EFFECTS OF AQUATIC EXERCISE AND PROGRESSIVE MUSCLE RELAXATION ON PHYSICAL FITNESS, PAIN SCORE AND EMOTIONAL DISTRESS AMONG OSTEOARTHRITIS PATIENTS

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by

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

AAOS	American Academy of Orthopedic Surgeons
ACR	American College of Rheumatology
ADL	Activities of daily living
AFAP	Arthritis Foundation Aquatic Program
AFM	Arthritis Foundation of Malaysia
ANOVA	Analysis of Variance
AE	Aquatic Exercises
ASPR	Age Standardized Prevalence Rate
ATRI	Aquatic Therapy & Rehab Institute
BMI	Body Mass Index
CAE	Combined Aquatic Exercise
CBT	Cognitive Behavioural Therapy
CI	Confidence Interval
cm	centimeter
CONSORT	Consolidated Standards of Reporting Trials
COPCORD	Community-Oriented Program for Control of Rheumatic Diseases
CPG	Clinical Practical Guidelines
CV	Coefficient of variation
CVR	Content Validity Ratio
DALYs	Disability-Adjusted Life Years
DASS-21	Depression, Anxiety and Stress Scale-21
Deg/Sec	Degree/Second
DJD	Degenerative Joint Disease
ESCEO	European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis
EULAR	European League Against Rheumatism
GI	Guided Imagery
HUSM	Hospital Universiti Sains Malaysia
ISK	Index for Severity of Knee Osteoarthritis
JSN	Joint Space Narrowing
Kg	Kilogram
Kg/m^2	$Kilogram/Meter^2$

K-L	Kellgren and Lawrence
KOA	Knee Osteoarthritis
KOOS	Knee Injury and Osteoarthritis Outcome Score
m	Meter
M	Mean
min	minutes
MCID	Minimum Clinically Important Differences
MBSR	Mindfulness-Based Stress Reduction
MOH	Ministry of Health
NICE	National Institute for Health and Clinical Excellence
NFR	Nociceptive Flexion Reflex
NSAIDs	Non-steroidal anti-inflammatory drugs
NIH	National Institutes of Health
OA	Osteoarthritis
OARSI	Osteoarthritis Research Society International
PEDro	Physiotherapy Evidence Database
PMR	Progressive Muscle Relaxation
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of life
RCT	Randomized Controlled Trial
ROM	Range of Motion
SD	Standard Deviation
SDS	Zung Self-Rating Depression Scale
SPSS	Statistical Package for Social Sciences
TKA	Total Knee Arthroplasty
USM	Universiti Sains Malaysia
VAS	Visual Analogue Scale
WHO	World Health Organization
WOMAC	Western Ontario and McMaster Universities Osteoarthritis
ZDA	Zero Depth Entry
6-MWT	Six-minute Walking Test

LIST OF APPENDICES

KESAN SENAMAN AKUATIK DAN RELAKSASI OTOT PROGRESIF KE ATAS KECERGASAN FIZIKAL, SKOR KESAKITAN DAN TEKANAN EMOSI DALAM KALANGAN PESAKIT OSTEOARTRITIS

ABSTRAK

Senaman akuatik dan relaksasi otot progresif sering disarankan sebagai rawatan bukan farmakologi bagi individu yang menghidap osteoartritis (OA); namun, keberkesanannya masih kurang dikaji secara menyeluruh. Kajian ini dijalankan untuk menilai kesan senaman akuatik, relaksasi otot progresif, serta gabungan kedua-duanya terhadap kecergasan fizikal, tahap kesakitan, dan tekanan emosi (termasuk kemurungan, kebimbangan, dan tekanan) dalam kalangan pesakit osteoartritis lutut di Malaysia. Kajian ini juga menumpukan perhatian kepada komponen intervensi yang praktikal. Seramai 46 peserta lelaki dan wanita yang telah disahkan mengalami osteoartritis lutut tahap II dan III serta memenuhi kriteria inklusi telah dipilih secara rawak ke dalam empat kumpulan: kumpulan akuatik (n = 11), kumpulan relaksasi otot progresif (n = 11), kumpulan gabungan (n = 12), dan kumpulan kawalan (n = 12). Peserta telah direkrut dari Klinik Ortopedik, Hospital Universiti Sains Malaysia (HUSM). Semua peserta menjalani penilaian kecergasan fizikal (Ujian Jalan 6-Minit [6-MWT], julat pergerakan [ROM]), skor kesakitan (Skala Analog Visual [VAS], skor kesakitan WOMAC), dan tekanan emosi (DASS-21) pada empat peringkat: permulaan kajian (baseline), selepas 4 minggu (pertengahan intervensi), selepas 8 minggu (pasca-intervensi), dan selepas 12 minggu (akhir intervensi), di Makmal Sains Sukan dan Senaman, Universiti Sains Malaysia (USM). Intervensi melibatkan program selama 12 minggu yang dijalankan dua kali seminggu (jumlah 24 sesi), merangkumi senaman akuatik, latihan relaksasi otot progresif, dan gabungan kedua-duanya. Analisis statistik

dijalankan menggunakan ANOVA faktorial campuran. Berbanding kumpulan kawalan, semua kumpulan intervensi menunjukkan peningkatan yang signifikan dari segi fleksibiliti, jarak berjalan, skor kesakitan, serta tahap kebimbangan, kemurungan dan tekanan. Kumpulan gabungan mencatatkan peningkatan tambahan dalam kecergasan fizikal yang diukur melalui 6-MWT (485.75 ± 42.16 m, p = .00) dan julat pergerakan (ROM)—fleksi lutut kanan (144 ± 6.88º, p = .00) dan kiri (147 ± 3.98º, p = .00); ekstensi lutut kanan (0.00 ± 0.00º, p = .00) dan kiri (0.00 ± 0.00º, p = .00)—sering kali melebihi pencapaian kumpulan akuatik dan relaksasi otot progresif secara individu. Begitu juga, terdapat pengurangan skor kesakitan VAS (13 ± 7.33 mm, p = .00), skor kesakitan WOMAC (0.08 ± 0.28, p = .00), dan tekanan emosi (kemurungan 0.16 ± 0.30, p = .00; kebimbangan 0.00 ± 0.00, p = .00; tekanan 0.08 ± 0.28, p = .00). Penambahbaikan ini kekal signifikan sehingga minggu ke-8 dan minggu ke-12 intervensi. Sepanjang 12 minggu, senaman akuatik, relaksasi otot progresif, dan terutamanya gabungan kedua-duanya, membawa kepada peningkatan ketara dalam kecergasan fizikal, pengurangan kesakitan, serta pengurangan tekanan emosi dalam kalangan pesakit osteoartritis lutut berbanding kumpulan kawalan. Pendekatan gabungan menunjukkan manfaat yang paling konsisten dan bermakna merentasi pelbagai ukuran hasil.

EFFECTS OF AQUATIC EXERCISES AND PROGRESSIVE MUSCLE RELAXATION ON PHYSICAL FITNESS, PAIN SCORE AND EMOTIONAL DISTRESS AMONG OSTEOARTHRITIS PATIENTS

ABSTRACT

Aquatic exercises and progressive muscle relaxation are commonly recommended as non-pharmacological treatments for individuals with osteoarthritis (OA); however, their effectiveness remains understudied. This study is designed to evaluate how aquatic exercise, progressive muscle relaxation, and their combination affect physical fitness, pain levels, and emotional distress (including depression, anxiety, and stress) in Malaysian knee osteoarthritis patients. It also focused on identifying practical intervention components. A total of 46 men and women with knee osteoarthritis diagnosed as grades II and III who met the inclusion criteria were randomly assigned to either an aquatic group (n = 11), a progressive muscle relaxation group (n = 11), a combination group (n = 12), or a control group (n = 12). Participants were recruited from the Orthopaedics clinic at Hospital Universiti Sains Malaysia (HUSM). All participants completed assessments for physical fitness (6-MWT, ROM), pain score (VAS, WOMAC pain), and emotional distress (DASS-21) at baseline, after 4 weeks (mid-intervention), after 8 weeks (post-intervention), and 12 weeks (end-intervention), respectively, at the Exercise and Sports Science Laboratory, Universiti Sains Malaysia (USM). The intervention consisted of a twelve-week programme, conducted twice weekly (totaling 24 sessions), which involved an aquatic exercise programme, progressive muscle relaxation training, and a combination of both over twelve consecutive weeks. Statistical analysis was performed using a mixed factorial ANOVA. Compared to the control group, all intervention groups experienced

significant improvements in flexibility, walking distance, pain scores, anxiety, depression, and stress. The combined group showed additional improvements in physical fitness, as measured by the 6-MWT (485.75 ± 42.16 m, $p = .00$) and ROM (range of motion), flexion in the right knee (144 ± 6.88º, $p = .00$) and left knee (147 ± 3.98º, $p = .00$); extension in the right knee (0.00 ± 0.00º, $p = .00$) and left knee (0.00 ± 0.00º, $p = .00$)—often following the aquatic and PMR groups. Similarly, there were reductions in pain VAS score (13 ± 7.33 mm, $p = .00$), WOMAC-pain score (0.08 ± 0.28, $p = .00$), and emotional distress (depression 0.16 ± 0.30, $p = .00$; anxiety 0.00 ± 0.00, $p = .00$; stress 0.08 ± 0.28, $p = .00$). These improvements remained significant at weeks 8 and 12 of the intervention. Over 12 weeks, aquatic exercises, progressive muscle relaxation, and their combination, especially, led to significantly improved physical fitness, reduced pain, and alleviated emotional distress in patients with knee osteoarthritis compared to the control group. The combined approach consistently yielded the highest meaningful benefits across various outcome measures.

CHAPTER 1

INTRODUCTION

1.1 Background and Scope of the Study

Osteoarthritis (OA) is the most common degenerative joint disease (DJD) (Arden *et al.*, 2014; Steinmetz *et al.*, 2023). Worldwide, osteoarthritis primarily affects large weight-bearing joints of the lower limbs, such as the hips, knees, and spine (Burt *et al.*, 2013). Nevertheless, the knee joint is often affected by osteoarthritis (Scott and Kowalczyk, 2008). (Figure 1.1). Osteoarthritis involves the progressive breakdown of cartilage, and its severity tends to increase with age. It causes joint pain. (Neogi, 2013; Sharma, 2021), and disability (Creamer *et al.*, 2000), impacts daily activities, and reduces physical activity (Briggs *et al.*, 2016; Özlü *et al.*, 2023). The movement restrictions, joint pain, and disabilities associated with knee osteoarthritis can also cause mood changes (Hawker and King, 2022). Consequently, individuals with knee osteoarthritis often experience a reduction in quality of life (Vitaloni *et al.*, 2019).

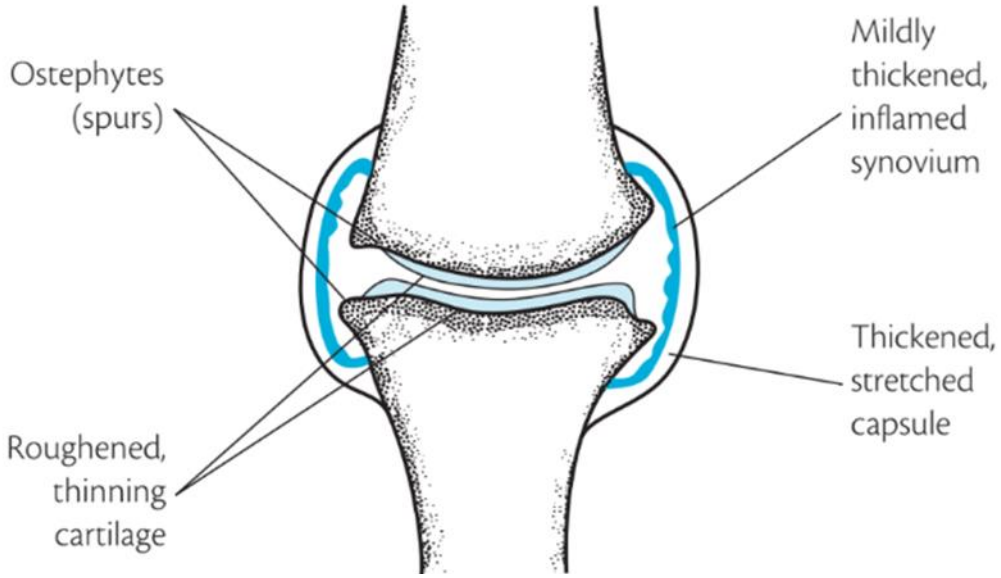

Figure 1.1 Knee Osteoarthritis. Adapted from Arden *et al.* (2008)

As stated by Kellgren and Lawrence (1957) Knee osteoarthritis is radiologically classified into five grades based on the presence of joint space narrowing (JSN) and osteophytes. Grade 0 indicates no changes, such as the absence of joint space narrowing and osteophytes. Grade I suggests doubtful joint space narrowing and possible osteophytic lipping. Grade II shows definite osteophyte formation and possible narrowing of the joint space. Grade III exhibits evident joint space narrowing, some sclerosis, multiple moderate osteophytes, and potential deformity of bone ends. Grade IV represents severe narrowing, marked sclerosis, large osteophytes, and deformity of the bony ends.

1.2 The Global Burden of Osteoarthritis

Osteoarthritis (OA) is a significant public health issue worldwide. In 2020, about 595 million people globally were affected by osteoarthritis (OA) (Steinmetz *et al.*, 2023). This number is expected to increase substantially in the coming decades due to the aging population. (Golightly *et al.*, 2012). Age remains a significant risk factor for developing osteoarthritis. The World Health Organization (WHO) estimated that 9.6% of men and 18% of women aged 60 and older experience symptoms of osteoarthritis (OA) and are affected by the condition worldwide (Abramoff and Caldera, 2020). (Mathers *et al.*, 2006; Murray *et al.*, 1996; WHO, 2013). Nevertheless, osteoarthritis remains a common disorder, with the number of cases increasing over the past few decades to affect 14% of the global population aged 30 and older. The number of cases is expected to continue rising in 2050 (Steinmetz *et al.*, 2023).

1.3 The Asian Burden of Osteoarthritis with Emphasis on Malaysia

While osteoarthritis (OA) is a global public health issue, its presentation in Asian populations, including those in Malaysia, requires consideration of unique genetic, lifestyle, and environmental factors. In Malaysia, osteoarthritis (OA) is a common condition, especially among older adults. According to the Arthritis Foundation of Malaysia (AFM) and the Clinical Practice Guideline (CPG), about 10% of people aged 60 and above in Malaysia are affected by osteoarthritis (OA), with half of these cases involving the knee, which is the most common site (AFM, 2011; CPG, 2013). Although specific data on patients with knee osteoarthritis (KOA) in Malaysia are unavailable, a study conducted by the Community-Oriented Program for Control of Rheumatic Diseases (COPCORD) on musculoskeletal pain showed that the knee was the most frequently affected area reported for joint complaints. Further analysis indicated that more than half of those experiencing knee pain were diagnosed with OA (Veerapen *et al.*, 2007). Indeed, Malaysians with knee osteoarthritis (KOA) reported experiencing a high level of pain (Veerapen *et al.*, 2007), along with functional disability and difficulty performing daily activities like walking and squatting (Veerapen *et al.*, 2004).

1.4 Current Management of Osteoarthritis

Osteoarthritis (OA) treatment focuses on maintaining or improving physical function, managing pain, increasing range of motion, and enhancing overall well-being. To date, there are no methods to prevent osteoarthritis (Buckwalter *et al.*, 2004; Turkiewicz *et al.*, 2014).

The current guidelines for managing osteoarthritis (OA) strongly recommend non-pharmacological approaches as the first treatment option for osteoarthritis (OA),

highlighting aquatic exercise and progressive muscle relaxation (PMR) as safe and effective choices. The American College of Rheumatology (ACR) conditionally recommends both aquatic exercise and mind-body interventions, such as progressive muscle relaxation, for knee osteoarthritis (KOA), emphasizing their benefits for patients with comorbidities or limited tolerance for land-based activity (Kolasinski *et al.*, 2020). The European League Against Rheumatism (EULAR) specifically endorses aquatic exercise as an effective way to improve joint mobility and reduce knee and hip osteoarthritis pain (Fernandes *et al.*, 2013; Moseng *et al.*, 2024), while the Osteoarthritis Research Society International (OARSI) recommends both aquatic exercise and relaxation techniques as non-pharmacological treatments (Arden *et al.*, 2021; McAlindon *et al.*, 2014). Studies show that aquatic exercise provides unique benefits through water's buoyancy and resistance properties, significantly improving physical function in osteoarthritis (OA) patients. Similarly, progressive muscle relaxation has been shown to effectively reduce pain perception and emotional distress related to chronic osteoarthritis symptoms (Baird and Sands, 2004; Dusek *et al.*, 2008; Elias *et al.*, 2015; Gay *et al.*, 2002; Krasilshchikov *et al.*, 2015). The European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO) also endorses these therapies as part of a comprehensive osteoarthritis (OA) management plan, especially for patients who cannot tolerate land-based exercises (Bruyère *et al.*, 2014). These American College of Rheumatology (ACR) endorsed and internationally recognised, evidence-based guidelines jointly recommend aquatic exercise (AE) and progressive muscle relaxation (PMR) as valuable, low-risk components of multimodal osteoarthritis treatment strategies, offering safe alternatives to pharmacological interventions.

In Malaysia, the existing clinical practice guidelines (CPG) from the Malaysian Ministry of Health (MOH) for managing knee osteoarthritis (OA) mainly focus on hospital-based care. This approach incorporates multidisciplinary methods such as medications, surgical interventions, and health education (CPG, 2013). Patients are advised to be informed about their diagnosis, weight management (particularly for obese individuals), range of motion exercises, strengthening activities, and aerobic training (CPG, 2013). However, limited information is available on the strategies and systems employed to ensure patient adherence to prescribed treatments in Malaysia. Furthermore, it appears that no community or home-based programmes are accessible or implemented as alternatives for patients who cannot afford hospital care.

1.5 Statement of Problem

Osteoarthritis, particularly knee osteoarthritis (KOA), is a common degenerative joint condition characterized by the gradual deterioration of cartilage, remodelling of the subchondral bone, and inflammation of the synovium. These changes lead to pain, stiffness, and limited movement (Hunter and Bierma-Zeinstra, 2019). As a leading cause of disability among older people globally, the prevalence of knee osteoarthritis is increasing due to ageing populations, obesity, and sedentary lifestyles (Sharma, 2021). It affects about 250 million people worldwide, with community studies in Malaysia showing prevalence rates of up to 30% among adults aged 55 and older. (Chen *et al.*, 2025; Veerapen *et al.*, 2007). In addition to physical symptoms, knee osteoarthritis (KOA) significantly impacts mental health, being linked to depression, anxiety, and stress, which can further reduce quality of life and adherence to treatment (Jackson *et al.*, 2022).

Although pharmacological and surgical options are available, conservative management remains the primary approach for knee osteoarthritis (KOA), especially for those with mild to moderate symptoms (Kolasinski *et al.*, 2020). Exercise therapy is commonly recommended as the first-line strategy because it helps improve muscle strength, joint stability, and mobility (Bannuru *et al.*, 2019; Bennell *et al.*, 2012). However, many KOA patients find it challenging to stick with traditional land-based exercises due to increasing pain, functional limitations, or fear of making symptoms worse (Bartels *et al.*, 2016). Similarly, psychological interventions that address stress and coping strategies are underused, despite evidence showing that psychological distress can lead to more pain and a decline in function (Isaji *et al.*, 2025; Tan *et al.*, 2021; Tang *et al.*, 2022). This highlights the need for accessible, patient-friendly treatments that target both the physical and psychological aspects of knee osteoarthritis (KOA).

Aquatic exercise (AE) provides a supportive environment for individuals with knee osteoarthritis (KOA), utilising the buoyancy, hydrostatic pressure, and thermal effects of water to reduce joint load, ease pain, and encourage movement (Becker, 2009; Hinman *et al.*, 2007; Wang *et al.*, 2007). Previous research has demonstrated that aquatic exercise (AE) can improve walking ability, quadriceps strength, and knee range of motion while decreasing pain and stiffness (Bartels *et al.*, 2016; Waller *et al.*, 2014). However, results remain inconsistent due to variations in study design, exercise protocols, and intervention lengths. Additionally, most aquatic exercise (AE) studies mainly focus on physical outcomes, with limited exploration of emotional well-being, despite the well-known connection between psychological distress and the severity of osteoarthritis (OA) symptoms (Fransen *et al.*, 2007; Jackson *et al.*, 2022; Tang *et al.*, 2022).

Progressive muscle relaxation (PMR) is an accessible and cost-effective mind–body technique that involves systematically tensing and relaxing muscle groups to reduce muscular tension and trigger a relaxation response (Jacobson, 1938; Varvogli and Darviri, 2011). Research suggests that progressive muscle relaxation (PMR) can reduce perceived pain, anxiety, and stress in individuals with chronic pain by decreasing sympathetic nervous system activity and improving pain coping strategies (Baird and Sands, 2004; Gay *et al.*, 2002). Despite its benefits, progressive muscle relaxation (PMR) remains relatively underused in managing knee osteoarthritis (KOA), especially when combined with physical exercise programs. Its ability to complement aquatic exercise (AE) by addressing psychological and neuromuscular factors makes it a promising additional therapy.

Considering the multidimensional effects of knee osteoarthritis (KOA), combining physical rehabilitation with psychological relaxation strategies offers significant potential. An integrated program of aquatic exercise (AE) and progressive muscle relaxation (PMR) could revolutionize the management of knee osteoarthritis (KOA), providing hope for both patients and healthcare professionals.

Another limitation in the current literature is the lack of studies that measure multiple, clinically relevant outcomes over time to evaluate the sustainability of intervention effects. Variables such as the six-Minute Walking Test (6-MWT) for physical fitness, knee Range of Motion (ROM) for joint mobility, Visual Analogue Scale (VAS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for pain assessment, as well as the Depression, Anxiety, and Stress Scale (DASS-21) for emotional distress, have rarely been combined in a single trial. This

comprehensive approach is crucial for understanding the full benefits and guiding holistic clinical practice.

Furthermore, many studies on non-pharmacological interventions for osteoarthritis (OA) often use short intervention periods or lack sufficient follow-up, making it difficult to determine the long-term effectiveness and lasting benefits of these interventions. A longer intervention duration and more frequent measurements are necessary to observe the progressive changes in physical fitness, pain scores, and emotional distress over time, providing a more comprehensive understanding of the intervention's impact. The current study aims to address this by implementing a 12-week intervention period with four repeated measurements.

Therefore, there is an urgent need for a well-designed randomized controlled trial to investigate the effects of aquatic exercise (AE), progressive muscle relaxation (PMR), and their combination (AE + PMR) on physical fitness, pain, and emotional distress in patients with knee osteoarthritis (KOA). A study conducted with rigorous scientific standards would address existing evidence gaps and provide valuable insights for integrating physical and psychological interventions into routine non-pharmacological management of knee osteoarthritis (KOA).

The current research also aims to specifically address the burden of osteoarthritis (OA) in the Malaysian context. While global data offers a broad understanding, local demographic characteristics, cultural nuances, and healthcare system details can influence treatment adherence and outcomes. Research conducted within the Malaysian population will provide valuable context-specific data, informing local healthcare policies and practices related to osteoarthritis (OA) management. This localized data is essential for developing culturally sensitive and accessible intervention programs.

This study examined the impact of aquatic exercises (AE), progressive muscle relaxation (PMR), and their combined approach (AE + PMR) on physical fitness, pain, and emotional distress in Malaysian patients with knee osteoarthritis. Using a randomized controlled trial (RCT) design, participants were divided into four groups: an aquatic exercise group (AE), a progressive muscle relaxation group (PMR), a combined intervention group (AE + PMR), and a control group. All interventions were conducted twice weekly over 12 weeks, totaling 24 sessions. Outcomes were measured at four time points: baseline, after 4 weeks (mid-intervention), after 8 weeks (post-intervention), and at 12 weeks (end of intervention). Physical fitness was assessed using the six-minute walking test (6-MWT) to evaluate aerobic capacity and endurance, along with Range of Motion (ROM) to assess joint flexibility. Pain intensity was measured using the Visual Analogue Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC-pain) subscale. Emotional distress was evaluated with the Depression, Anxiety, and Stress Scale (DASS-21).

1.6 Research Questions

The main research question guiding this study is: What are the individual and combined effects of aquatic exercise (AE) and progressive muscle relaxation (PMR) on physical fitness, pain score, and emotional distress among Malaysian patients with osteoarthritis (OA)?

Specifically, this research seeks to address the following questions:

1. How do aquatic exercises, progressive muscle relaxation, and their combination influence physical fitness, as assessed by the 6-Minute Walking Test (6-MWT) and Range of Motion (ROM), in Malaysian

osteoarthritis (OA) patients over a 12-week intervention with four repeated measurements?

2. What are the effects of aquatic exercises, progressive muscle relaxation, and their combinations on pain scores, assessed by the Visual Analogue Scale (VAS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC-pain) subscale, in Malaysian osteoarthritis (OA) patients over a 12-week intervention with four repeated measurements?
3. To what extent do aquatic exercises, progressive muscle relaxation, and their combination impact emotional distress, as measured by the Depression Anxiety Stress Scales (DASS-21), in Malaysian osteoarthritis (OA) patients during a 12-week intervention with four repeated measurements?

1.7 The Objective of the Study

The objectives of this study were aimed to provide a comprehensive assessment of the interventions under investigation. These include:

1.7.1 General Objective

The main aim of this study was to evaluate the impact of a 12-week programme that included aquatic exercise (AE), progressive muscle relaxation (PMR), and their combination (AE + PMR) on physical fitness (as measured by the 6-MWT and ROM), pain levels (as assessed by the VAS/WOMAC-pain subscale), and emotional distress (as measured by the DASS-21) in patients with knee osteoarthritis (KOA).

1.7.2 Specific Objective

This study had specific objectives with the following aims:

1. To evaluate the impact of aquatic exercise (AE) on physical fitness, pain levels, and emotional distress in patients with knee osteoarthritis (KOA).
2. To assess the effects of progressive muscle relaxation (PMR) on physical fitness, pain levels, and emotional distress in patients with knee osteoarthritis (KOA).
3. To determine whether a combined aquatic exercise and progressive muscle relaxation (AE + PMR) programme yields superior outcomes compared to either intervention alone or no intervention.
4. To analyze the progression of intervention effects on physical fitness, pain level, and emotional distress across four time points (baseline, 4 weeks, 8 weeks, and 12 weeks) to understand intervention trajectories.
5. To analyze the connections between improvements in physical fitness and decreases in pain and emotional distress indicators.
6. To compare adherence rates and safety profiles across aquatic exercise (AE), progressive muscle relaxation (PMR), combined interventions (AE + PMR), and control groups.
7. To provide culturally informed recommendations for integrative osteoarthritis (OA) interventions within the Malaysian healthcare context.
8. To contribute to the evidence supporting the inclusion of psychological techniques in comprehensive osteoarthritis (OA) management.

1.8 The Hypotheses of the Study

Based on the available literature and initial clinical evidence, the following hypotheses were developed to meet the study's objectives:

1.8.1 Null Hypotheses (Ho)

1. Aquatic exercise (AE) has no significant effect on physical fitness, pain levels, or emotional distress in patients with knee osteoarthritis (KOA).
2. Progressive muscle relaxation (PMR) has no significant effect on physical fitness, pain levels, or emotional distress in patients with knee osteoarthritis (KOA).
3. There are no significant differences in physical fitness, pain levels, or emotional distress between the combined intervention group (AE + PMR) and the single-intervention or control groups.
4. There are no significant changes in physical fitness, pain levels, or emotional distress across the four time points (baseline, week 4, week 8, and week 12), irrespective of the intervention group.
5. Improvements in physical fitness are not significantly correlated with reductions in pain or emotional distress among patients with knee osteoarthritis (KOA).
6. There are no significant differences in adherence rates or safety profiles among the aquatic exercise (AE), progressive muscle relaxation (PMR), combined (AE + PMR), and control groups.
7. Culturally informed osteoarthritis (OA) interventions are not perceived as more acceptable or effective among Malaysian patients than standard interventions.

8. Inclusion of psychological techniques, such as progressive muscle relaxation (PMR), does not significantly enhance outcomes in osteoarthritis (OA) rehabilitation compared to standard physical interventions alone (AE).

1.8.2 Alternative Hypotheses (H_A)

1. Aquatic exercise (AE) significantly improves physical fitness, reduces pain levels, and alleviates emotional distress among patients with knee osteoarthritis (KOA).
2. Progressive muscle relaxation (PMR) significantly improves physical fitness, reduces pain levels, and alleviates emotional distress in patients with knee osteoarthritis (KOA).
3. The combined intervention (AE + PMR) yields significantly better outcomes in physical fitness, pain reduction, and emotional distress compared to either intervention alone or no intervention.
4. There are significant changes in physical fitness, pain levels, and emotional distress across the four time points, indicating meaningful intervention effects over time.
5. Improvements in physical fitness are significantly correlated with reductions in pain and emotional distress among patients with knee osteoarthritis (KOA).
6. There are significant differences in adherence rates and/or safety profiles among the aquatic exercise (AE), progressive muscle relaxation (PMR), combined (AE + PMR), and control groups.

7. Culturally informed osteoarthritis (OA) interventions are perceived as more acceptable and/or effective among Malaysian patients than standard interventions.
8. Inclusion of psychological techniques, such as progressive muscle relaxation (PMR), significantly enhances outcomes in osteoarthritis (OA) rehabilitation compared to standard physical interventions alone (AE).

1.9 Conceptual Framework

The conceptual framework for this study combines physiological and psychological models with the holistic rehabilitation approach. Osteoarthritis (OA), as a chronic degenerative condition, affects physical fitness, causes ongoing pain, and leads to emotional distress. Aquatic exercise (AE) and progressive muscle relaxation (PMR), a non-pharmacological intervention, were thought to impact these areas through various physiological and psychological mechanisms.

This model integrates three intervention pathways, aquatic exercise (AE), progressive muscle relaxation (PMR), and a combination of both (AE + PMR), and examines their effects on three key outcome areas: physical fitness measured through (6-MWT and ROM), pain perception (using VAS and WOMAC), and emotional well-being (using DASS-21). (Figure 1.2).

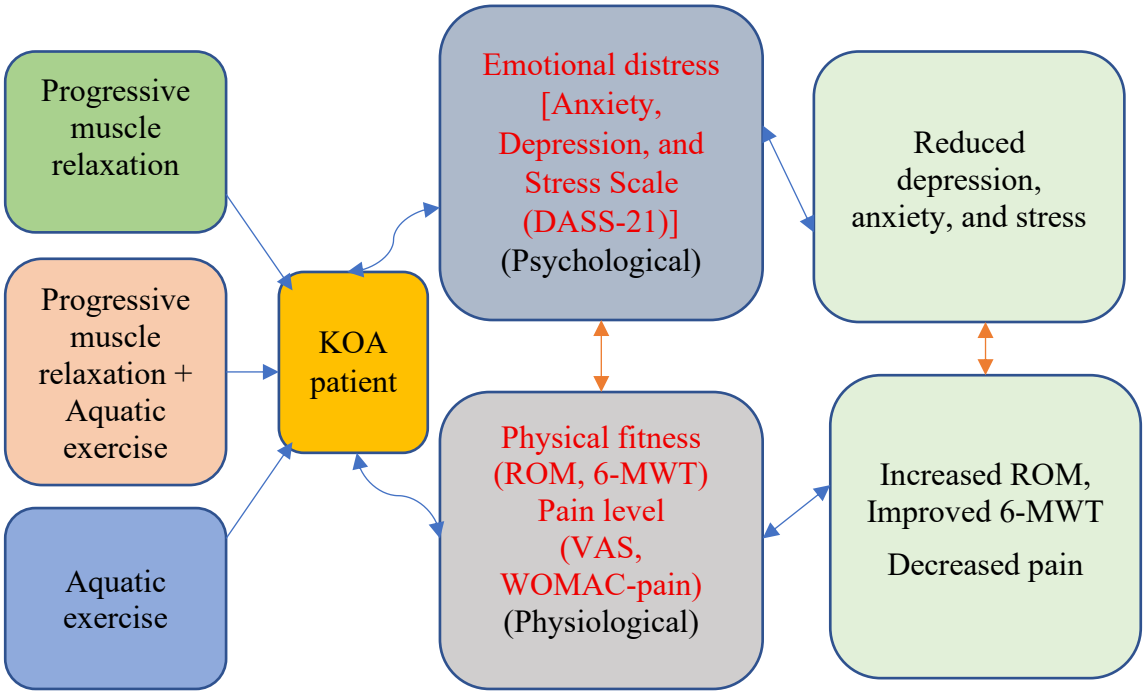

Figure 1.2 Conceptual framework of the study. Source: Author's own

1.10 Significance of the Study

The results of this study may provide empirical evidence to support the development of integrated non-pharmacological osteoarthritis (OA) management strategies that address both physical and emotional aspects. Using a controlled, repeated-measures design with multiple intervention groups, the research aims to clarify the separate and combined impacts of aquatic exercises (AE) and progressive muscle relaxation (PMR). Gaining a clearer understanding of these effects can inform the development of clinical guidelines and rehabilitation programmes tailored to the specific needs of patients with osteoarthritis (OA).

Furthermore, showing improvements in key outcomes, such as the 6-Minute Walking Test (6-MWT), Range of Motion (ROM), Visual Analogue Scale (VAS), the

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC-pain) subscale, and Depression, Anxiety, and Stress Scale (DASS-21), could promote wider adoption in community and healthcare environment. This is especially important in countries like Malaysia and similar populations, where cultural habits and limited resources affect treatment adherence. Promoting strategies that improve physical fitness and decrease pain and emotional distress may result in a better quality of life and lower healthcare costs related to osteoarthritis (OA).

The study also improves the limited understanding of combining aquatic exercise (AE) and progressive muscle relaxation (PMR), potentially paving the way for more comprehensive osteoarthritis (OA) treatment models. Successful adoption could encourage further research into multimodal rehabilitation that considers the biopsychosocial aspects of chronic musculoskeletal conditions.

1.11 Contribution

This PhD research significantly advances the understanding and management of knee osteoarthritis by exploring the combined effects of aquatic exercise (AE) and progressive muscle relaxation (PMR) on physical fitness, pain relief, and emotional well-being. While previous studies have examined the benefits of aquatic exercise (AE) and progressive muscle relaxation (PMR) individually, this study uniquely combines both interventions, addressing a critical gap in the existing literature concerning their potential synergistic effects. It assesses multiple outcomes, including functional capacity (using the 6-Minute Walking Test - 6-MWT and Range of Motion - ROM), pain levels (with the Visual Analogue Scale -VAS and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC- pain) subscales), and psychological distress (via the Depression, Anxiety, and Stress Scale- DASS-21). The research

employs a comprehensive physiological and psychological approach, aligned with modern models of chronic disease management in osteoarthritis (OA) patients.

Furthermore, this study addresses essential gaps in previous research, such as the absence of standardized, long-term intervention protocols and culturally tailored programmes for underserved populations. Using a diverse sample that reflects specific regional contexts, like Malaysia, provides valuable insights into the feasibility, acceptability, and outcomes of combining aquatic exercise (AE) with progressive muscle relaxation (PMR) within a community environment. This localization enhances the overall relevance and clinical importance of the findings, while also acknowledging distinct factors that influence adherence and emotional well-being.

1.12 Conceptual Definitions and Operational Definitions

	Conceptual Definitions	**Operational Definitions**
Aquatic Exercise (AE)	Therapeutic physical activity that utilises water's properties, such as buoyancy, hydrostatic pressure, and viscosity, to create a low-impact environment for reducing joint stress and enhancing cardiovascular endurance (Brody and Geigle, 2009; Kisner *et al.*, 2017).	In this study, aquatic exercise involves supervised sessions conducted twice a week for 45 to 60 minutes each, over 12 weeks (totalling 24 sessions). The programme includes warm-up, stretching, aerobic activities, flexibility exercises, strengthening routines, and cool-down, all performed in a pool with water temperature appropriate for therapeutic use.
Progressive Muscle Relaxation (PMR):	A mind-body relaxation technique that involves systematically tensing and	In this study, progressive muscle relaxation involves an intervention conducted twice

	relaxing muscle groups to reduce physical and psychological stress, first conceptualized by Jacobson (1934) and adapted for use in chronic pain populations (McCallie *et al.*, 2006; Smith, 2005).	weekly for 20 to 30 minutes each session over 12 weeks, where participants practice tensing each muscle group for a few seconds before relaxing, combined with controlled breathing exercises.
Osteoarthritis (OA):	A progressive degenerative joint disorder characterised by the deterioration of articular cartilage, development of osteophytes, sclerosis of subchondral bone, and synovial inflammation, resulting in pain, stiffness, and reduced function (Arden *et al.*, 2008; Yue and Berman, 2022).	In this study, osteoarthritis diagnosis is confirmed both clinically and radiographically in patients presenting with joint pain and functional limitations who meet the established criteria for knee osteoarthritis. Inclusion requires a doctor-confirmed diagnosis based on recognized diagnostic standards.
Knee Osteoarthritis (KOA):	Osteoarthritis confined to the knee joint is characterized by cartilage degeneration, bone remodelling, and symptoms such as joint pain, swelling, limited range of motion, and decreased ability to bear weight (Scott and	In this study, knee osteoarthritis is defined as OA affecting the knee joint in participants selected based on clinical signs and symptoms, with additional confirmation through radiographic evidence such as joint space narrowing or osteophytes, classified according to the Kellgren-Lawrence grading system.

	Kowalczyk, 2008; Sharma, 2021).	
Pain	An unpleasant sensory and emotional experience related to actual or potential tissue damage, as defined by the International Association for the Study of Pain. (IASP), (Kloth *et al.*, 2011; Vadivelu *et al.*, 2011).	In this study, pain intensity is measured using the visual analogue scale (VAS), a 0-100 mm scale where 0 indicates no pain and 100 represents the worst possible pain, and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale, which evaluates the frequency and severity of pain at baseline and throughout the intervention period.
Knee Pain	Pain typically affects only the knee joint and is often associated with knee osteoarthritis (KOA), a condition resulting from the degeneration and inflammation of joint tissue (Felson and Schaible, 2010).	In this study, knee pain is assessed in participants using self-reported measures, including VAS and WOMAC pain scores, collected at baseline and during the intervention period.
Physical Fitness	A composite measure of attributes related to the ability to perform physical activity, including aerobic endurance, muscular strength, flexibility, balance, and joint health	In this study, participants' physical fitness was assessed using the six-minute walk test (6-MWT) to measure aerobic capacity and endurance, and goniometric measurements of knee range of motion (ROM) to evaluate joint flexibility at

	mobility (Hermassi *et al.*, 2023; Powell, 2011).	baseline and throughout the intervention period.
Emotional Distress	A psychological construct comprising symptoms of depression, anxiety, and stress, frequently occurring alongside chronic pain conditions and negatively impacting coping and quality of life (Daly and Macchia, 2023; Melton *et al.*, 2007).	In this study, emotional distress is assessed using the Depression Anxiety Stress Scale (DASS-21). This validated self-report tool measures levels of depressive symptoms, anxiety, and stress at baseline and throughout the intervention.

1.13 Summary

Osteoarthritis (OA), particularly affecting the knee, presents a complex burden characterized by impaired physical fitness, persistent pain, and emotional distress. Non-pharmacological interventions, such as aquatic exercise (AE) and progressive muscle relaxation (PMR), offer promising options for addressing these issues. This study carefully examines the individual and combined effects of these interventions over 12 weeks in a Malaysian group with knee osteoarthritis (KOA), using repeated measures across validated physical and psychological outcomes. The results aim to improve osteoarthritis (OA) management through comprehensive, culturally appropriate, and sustainable care approaches that enhance physical fitness, reduce pain, and support emotional well-being.

This chapter details the study's rationale, emphasising the global and regional impacts of osteoarthritis (OA), the complex challenges faced by those affected, and the potential of aquatic exercises (AE) and progressive muscle relaxation (PMR) as treatment options. It describes the research questions, aims, hypotheses, and conceptual

framework, establishing a foundation for the forthcoming empirical research on how these methods influence physical fitness, pain, and emotional distress in patients with knee osteoarthritis (KOA).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Osteoarthritis (OA) is a musculoskeletal disease diagnosed structurally and clinically. It primarily affects weight-bearing joints, such as the knee joints, and results in loss of function (Becker, 2009; Hale *et al.*, 2012; Sharma *et al.*, 2001). Clinically, patients with osteoarthritis (OA) experience severe pain, morning stiffness, loss of range of motion, muscle weakness, and joint disability (Becker, 2009; Loeser *et al.*, 2012). In Malaysia, 14.4% of people complain of joint and musculoskeletal pain, increasing with age (Veerapen *et al.*, 2007).

2.2 Prevalence of Osteoarthritis (OA)

2.2.1 Globally and Asia Prevalence of Osteoarthritis (OA)

Osteoarthritis (OA) is a widespread chronic degenerative joint disease and a main global public health issue (Hale *et al.*, 2012; Li *et al.*, 2024b; Qiao *et al.*, 2024). It is characterized by the breakdown of joint cartilage, inflammation, and ongoing pain and stiffness, which can restrict flexibility and mobility. The disease results from a complex interaction of biomechanical, biochemical, and cellular processes that affect the entire joint structure, rather than simply being a result of "wear and tear". Osteoarthritis (OA) is a leading cause of disability worldwide, with substantial socioeconomic impacts in both developed and developing countries (Li *et al.*, 2024b).

Over the past few decades, the global burden of osteoarthritis (OA) has steadily risen (Li *et al.*, 2024b). In 2017, the age-standardized point prevalence was 3754.2 per 100,000 people, marking a 9.3% increase since 1990 (Safiri *et al.*, 2020). The global

age-standardized incidence rate in 2017 was 181.2 per 100,000, an 8.2% rise from 1990 (Safiri *et al.*, 2020). By 2021, around 607 million people worldwide were affected by osteoarthritis (OA), with 46.6 million new cases and 21.3 million Disability-Adjusted Life Years (DALYs) (Qiao *et al.*, 2024). The age-standardized prevalence rate in 2021 reached 6967.29 per 100,000 people (Qiao *et al.*, 2024). This increasing trend is expected to continue, driven by longer life expectancy and an aging global population (Qiao *et al.*, 2024; Safiri *et al.*, 2020).

In 2019, the global age-standardized prevalence rate (ASPR) for knee osteoarthritis (KOA) was 4375.95 per 100,000 people (Li *et al.*, 2024b). The prevalence of osteoarthritis (OA) is higher in women and increases with age, reaching its peak in age groups over 95 years (Safiri *et al.*, 2020). In 2017, the United States had one of the highest age-standardized prevalence rates at 6128.1 cases per 100,000 people, reflecting a 23.2% increase since 1990. (Safiri *et al.*, 2020). Other countries with high prevalence include American Samoa (5281 per 100,000) and Kuwait (5234.6 per 100,000) (Safiri *et al.*, 2020). In Germany, 17.9% of adults over 18 reported suffering from osteoarthritis (OA) in the past year, with prevalence reaching 48.1% for women and 31.2% for men aged 65 and older. Knee osteoarthritis (KOA) is the most common form of osteoarthritis (OA) worldwide, accounting for over 56% of cases in 2021. (Li *et al.*, 2024b; Qiao *et al.*, 2024).

In Asia, the prevalence of osteoarthritis (OA) ranges from 20.5% to 68.0%, with knee OA being particularly common, affecting 13.1% to 71.1% of populations in different countries (Zamri *et al.*, 2019). The Western Pacific Region reported high cases

in 2019, with approximately 7,319.87 cases per 100,000 people. (Li *et al.*, 2024b). Japan had a notably higher prevalence rate of 12,610.12 per 100,000 in 2019 (Li *et al.*, 2024b).

East and South Asia are among the top three regions with the highest osteoarthritis (OA) burdens globally (Qiao *et al.*, 2024). In Malaysia, knee osteoarthritis (KOA) is common among older adults; a study in an eastern coastal state of Malaysia found that over half (57.9%) of patients used traditional and complementary medicine to treat knee osteoarthritis (KOA) (Shafii *et al.*, 2018). Women tend to have higher rates of symptomatic knee osteoarthritis (KOA), with one study reporting that 93% of affected patients were women (Veerapen *et al.*, 2004). Those with knee pain often experience significant disability, radiological abnormalities, and varus deformity (Veerapen *et al.*, 2004; Veerapen *et al.*, 2007).

Healthcare utilization among older Malaysian adults with knee osteoarthritis (KOA) is notably higher compared to those without the condition, indicating greater healthcare needs. The increasing prevalence of osteoarthritis (OA) worldwide and in Asia, particularly knee osteoarthritis (KOA), emphasizes the urgent need for effective prevention and management strategies (Li *et al.*, 2024b; Qiao *et al.*, 2024; Safiri *et al.*, 2020). However, this increasing demand on healthcare resources highlights the financial and logistical burden that osteoarthritis (OA) places on the Malaysian healthcare system (Kamsan *et al.*, 2021). Factors like advanced age, female sex, and obesity are consistently key risk factors across populations (Zamri *et al.*, 2019). Additional factors include family history, joint injury, and specific occupations (Zamri *et al.*, 2019). Addressing these modifiable risks through lifestyle changes, like lowering obesity and