2, 3, and 4 have similar p-values, while Participants 1 and 5 have different p-values in the two groups. However, both groups demonstrate a positive impact on the weekly oxygen saturation levels of female Hajj pilgrims.

5.3.8 Paired t-test analysis Male Group A (Control Group) on weekly heart rate.

5.3.8.1 Male Participant 1 Group A (Control Group) pre and posttest on weekly heart rate.

Table 5.31: Data Participant 1 group A on weekly heart rate

Participant 1 - Group A		
Age		29 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	71	69
2	69	69
3	69	68
4	67	67
5	66	65
6	66	65
7	66	65
8	65	64

Table 5.31 presents the weekly heart rate results of Participant 1 from the Male control group, who completes a training program without using the 3D Sa'I VR application. The results demonstrate that Participant 1's mean heart rate improves by M = 0.88 with a standard deviation of SD = 0.64. Furthermore, a paired t-test shows a statistically significant improvement in performance, t(7) = 3.862, p = 0.006. These findings indicate that Participant 1's heart rate improves significantly during the 8-session program, from the pretest to the posttest.

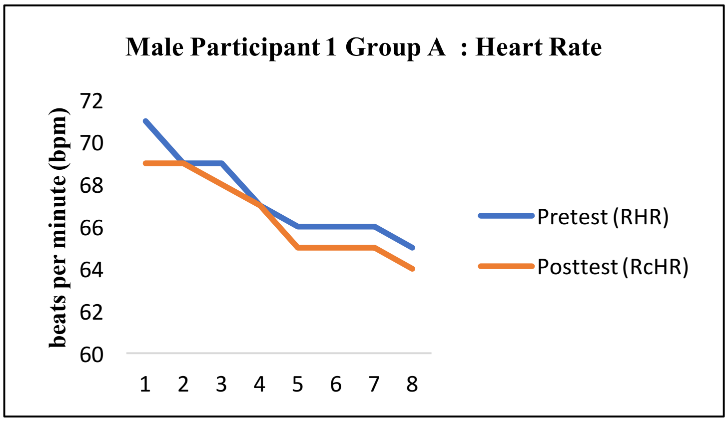

Figure 5.21 Measurement heart rate male participant 1 Group A

The line chart presented in Figure 5.21 provides a visual representation of the weekly progress of Male Participant 1 in Group A during an 8-session training program.

5.3.8.2 Male Participant 2 Group A (Control Group) pre and posttest on weekly Heart Rate.

Table 5.32: Data Participant 2 group A on weekly heart rate

Participant 2 - Group A		
Age		28 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	67
2	69	68
3	68	67
4	67	67
5	67	66
6	66	65
7	65	65
8	65	64

Table 5.32 displays the weekly heart rate results of Participant 2 in the male control group, who completed the training program without using the 3D Sa'I VR application. The findings show that Participant 2's mean heart rate improves by M = 0.75 with a standard deviation of SD = 0.46. Additionally, a paired t-test indicates a statistically significant improvement in performance, t(7) = 4.583, p = 0.003.

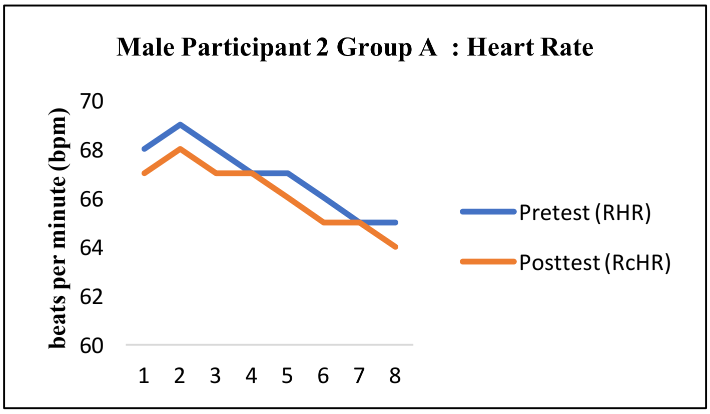

Figure 5.22: Measurement heart rate Male participant 2 Group A

Figure 5.22 is a line chart that visually depicts the weekly progress of male Participant 2 in Group A during an 8-session training program.

5.3.8.3 Male Participant 3 Group A (Control Group) pre and posttest on weekly Heart Rate.

Table 5.33: Data Participant 3 group A on weekly heart rate

Participant 3 - Group A		
Age		27 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	68	66
3	67	66
4	67	66
5	66	66
6	66	65
7	65	65
8	65	64

Table 5.33 shows the weekly heart rate results of Male Participant 3 in the control group indicating a mean heart rate improvement of M = 0.88 with a standard deviation of SD = 0.64. Additionally, the paired t-test shows a statistically significant improvement in performance, with t(7) = 3.862 and p = 0.006. These results show that Participant 3's heart rate improves significantly from pretest to posttest during the 8-session program.

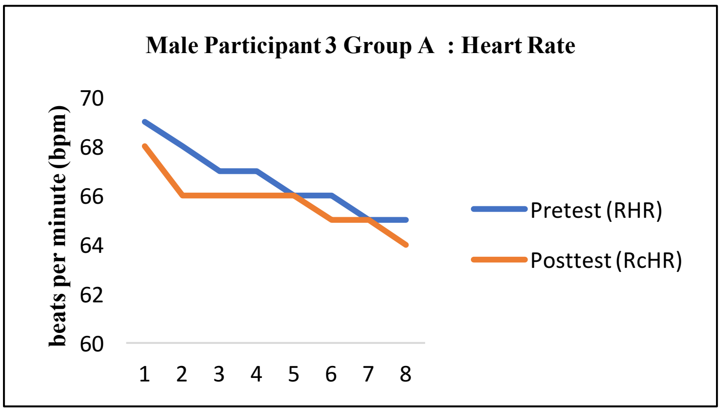

Figure 5.23: Measurement heart rate Male participant 3 Group A

The line chart in Figure 5.45 displays the weekly changes in heart rate for male Participant 3 in Group A during an 8-session training program.

5.3.8.4 Male Participant 4 Group A (Control Group) pre and posttest on weekly Heart Rate.

Table 5.34: Data Participant 4 group A on weekly heart rate

Participant 4 - Group A		
Age		25 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	70	69
2	69	68
3	68	67
4	67	67
5	66	65
6	66	65
7	65	65
8	65	64

Table 5.34 shows the results of Participant 4 in the male control group, where the heart rate improves by M = 0.75 with a standard deviation of SD = 0.46. Moreover, the paired t-test demonstrates a statistically significant improvement in performance, with $t(7) = 4.583$, $p = 0.003$. These findings indicate that Participant 4 experiences a significant improvement in heart rate from pretest to posttest over the course of the 8-session program.

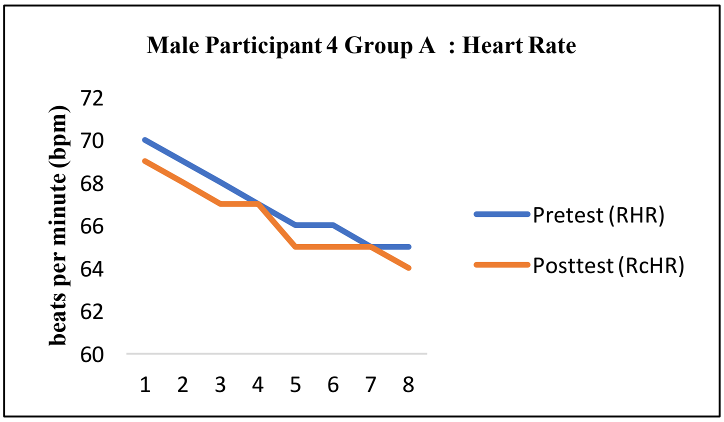

Figure 5.24: Measurement heart rate Male participant 4 Group A

The line chart shown in Figure 5.24 presents the weekly heart rate changes of male Participant 4 in the male control group during an 8-session training program.

5.3.8.5 Male Participant 5 Group A (Control Group) pre and posttest on weekly Heart Rate.

Table 5.35: Data Participant 5 group A on weekly heart rate

Participant 5 - Group A		
Age		23 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	68
2	67	66
3	70	68
4	67	66
5	67	65
6	67	65
7	66	65
8	65	64

Table 5.35 displays the results of Participant 5 in the male control group, where the average heart rate improves by M = 1.25 with a standard deviation of SD = 0.71. Moreover, the paired t-test demonstrates a statistically significant improvement in performance, with t(7) = 5.000, p = 0.002. These findings indicate that Participant 5 experiences a significant improvement in heart rate from pretest to posttest over the course of the 8-session program.

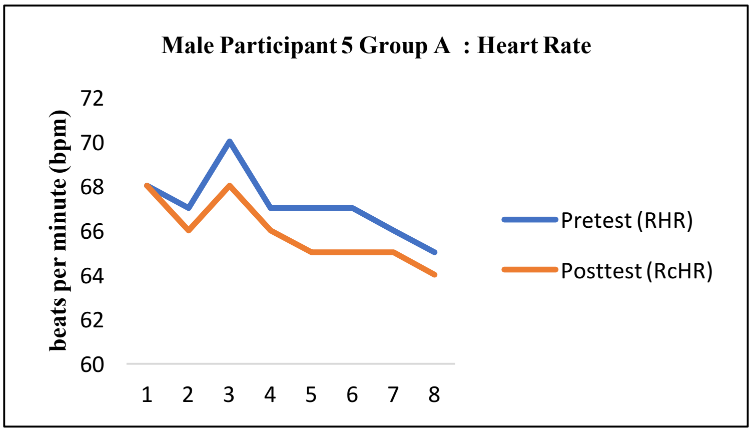

Figure 5.25: Measurement heart rate Male participant 5 Group A

The line chart represented in Figure 5.25 illustrates the weekly heart rate results of male Participant 5 from the male control group throughout an 8-session training program.

5.3.9 Paired t-test analysis Male Group B (Treatment Group) on weekly Heart Rate.

5.3.9.1 Male Participant 1 Group B (Treatment Group) pre and posttest on weekly Heart Rate.

Table 5.36: Data Participant 1 group B on weekly heart rate

Participant 1 - Group B		
Age		29 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	70	69
2	69	68
3	68	67
4	67	65
5	66	65
6	66	65
7	65	65
8	65	65

Table 5.36 shows the weekly heart rate results of Participant 1 in the male treatment group, who completes an 8-session training program. The results indicate that Participant 1's average heart rate improves by M = 0.88 (SD = 0.64)

from pretest to posttest. A paired t-test reveals a statistically significant improvement in performance, $t(7) = 3.862$, $p = 0.006$. These findings indicate that the training program using the 3D Sa'I VR application is effective in improving Participant 1's heart rate over the course of the program.

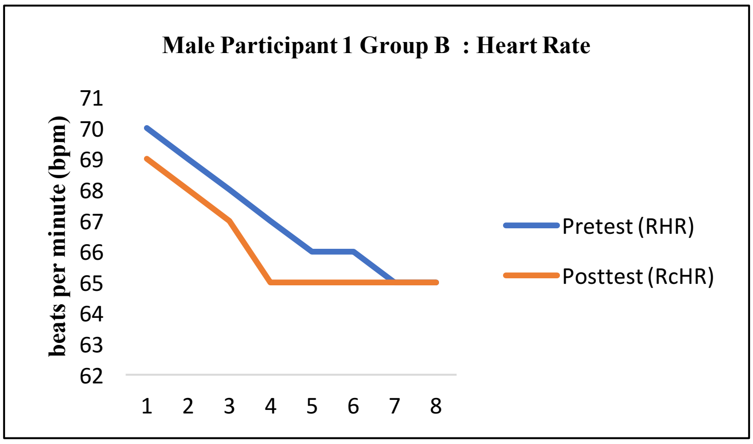

Figure 5.26: Measurement heart rate Male participant 1 Group B

The line chart represented in Figure 5.26 illustrates the weekly heart rate results of male Participant 1 from the male control group throughout an 8-session training program.

5.3.9.2 Male Participant 2 Group B (Treatment Group) pre and posttest on weekly Heart Rate.

Table 5.37: Data Participant 2 group B on weekly heart rate

Participant 2 - Group B		
Age		28 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	67	66
3	69	67
4	67	66
5	66	66
6	66	65
7	65	65
8	65	64

Table 5.37 displays the weekly heart rate results of Participant 2 in the male treatment group, who completes an 8-session training program using the 3D Sa'I

VR application. The results demonstrate that Participant 2's average heart rate increases by M = 0.88 (SD = 0.64) from pretest to posttest. Additionally, a paired t-test reveals a statistically significant improvement in performance, t(7) = 3.862, p = 0.006. The results indicate that Participant 2's heart rate improves after completing the 8-session training program using the 3D Sa'I VR application.

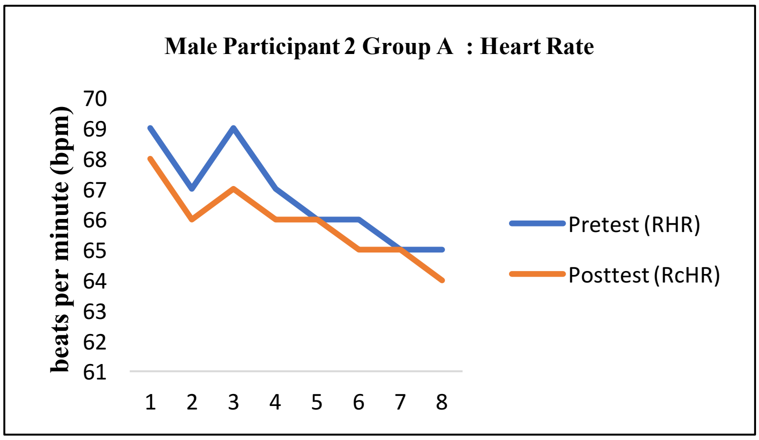

Figure 5.27: Measurement heart rate Male participant 2 Group B

Figure 5.27 presents the weekly heart rate results of male Participant 2 from the male control group during an 8-session training program.

5.3.9.3 Male Participant 3 Group B (Treatment Group) pre and posttest on weekly Heart Rate.

Table 5.38: Data Participant 3 group B on weekly heart rate

Participant 3 - Group B		
Age		27 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	68
2	67	66
3	68	67
4	67	66
5	67	65
6	67	65
7	66	65
8	65	64

Table 5.38 displays the weekly heart rate results of Participant 3 in the male treatment group with an average heart rate improving by M = 1.13 (SD = 0.64) from pretest to posttest. Moreover, a paired t-test indicates a statistically significant improvement in performance, $t(7) = 4.965$, $p = 0.002$. These findings indicate that the training program using the 3D Sa'I VR application is effective in enhancing Participant 3's heart rate over the course of the program.

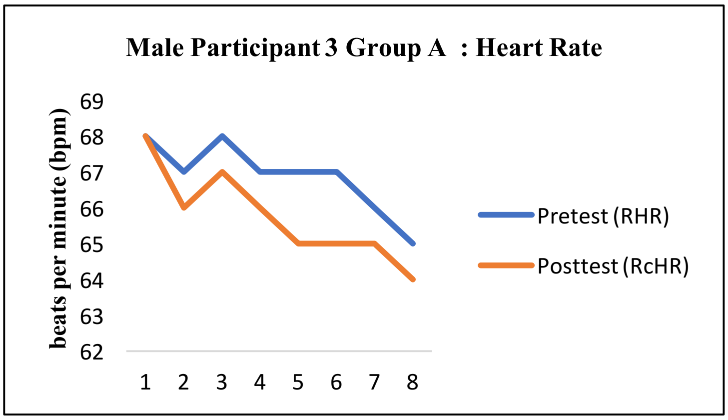

Figure 5.28: Measurement heart rate Male participant 3 Group B

Figure 5.28 display the weekly heart rate results of male Participant 3 from the male treatment group throughout an 8-session training program using the 3D Sa'I VR application.

5.3.9.4 Male Participant 4 Group B (Treatment Group) pre and posttest on weekly Heart Rate.

Table 5.39: Data Participant 4 group B on weekly heart rate

Participant 4 - Group B		
Age		25 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	68	68
2	67	66
3	70	68
4	67	66
5	67	65
6	67	65
7	66	65
8	65	64

Table 5.39 presents the weekly heart rate results of Participant 4 indicating an average heart rate improvement of M = 1.25 (SD = 0.64) from pretest to posttest, and a paired t-test reveals a statistically significant improvement in performance, t(7) = 5.000, p = 0.002. The results indicate that the 8-session training program using the 3D Sa'I VR application is effective in improving Participant 4's heart rate over the course of the program.

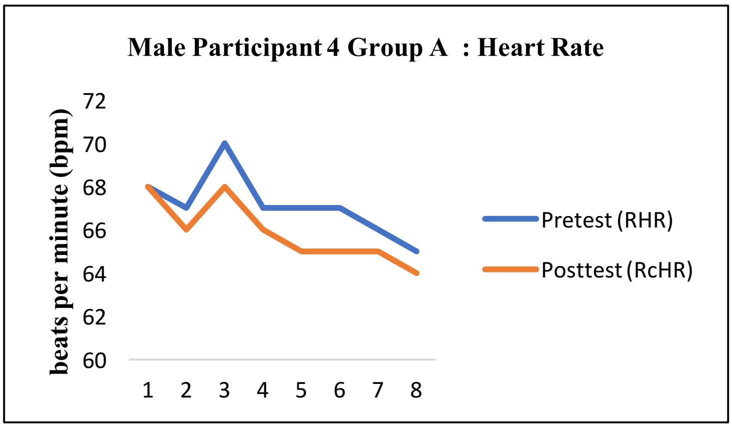

Figure 5.29: Measurement heart rate Male participant 4 Group B

Figure 5.29 displays a line chart depicting the weekly heart rate results of Participant 4 from the male treatment group during an 8-session training program using the 3D Sa'I VR application.

5.3.9.5 Male Participant 5 Group B (Treatment Group) pre and posttest on weekly Heart Rate.

Table 5.40: Data Participant 5 group B on weekly heart rate

Participant 5 - Group B		
Age		23 years old
Sessions	Pretest (RHR)	Posttest (RcHR)
1	69	68
2	68	67
3	68	66
4	67	66
5	66	65
6	66	65
7	65	65
8	65	64

Table 5.40 presents the weekly heart rate results of Participant 5 indicating an average heart rate improvement of M = 1.00 (SD = 0.54) from pretest to posttest, and a paired t-test reveals a statistically significant improvement in performance, t(7) = 5.292, p = 0.001. The results indicate that the 8-session training program using the 3D Sa'I VR application is effective in improving Participant 5's heart rate over the course of the program.

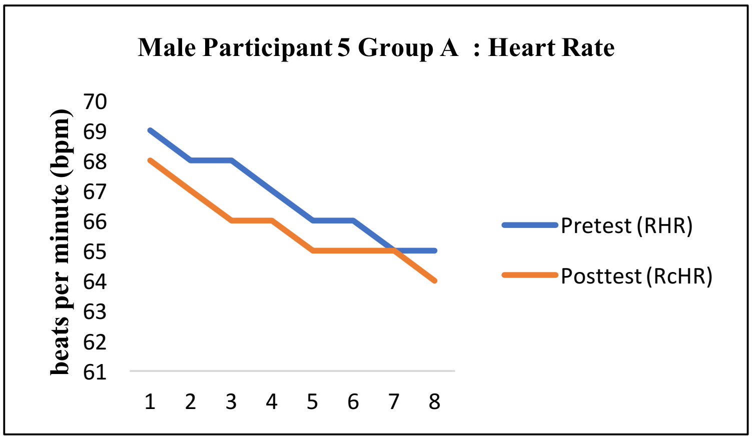

Figure 5.30: Measurement heart rate Male participant 5 Group B

Figure 5.30 displays a line chart depicting the weekly heart rate results of Participant 5 from the male treatment group during an 8-session training program using the 3D Sa'I VR application.

5.3.10 Combine result Male Group A and Group B pre and posttest on weekly Heart Rate.

Table 5.41: Data combine male for both group on weekly Heart rate

Male	Age	M	Std	t	df	Sig
Group A (Control Group)						
Participant 1	29 years old	0.88	0.64	3.862	7	.006
Participant 2	28 years old	0.75	0.46	4.583	7	.003
Participant 3	26 years old	0.88	0.64	3.862	7	.006
Participant 4	25 years old	0.75	0.46	4.583	7	.003
Participant 5	23 years old	1.25	0.71	5.000	7	.002
Group B (Treatment Group)						
Participant 1	29 years old	0.88	0.64	3.862	7	.006
Participant 2	28 years old	0.88	0.64	3.862	7	.006
Participant 3	26 years old	1.13	0.46	4.965	7	.002
Participant 4	25 years old	1.25	0.46	5.000	7	.002
Participant 5	23 years old	1.00	0.71	5.292	7	.001

Table 5.41 displays the weekly effects of heart rate for male participants in both groups. In Group A, Participants 1, 2, 3, and 4 show a significant improvement in mean heart rate from M = 0.75 to M = 0.88, with a corresponding increase in standard deviation from SD = 0.46 to SD = 0.64. Paired t-tests confirm these improvements are statistically significant, with p-values ranging from 0.003 to 0.006. Additionally, Participant 5's mean heart rate improves significantly by M = 1.25, with a standard deviation of SD = 0.71, and the paired t-test shows a p-value of 0.002.

In Group B, Participants 1, 2, 4, and 5 also show significant improvements in mean heart rate, from M = 0.88 to M = 1.25, and standard deviation from SD = 0.54 to SD = 0.64. Paired t-tests confirm these improvements are statistically significant, with p-values ranging from 0.001 to 0.006. Furthermore, Participant 3's mean heart rate improves significantly by M = 1.13, with a standard deviation of SD = 0.64, and the paired t-test shows a p-value of 0.002. When comparing the p-values of Group A and Group B, there is no significant difference except for Participant 5, who has a p-value of 0.002 in Group A and 0.001 in Group B. Overall, these results suggest that the 3D Sa'I VR application has a positive impact on the weekly heart rate of male Hajj pilgrims in both groups.

5.3.11 Combine result Male Group A and Group B on weekly Blood Pressure.

Table 5.42: Data combine Male for both group on weekly blood pressure

Male	Age	M		Std		t		df	Sig	
Group A		Sys BP	Dia BP	Sys BP	Dia BP	Sys BP	Dia BP		Sys BP	Dia BP
Participant 1	29 yrs. old	0.75	1.38	0.71	1.06	3.000	3.667	7	.020	.008
Participant 2	28 yrs. old	1.00	1.25	0.76	0.71	3.742	5.000	7	.007	.002
Participant 3	26 yrs. old	0.75	3.25	0.46	2.25	4.583	4.082	7	.003	.005
Participant 4	25 yrs. old	0.88	2.25	0.64	1.99	3.862	3.211	7	.006	.015
Participant 5	23 yrs. old	1.13	2.13	0.84	1.25	3.813	4.822	7	.007	.002
Group B										
Participant 1	29 yrs. old	0.75	2.00	0.71	1.69	3.000	3.347	7	.020	.012
Participant 2	28 yrs. old	0.75	2.13	0.46	1.25	4.583	4.822	7	.003	.002
Participant 3	26 yrs. old	1.75	1.62	1.04	0.92	4.782	5.017	7	.002	.002
Participant 4	25 yrs. old	1.00	1.50	0.54	1.07	5.292	3.969	7	.001	.005
Participant 5	23 yrs. old	0.63	0.88	0.52	0.23	3.416	3.862	7	.011	.006

The data in Table 5.42 present the combined results for male groups A and B, indicating the effectiveness of the weekly training program on the blood pressure of Hajj pilgrims. For group A, participant 1 demonstrates a significant improvement in systolic BP with a mean difference of M = 0.75 (SD = 0.71) and a paired t-test result of t(7) = 3.000, p = .020. The diastolic BP also shows improvement, with a mean difference of M = 1.38 (SD = 1.06) and a paired t-test result of t(7) = 3.667, p = .008. Similarly, for participant 2 in group A, there is a significant improvement in systolic BP with a mean difference of M = 1.00 (SD = 0.76) and a paired t-test result of t(7) = 3.742, p = .007. The diastolic BP shows a mean difference of M = 1.25 (SD = 0.71) and a paired t-test result of t(7) = 5.000, p = .002. Participant 3 in group A also shows significant improvements in systolic BP with a mean difference of M = 0.75 (SD = 0.46) and a paired t-test result of t(7) = 4.583, p = .003. The diastolic BP also shows improvement with a mean difference of M = 3.25 (SD = 2.25) and a paired t-test result of t(7) = 4.082, p = .003.

Moving on to group B, participant 1 shows a mean improvement in systolic BP with a mean difference of M = 0.75 (SD = 0.071) and a paired t-test result of t(7) = 3.000, p = .020. The diastolic BP also shows improvement with a mean difference of M = 2.00 (SD = 1.69) and a paired t-test result of t(7) = 3.347, p = .012. Participant 2 in group B shows significant improvements in systolic BP with a mean difference of M = 0.75 (SD = 0.46) and a paired t-test result of t(7) = 4.583, p = .003. The diastolic BP also shows improvement with a mean difference of M = 2.18 (SD = 1.25) and a paired t-test result of t(7) = 4.822, p = .003. Participant 3 in group B demonstrates a significant improvement in systolic BP with a mean difference of M = 1.75 (SD = 1.04) and a paired t-test result of t(7) = 4.782, p = .002. The diastolic BP also shows improvement with a mean difference of M = 1.62 (SD = 0.92) and a paired t-test result of t(7) = 5.017, p = .002. For participant 4 in group B, there is a significant improvement in systolic BP with a mean difference of M = 1.00 (SD = 0.54) and a paired t-test result of t(7) = 5.292, p = .001. The diastolic BP also shows improvement with a mean difference of M = 1.50 (SD = 1.07) and a paired t-test result of t(7) = 4.822, p = .001. Participant 5 in group B does not show a significant improvement in systolic BP with a mean difference of M = 0.25 (SD = 0.96) and a paired t-test result of t(7) = 1.430, p = .197. The diastolic BP also does not show significant improvement with a mean difference of M = 0.38 (SD = 0.93) and a paired t-test result of t(7) = 1.566, p = .15.

Overall, the combined results of male groups A and B show that the weekly training program has a significant positive impact on the blood pressure of Hajj pilgrims. Specifically, the systolic BP shows a mean improvement in performance ranging from 0.63 to 1.75 (SD ranging from 0.46 to 1.04), and the paired t-test results range from 3.000 to 5.292, with corresponding p-values ranging from .020 to .001. Likewise, the diastolic BP shows a mean improvement in performance ranging from 1.38 to 2.18 (SD ranging from 0.71 to 1.69), and the paired t-test results range from 3.347 to 5.017, with corresponding p-values ranging from .003 to .002.

5.3.12 Paired t-test analysis Male Group A (Control Group) on weekly Oxygen Saturation.

5.3.12.1 Male Participant 1 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.43: Data Participant 1 group A on weekly oxygen saturation

Participant 1 - Group A		
Age		29 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	99	98
2	97	95
3	95	95
4	96	95
5	97	96
6	95	95
7	97	95
8	96	96

The results of the weekly oxygen saturation in the training program for Male control group participant 1, conducted without using the 3D Sa'I VR application, are presented in Table 5.43 The results indicate that Participant 1 shows a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.84. The paired t-test confirms that there is a significant improvement in performance, t(7) = 2.966, p = 0.021. These results indicate that the training program positively impacts Participant 1's SpO2 levels.

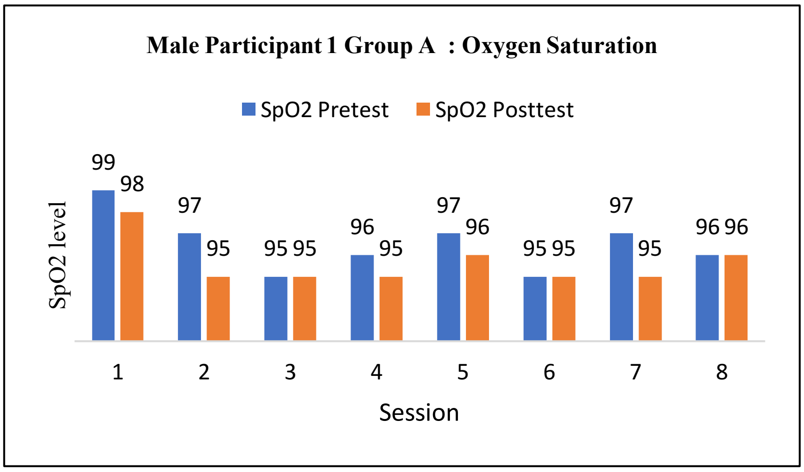

Figure 5.31: Measurement Male participant 1 Group A SpO2

Figure 5.31 displays cluster column the weekly oxygen saturation results of Participant 5 from the male treatment group during an 8-session training program.

5.3.12.2 Male Participant 2 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.44: Data Participant 2 group A on weekly oxygen saturation

Participant 2 - Group A		
Age		28 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	98	97
3	96	95
4	97	97
5	96	96
6	95	95
7	96	96
8	97	96

The results of the weekly training program for Male control group participant 2, conducted without using the 3D Sa'I VR application, are presented in Table 5.44 The results indicate that Participant 2 shows a statistically significant mean improvement of M = 0.50 with a standard deviation of SD = 0.54. The paired t-test confirms that there is a significant improvement in performance, t(7) = 2.646, p = 0.033.

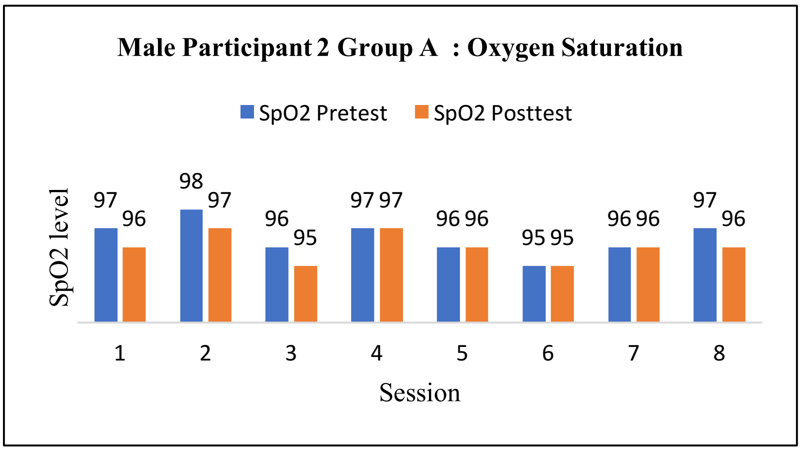

Figure 5.32: Measurement Male participant 2 Group A SpO2

The weekly oxygen saturation results of Participant 2 from the male control group during an 8-session training program are depicted in Figure 5.32 as a clustered column chart.

5.3.12.3 Male Participant 3 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.45 Data Participant 3 group A on weekly oxygen saturation

Participant 3 - Group A		
	Age	27 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	98	97
2	96	96
3	97	95
4	97	97
5	98	95
6	97	96
7	97	95
8	95	95

The results of the weekly oxygen saturation in the training program for Male control group participant 3 are presented in Table 5.45, indicating that Participant 3 shows a statistically significant mean improvement of M = 1.33 with a standard deviation of SD = 1.13. The paired t-test confirms that there is a significant improvement in performance, t(7) = 2.826, p = 0.026. These results indicate that the training program positively impacts Participant 3's SpO2 levels.

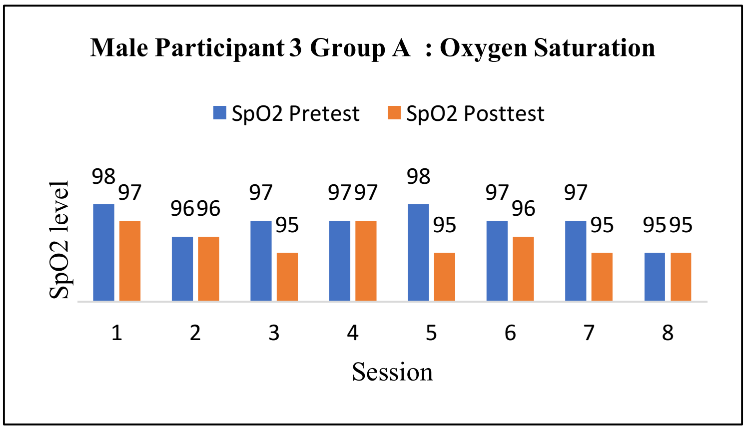

Figure 5.33 Measurement Male participant 3 Group A SpO2

Figure 5.33 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 3 in the male control group during an 8-session training program.

5.3.12.4 Male Participant 4 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.46: Data Participant 4 group A on weekly oxygen saturation

Participant 4 - Group A		
Age		25 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	96	96
3	96	95
4	97	96
5	96	96
6	96	96
7	96	95
8	97	96

The results of the weekly training program for Male control group participant 4 are presented in Table 5.46 Participant 4 shows a statistically significant mean improvement of M = 0.63 with a standard deviation of SD = 0.52. The paired t-test confirms that there is a significant improvement in performance, t(7) = 3.416, p = 0.011.

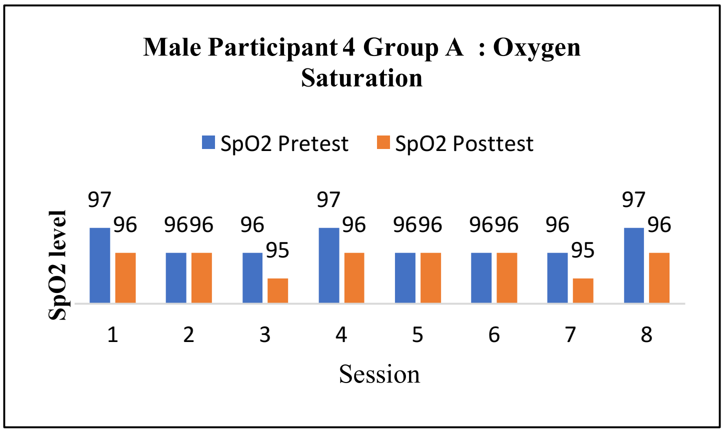

Figure 5.34: Measurement Male participant 4 Group A SpO2

Figure 5.34 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 4 in the male control group during an 8-session training program.

5.3.12.5 Male Participant 5 Group A (Control Group) pre and posttest on weekly Oxygen Saturation.

Table 5.47: Data Participant 5 group A on weekly oxygen saturation

Participant 5 - Group A		
Age		23 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	98	96
3	96	95
4	97	96
5	97	96
6	96	95
7	96	96
8	95	95

The results of the weekly oxygen saturation during the training program for Male control group participant 5 are presented in Table 5.47 Participant 5 shows a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.64. The paired t-test confirms that there is a significant improvement in performance, t(7) = 3.862, p = 0.006.

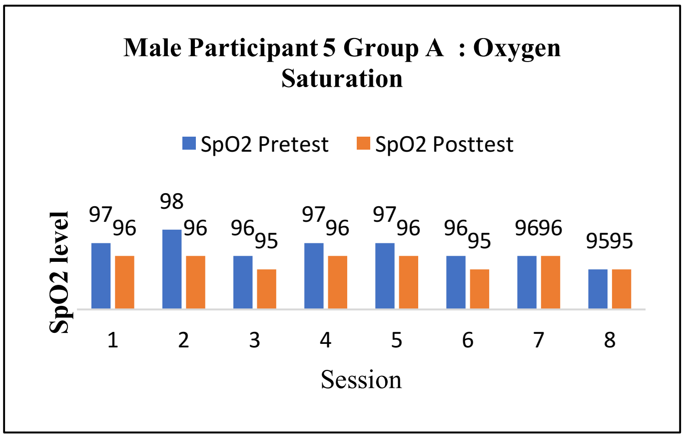

Figure 5.35: Measurement Male participant 5 Group A SpO2

Figure 5.35 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 5 in the male control group during an 8-session training program.

5.3.13 Paired t-test analysis Male Group B (Treatment Group) on weekly Oxygen Saturation.

5.3.13.1 Male Participant 1 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.48: Data Participant 1 group B on weekly oxygen saturation

Participant 1 - Group B		
Age		29 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	96	96
2	95	95
3	97	96
4	99	98
5	97	96
6	96	96
7	96	95
8	95	95

Table 5.48 presents the results of weekly oxygen saturation measurements taken during an 8-session training program for Participant 1 in the male treatment group using the 3D Sa'I VR application. Participant 1 shows a statistically significant mean improvement of M = 0.50 with a standard deviation of SD = 0.54, indicating an increase in oxygen saturation levels over the course of the training program. This finding is further supported by a paired t-test, which reveals a significant improvement in performance with a t-value of 2.646 and a p-value of 0.033, based on a sample size of 8 sessions.

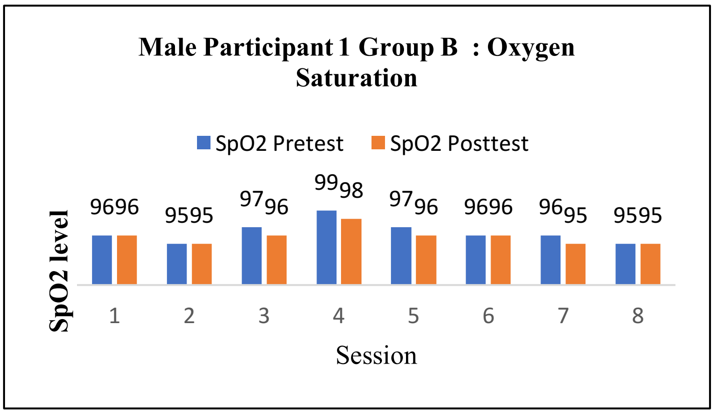

Figure 5.36: Measurement Male participant 1 Group B SpO2

Figure 5.36 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 1 in the male treatment group during an 8-session training program.

5.3.13.2 Male Participant 2 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.49: Data Participant 2 group B on weekly oxygen saturation

Participant 2 - Group B		
Age		28 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	99	97
2	97	95
3	97	96
4	96	95
5	96	95
6	96	96
7	97	95
8	95	95

Table 5.49 presents the results of the weekly oxygen saturation measurements for male Participant 2 in the treatment group during the training program. Participant 2 shows a statistically significant mean improvement of M = 1.13 with a standard deviation of SD = 0.84, indicating an increase in oxygen saturation levels over the course of the training program. This finding is further supported by a paired t-test, which reveals a significant improvement in

performance with a t-value of 3.813 and a p-value of 0.007, based on a sample size of 8 sessions.

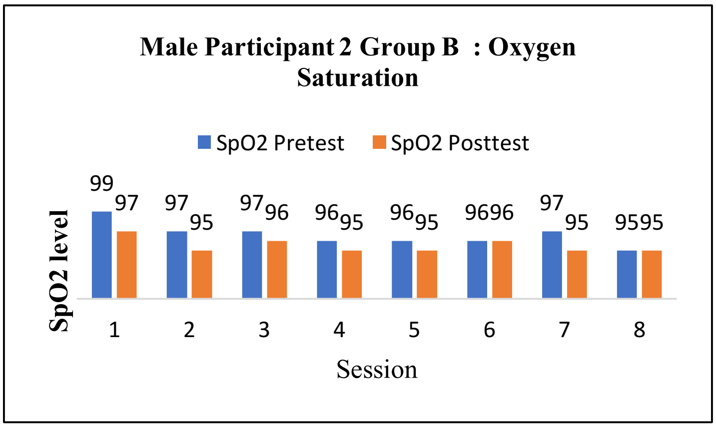

Figure 5.37: Measurement Male participant 2 Group B SpO2

Figure 5.37 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 2 during an 8-session training program.

5.3.13.3 Male Participant 3 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.50: Data Participant 3 group B on weekly oxygen saturation

Participant 3 - Group B		
Age		27 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	98	97
2	96	96
3	97	95
4	96	96
5	98	95
6	96	95
7	97	95
8	95	95

Table 5.50 presents the results of the weekly oxygen saturation measurements for male Participant 3 in the treatment group during the training program. Participant 3 shows a statistically significant mean improvement of M = 1.13 with a standard deviation of SD = 1.13, indicating an increase in oxygen saturation levels over the course of the training program. This finding is further supported by a paired t-test, which reveals a significant improvement in

performance with a t-value of 2.826 and a p-value of 0.026, based on a sample size of 8 sessions.

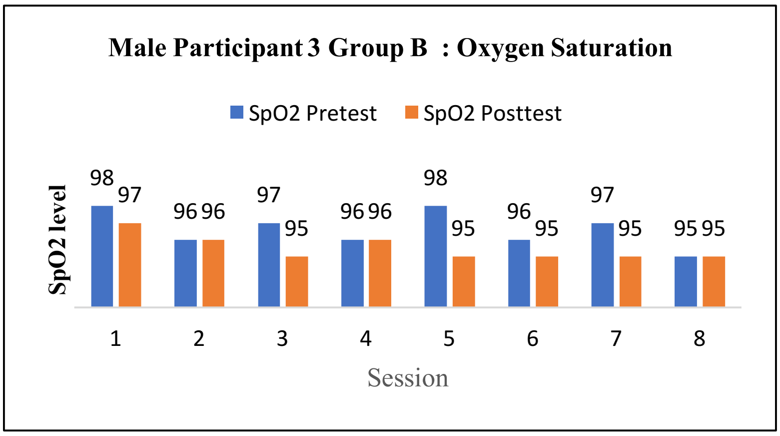

Figure 5.38: Measurement Male participant 3 Group B SpO2

Figure 5.38 demonstrate a clustered column chart depicting the weekly oxygen saturation results of Participant 3 during an 8-session training program.

5.3.13.4 Male Participant 4 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.51: Data Participant 4 group B on weekly oxygen saturation

Participant 4 - Group B		
Age		25 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	97	96
2	98	97
3	97	95
4	96	96
5	96	95
6	96	95
7	97	96
8	95	95

Table 5.51 presents the results of the weekly oxygen saturation measurements for male Participant 4 in the treatment group during the training program. Participant 4 shows a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.64, indicating an increase in oxygen saturation levels over the course of the training program. This finding is further

supported by a paired t-test, which reveals a significant improvement in performance with a t-value of 3.862 and a p-value of 0.006, based on a sample size of 8 sessions.

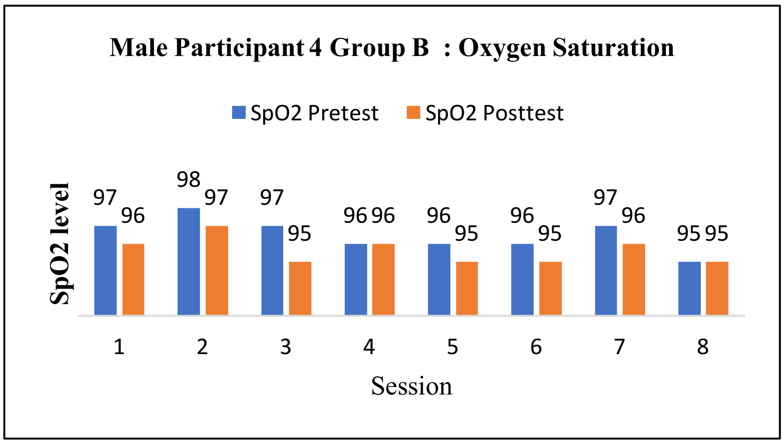

Figure 5.39: Measurement Male participant 4 Group B SpO2

Figure 5.39 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 4 during an 8-session training program.

5.3.13.5 Male Participant 5 Group B (Treatment Group) pre and posttest on weekly Oxygen Saturation.

Table 5.52: Data Participant 5 group B on weekly oxygen saturation

Participant 5 - Group B		
Age		23 years old
Sessions	SpO2 Pretest	SpO2 Posttest
1	99	98
2	97	95
3	95	95
4	97	96
5	97	96
6	95	95
7	97	95
8	96	96

Table 5.52 presents the results of the weekly oxygen saturation measurements for male Participant 5 in the treatment group during the training program. Participant 5 shows a statistically significant mean improvement of M = 0.88 with a standard deviation of SD = 0.84, indicating an increase in oxygen

saturation levels over the course of the training program. This finding is further supported by a paired t-test, which reveals a significant improvement in performance with a t-value of 2.966 and a p-value of 0.021, based on a sample size of 8 sessions.

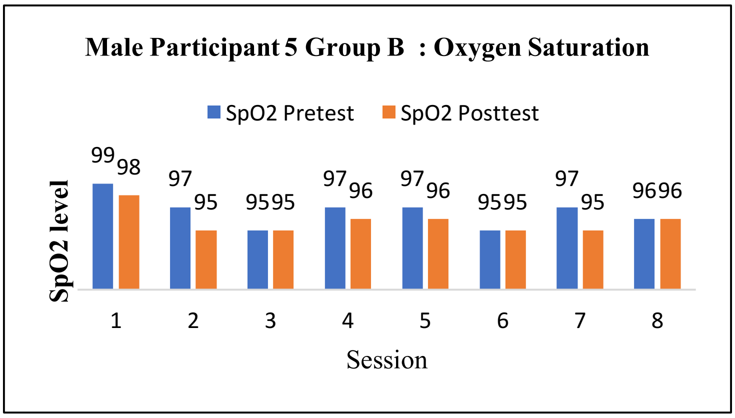

Figure 5.40: Measurement Male participant 5 Group B SpO2

Figure 5.40 displays a clustered column chart depicting the weekly oxygen saturation results of Participant 5 during an 8-session training program.

5.3.14 Combine result Male Group A and Group B pre and posttest on weekly Oxygen Saturation.

Table 5.53: Combine result Male Group A and B on weekly Oxygen Saturation

Male	Age	M	Std	t	df	Sig
Group A (Control Group)						
Participant 1	29 years old	0.88	0.84	2.966	7	.021
Participant 2	28 years old	0.50	0.54	2.646	7	.033
Participant 3	26 years old	1.13	1.13	2.826	7	.026
Participant 4	25 years old	0.63	0.52	3.416	7	.011
Participant 5	23 years old	0.88	0.64	3.862	7	.006
Group B (Treatment Group)						
Participant 1	29 years old	0.50	0.54	2.646	7	.033
Participant 2	28 years old	1.13	0.84	3.813	7	.007
Participant 3	26 years old	1.13	1.13	2.826	7	.026
Participant 4	25 years old	0.88	0.64	3.862	7	.006
Participant 5	23 years old	0.88	0.84	2.966	7	.021

Table 5.53 show both Group A and Group B, all participants statistically significant mean improvements in oxygen saturation levels over the course of the training program. In Group A, Participant 1 shows a mean improvement of M = 0.88 with a standard deviation of SD = 0.84, supported by a paired t-test (t(7) = 2.966, p = 0.021). Participant 2 shows a mean improvement of M = 0.50 with a standard deviation of SD = 0.54, supported by a paired t-test (t(7) = 2.646, p = 0.033). Participant 3 shows a mean improvement of M = 1.33 with a standard deviation of SD = 1.13, supported by a paired t-test (t(7) = 2.826, p = 0.026). Participant 4 shows a mean improvement of M = 0.63 with a standard deviation of SD = 0.52, supported by a paired t-test (t(7) = 3.416, p = 0.011). Participant 5 shows a mean improvement of M = 0.88 with a standard deviation of SD = 0.64, supported by a paired t-test (t(7) = 3.862, p = 0.006).

Similarly, in Group B, Participant 1 shows a mean improvement of M = 0.50 with a standard deviation of SD = 0.54, supported by a paired t-test (t-value = 2.646, p-value = 0.033). Participant 2 shows a mean improvement of M = 1.13 with a standard deviation of SD = 0.84, supported by a paired t-test (t-value = 3.813, p-value = 0.007). Participant 3 shows a mean improvement of M = 1.13 with a standard deviation of SD = 1.13, supported by a paired t-test (t-value = 2.826, p-value = 0.026). Participant 4 shows a mean improvement of M = 0.88 with a standard deviation of SD = 0.64, supported by a paired t-test (t-value = 3.862, p-value = 0.006). Participant 5 shows a mean improvement of M = 0.88 with a standard deviation of SD = 0.84, supported by a paired t-test (t-value = 2.966, p-value = 0.021).

Based on the results of the study, both Group A and Group B show statistically significant improvements in performance and oxygen saturation levels following a training program. In Group A, all five participants show significant improvements, with mean improvements ranging from 0.63 to 1.33 and p-values ranging from 0.006 to 0.021. In Group B, all five participants also show significant improvements, with mean improvements ranging from 0.50 to 1.13 and p-values ranging from 0.007 to 0.033. The results suggest that the training program is effective for both groups and may be a useful intervention for improving performance and oxygen saturation levels.

CHAPTER SIX

DUSCUSSION AND CONCLUSION

6.1 Introduction

In this chapter, the researcher presents the findings of a study that aims to investigate the impact of a 3D VR application on the effectiveness of a training program for Hajj pilgrims, as well as the effect of weekly cardiorespiratory fitness training on their heart rate, blood pressure, and oxygen saturation.

To achieve this, the researcher likely collects data from a sample of Hajj pilgrims who undergo the training program, either with or without the use of the 3D VR application. The researcher measures the participants' heart rate, blood pressure, and oxygen saturation at various points in time throughout the study, such as before and after the training program. The collected data is then analyzed to determine whether there are any statistically significant differences in the physiological measures between the group that uses the 3D VR application and the group that does not. Additionally, the data is analyzed to identify any significant changes in the physiological measures over time within each group.

The purpose of this chapter is to present the results of the data analysis and to draw conclusions about the effects of the 3D VR application and weekly cardiorespiratory fitness training on the physiological measures of the Hajj pilgrims.

Research Question 2a: What is the impact of using the 3D Sa'i VR application on the effectiveness of a training program for Hajj pilgrims?

6.2 The impact of using the 3D Sa’I VR application on the effectiveness of the training program for Hajj pilgrims

Based on the study results, it is concluded that the utilization of the 3D Sa'I VR application significantly enhances the effectiveness of the training program for both male and female Hajj pilgrims. Participants who utilized the application demonstrated greater performance improvements compared to those who did not use it. Specifically, females showed a statistically significant mean improvement of 0.81, while males exhibited a statistically significant mean improvement of 0.93. These findings align with previous research highlighting the effectiveness of VR technology in diverse training settings. Lu et al. (2021) reported the effectiveness of VR-based training in enhancing surgical performance among medical students, while Park et al. (2020) found VR-based training to be beneficial in improving learning outcomes for engineering students. Additionally, Winter C, Kern F, Gall D., et al. (2021) conducted studies investigating the feasibility and acceptance of immersive VR applications for gait rehabilitation in patients with MS and stroke. Their findings demonstrated that immersive VR training resulted in increased walking speeds, improved mood, and higher motivation compared to traditional treadmill training without VR. However, it should be noted that the effectiveness of VR technology can be influenced by factors such as task type, immersion level, and individual learning styles. Therefore, further research is warranted to explore the potential of VR technology in various training contexts. In conclusion, the utilization of the 3D Sa'I VR application significantly enhances the effectiveness of the training program for Hajj pilgrims, suggesting that VR technology has the potential to enhance training programs in diverse contexts.

Research Question 2b: What is the effect of weekly cardiorespiratory fitness training on the heart rate, blood pressure, and oxygen saturation of Hajj pilgrims?

6.3 The effect of weekly cardiorespiratory fitness training on the heart rate, blood pressure, and oxygen saturation of Hajj pilgrims

Monitoring physiological parameters, such as heart rate, blood pressure, and oxygen saturation, is critical for assessing individuals' health status and tracking their progress before and after training. These parameters are essential to understand the physiological responses to exercise, allowing trainers and health professionals to tailor training programs to meet individual needs and assess program effectiveness in improving cardiovascular health. Based on the study's results, it can be concluded that weekly cardiorespiratory fitness training has a significant positive impact on the heart rate, blood pressure, and oxygen saturation of both male and female Hajj pilgrims. The study compares the weekly heart rate performance of male Hajj pilgrims who use the 3D Sa'I VR application (Group B) with those who do not (Group A). Paired t-tests show statistically significant improvements in heart rate for all participants in both groups, except for Participant 5 in Group A, who shows significant improvement only when using the 3D Sa'I VR application. The results suggest that the 3D Sa'I VR application has a positive impact on the weekly heart rate of male Hajj pilgrims in both groups.

The effectiveness of a weekly training program on the blood pressure of male Hajj pilgrims in Groups A and B is analyzed individually for each participant, with both systolic and diastolic blood pressure measured. Overall, the program has a significant positive impact on participants' blood pressure. The mean improvement in systolic BP ranges from 0.63 to 1.75, and the mean improvement in diastolic BP ranges from 1.38 to 2.18. The paired t-test results range from 3.000 to 5.292, with corresponding p-values ranging from .020 to .001. The study suggests that the weekly training program is effective in improving blood pressure in Hajj pilgrims. Weekly oxygen saturation levels for males find that both Group A and Group B show significant improvements in performance and oxygen saturation levels following the training program. All five participants in both groups show significant improvements, with mean improvements ranging from 0.50 to 1.33 and p-values ranging from 0.006 to 0.033. The study suggests that the training program is effective for improving performance and oxygen saturation levels. It can be concluded that the weekly training program, including the use of the 3D Sa'I VR application, is effective in improving the weekly heart rate, oxygen saturation levels, and blood pressure of male Hajj pilgrims.

All participants in both Group A and Group B show significant improvements in heart rate, oxygen saturation levels, and blood pressure. The mean improvements in heart rate range from 0.75 to 1.25, the mean improvements in oxygen saturation range from 0.50 to 1.33, and the mean improvements in systolic and diastolic blood pressure range from 0.63 to 2.18. For females, the study finds that both groups show improvements in performance, with Group B participants using the 3D Sa'I VR application demonstrating a greater mean improvement in performance compared to Group A participants who do not use the application. The 3D Sa'I VR application also has a positive impact on the weekly heart rate of the participants in both groups. In terms of oxygen saturation levels, both groups show positive results, with Participants 1-4 in Group A and Participants 1, 2, 3, and 5 in Group B exhibiting a significant mean improvement in performance. The paired t-tests confirm significant improvements in performance, with p-values ranging from 0.011 to 2.966. While the comparison of p-values between the two groups shows that some participants have similar p-values while others have different p-values, both groups demonstrate improvement. For females, the study finds that both groups show improvements in performance, with Group B participants using the 3D Sa'I VR application demonstrating a greater mean improvement in performance compared to Group A participants who do not use the application. The study also highlights the importance of considering gender differences in the effectiveness of training programs.

The results show that male and female Hajj pilgrims may respond differently to the same training program, and virtual reality technology may have a greater impact on the performance of male participants. This underscores the need for tailored exercise interventions that consider individual differences and preferences. According to Kim et al. (2021), their study reveals VR relaxation demonstrates a greater impact on enhancing parasympathetic activity and reducing stress levels, which are associated with improved cardiovascular function. On the other hand, biofeedback proves more effective in reducing muscle tension. These findings suggest that VR has the potential to be a valuable tool for stress reduction, offering a cost-effective and easily accessible alternative to traditional non-pharmacological interventions. Additionally, the study highlights the promising role of VR technology in mental health treatment. Furthermore, research has shown that using VR can reduce the feelings of fatigue and exertion during exercise. The distraction and immersion provided by VR technology can lead to lower heart rate and blood pressure responses during physical activity (Fernandes et al., 2020). Therefore, incorporating VR technology into exercise interventions may have additional benefits in terms of cardiovascular health improvement. Overall, the study provides valuable insights into the potential of exercise interventions and virtual reality technology in improving cardiovascular health in Hajj pilgrims. By monitoring physiological parameters and considering gender differences, trainers and health professionals can develop more effective and personalized training programs that can have a positive impact on the health and well-being of individuals.

6.4 Implication of the study

The use of the 3D Sa'i VR application in training programs for Hajj pilgrims significantly improves their performance, as reflected in decreased time distance during the post-2.4km Fitness test. This suggests that VR technology is a valuable tool for enhancing the training experience and improving the overall performance of Hajj pilgrims. The findings of this study have practical implications for the development of training programs for Hajj pilgrims. The use of VR technology, such as the 3D Sa'i VR application, is an effective way to enhance the training experience and improve the overall performance of Hajj pilgrims. The study highlights the potential benefits of VR technology in the context of religious practices and rituals. Using VR technology in religious contexts enhances the religious experience and facilitates greater engagement with religious practices.

Future research should focus on conducting studies with larger sample sizes to confirm the findings of this study. Additionally, it would be valuable to investigate the long-term effects of using VR technology in training programs for Hajj pilgrims and other religious practices. This study supports the findings of a meta-analysis by Pashaei and colleagues (2021), which find that the use of VR technology in medical education leads to significant improvements in knowledge and skills acquisition. This suggests that VR technology has broad potential for enhancing educational and training programs across a range of domains, including religious education and practice. Overall, the implications of this study suggest that the use of VR technology, such as the 3D Sa'i VR application, is an effective way to enhance the training experience and improve the overall performance of Hajj pilgrims. Additionally, the study highlights the potential benefits of VR technology in the context of religious practices and rituals, which may have broader implications beyond the Hajj pilgrimage.

6.5 Recommendation for future research

There are several recommendations for future research:

1. Increase the sample size: As the initial study employed a small sample size, a larger-scale study would improve the generalizability of the findings. A larger number of participants from various backgrounds and ages would provide a more thorough knowledge of the influence of the 3D Sa'I VR application for Hajj pilgrims.

2. Include a broader age range: While the initial study focused on individuals aged 18-29, expanding the age range to include older participants would be advantageous. This would allow for a more comprehensive examination of the 3D Sa'I VR application's impact on pilgrims' cardiorespiratory performance by comparing its effectiveness across different age groups.

3. Long-term follow-up: Extend the study's duration to incorporate long-term follow-up evaluations. Monitoring the participants' cardiorespiratory performance over time, such as several months or years following the Hajj journey, would provide insight into the long-term implications of the 3D Sa'I VR programme on their health and fitness levels.

4. Conduct a randomized controlled trial: To improve the study's internal validity, use a randomized controlled trial design. A more thorough study of the

application's effectiveness in increasing cardiorespiratory performance would be possible if participants were randomly assigned to either the treatment group (using the 3D Sa'I VR application) or the control group (without the application).

5. Incorporate objective measurements of cardiorespiratory performance, such as VO2 max testing or other standard fitness evaluations, in addition to self-reported indicators. This would provide more precise and trustworthy statistics for assessing the influence of the 3D Sa'I VR application on pilgrims' fitness levels.

6. Expand the assessment to incorporate additional important health factors such as stress levels, sleep quality, and overall well-being. Considering these additional factors would provide a more comprehensive knowledge of the 3D Sa'I VR application's impact on Hajj pilgrims' overall health management.

By addressing these recommendations, future research can further explore the potential benefits and implications of using the 3D Sa'I VR application in training programs for Hajj pilgrims, contributing to improved health outcomes and enhanced experiences during their Hajj journey.

6.6 Conclusion

In conclusion, the development of the 3D Sa'i VR application for Hajj pilgrims provides an effective solution to address the lack of physical fitness preparation and the absence of a systematic training program for Hajj pilgrims. The use of the 3D Sa'i VR application demonstrates a positive impact on the cardiorespiratory fitness of participating Hajj pilgrims. The study investigates the impact of using the 3D Sa'i VR application on the effectiveness of the training program for Hajj pilgrims. It measures the weekly cardiorespiratory fitness of the pilgrims, including heart rate, blood pressure, and oxygen saturation. The findings reveal that the use of the 3D Sa'i VR application significantly improves the cardiorespiratory fitness of the pilgrims.

The results suggest that the 3D Sa'i VR application proves to be a valuable tool for Hajj pilgrims in their physical preparation for the pilgrimage. It helps simulate the Hajj pilgrimage experience, incorporating the physical challenges encountered during the journey. The application also offers a systematic training program that can be tailored to the individual needs and fitness levels of the pilgrims. However, it is important to note that the study has limitations, such as a small sample size and a lack of diversity within the sample population. Therefore, future research should aim to conduct larger-scale studies with more diverse samples to enhance the generalizability of the findings.

In summary, the 3D Sa'i VR application demonstrates promise in improving the cardiorespiratory fitness of Hajj pilgrims and serves as a useful tool to address the lack of physical fitness preparation and the absence of a systematic training program. The application provides an immersive and engaging experience for Hajj pilgrims, assisting them in preparing for the physical demands of the pilgrimage. Future research should continue to explore its potential benefits in various contexts and populations.

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