



**EFFECTS OF WHOLE FOOD PLANT BASED PROGRAM ON
BODY COMPOSITION, PAIN, DISABILITY AND PHYSICAL
CAPACITY IN OVERWEIGHT PATIENT WITH
OSTEOARTHRITIS**

KHWANSIRIN CHANTAWAT

**MASTER OF SCIENCE
IN
HEALTH PROMOTION THROUGH INTEGRATIVE MEDICINE**

SCHOOL OF INTEGRATIVE MEDICINE

MAE FAH LUANG UNIVERSITY

2025

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**THIS THESIS IS A PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
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THESIS APPROVAL
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IN

HEALTH PROMOTION THROUGH INTEGRATIVE MEDICINE

Thesis Title: Effects of Whole Food Plant Based Program on Body Composition, Pain, Disability and Physical Capacity in Overweight Patient with Osteoarthritis

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Khwansirin Chantawat

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ABSTRACT

Knee osteoarthritis is a chronic musculoskeletal disorder commonly found among overweight patients. In 2019, it was reported that the prevalence exceeded 50% of the global population, and in Thailand, approximately 46% of the population is affected. Overweight and obesity are important risk factors associated with disease progression. Increased body weight leads to greater mechanical loading on the knee joint, while excess adipose tissue is associated with chronic low-grade inflammation, which may accelerate cartilage degeneration and increase pain severity. Lifestyle modification, particularly dietary intervention, has therefore gained attention as a non-pharmacological strategy for disease management. However, randomized controlled trials evaluating the effects of a Whole-Food Plant-Based (WFPB) diet on clinical and functional outcomes in patients with knee osteoarthritis remain limited.

To evaluate the effects of a Whole-Food Plant-Based dietary program on body composition, pain severity, disability, and physical capacity in overweight patients with knee osteoarthritis.

This randomized controlled trial included 38 overweight older adults diagnosed with knee osteoarthritis in Chiang Rai Province, Thailand. Participants were randomly assigned to either a WFPB diet intervention group ($n = 19$) or a control group receiving dietary advice based on the Thailand Dietary Guidelines ($n = 19$) for 12 weeks. Body composition was assessed using bioelectrical impedance analysis. Pain severity and

disability were evaluated using the Visual Analog Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), respectively. Physical capacity was assessed using the Five-Times Sit-to-Stand Test (FTSST). Data were analyzed using descriptive statistics, repeated-measures ANOVA, and ANCOVA.

The intervention group showed significant reductions in body weight, body mass index, body fat percentage, and visceral fat compared with the control group ($p < 0.001$). In addition, VAS pain scores and WOMAC scores decreased significantly in the intervention group, whereas the control group showed a tendency toward worsening symptoms. Physical capacity also improved significantly in the intervention group, as indicated by reduced completion time in the FTSST ($p < 0.001$).

A Whole-Food Plant-Based dietary program significantly improved body composition, reduced pain and disability, and enhanced physical capacity in overweight older adults with knee osteoarthritis. These findings suggest that a plant-based dietary approach may serve as a promising non-pharmacological strategy for managing knee osteoarthritis in community settings.

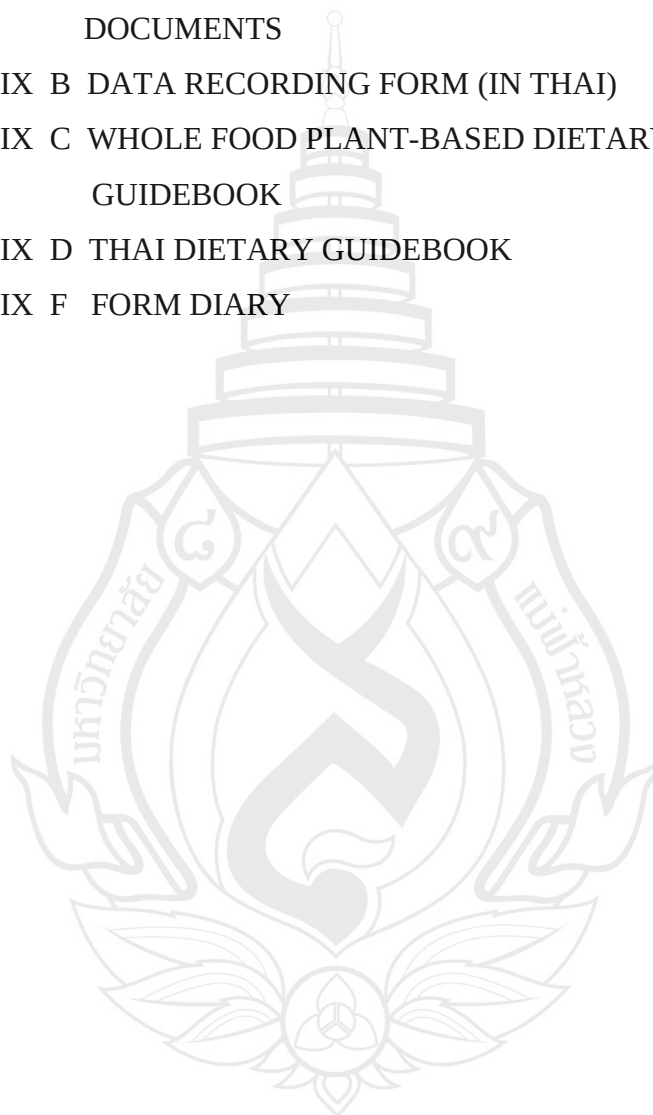
Keywords: Whole-food Plant-based Diet, Nutritional, Knee Osteoarthritis, Functional Limitation, Obesity, Degenerative Joint, Pain, Weight Loss

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CHAPTER 1

INTRODUCTION

This research aimed to explore the benefits of food plants and home-based education on functional capacity, body composition, pain, and disability among patients with knee osteoarthritis. Details of this part were described as follows;

1.1 Rationale and Background

Osteoarthritis (OA) was a prevalent chronic joint disease that posed significant health challenges worldwide, particularly among individuals aged 45–75 years. Over half of this population reported pain and stiffness, and up to 90% demonstrated radiographic signs of the condition (Andrianakos et al., 2006; Dantas et al., 2021; Dillon et al., 2006). The prevalence of knee osteoarthritis in Asia was approximately 19.2%, which was higher than that in Europe (13.4%) and North America (15.8%), with Thailand exhibiting a notably higher prevalence of 46.3% (Cui et al., 2020a). The burden of OA was compounded by its adverse effects on physical function and psychological well-being, with a considerable proportion of patients experiencing functional limitations that led to progressive decline (Parmelee et al., 2007). Chronic pain, stiffness, and joint deformity associated with OA significantly diminished quality of life (Boutron et al., 2008; Yildiz et al., 2010). Notably, knee OA was particularly debilitating, affecting an estimated 32.5 million individuals globally (Grotle et al., 2008; Xu et al., 2021).

The exact etiology of knee OA remained unclear, and disease development was considered multifactorial, involving mechanical and biological factors such as age, sex, genetics, and obesity. Obesity was identified as the most significant modifiable risk factor for knee osteoarthritis (Raud et al., 2020). Increased body weight elevated mechanical loading on the knee joint, accelerating cartilage degeneration by approximately 10–50%. Additionally, adipose tissue produced pro-inflammatory cytokines that contributed to joint inflammation and structural deterioration (Sowers &

Karvonen-Gutierrez, 2010). Therefore, weight management was regarded as a crucial component in the management of knee OA (Woolf et al., 2006).

Although OA is incurable, several treatment modalities were available to manage symptoms, including pharmacological therapy, surgical interventions such as total knee replacement, and non-pharmacological approaches. In recent years, increasing attention had been directed toward lifestyle modifications, particularly dietary changes and physical activity, as non-pharmacological strategies to alleviate symptoms and slow disease progression in knee OA (Shahid et al., 2022; Sinha et al., 2024).

Dietary interventions, especially plant-based diets, had gained increasing interest due to their potential anti-inflammatory properties, favorable effects on body weight, and overall health benefits. Plant-based diets rich in fruits, vegetables, whole grains, legumes, nuts, and seeds were associated with reduced systemic inflammation, improved metabolic health, and effective weight management, all of which were relevant to the management of knee OA symptoms (Clinton et al., 2015; Dressler et al., 2022; Greger, 2020; Walrabenstein et al., 2021).

Despite evidence supporting the role of weight management and anti-inflammatory diets in knee OA, most previous interventions were conducted in supervised or clinic-based settings, which limited feasibility and long-term adherence for many patients (Law et al., 2024). Moreover, limited evidence was available regarding the effectiveness of whole food plant-based programs on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis.

Additionally, previous research often overlooked the potential of self-guided dietary programs to enhance patient autonomy, adherence, and long-term health outcomes. The lack of randomized controlled trials evaluating the effects of a self-guided whole food plant-based diet program on these clinical outcomes represented a significant gap in the literature. Understanding whether a simple, cost-effective, and scalable educational intervention could yield meaningful health benefits was essential for developing accessible knee OA management strategies, particularly in resource-limited settings. Furthermore, the mechanisms through which plant-based diets might influence OA symptoms—such as reductions in systemic inflammation, improvements in body composition, and enhancements in physical capacity—required further

clarification. Thus, the proposed randomized controlled trial aims to explore the 12-week effects of a whole food plant-based program on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis. This study seeks to provide valuable insights into the potential benefits of dietary interventions tailored to Thai individuals' unique cultural and dietary contexts, ultimately contributing to enhanced management strategies for knee OA.

Therefore, the present randomized controlled trial was conducted to examine the 12-week effects of a whole food plant-based diet program on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis. This study aimed to provide evidence-based insights into the benefits of dietary interventions adapted to the cultural and dietary context of Thai individuals, thereby contributing to improved management strategies for knee OA.

1.2 Research Question

Can a whole food plant-based diet (WFPD) program change body composition, pain, disability, and physical capacity among patients with overweight knee osteoarthritis?

1.3 Objective of the Study

This study aimed to evaluate the effects of a 12-week whole food plant-based diet (WFPD) program on body composition, pain, disability, and physical capacity in patients with overweight knee osteoarthritis.

1.4 Hypotheses of the Study

The researcher hypothesized that participation in the WFPD program would lead to improvements in body composition among patients with overweight knee osteoarthritis. Furthermore, the consumption of a WFPD—characterized by high fiber,

antioxidant content, and anti-inflammatory compounds from plant-based foods—was expected to reduce pain and disability and enhance functional capacity. These effects were anticipated to reach clinical significance after 12 weeks (Messier et al., 2018)

1.5 Scope of the Study

The scope of this study included examining the effects of a 12-week whole food plant-based diet intervention in individuals diagnosed with overweight knee osteoarthritis. The investigation focused on changes in body composition, pain, disability, and physical capacity, with data collected through clinical assessments, standardized questionnaires, and body composition analyses.

1.6 Benefit of the Study

The findings of this study provided evidence regarding the potential therapeutic role of a whole food plant-based diet in alleviating symptoms and improving functional outcomes in patients with knee osteoarthritis. The results supported the integration of dietary interventions into standard OA management, emphasizing non-pharmacological strategies to reduce pain, enhance mobility, and improve quality of life. Additionally, this study contributed to a deeper understanding of the relationship between diet, body composition, and osteoarthritis progression, which may inform future nutritional guidelines and public health strategies for the prevention and management of osteoarthritis in overweight and obese populations.

CHAPTER 2

LITERATURE REVIEW

This chapter reviewed the literature relevant to this study. The review covered osteoarthritis of the knee, including its definition, incidence, prevalence, etiology, symptoms, and severity, as detailed below.

2.1 Knee Osteoarthritis

2.1.1 Definition, incidence, and prevalence of knee osteoarthritis

Knee osteoarthritis (knee OA) was defined as a degenerative joint disease characterized by progressive cartilage breakdown, leading to pain, inflammation, swelling, stiffness, reduced joint mobility, and functional impairment, all of which adversely affected patients' daily activities and lifestyle (Hunter & Bierma-Zeinstra, 2019; Vincent & Vincent, 2012).

2.1.2 The incidence of knee osteoarthritis was estimated at approximately 240 new cases per 100,000 persons annually among adults aged 45 years and older (Dillon et al., 2006). Thailand experienced one of the most significant increases in knee OA incidence during the study period, with an estimated annual percentage change (EAPC) of 0.56 (95% CI: 0.54–0.58). A systematic review conducted in Asia reported that the prevalence of radiographic knee OA among adults aged over 50 years was approximately 28.7%, while symptomatic knee OA affected 10–20% of the population (Cui et al., 2020a). The prevalence of knee osteoarthritis increased with advancing age and was more common among individuals older than 45 years. Women were found to have a higher risk of developing knee OA compared with men. Geographic variation in prevalence was observed across different populations and regions (Cui et al., 2020b). Consequently, healthcare providers, policymakers, and the general public were advised to recognize the high prevalence of knee OA and its modifiable risk factors, particularly obesity (Cui et al., 2020b). In Thailand, a population-based study conducted in Phra

Nakhon Si Ayutthaya Province reported a knee OA prevalence of 13.1%. Higher prevalence rates were observed among individuals aged 60–69 years (17.3%), females (15.58%), overweight individuals (16.49%), those with a family history of knee OA (72.0%), and individuals with a history of knee injury (28.57%). These findings highlighted the increased burden of knee OA among elderly populations and individuals with higher body weight (Bosittipichet, 2017).

2.1.3 The etiology of knee osteoarthritis (knee OA)

Knee osteoarthritis was characterized by progressive cartilage degradation, subchondral bone remodeling, and synovial inflammation. Its development was considered multifactorial, involving complex interactions between mechanical, biological, and genetic factors.

Age was identified as the most significant risk factor, as cartilage elasticity and regenerative capacity declined with advancing age, increasing vulnerability to joint damage. Although knee OA was more prevalent in individuals over 50 years, early-onset disease could occur as early as 45 years of age, particularly in individuals with predisposing factors such as obesity, joint injury, or excessive mechanical loading.

Excess body weight was recognized as a major modifiable risk factor. The prevalence of radiographic knee OA reached approximately 19.2% among populations aged over 45 years (Davis & Kane, 2025). Postmenopausal women were found to have a higher risk of knee OA than men, possibly due to hormonal changes and differences in joint biomechanics (Srikanth et al., 2005). Genetic factors also contributed, as first-degree relatives of patients with knee OA demonstrated an increased risk of developing the disease (Chapman & Valdes, 2012).

Previous studies demonstrated a strong association between overweight, obesity, and radiographic knee OA (Grotle et al., 2008). Excess body weight increased mechanical loading on the knee joint, accelerating cartilage degeneration. Specifically, each 1-kg increase in body weight amplified knee joint load by approximately four to six times during walking, while a 5-kg weight gain was associated with a 36% increased risk of knee OA (Riddle & Stratford, 2013). In addition to mechanical effects, adipose tissue secreted pro-inflammatory cytokines that contributed to systemic inflammation and joint degeneration (Sowers & Karvonen-Gutierrez, 2010). As a result, the World Health Organization recognized obesity as a key factor in the development of

osteoarthritis As a result, the World Health Organization recognized obesity as a key factor in the development of osteoarthritis (Woolf et al., 2006).

2.1.4 Symptoms and severity of knee osteoarthritis (knee OA)

Knee osteoarthritis presented with a spectrum of symptoms that significantly impaired physical function and quality of life. Pain was the most prominent symptom, typically worsening with physical activity and improving with rest. This pattern of pain often resulted in reduced mobility and diminished participation in daily activities. Other common symptoms included joint stiffness, particularly after periods of inactivity, and limited range of motion. As the disease progressed, symptoms became more severe, potentially leading to functional disability and the need for surgical intervention (Zhang & Jordan, 2010a). The key clinical manifestations were described as follows:

Pain was the predominant clinical feature, often exacerbated by activity and relieved by rest (Abhishek & Doherty, 2013). Morning stiffness was generally brief and self-limiting. With disease progression, pain could occur at rest and during nighttime, indicating more advanced joint involvement (Abhishek & Doherty, 2013).

Patients frequently experienced reduced range of motion and joint stiffness, which interfered with activities of daily living (Tuncay Duruöz et al., 2023). Crepitus, or a grating sensation during joint movement, was commonly reported (Poerwanto & Tedyanto, 2023; Abhishek & Doherty, 2013). Functional limitations due to pain and stiffness often led to decreased activity participation and lowered quality of life (Hochberg, 2012; White & Thoma, 2024).

Physical examination often revealed joint swelling and bony enlargement of the knee (Poerwanto & Tedyanto, 2023; Abhishek & Doherty, 2013). Muscle weakness, particularly of the quadriceps, along with impaired proprioception, contributed to joint instability and reduced mobility (Anwer & Alghadir, 2016; Bilać, 2016). In severe cases, joint deformity and muscle atrophy were observed, further compromising joint function (Abhishek & Doherty, 2013; Bilać, 2016).

Although knee OA was generally associated with low-grade inflammation, some patients experienced joint effusion, resulting in visible swelling (Abhishek & Doherty, 2013). Asymmetrical joint swelling was also reported, contributing to pain and functional limitation (Poerwanto & Tedyanto, 2023).

In addition to physical symptoms, knee osteoarthritis was associated with psychosocial consequences, including sleep disturbances, depressive symptoms, and reduced levels of physical activity. These factors often created a vicious cycle that exacerbated disease progression (White & Thoma, 2024). Reduced physical activity also increased the risk of comorbid conditions, such as cardiovascular disease (White & Thoma, 2024).

The severity of knee osteoarthritis was commonly classified using the Kellgren–Lawrence (KL) grading system, which ranged from Grade 0, indicating no radiographic evidence of OA, to Grade 4, representing severe disease characterized by large osteophytes, marked joint space narrowing, and subchondral sclerosis (Figure 2.1) (Kellgren & Lawrence, 1957; Zhang & Jordan, 2010b); Niinimäki et al., 2022) Previous studies demonstrated a moderate positive correlation between KL grade and clinical symptoms, including pain intensity and kinesiophobia, suggesting that higher radiographic severity was associated with increased pain and fear of movement (Chen et al., 2019; Kellgren & Lawrence, 1957).

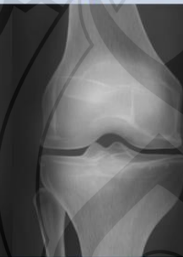
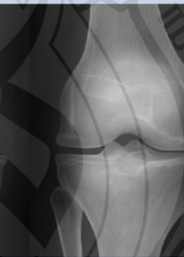
Kellgren-Lawrence (KL) grading scale					
					
	Grade 1	Grade 2	Grade 3	Grade 4	
CLASSIFICATION	Normal	Doubtful	Mild	Moderate	Severe
DESCRIPTION	No features of OA	Minute osteophyte: doubtful significance	Definite osteophyte: normal joint space	Moderate joint space reduction	Joint space greatly reduced: subchondral sclerosis

Figure 2.1 Kellgren and Lawrence grades

2.1.5 Current treatments for knee osteoarthritis

As knee osteoarthritis was a multifactorial disease, effective management required a multimodal approach that incorporated pharmacological, surgical, and non-pharmacological strategies based on current clinical evidence.

2.1.5.1 Pharmacological treatments were used to manage pain and inflammation and were typically introduced when non-pharmacological interventions did not adequately control symptoms.

1. Acetaminophen was recommended as a first-line treatment for mild pain. It was generally considered safe, although cautious use was advised to minimize the risk of hepatotoxicity.

2. NSAIDs, such as ibuprofen and diclofenac, were commonly prescribed for pain relief and inflammation control. However, long-term use was associated with potential adverse effects, including gastrointestinal irritation and increased cardiovascular risk (Jones et al., 2019; Joseph Flood, 2010).

3. Intra-articular injections and hyaluronic acid injections were used to provide temporary symptom relief in selected patients by reducing joint inflammation and improving joint lubrication (Wang & He, 2015).

4. Surgical and procedural treatments: Surgical intervention was generally reserved for patients with advanced knee OA who did not respond to conservative management.

Total Knee Arthroplasty (TKA) was considered the gold-standard treatment for end-stage knee osteoarthritis and has been shown to significantly improve pain and quality of life. Nevertheless, it involved surgical risks and required a prolonged recovery period.

Arthroscopic procedures were previously performed for degenerative knee OA but were no longer routinely recommended due to limited clinical benefit (Zhang et al., 2008).

2.1.5.2 Nonpharmacological treatments were regarded as first-line treatments for knee osteoarthritis and were recommended regardless of disease severity. These approaches aimed to reduce pain, improve physical function, and slow disease progression.

1. Weight management was identified as one of the most effective interventions for knee OA. A reduction in body weight of as little as 10% was shown to significantly decrease pain and improve joint function (Hochberg, 2012; Messier et al., 2004, 2013).

2. Exercise therapy, regular physical activity, particularly moderate-intensity exercise, was found to be safe and beneficial in improving joint function, reducing pain, and enhancing overall quality of life in individuals with knee OA. Exercise programs emphasized safety and evidence-based recommendations.

3. Physical therapy *programs* focusing on strengthening the muscles surrounding the knee joint were demonstrated to reduce pain and improve mobility (Hunt et al., 2013).

4. Patient education and self-management, educational interventions focusing on activity pacing, proper posture, and appropriate dietary habits were associated with improved long-term outcomes and enhanced self-management skills (Walrabenstein et al., 2021).

Overall, pharmacological treatments provided effective symptomatic relief, while surgical options remained essential for patients with severe disease. However, these approaches were associated with notable limitations and potential risks. Consequently, increasing emphasis was placed on non-pharmacological interventions. The management of knee osteoarthritis requires a personalized, stepwise approach, with lifestyle modifications—particularly weight loss, exercise, and self-management strategies—recognized as effective and sustainable methods for prevention and long-term management.

2.2 The Relationship between Knee Osteoarthritis (Knee OA) and Weight

Body weight was identified as a major risk factor for the development and progression of knee osteoarthritis, not only through increased mechanical stress but also via metabolic and inflammatory pathways. Excess adiposity contributed to systemic inflammation, which played a role in cartilage degradation and joint degeneration, particularly in the knee joint (Zhang & Jordan, 2010a).

Obesity increased the risk of knee osteoarthritis through two primary mechanisms: biomechanical loading and metabolic dysfunction. Excess body weight placed additional mechanical stress on the knee joint, leading to cartilage breakdown,

subchondral bone remodeling, and progressive joint degeneration (Berenbaum, 2013). For every 1-kg increase in body weight, the load transmitted across the knee joint during walking was estimated to increase by four to six times. Furthermore, a 5-kg increase in body weight was associated with a 36% higher risk of developing knee osteoarthritis (Riddle & Stratford, 2013). Evidence from previous studies suggested that weight loss in overweight and obese individuals with knee osteoarthritis resulted in significant improvements in pain severity and functional performance (Messier et al., 2013). Therefore, interventions targeting both obesity and knee osteoarthritis simultaneously were considered essential for effective management and improved clinical outcomes in this population.

2.3 The Weight Management

Weight management was recognized as one of the most effective non-pharmacological strategies for both the prevention and treatment of knee osteoarthritis. Excess body weight increased joint loading and systemic inflammation, thereby accelerating the onset and progression of knee OA (Lim et al., 2022).

Weight management was defined as a reduction in body weight, typically measured in kilograms or pounds, achieved through decreased caloric intake and increased energy expenditure via physical activity (Pojednic et al., 2022). In the present study, weight management was implemented using a whole food plant-based dietary intervention combined with home-based education. Evidence from the BROAD study demonstrated that adherence to a whole food plant-based diet resulted in significantly greater weight loss compared with conventional care in a community setting, with a mean reduction of 11.5 kg at six months (Wright et al., 2017).

Weight management played a critical role in both the prevention and management of knee osteoarthritis. Previous evidence consistently indicated that even modest weight loss significantly reduced joint loading, pain, and inflammation, while improving physical function and quality of life (Messier et al., 2013; Vincent et al., 2012). Obesity not only accelerated the progression of knee OA through increased mechanical stress but also contributed to chronic low-grade systemic inflammation,

which exacerbated joint degeneration. Consequently, comprehensive weight management strategies incorporating dietary modification, physical activity, and behavioral support were strongly recommended as first-line, non-pharmacological interventions for individuals with or at risk of knee osteoarthritis.

2.4 Dietary Interventions

Dietary interventions were increasingly recognized as critical tools in health promotion, weight management, metabolic health improvement, and chronic disease prevention. In this study, four widely discussed dietary approaches were reviewed, including the ketogenic diet, low-carbohydrate diet, low-fat diet, and whole food plant-based diet (WFPD) (Table 2.1).

2.4.1 Ketogenic diet was characterized by extreme carbohydrate restriction, typically less than 50 g per day or approximately 10% of total energy intake, thereby inducing a metabolic state of ketosis. Dietary fat constituted approximately 70% of total daily energy intake, while protein accounted for around 20%. Previous studies reported several benefits of the ketogenic diet, including improved glycemic control (e.g., reduced HbA1c levels) in patients with type 2 diabetes, its established role in the management of refractory epilepsy, rapid fat loss, and appetite suppression. However, several limitations and potential adverse effects were also identified (Zhou et al., 2022)

1. Nutrient deficiencies without careful planning (e.g., fiber, potassium, magnesium)
2. A cause "keto flu" during adaptation, the symptoms (e.g., fatigue, headache, nausea, dizziness, irritability or mood swings, muscle cramps or soreness, brain fog or difficulty concentrating, sugar cravings, sleep disturbances) usually appear within the first few days of starting the diet and can last from a few days to a week, although duration varies.
3. Concerns over long-term cardiovascular risks due to high saturated fat intake.

4. Micronutrient deficiencies and potential gastrointestinal side effects. Because of the restrictions or elimination of many fruits, whole grains, legumes, and some vegetables, individuals may fall short of several essential vitamins and minerals.

2.4.2 Low-carbohydrate diets were defined by restricted carbohydrate intake, typically below 30–50 g per day, with a corresponding increase in fat and protein consumption. This dietary pattern reduced postprandial insulin secretion and enhanced lipolysis. Previous studies demonstrated beneficial effects on glycemic control in patients with type 2 diabetes. However, several limitations were reported, including (Papadopoulou & Nikolaidis, 2023)

1. Increased intake of saturated fat may elevate LDL cholesterol levels in some individuals.
2. Reduced dietary fiber intake if carbohydrate restriction was not carefully balanced with adequate plant-based food consumption.

2.4.3 Low-fat diet, emphasized reduced total fat intake, typically limited to approximately 20% of total daily energy intake, while prioritizing high carbohydrate consumption derived primarily from whole grains, fruits, and vegetables. These diets encouraged the consumption of at least five servings of fruits and vegetables and a minimum of six servings of grains per day (Howard et al., 2006). Previous studies demonstrated that low-fat diets were associated with significant reductions in LDL cholesterol and cardiovascular risk and were effective for weight loss when total caloric intake was controlled.

2.4.4 Whole food plant-based diet (WFPD) refers to a dietary pattern that emphasizes minimally processed plant foods while excluding or minimizing animal-derived products. This dietary approach prioritized the consumption of fruits, vegetables, whole grains, legumes, nuts, and seeds (Kim et al., 2019). WFPD was rich in dietary fiber, antioxidants, and anti-inflammatory compounds, which were associated with reduced systemic inflammation, improved insulin sensitivity, and sustainable weight loss. (Barnard et al., 2005; Walrabenstein et al., 2021). The weight-loss effects of WFPD were facilitated through several interrelated physiological and behavioral mechanisms, including

1. Low energy density and caloric intake reduction: WFPD was characterized by low energy density due to its high water and fiber content. Foods with

low energy density allowed for greater food volume consumption while providing fewer calories, thereby increasing satiety and promoting spontaneous reductions in total energy intake without intentional caloric restriction. Previous research demonstrated that reduced dietary energy density led to significant decreases in daily caloric intake while maintaining satiety (Rolls et al., 2006).

2. High fiber intake and satiety regulation: WFPD provided high levels of dietary fiber, which slowed gastric emptying, enhanced stomach distension, and stimulated satiety hormones such as glucagon-like peptide-1 (GLP-1) and peptide YY (PYY). These mechanisms enhanced feelings of fullness and delayed hunger. Previous studies reported that high-fiber diets were associated with reduced energy intake and lower body weight (Howarth et al., 2001; J. L. Slavin, 2005). Additionally, low-fat, high-carbohydrate dietary patterns improved insulin sensitivity and reduced circulating insulin levels, thereby decreasing lipogenesis and enhancing lipid oxidation. Randomized controlled trials demonstrated greater weight loss and improved insulin sensitivity in individuals following low-fat vegan diets compared with conventional dietary interventions (Barnard et al., 2005; Adokwe et al., 2024).

3. Increased thermic effect of food: The thermic effect of food (TEF), defined as the energy expenditure associated with digestion, absorption, and metabolism, was higher for unprocessed, carbohydrate-rich foods compared with fat-rich or ultra-processed foods. As WFPD primarily consisted of complex carbohydrates and fiber, it promoted higher postprandial energy expenditure. Hall et al. reported that ultra-processed diets were associated with lower TEF and increased energy intake compared with unprocessed diets (Hall et al., 2019).

4. Gut Microbiome Modulation: Plant-based diets enhanced gut microbial diversity and promoted the growth of short-chain fatty acid (SCFA)-producing bacteria, including *Bifidobacterium* and *Lactobacillus* species. SCFAs such as butyrate and propionate were associated with improved energy metabolism, reduced systemic inflammation, and decreased adiposity. Previous studies demonstrated that plant-rich diets were correlated with favorable gut microbiota profiles supporting weight regulation (David et al., 2014; Zeevi et al., 2015).

5. Avoidance of hyperpalatable and addictive foods: WFPD excluded most ultra-processed and hyperpalatable foods high in added fats, sugars, and sodium, which

were implicated in overeating and addictive-like eating behaviors. By eliminating these dietary triggers, individuals experienced improved appetite regulation and reduced reward-driven food intake. Schulte et al. reported that highly processed foods combining refined carbohydrates and fats were strongly associated with addictive-like eating behaviors (Schulte et al., 2015).

Overall, the whole food plant-based diet promoted weight loss through multiple complementary mechanisms, including reduced energy density, increased satiety from dietary fiber, improved insulin sensitivity, enhanced thermogenesis, modulation of the gut microbiota, and avoidance of hyperpalatable foods. These features enabled spontaneous caloric reduction and sustainable weight management without intentional restriction, thereby supporting the role of WFPD as an effective dietary approach for obesity prevention and treatment.

Table 2.1 Comparison of Ketogenic, Low-Carb, Low-Fat, and Whole Food Plant-Based Diet

Feature	Ketogenic	Low-Carb	Low-Fat	Whole Food Plant-Based
Carb Intake	Very Low	Moderate–Low	High	Moderate–High
Fat Intake	Very High	High	Low	Low
Animal Products	High intake	Allowed	Allowed	Minimal or none
Weight Loss Evidence	Strong (Short term)	Strong (Short term)	Moderate	Moderate
Heart Health	Mixed (Concerns)	Mixed	Good (Mixed results)	Excellent (Reversal shown)
Diabetes Control	Very Good	Good	Moderate	Very Good
Long-term Adherence	Low–Moderate	Moderate	Moderate	Moderate–High
Nutrient Density	Low (If unplanned)	Variable	Moderate	High

Each dietary strategy offered unique metabolic benefits and challenges. While ketogenic and low-carbohydrate diets were effective for short-term weight loss and glycemic control, whole food plant-based diets demonstrated the most robust evidence for long-term cardiovascular and metabolic health, with the added benefit of environmental sustainability (Barnard et al., 2005; Ornish et al., 1990). This research adapted a whole food plant-based dietary intervention to Thai cuisine, making it well-suited for implementation within a Thai population. The adaptation aimed to maintain participants' cultural and culinary preferences while adhering to the core principles of a plant-based diet.

2.5 Comparison between Jae, Vegan, and Whole-food Plant-based Diets (WFPD)

Plant-based eating patterns have gained increasing global attention, with distinct forms emerging in different cultural and ethical contexts. In Thailand, the “Jae” (ใจ) diet has been widely practiced, while veganism and the whole-food plant-based diet (WFPD) have been increasingly adopted for health and environmental reasons. This research compared these three dietary approaches in terms of cooking methods, health effects, environmental impact, and evidence-based health outcomes, supported by current scientific literature.

Although all three diets excluded animal products, their culinary practices differed substantially. Jae and vegan diets often included significant amounts of cooking oil and processed plant-based ingredients, whereas the WFPD emphasized whole, minimally processed foods and oil-free cooking methods. Consequently, the WFPD was considered the most health-promoting dietary pattern in terms of cooking strategy and nutrient quality. Among the three approaches, the WFPD demonstrated the strongest scientific evidence supporting chronic disease prevention.

Previous studies demonstrated that adherence to a whole food plant-based diet was associated with a significantly reduced risk of chronic diseases. Evidence suggested that a WFPB diet lowered the risk of type 2 diabetes by improving insulin sensitivity and enhancing glycemic regulation (Greger, 2020). Additionally, it was

associated with reduced risks of certain types of cancer, obesity, and cardiovascular disease, alongside improvements in blood pressure and lipid profiles. The high fiber content and low energy density of the diet promoted weight loss and improved gut microbiome composition, which contributed to enhanced immune regulation and anti-inflammatory effects. These effects were reflected in reduced levels of C-reactive protein (CRP), a key biomarker of systemic inflammation, and were associated with potential alleviation of symptoms and slowed progression of osteoarthritis (da Costa et al., 2021; Dragan et al., 2020; Toumpanakis et al., 2018).

Dietary modification has increasingly been recognized as a potential non-pharmacological strategy for managing osteoarthritis symptoms. Incorporation of a high-fiber, whole food plant-based diet as part of a comprehensive lifestyle intervention contributed to improved clinical outcomes, enhanced quality of life, and may have supported a slowing of osteoarthritis progression (Table 2.2).

Table 2.2 Comparison of Jae, Vegan, and WFPB diet

Feature	Jae Diet	Vegan Diet	WFPB Diet
Principles	Avoids meat, animal products, and pungent vegetables (garlic, onion) for religious reasons	Avoids all animal products for ethical/environmental reasons	Avoids animal products and processed foods; emphasizes whole plant foods
Processed foods	Permitted (soy protein, mock meats, high oil/salt)	Permitted (vegan sausages, vegan cheeses)	Not permitted (minimizes oil, sugar, refined grains)
Typical techniques	Stir-frying, deep-frying, high use of oil, and soy sauces	Baking, frying, steaming, and commercial mock meats	Steaming, boiling, dry sautéing, and minimal seasoning
Oil use	Heavy use (palm oil, soybean oil)	Moderate, depends on recipe (e.g., olive, coconut)	Avoids oils entirely
Sodium/MSG	High in processed Jae dishes	Variable, often high in vegan-ready meals	Minimal use; relies on herbs and natural seasoning

Table 2.2 (continued)

Feature	Jae Diet	Vegan Diet	WFPB Diet
Health Implications	Higher risk of sodium/fat-related health issues	Potential saturated fat from processed foods	Associated with reduced risk of heart disease, diabetes, and obesity
Advantages	Widely available in Thailand, low-cost	Reduces environmental impact, cruelty-free	Strongly linked to the prevention/reversal of chronic disease
Drawbacks	Often high in sodium and processed ingredients	May include ultra-processed foods, refined carbs	Requires food preparation and social adjustments
Evidence Base	Limited clinical studies	Some evidence of LDL reduction and cancer protection	Robust evidence in heart disease, diabetes, and weight management

2.6 WFPD Principles Applied to Thai Food

Whole-food plant-based diet (WFPD) principles were applied to Thai cuisine, including specific food recommendations and example meal ideas for participants. The information was supported by evidence from the Institute of Nutrition, Mahidol University (2021), the Thai Food Composition Database (Thai FCD, 2015), Food Composition Tables for East Asia by the FAO (2017), and Diet, Nutrition and the Prevention of Chronic Diseases: Report of a Joint WHO (2021).

2.6.1 Vegetables

1. Leafy greens were categorized as non-starchy vegetables that were low in calories and carbohydrates but rich in dietary fiber, vitamins (A, C, and K), minerals (iron, calcium, and magnesium) (Tucker, 2014), and phytonutrients such as antioxidants and polyphenols. These vegetables exhibited a low glycemic index, high nutrient density, and were shown to promote satiety, support gut health, and exert anti-

inflammatory effects. High-fiber diets derived from vegetables were associated with reduced systemic inflammation, a lower risk of obesity, and a decreased incidence of chronic diseases (Boeing et al., 2012) (Table 2.3).

Table 2.3 Nutrient profile of selected Thai green leafy vegetables (per 100g)

Vegetable	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Chinese Kale	33	1.3	6.7	Vit A: 10,302 IU Vit C: 80.4 mg Vit K: 547.4 µg	Ca: 90.5 mg Fe: 1.1 mg Ma: 22.8 mg
Morning Glory	25	2.1	3.1	Vit A: 2,700 IU Vit C: 35 mg	Ca: 77 mg Fe: 2 mg K: 510 mg
Chinese Cabbage	16	1.2	3.2	Vit C: 27 mg Vit K: 42.9 µg Folate: 79 µg	Ca: 93 mg Fe: 1 mg K: 238 mg
Sweet leaf (Pal wan ban)	42	3.2	6.8	Vit C: 146 mg	Ca: 120 mg Fe: 2.5 mg
Ivy gourd leaves	25	2.3	4.6	Vit A: 1,000 IU Vit C: 40 mg	Ca: 24 mg Fe: 0.9 mg K: 170 mg

2. Root vegetables were defined as underground plant parts that were consumed as food. They were naturally rich in complex carbohydrates, dietary fiber, vitamins (A, C, and B-complex), and minerals (potassium, manganese, and magnesium). They were low in fat and typically exhibited a low to moderate glycemic load, particularly when consumed whole and unpeeled (Li et al., 2016; Turner-McGrievy et al., 2015) (Table 2.4).

Table 2.4 Nutrient profile of selected Thai root vegetables (per 100g)

Root Vegetable	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Sweet Potato	86	3.0	20.1	Vit A: 14,187 IU Vit C: 2.4 mg	Ca: 30 mg K: 337 mg
Taro	112	4.1	26.5	Vit C: 4.5 mg Vit E: 2.9 mg	K: 591 mg Ma: 33 mg
Cassava	191	1.8	42.4	Vit C: 20.6 mg	Ca: 16 mg Fe: 0.3 mg
Radish	18	1.6	4.1	Vit C: 22.2 mg	Ca: 27 mg K: 276 mg
Pumpkin	26	0.5	6.5	Vit A: 8,513 IU Vit C: 9 mg	Ca: 21 mg K: 340 mg
Carrot	41	2.8	9.6	Vit A: 16,706 IU Vit C: 5.9 mg Vit K: 13.2 µg	Ca: 33 mg K: 320 mg

3. Cruciferous vegetables belonged to the Brassicaceae family and were rich in biologically active compounds, most notably glycosylates, which served as precursors to isothiocyanates. For example, sulforaphane, a major isothiocyanate derived from glucoraphanin in broccoli, was shown to induce detoxification enzymes, promote apoptosis of damaged cells, and modulate carcinogen metabolism, as well as indole-3-carbinol activity. (Ağagündüz et al., 2022) These compounds exhibited antioxidant, anti-inflammatory, and anticarcinogenic effects. In addition, cruciferous vegetables were rich in calcium, vitamin K, and magnesium, which were essential for bone metabolism and were associated with a reduced risk of osteoporosis and a slower progression of osteoarthritis (Tucker, 2014; Xu et al., 2021) (Table 2.5).

Table 2.5 Nutrient profile of selected cruciferous vegetables (per 100g)

Cruciferous Vegetable	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Broccoli	34	2.6	6.6	Vit C: 89.2 mg Vit K: 101.6 µg Folate: 63 µg	Ca: 47 mg Fe: 0.73 mg K: 316 mg
Cabbage	25	2.5	5.8	Vit C: 36.6 mg Vit K: 76 µg Folate: 43 µg	Ca: 40 mg Fe: 0.47 mg K: 170 mg
Cauliflower	25	2.0	5.0	Vit C: 48.2 mg Vit K: 15.5 µg Folate: 57 µg	Ca: 22 mg Fe: 0.42 mg K: 142 mg
Kale	49	3.6	8.8	Vit C: 93.4 mg Vit K: 817 µg Folate: 62 µg	Ca: 254 mg Fe: 1.6 mg K: 491 mg
Bok choy	13	1.0	2.2	Vit C: 45 mg Vit: 45.5 µg Folate: 66 µg	Ca: 105 mg Fe: 0.8 mg K: 252 mg

4. Mushrooms were low in calories and fat but were rich in dietary fiber, vitamins, minerals, and various bioactive compounds. They were considered a functional food due to their high nutrient density and health-promoting properties (Valverde et al., 2015; Wasser, 2014). Mushrooms were shown to provide scientifically supported health benefits, and their rich nutritional profile, combined with unique phytochemicals, made them an ideal component of a whole food plant-based diet (Table 2.6).

Table 2.6 Nutrient profile of selected mushrooms (per 100g)

Mushroom	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Shiitake	34	2.5	6.8	Vit B6: 0.3 mg Vit B9: 13 µg	K: 304 mg P: 112 mg
Oyster	33	2	6.1	Vit B3: 4.96 mg Vit B9: 38 µg	K: 361 mg P: 120 mg
King oyster	24	4.3	7.4	Vit B5: 1.5 mg	K: 285 mg
Straw mushroom	32	1.2	4.9	Vit C: 2.1 mg	K: 356 mg Fe: 1 mg Mg: 10 mg
Enoki	24	2	5	Vit B9: 48 µg	P: 68 mg K: 23 mg Zn: 0.4 mg Se: 1.4 µg

5. Tropical fruits were fruits that grew naturally in tropical climates—regions located near the equator that were warm and humid year-round. They were often colorful, sweet, and juicy, and were rich in nutrients, particularly vitamin C. High-fiber tropical fruits such as papaya, banana, and dragon fruit were shown to aid digestion and help regulate blood glucose levels (J. Slavin, 2013), and they contained abundant antioxidants that contributed to the reduction of oxidative stress (Lobo et al., 2010) (Table 2.7)

Table 2.7 Nutrient profile of selected Thai tropical fruit (per 100g)

Tropical Fruit	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Papaya	43	1.7	10.8	Vit A: 950 IU Vit C: 60.9 mg	Ca: 20 mg P: 182 mg

Table 2.7 (continued)

Tropical Fruit	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Banana	89	2.6	22.8	Vit C: 8.7 mg Vit B6: 0.4 mg	P: 358 mg Mg: 27 mg
Mango	60	1.6	14.9	Vit A: 1082 IU Vit C: 36.4 mg	P: 168 mg Mg: 10 mg
Pineapple	50	1.4	13.1	Vit C: 47.8 mg Vit B1: 0.08 mg	Ca: 13 mg P: 109 mg
Guava	68	5.4	14.3	Vit A: 624 IU Vit C: 228.3 mg	P: 417 mg Mg: 22 mg
Durian	150	3.8	27.1	Vit C: 19.7 mg Vit B6: 0.3 mg	Po: 436 mg Mg: 30 mg
Mangosteen	73	1.8	17.9	Vit C: 2.9 mg Vit B9: 31 µg	Ca: 12 mg P: 48 mg
Longan	60	1.1	15.1	Vit C: 84 mg Vit B2: 0.14 mg	P: 266 mg Mg: 10 mg
Rambutan	68	0.9	16.5	Vit C: 20.9 mg Vit A: 0 IU	Ca: 22 mg P: 42 mg
Dragon fruit	57	3.0	15.2	Vit C: 3 mg Vit B1: 0.04 mg	Fe: 1.9 mg Mg: 10 mg

6. Citrus fruits were rich in vitamin C and were shown to support immune function, promote collagen synthesis, and help reduce the severity and duration of common colds (Carr & Maggini, 2017). They also contained substantial amounts of dietary fiber, particularly pectin, which was associated with improved digestive function and reduced fat absorption. (Slavin, 2013) In addition, citrus fruits were rich in flavonoids such as hesperidin, which were reported to improve lipid profiles and contribute to the reduction of blood pressure (Mahmoud et al., 2019) (Table 2.8).

Table 2.8 Nutrient profile of selected citrus fruit (per 100g)

Citrus Fruit	Energy (kcal)	Fiber (g)	Carb (g)	Notable Vitamins	Notable Minerals
Lime	30	2.8	10.5	Vit C: 29.1 mg	Ca: 33 mg P: 102 mg
Lemon	29	2.8	9.3	Vit C: 53 mg	Ca: 26 mg P: 138 mg
Pomelo	38	1.0	9.6	Vit C: 61 mg	Ca: 4 mg P: 216 mg
Mandarin	53	1.8	13.3	Vit A: 681 IU Vit C: 26.7 mg	Ca: 37 mg P: 166 mg

7. Whole Grains were cereal grains that retained all essential components of the grain kernel. They provided superior nutritional value, including high amounts of dietary fiber, B vitamins, iron, magnesium, and various phytochemicals (Slavin, 2005). Numerous epidemiological studies and randomized controlled trials had demonstrated the health benefits of whole grain consumption, including an approximately 21% reduction in the risk of cardiovascular disease, type 2 diabetes, obesity, and certain cancers (Aune et al., 2016) (Table 2.9)

Table 2.9 Nutrient profile of selected whole grains (per 100g)

Grain Type	Energy (kcal)	Fiber (g)	Carbs (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
Brown rice	111	1.8	23	2.6	0.9	Vit B1: 0.18 mg	Mg 43 mg P 83 mg Mn 1.1 mg Se 9.8 µg
Rice berry rice	130	1.8	30	3	0.9	Vit B9: 20 µg Vit E: 0.5 mg	Fe: 1.0 mg Zn: 0.8 mg

Table 2.9 (continued)

Grain Type	Energy (kcal)	Fiber (g)	Carbs (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
Quinoa	120	2.8	21.3	4.1	1.9	Vit B9: 42 µg	P 70 mg Fe 0.9 mg Mg 64 mg Fe 1.5 mg Zn 1.1 mg Mn 0.6 mg

8. Legumes were rich sources of plant protein, making them essential components of sustainable plant-based diets and beneficial for muscle synthesis and maintenance. Their high dietary fiber content was associated with improved bowel health and favorable lipid profiles, including reduced cholesterol levels. Legumes also provided important micronutrients, particularly iron and folate, which supported hematopoiesis, while minerals such as magnesium and potassium contributed to cardiovascular and metabolic health (Adokwe et al., 2024; Aune et al., 2017; Slavin, 2005) (Table 2.10).

Table 2.10 Nutrient profile of selected legumes (per 100g)

Legume	Energy (kcal)	Carbs (g)	Fiber (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
Mung beans	105	19.2	7.6	7	0.4	Vit B1: 0.12 mg Vit B9: 159 µg	Mg: 48 mg Fe: 1.4 mg P: 99 mg, K: 266 mg
Soybeans	173	9.9	6	16.6	9	Vit B2: 0.15 mg Vit B9: 165 µg	Fe: 2.1 mg Ca: 277 mg

Table 2.10 (continued)

Legume	Energy (kcal)	Carbs (g)	Fiber (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
							Mg: 86 mg K: 515 mg
Red kidney beans	127	22.8	6.4	8.7	0.5	Vit B1: 0.17 mg Vit B9: 130 µg	Fe: 2.9 mg Mg: 45 mg K: 405 mg
Black beans	132	23.7	8.7	8.9	0.5	Vit B6: 0.13 mg Vit B9: 149 µg	Fe: 2.1 mg Mg: 70 mg K: 355 mg
Winged bean	49	3	2.8	6.9	0.7	Vit B1: 0.44 mg Vit B2: 0.17 mg	Ca: 40 mg Fe: 1.0 mg P: 65 mg Mg: 55 mg
Yardlong bean	47	8.4	2.9	2.8	0.4	Vit C: 18.8 mg Vit B9: 62 µg	Ca: 50 mg Mg: 44 mg K: 240 mg
Green peas	84	14.5	5.1	5.4	0.4	Vit C: 14.2 mg Vit B9: 65 µg	Mg: 33 mg Fe: 1.5 mg P: 117 mg K: 244 mg
Edamame	121	8.9	5.2	11.9	5.2	Vit K: 26 mcg Vit B9: 311 mcg	Fe: 2.3 mg Ca: 63 mg

Table 2.10 (continued)

Legume	Energy (kcal)	Carbs (g)	Fiber (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
							Mg: 61 mg K: 436 mg

9. Nuts and seeds were widely consumed in traditional diets and held substantial potential for modern nutritional strategies due to their rich profiles of healthy fats, plant protein, dietary fiber, vitamins, and minerals. For example, sesame seeds were reported to provide calcium levels surpassing those of dairy products on a per-gram basis, while sunflower seeds offered exceptionally high vitamin E content. Peanuts and cashews served as affordable sources of plant protein and healthy fats. These nutritional properties supported their integration into whole-food plant-based (WFPB) diets, particularly for Thai populations seeking culturally congruent plant-based alternatives. Furthermore, the dietary fiber content of nuts and seeds was associated with improved gut health and enhanced satiety, while their micronutrient composition contributed to a reduced risk of chronic diseases (Barnard et al., 2005; Jenkins et al., 2001; Ros, 2010) (Table 2.11).

Table 2.11 Nutrient profile of selected nuts and seeds (per 100g)

Nuts & Seeds	Energy (kcal)	Carb (g)	Fiber (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
Peanuts	567	16.1	8.5	25.8	49.2	Vit B3: 12.1 mg Vit B1: 0.64 mg Vit E: 8.33 mg	Mg: 168 mg P: 376 mg K: 705 mg
Cashew nuts	553	30.2	3.3	18.2	43.9	Vit B1: 0.42 mg Vit B6: 0.1	Mg: 82.9 mg

Table 2.11 (continued)

Nuts & Seeds	Energy (kcal)	Carb (g)	Fiber (g)	Protein (g)	Fat (g)	Notable Vitamins	Notable Minerals
						mg	Cu: 0.6 mg
						Vit K: 9.7 µg	Mn: 0.5 mg
White sesame seeds	573	23.4	11.8	17.7	49.7	Vit B1: 0.79 mg	Ca: 975 mg
						Vit B6: 0.79 mg	Fe: 14.55 mg
							Mg: 351 mg
Black sesame seeds	573	23.4	11.8	17.7	49.7	Vit B1: 0.79 mg	Ca: 1,125 mg
						Vit E: 0.25 mg	Fe: 9.5 mg
							Mg: 351 mg
Sunflower seeds	584	20	8.6	20.8	51.5	Vit B1: 1.48 mg	Cu: 4.16 mg
						Vit E: 35.17 mg	Mg: 325 mg
							P: 660 mg
Pumpkin seeds	559	10.7	6	30.2	49	Vit E: 2.18 mg	Se: 53 µg
							Mg: 262 mg
							Zn: 7.81 mg
							P: 1233 mg
Lotus seeds	332	64.5	13.9	15.4	2	Vit B1: 0.5 mg	Mn: 2.3 mg
							P: 168 mg

10. Herbs and Spices: Thai herbs and spices were essential components of traditional cuisine and folk medicine. Common examples, such as holy basil, lemongrass, galangal, and kaffir lime, were not only used as flavor enhancers but were also recognized as potent sources of antioxidants, vitamins, and minerals. Their health-promoting properties were increasingly supported by scientific evidence. For instance, turmeric was rich in curcumin and iron and was shown to exert anti-inflammatory and antioxidant effects (Hewlings & Kalman, 2017). Holy basil provided significant amounts of vitamins A and K, supporting immune and bone health. Garlic contains

allicin, a bioactive compound known for its cardiovascular and antimicrobial benefits (Banerjee & Maulik, 2002). Overall, Thai herbs and spices contributed not only to culinary diversity but also offered substantial nutritional and therapeutic benefits. Regular incorporation of these ingredients into the diet was suggested to enhance the health-promoting potential of plant-based dietary patterns (Table 2.12).

Table 2.12 Nutrient profiles of selected Thai herbs and spices (per 100g)

Herbs & Spices	Energy (kcal)	Carb (g)	Fiber (g)	Protein (g)	Notable Vitamins	Notable Minerals
Holy basil	23	2.7	1.6	3.2	Vit A: 5275 IU Vit C: 18 mg Vit K: 414.8 µg	Cu: 177 mg Fe: 3.2 mg Mg: 64 mg
Ginger root	80	2	17.8	1.8	Vit B6: 0.16 mg Vit C (5 mg)	K: 415 mg Mg: 43 mg Mn: 0.2 mg
Lemongrass	99	25.3	0.8	1.8	Vit C: 2.6 mg Vit B9: 75 µg	K: 723 mg Fe: 8.2 mg Mg: 5.2 mg
Galangal root	71	15.7	2	1	Vit C: 5 mg Vit B3: 0.3 mg	Fe: 1.0 mg K: 200 mg Zn: 1.2 mg
Kaffir lime leaves	60	14.1	2.2	1.5	Vit C: 45 mg Vit A: 200 IU	Cu: 170 mg Fe: 2.7 mg P: 34 mg
Turmeric root	312	67.1	22.7	9.7	Vit C: 25.9 mg Vit B6: 0.1 mg	Fe: 41.4 mg K: 2080 mg Mn: 7.8 mg
Fingerroot (Krachai)	93	21	2	1.5	Vit A: 9 µg Vit C: 4 mg	K: 446 mg Fe: 0.8 mg

Table 2.12 (continued)

Herbs & Spices	Energy (kcal)	Carb (g)	Fiber (g)	Protein (g)	Notable Vitamins	Notable Minerals
						Zn: 0.5 mg
Thai garlic	149	33.1	2.1	6.4	Vit C: 31.2 mg Vit B6: 1.2 mg	Mn: 1.7 mg Se: 14.2 µg Cu: 181 mg
Chili pepper	282	10.3	49	12	Vit C: 143.7 mg Vit A: 952 IU Vit B6: 2.5 mg	K: 322 mg Mg: 152 mg Fe: 2.4 mg

Thai foods excluded (Raw material)

1. Animal products: Meat (chicken, pork, beef), dairy (milk, cheese, yogurt), eggs, and seafood were excluded from the dietary intervention.
2. Refined and processed foods, such as white rice (which was replaced with brown rice), sugary snacks, fried foods, and processed oils, were also excluded.
3. Added sugars were limited, including sweeteners such as sugar, honey, and syrups. Naturally sweet fruits were instead used for desserts and beverages.

Example of a dish (Thai cuisine)

1. One cup of cooked brown rice and quinoa blend

Brown rice and quinoa were used as staple whole grains due to their high nutritional value. The combination of these two grains provided a synergistic profile of complex carbohydrates, plant-based proteins, dietary fiber, and essential micronutrients. Brown rice (*Oryza sativa*) was a minimally processed cereal grain that retained its bran and germ, while quinoa (*Chenopodium quinoa*) was a pseudocereal recognized for its complete protein profile. This combination enhanced both the amino acid composition and micronutrient content of meals. (Alvarez-Jubete et al., 2010; Olmos et al., 2022)

Methodology: The nutritional data presented were derived from the USDA Food Data Central (2024) and supporting scientific literature. Nutrient values were calculated based on a 1:1 ratio by volume ($\frac{1}{2}$ cup cooked brown rice combined with $\frac{1}{2}$ cup cooked quinoa, yielding 1 cup of the blended preparation) (Table 2.13)

Table 2.13 The nutritional profile for 1 cup of cooked rice (approx. 195 grams)

Nutrient	Amount	Unit	Source
Energy	222	kcal	USDA (2024)
Protein	6.2	grams	USDA
Total carbohydrates	40.4	grams	USDA
Dietary fiber	4.1	grams	USDA
Total fat	3.2	grams	USDA
Iron	2	mg	~11% DV
Magnesium	78	mg	~19% DV
Phosphorus	180	mg	~14% DV
Potassium	170	mg	~5% DV
Zinc	1.4	mg	~13% DV
Folate	36	mcg	~9% DV
Vitamin B1 (Thiamin)	0.19	mg	~16% DV
Manganese	1.1	mg	~48% DV

2. One serving of mushroom congee

Congee was a traditional rice porridge commonly consumed across many Asian cultures. While it was typically prepared with animal protein, a whole-food plant-based (WFPB) adaptation was able to provide similar comfort and nutritional benefits. This paper explored the benefits of mushroom congee, which utilizes mushrooms as a plant-based protein source while incorporating the medicinal properties of garlic, ginger, and other herbs traditionally used in the dish. Mushrooms provide not only protein but also essential micronutrients, including iron, B vitamins, and antioxidants, thereby contributing to the overall health-promoting potential of the dish. (Roupas et al., 2012)

Serving size and ingredient: The serving size was approximately 1 cup of cooked congee, weighing about 250 grams. The preparation typically included ¼ cup uncooked jasmine or brown rice (rinsed), 1.5–2 cups of water or low-sodium vegetable broth, 80–100 g of mixed mushrooms (e.g., oyster, shiitake, and enoki), sliced, 1 clove of garlic (minced), one small slice of fresh ginger (optional, thinly sliced or minced), 1–2 teaspoons of low-sodium soy sauce or tamari (optional for saltiness), one spring onion (chopped, used as garnish), fresh coriander (optional), and white pepper or chili flakes added to taste.

Table 2.14 The nutritional profile for 1 serving of congee (approx. 250 grams)

Nutrient	Amount	Unit	Source
Energy	~150 kcal	kcal	USDA
Protein	~5 g	grams	USDA
Fat	~2.5 g	grams	USDA
Carbohydrates	~30 g	grams	USDA
Fiber	~2–3 g	grams	USDA
Vitamin C	~4 mg	mg	5% DV
Folate (B9)	~20 µg	µg	5% DV
Potassium	~300 mg	mg	6% DV
Calcium	~30 mg	mg	3% DV
Iron	~1.5 mg	mg	8% DV
Magnesium	~30 mg	mg	7% DV

3. One serving of stir-fried Bok choy (WFPB)

Stir-fried Bok choy is a popular dish in Asian cuisine, recognized for its nutritional richness and culinary simplicity. This paper analyzed its macro- and micronutrient contributions. Based on nutrient databases and scientific studies, the analysis highlighted the dish's value in supporting a whole-food plant-based (WFPB) diet.

When prepared using WFPB methods (oil-free or with minimal oil and without animal-based seasonings), the dish remained low in calories while being rich

in dietary fiber, vitamins, and minerals. This preparation method aligned well with low-calorie, high-nutrient dietary patterns recommended for chronic disease prevention.

Serving size and preparation method: A typical serving of vegan stir-fried bok choy was approximately 1 cup cooked, weighing about 150 grams. This serving was prepared using water or low-sodium vegetable broth for stir-frying, combined with garlic and soy sauce, without the use of oil or animal-derived ingredients.

Table 2.15 The nutritional profile for 1 serving of Bok choy stir-fried (approx. 150 grams)

Nutrient	Amount	Unit	Source
Energy	54	kcal	USDA, 2024
Protein	3.1	grams	USDA
Carbohydrates	9.4	grams	USDA
Dietary fiber	3.7	grams	USDA
Total fat	0.6	grams	USDA
Vitamin A	5560	IU	~111% DV
Vitamin C	44	mg	~73% DV
Vitamin K	132	mcg	~110% DV
Folate	75	mcg	~19% DV
Calcium	158	mg	~12% DV
Iron	1.8	mg	~10% DV
Magnesium	33	mg	~8% DV
Potassium	503	mg	~11% DV

4. One serving of Pad-Thai (WFPB)

Pad Thai was globally recognized as a traditional Thai stir-fried noodle dish. In this study, animal-based ingredients were replaced with plant-based alternatives while retaining flavor and nutritional complexity. This paper presented the nutritional composition of one standard serving, including energy, macronutrients, dietary fiber, vitamins, and minerals. The suitability of Pad Thai within a whole-food plant-based (WFPB) dietary framework was evaluated, demonstrating the potential to preserve

culinary culture while improving health outcomes through reduced intake of saturated fat and dietary cholesterol.

Serving size and ingredients: A standard serving of plant-based Pad Thai weighed approximately 300 grams. The dish typically included 120 g of cooked rice noodles, 50 g of firm tofu, 30 g of mung bean sprouts, 30 g of shredded carrots, 20 g of chopped green onions, 15 g of crushed peanuts, and 10 g of a tamarind sauce and soy sauce mixture. Small amounts of garlic, chili, and minimal oil compatible with WFPB principles were also used.

Table 2.16 The nutritional profile for 1 serving of Pad-Thai (approx. 300 grams)

Nutrient	Amount	Unit	Source
Energy	410	kcal	USDA, 2024
Protein	12.5	grams	USDA
Carbohydrates	57	grams	USDA
Dietary fiber	5.3	grams	USDA
Total fat	14.2	grams	USDA
Saturated fat	2	grams	USDA
Vitamin A	4200	IU	~84% DV
Vitamin C	16	mg	~27% DV
Folate	60	mcg	~15% DV
Calcium	180	mg	~14% DV
Iron	2.3	mg	~13% DV
Magnesium	65	mg	~15% DV
Potassium	460	mg	~10% DV
Zinc	1.2	mg	~11% DV

5. One serving of mushroom tom yum

Tom Yum is a quintessential Thai soup known for its bold flavor profile, characterized by sour, spicy, and aromatic notes. Traditionally prepared with shrimp, the dish was adapted in this study using mushrooms to align with whole-food plant-based (WFPB) dietary principles. Mushrooms served as a meat substitute by providing

an umami flavor, while lemongrass, galangal, and kaffir lime leaves contributed antimicrobial and antioxidant properties (Roupas et al., 2012)

Serving size and ingredients: The preparation typically included 1 cup of water or vegetable broth, 80 g of mixed mushrooms, one stalk of lemongrass, 1–2 slices of galangal, 1–2 kaffir lime leaves, one Thai chili, one tomato, one shallot, one teaspoon of soy sauce, one teaspoon of lime juice, a pinch of coconut sugar, and ½ teaspoon of chili paste (optional). Fresh coriander and spring onion were used as garnishes.

Table 2.16 The nutritional profile for 1 serving of Pad-Thai (approx. 300 grams)

Nutrient	Amount	Unit	Source
Energy (kcal)	~80	kcal	USDA, INMU
Protein	~5	grams	USDA
Fat	~2.5	grams	USDA
Carbohydrates	~11	grams	USDA, INMU
Fiber	~2.5	grams	USDA
Vitamin C	~15	mg	17% DV
Folate (B9)	~50	µg	12.5% DV
Potassium	~300	mg	6% DV
Calcium	~40	mg	3% DV
Iron	~1.2	mg	7% DV
Magnesium	~30	mg	7% DV
Sodium	~400	mg	17% DV

2.7 Home-Based and Self-administered Interventions

Home-based interventions have demonstrated success in chronic disease management due to their accessibility, cost-effectiveness, and flexibility. Self-administered programs empowered patients to manage their own health, thereby improving adherence and health outcomes (Hébert et al., 2012; Hestmann et al., 2023). In the context of osteoarthritis (OA), home-based interventions, when combined with education and minimal supervision, were shown to lead to improvements in physical function and quality of life.

2.8 Outcome Assessment

Accurate and reliable outcome assessments were essential for evaluating the effectiveness of interventions and monitoring functional limitations in individuals with knee osteoarthritis (OA). The following tools were commonly used in both clinical practice and research to assess body composition, pain, disability, and physical function in overweight individuals with knee OA.

2.8.1 Primary outcome

Body Composition

Body composition was an essential marker of overall metabolic health and physical status, particularly in overweight individuals with knee osteoarthritis, where excess adiposity contributed to systemic inflammation, increased mechanical joint loading, and functional impairment (Vincent & Vincent, 2012; Messier et al., 2013).

1. Body mass index (BMI) was a widely used indicator of general adiposity and was calculated by dividing body weight in kilograms by the square of height in meters (kg/m^2). A high BMI was a well-established risk factor for the onset and progression of knee OA due to increased mechanical joint loading and associated inflammatory processes (Yusuf et al., 2010).

2. Waist-hip ratio (WHR) was calculated by dividing waist circumference by hip circumference and served as an indicator of central (visceral) obesity. Central obesity was linked to systemic inflammation and was identified as an independent risk factor for OA severity (Yusuf et al., 2010). WHR was therefore useful for evaluating obesity-related risks beyond those captured by BMI alone.

3. Body fat percentage (%BF), a higher body fat percentage was strongly associated with knee OA severity and disease progression. Excess adipose tissue secreted pro-inflammatory adipokines such as leptin and resistin, which had been detected in synovial fluid and were associated with cartilage degradation (Griffin & Guilak, 2005). A randomized controlled trial by Messier et al. involving 454 overweight adults with knee OA demonstrated that a 10% reduction in body weight, primarily from fat mass, resulted in a 50% improvement in pain and physical function ($p < 0.001$) (Messier et al., 2013).

4. Skeletal muscle mass (SMM) , particularly in the quadriceps, played a critical role in shock absorption and knee joint stabilization. Reduced muscle mass and strength (sarcopenia) have been consistently associated with increased pain, joint instability, and impaired mobility in patients with knee OA (Dharmakulsakti et al., 2022).

5. Visceral Fat Level, visceral adiposity, as measured by dual-energy X-ray absorptiometry (DXA) or bioelectrical impedance analysis (BIA), was a robust marker of metabolic inflammation and insulin resistance. A study by Yusuf et al. reported a strong association between visceral fat and symptomatic knee OA, independent of BMI (Yusuf et al., 2010). Unlike subcutaneous fat, visceral fat acted as a potent endocrine organ, producing inflammatory cytokines such as TNF- α and IL-1 β , which were directly involved in synovial inflammation and cartilage degeneration (Liu-Bryan & Terkeltaub, 2015).

6. Segmental lean analysis was used to detect asymmetries in muscle mass distribution, which were commonly observed in knee OA due to pain-avoidant behaviors. This analysis aided in identifying limb dominance, muscle atrophy, and the need for targeted rehabilitation strategies (Hassan et al., 2001).

7. Basal metabolic rate (BMR) was largely influenced by lean body mass. Individuals with knee OA often exhibited reduced physical activity levels, leading to lower BMR and increased fat accumulation. Improvements in muscle mass through physical activity increased BMR, enhanced metabolic health, and reduced systemic inflammatory burden (Bouchonville & Villareal, 2013).

2.8.2 Secondary Outcome

1. Pain

The Visual Analog Scale (VAS) was a recognized and validated instrument commonly used to measure pain intensity in individuals with knee osteoarthritis. It demonstrated excellent test–retest reliability (ICC > 0.97) and strong correlations with other pain assessment tools, including the Numeric Rating Scale (NRS) and Verbal Rating Scale (VRS). Its high sensitivity to changes in pain intensity made it particularly suitable for evaluating treatment outcomes, including pain reduction following interventions. The VAS had been adapted for use across diverse cultural contexts while maintaining its reliability and validity. Although it primarily quantified pain intensity

and did not capture the multidimensional nature of pain, the VAS remained a practical and responsive tool for clinical and research applications in knee OA (Alghadir et al., 2018; Hawker et al., 2011).

2. Disability

Western Ontario and McMaster University (WOMAC) was a well-validated instrument used to assess pain, stiffness, and physical function in patients with knee osteoarthritis. It demonstrated high internal consistency, with Cronbach's alpha coefficients exceeding 0.93, and strong test-retest reliability, with intraclass correlation coefficients ranging from 0.71 to 0.95. Construct and convergent validity had been supported through significant correlations with established measures such as the Knee Injury and Osteoarthritis Outcome Score (KOOS), VAS, and Short Form-12 (SF-12). The WOMAC was responsive to clinical changes over time, particularly following therapeutic interventions. Recent Rasch analysis enabled the conversion of ordinal WOMAC scores into interval-level data, enhancing measurement precision and interpretability. Although cultural and linguistic adaptations preserved its psychometric properties, further validation in larger and more diverse populations had been recommended (Khuman et al., 2018; Salaffi et al., 2003).

3. Physical capacity

Five-time sit-to-stand (FTSTS) was a simple, quick, and reliable clinical assessment tool used to evaluate lower limb muscle strength, functional mobility, and physical performance. It was particularly valuable for assessing individuals with knee osteoarthritis, especially those who were overweight or obese, as excess body weight increased joint loading, pain, and physical limitations. (Alnahdi et al., 2012; Dobson et al., 2013).

The test required participants to rise from a standard-height chair and sit down five consecutive times as quickly as possible without using their arms, with the total time recorded. In overweight individuals with knee OA, performance on the 5xSTS was often impaired due to reduced quadriceps strength, joint pain, stiffness, and altered movement patterns. (Bohannon, 2006; Suetta et al., 2004).

Several studies demonstrated that prolonged 5xSTS completion times were associated with reduced physical function, impaired balance, and increased fall risk in older adults and individuals with musculoskeletal disorders. In patients with knee OA,

longer sit-to-stand times reflected diminished functional capacity and were significantly correlated with self-reported disability and other performance-based measures, including the Timed Up and Go Test (TUGT) and the 6-Minute Walk Test (6MWT) (Dobson et al., 2013).

The reliability of the 5xSTS test was high, with intraclass correlation coefficients exceeding 0.90 for both intra-rater and inter-rater reliability (Goldberg et al., 2012; Jones et al., 2013). The Minimal Detectable Change (MDC) for individuals with knee OA ranged from 2.5 to 3.6 seconds and was considered clinically meaningful for monitoring changes over time (Amano & Suzuki, 2018).

Due to its ease of administration, minimal equipment requirements, and strong psychometric properties, the 5xSTS test was a practical and effective outcome measure for use in both clinical and research settings to assess physical function in overweight individuals with knee OA.



CHAPTER 3

METHODOLOGY

3.1 Study Design and Setting

This study was a parallel-group, assessor-blinded randomized controlled trial (RCT) conducted to evaluate the effects of a 12-week whole-food plant-based diet (WFPD) on body composition, pain, disability, and physical capacity. The study was carried out in Chiang Rai Province, Thailand, between July and October 2025. Ethical approval (EC 25153-25) for the study was obtained from the relevant institutional review board before the commencement of data collection.

3.2 Participants

3.2.1 Sample size estimation

The sample size was estimated using the following formula:

$$n/group = \frac{2(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{(\mu_1 - \mu_2)^2} \text{ (Chirawatkul, 2009) in which,}$$

n = sample size/group

$Z_{\alpha/2}$ = Z value corresponding to the significance level (two-tailed)

Z_{β} = Z-value for the type II error

σ^2 = variance

$\mu_1 - \mu_2$ = mean difference

At the time of study planning, no existing data were available on the effects of a whole-food plant-based diet (WFPD) on physical capacity, pain, body composition, and disability in patients with knee osteoarthritis. Therefore, the sample size calculation was based on data from comparable studies, including those reported by Clinton (Clinton et al., 2015).

The study was powered to detect a clinically meaningful between-group difference in the primary outcome. A recent randomized controlled trial comparing a whole food plant-based diet with a usual diet without nutritional intervention in overweight individuals with knee osteoarthritis reported an effect size (standardized mean difference) of 1.0 (95% CI: 0.5 to 1.6) for self-reported pain and function. The lower bound of this confidence interval (0.5) was used as a conservative estimate of the anticipated effect size for the present study. This estimate was further supported by the researcher's pilot trial of an anti-inflammatory diet, which demonstrated an effect size of 0.65.

To achieve 80% statistical power to detect an effect of this magnitude at a two-tailed significance level of 0.05, a minimum sample size of 32 participants was required. To allow for an anticipated attrition rate of 20%, a total of 38 participants were recruited.

3.2.2 Participant criteria

Inclusion criteria

1. Fulfill National Institute for Health and Care Excellence (National Institute for Health and Care Excellence (UK) 2014) clinical criteria for osteoarthritis:

1) Reported activity-related knee joint pain with an average pain severity ≥ 4 on an 11-point Numeric Rating Scale (NRS; 0 = no pain, 10 = worst pain imaginable) during the previous week.

2) Had no morning stiffness or morning stiffness lasting ≤ 30 minutes

3) Age 50 - 75 years

2. Had a history of knee pain on most days of the previous month or knee pain lasting at least 3 months

3. Able to attend 3–4 telephone consultations and complete scheduled assessments

4. Had a body mass index (BMI) between 25.00 – 29.90 kg·m².

5. Were able to understand written and spoken Thai and provide informed consent

Exclusion criteria

1. Any medical condition that could interfere with study participation (e.g., tumors, fibromyalgia)

2. Plans to undergo knee surgery within the next 6 months
3. Already been strictly following an anti-inflammatory diet (e.g., low-carbohydrate, paleo, Mediterranean diets)
4. A habitual diet excluding all animal products (e.g., vegan diet)
5. An inability to follow the anti-inflammatory diet program due to medical contraindications, food allergies or hypersensitivity, or family-related reasons.
6. Been taking diabetes medications that significantly affect blood glucose levels (including insulin, sodium-glucose co-transporter-2 inhibitors, or sulfonylureas), to minimize the risk of hypoglycemia or ketoacidosis
7. Experienced a weight fluctuation greater than 5 kg during the previous 3 months.
8. Received a knee injection, sustained a knee injury, or undergone knee surgery within the past 3 months.
9. A diagnosed psychiatric disorder (excluding anxiety and depression)
10. A history of eating disorders or bariatric surgery
11. Undergone total knee arthroplasty in all eligible knee joints

3.3 Research Protocol

Participants were recruited from local primary care clinics, community health centers, and hospitals in Chiang Rai Province, Thailand. Recruitment strategies included community advertisements, posters, market stall outreach, and social media platforms. Potential participants were initially screened for eligibility via telephone. Eligible individuals were then invited to attend an interview and baseline assessment

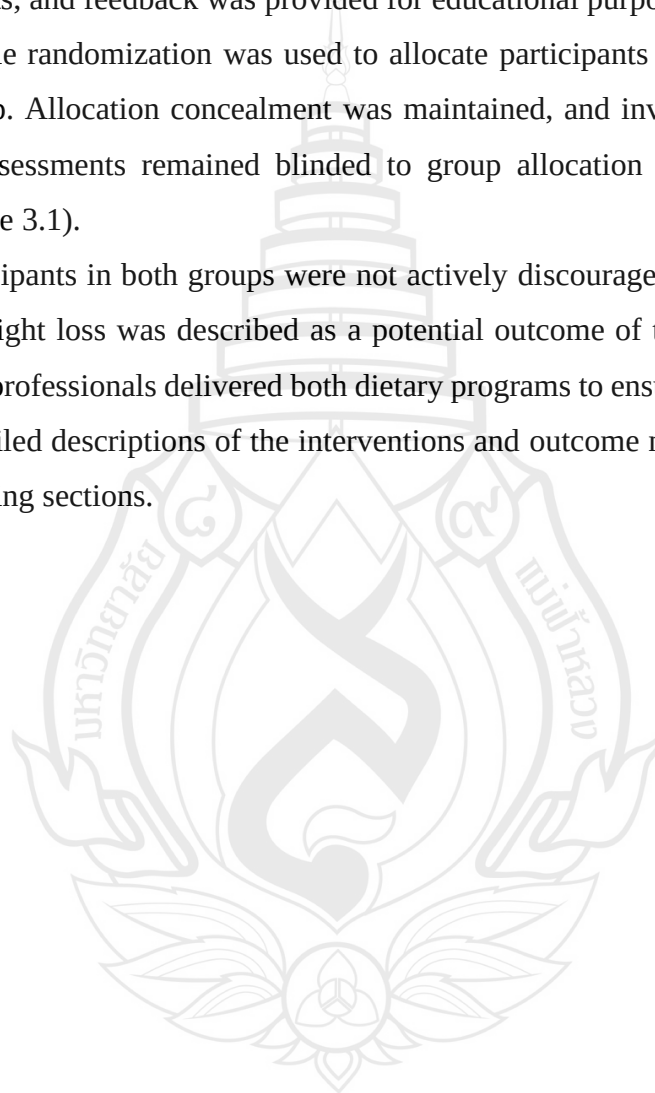
Baseline assessments included the collection of demographic information, body composition measured using bioelectrical impedance analysis (InBody), pain assessed using the visual analog scale (VAS), disability evaluated using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and physical capacity measured by the five-times sit-to-stand test (5xSTS).

Then they were randomly assigned to the groups: (1) Whole-food plant-based diet (WFPD) dietary program (experimental group), (2) Standard care dietary program

(control group). Before initiating the interventions, all participants received detailed study instructions and an introduction to their assigned dietary program. Participants commenced their respective programs on the following day. Both groups participated in their assigned interventions for a total duration of 12 weeks, with telephone follow-up conducted every two days. Outcome measures were reassessed at scheduled follow-up time points, and feedback was provided for educational purposes (Figure 3.1).

Simple randomization was used to allocate participants to the intervention or control group. Allocation concealment was maintained, and investigators conducting follow-up assessments remained blinded to group allocation throughout the study period (Figure 3.1).

Participants in both groups were not actively discouraged from losing weight; however, weight loss was described as a potential outcome of the interventions. The same health professionals delivered both dietary programs to ensure consistency across groups. Detailed descriptions of the interventions and outcome measures are provided in the following sections.



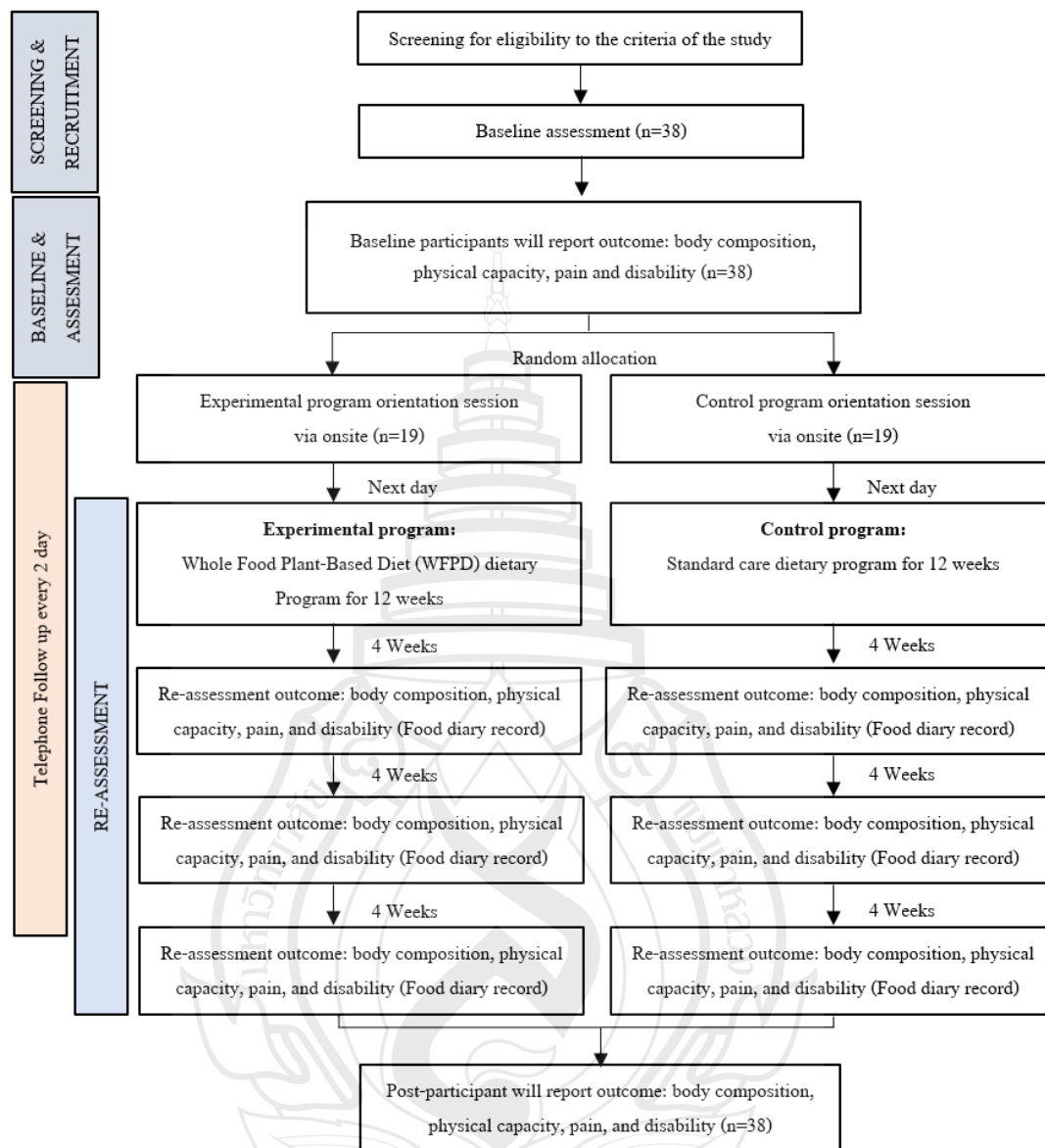


Figure 3.1 Flow of participants through the trial.

3.3.1 Details of whole food plant-based diet (WFPD) dietary program

The whole-food plant-based (WFPB) diet implemented in this study was based on the dietary protocols developed by Ornish and Barnard (Barnard et al., 2005; Ornish et al., 1990). Accordingly, the study menus were designed as presented in Table 3.1.

Table 3.1 Example menu of whole food plant-based diet (WFPD)

Meal	Menu list
Breakfast	1. Soy milk with mixed beans and grains. 2. Soy yogurt with whole wheat bread and fresh fruits. 3. Smoothie vegetables and fruits. 4. Smoothie mixed beans and grains. 5. Whole wheat vegetable and mushroom sandwich. 6. Steamed pumpkin, sweet potato, and fresh fruits. 7. Steamed tofu with soy sauce and fresh fruits. 8. Congee with mushrooms and fresh fruits. 9. Thai-Style Grilled Sweet Potatoes. 10. Tofu scramble with Thai Herbs. 11. Banana Sticky Rice in Banana Leaf (Khao Tom Mat) 12. Thai rice soup with tofu and vegetables. 13. Chia seed pudding with Thai Fruits. 14. Grilled tofu with sticky rice. 15. Thai banana pancakes. 16. Toasted whole-grain bread with peanut butter and banana.
Lunch	1. Vegetable soup with soy tofu and brown rice. 2. Thai-style vegetable and mushrooms Sukiyaki. 3. Oilless stir-fried morning glory and brown rice. 4. Oilless stir-fried mushrooms with garlic and pepper with brown rice. 5. Oilless stir-fried shiitake mushrooms and brown rice. 6. Oilless stir-fried mixed mushrooms with Thai basil and brown rice. 7. Oilless stir-fried kale and brown rice 8. Oilless stir-fried cabbage with soy sauce and brown rice. 9. Oilless stir-fried tofu with ginger and brown rice. 10. Oilless stir-fried bean sprouts with tofu and brown rice. 11. Oilless stir-fried mushrooms with curry and brown rice. 12. Oilless stir-fried broccoli and brown rice. 13. Oilless Pad-Thai tofu and fresh fruit.

Table 3.1 (continued)

Meal	Menu list
Lunch	14. Mixed vegetable noodle in gravy. 15. Hot and spicy mixed mushroom salad. 16. Tofu garden spring roll and spicy sauce. 17. Thai-style spicy papaya salad and grilled tofu. 18. Thai-style spicy corn salad. 19. Oilless fried brown rice with tofu. 20. Oilless stir-fried noodles with mixed vegetables and black soy sauce. 21. Mushroom Tom-Yum noodles. 22. Tofu wonton soup. 23. Thai Pineapple Fried Rice. 24. Red Curry Paste mixed with vegetables and brown rice. 25. Thai mushroom curry and brown rice 26. Rice Noodles with Soy Sauce and Morning Glory 27. Burmese-style chickpea tofu dipping. 28. Oilless stir-fried peas, carrots, and brown rice 29. Oilless stir-fried Tofu with Holy Basil (Pad Krapow Tofu) 30. Oilless stir-fried eggplant with chili, basil, and brown rice.
Dinner	1. Mushrooms Tom Yum with brow rice. 2. Steamed vegetables with tofu and soy sauce. 3. Steamed vegetables with chili paste and brown rice. 4. Grilled mushrooms with hot and spicy sauce. 5. Mixed vegetables sour soup with brown rice 6. Stir-fried mixed mushrooms and vegetables with brown rice. 7. Mixed mushroom spicy soup and grilled tofu. 8. Tofu spicy (Larb) and steamed vegetables. 9. Tofu with tamarind sauce and brown rice 10. Northern-style tofu and tomato chili paste, and steamed vegetables. 11. Northern-style Chinese cabbage sour soup and brown rice. 12. Tofu with sweet and sour chill sauce and brown rice.

Table 3.1 (continued)

Meal	Menu list
Dinner	13. Steamed mixed mushrooms and tofu spring roll. 14. Oilless stir-fried pumpkin with tofu and brown rice. 15. Steamed tofu with Thai herbs and vegetables. 16. Five-spice soup with tofu and brown rice 17. Jab Chai, mixed vegetables and tofu soup. 18. Thai spicy mixed mushrooms soup and brown rice. 19. Kaeng Khae tofu and brown rice. 20. Vegetarian Thai Dumplings. 21. Grilled Eggplant Salad (Yum Makua Yao). 22. Banana Leaf Steamed Curry (Hor Mok vegetables). 23. Noodle Salad with Peanut Dressing 24. Thai seaweed soup and brown rice. 25. Thai pumpkin soup with brown rice. 26. Spicy Mushroom Salad (Yum Het). 27. Spicy long bean salad. 28. Larb mushroom. 29. Yum Tofu with Thai Herbs. 30. Thai pomelo salad with tofu.

In instances where the prescribed menu did not align with the provided examples for certain meals or days, participants were encouraged to contact the researcher directly for appropriate guidance and recommendations.

In addition, all participants received detailed instructions regarding adherence to the WFPD dietary approach. This dietary pattern was defined by the consumption of unrefined or minimally refined plant-based foods and the exclusion of animal products, eggs, and highly processed ingredients. Dietary fat intake was recommended to be limited to a maximum of 10% of total energy intake, in accordance with established WFPD principles. The core principles of the diet included the following,

Plant-derived food sources consisted of whole, unprocessed botanical foods without preservatives or industrial processing, with approximately 75% of total intake derived from vegetables and fruits and 15% from legumes, nuts, and seeds.

Minimally processed foods involve only minimal modification or cooking processes to preserve nutritional integrity, fiber content, and phytochemical composition.

Minimizes ingredients were 10% or eliminates processed oils, refined carbohydrates (e.g., white flour, sugar), artificial additives, and ultra-processed plant-based alternatives (e.g., vegan meats and snacks).

Participants were permitted to adjust their medications and dietary supplements in accordance with their physician's advice during the study period; however, they were discouraged from making substantial changes to their existing medical pain management regimens.

All participants were allowed to eat ad libitum and were not required to count calories. However, to support weight loss, participants were encouraged to limit their food intake to three meals per day. Educational materials highlighting the benefits of a whole-food plant-based diet were provided weekly to reinforce dietary adherence and understanding (Greger, 2020; Walrabenstein et al., 2021).

3.3.2 Details of the standard care dietary program

Participants allocated to the standard care dietary program received dietary advice and education based on the Thailand Dietary Guidelines. This program incorporated the summary plate method, which consisted of 50% vegetables, 25% carbohydrates, and 25% lean protein. The dietary guidance aimed to optimize nutritional intake through adequate consumption of foods from the five core food groups: grains and cereals; fruits; vegetables and legumes; lean meats, poultry, fish, eggs, and tofu; and reduced-fat dairy products or appropriate alternatives. Participants were also advised to limit the intake of foods high in saturated fat, added salt, sugars, and alcohol.

3.4 Outcome Measurements

Participants were assessed for clinical and functional outcomes. The primary outcome was body composition, while secondary outcomes included pain, disability, and physical capacity. All outcome measures were assessed in a randomized sequence.

Prior to data collection, the assessor received standardized training in all testing protocols and practiced administering the assessments using standard commands on five healthy individuals. Outcome measures were collected at baseline and subsequently at monthly follow-up assessments. Details of each assessment are described below:

3.4.1 Body composition

Body composition was assessed using an InBody bioelectrical impedance analysis (BIA) device. The following parameters were measured: (1) body weight, (2) body mass index (BMI), (3) waist-to-hip ratio (WHR), (4) body fat percentage, (5) visceral fat level, (6) muscle mass, (7) skeletal muscle mass, and (8) basal metabolic rate (BMR).

Prior to assessment, participants were instructed to refrain from food intake for at least four hours, avoid strenuous physical activity for 12 hours, and use the restroom approximately 30 minutes before testing to enhance measurement accuracy. Participants stood barefoot on the InBody device sensors and followed the manufacturer's standardized procedures, allowing the device to automatically collect and analyze the data. All measurements were recorded and subsequently used for analyses examining the relationship between body composition and clinical outcomes in individuals with knee osteoarthritis.

3.4.2 Pain

Pain intensity was assessed using the visual analog scale (VAS). Participants were seated comfortably in a quiet environment and presented with a 10-centimeter horizontal line labeled "no pain" at the left endpoint and "worst imaginable pain" at the right endpoint. Participants were instructed to mark the point on the line that best represented their current level of knee pain related to osteoarthritis.

The assessor then measured the distance from the “no pain” endpoint to the participant’s mark in centimeters, recorded to the nearest millimeter. Pain assessments were conducted at baseline and at all scheduled follow-up time points. Participants were encouraged to report their pain level based on their current perception, without time pressure, to ensure consistency and accuracy (Alghadir et al., 2018).

3.4.3 Disability

Disability was evaluated using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Prior to administration, participants received standardized instructions emphasizing honest and accurate reporting of symptoms experienced during the preceding 48 hours.

The WOMAC questionnaire consists of 24 items across three subscales: pain (5 items), stiffness (2 items), and physical function (17 items). Responses were scored using a Likert scale ranging from 0 (none) to 4 (extreme).

For interpretative purposes, the total WOMAC score may be categorized into severity levels as follows: 0–24 (mild), 25–48 (moderate), 49–72 (severe), and 73–96 (very severe). A reduction in the WOMAC score over time reflects clinical improvement, indicating decreased pain and enhanced physical function (Tubach et al., 2005).

Participants completed the questionnaire in a quiet environment, either in paper-based or electronic format. Total and subscale scores were calculated for analysis to reflect the severity of symptoms and functional limitations associated with knee osteoarthritis. (Salaffi et al., 2003) (see Appendix A).

3.4.4 Five times sit-to-stand test (FTSST)

For the five-times sit-to-stand test, participants were seated on a standard chair with their back against the backrest and feet flat on the floor, with arms crossed over the chest. Upon the verbal command “Go,” participants stood up to a fully upright position and returned to a seated position five times as quickly as possible.

The total time required to complete the five repetitions was recorded using a stopwatch. Participants were required to achieve full knee extension during standing and full contact with the chair during sitting. Three trials were conducted, and the mean time across trials was calculated and used for statistical analysis. (Poncumhak et al., 2016).

The performance is interpreted based on completion time, with shorter durations indicating better functional capacity. Reference values suggest that a completion time of ≤ 12 seconds reflects normal functional performance, whereas times > 12 seconds indicate reduced lower extremity strength and functional limitation. Times exceeding 15 seconds are associated with an increased risk of functional decline and falls (Bohannon, 2006).

In the present study, improvement in physical capacity was defined as a reduction in FTSST completion time following the intervention. Consistent with previous studies, a decrease of approximately ≥ 2 seconds was considered a clinically meaningful improvement (MCID), reflecting enhanced muscle strength and functional mobility (Wright et al., 2017).

3.5 Statistical Analysis

Descriptive statistics were used to summarize participant characteristics and study outcomes. Baseline characteristics between groups were compared using independent samples *t*-tests for continuous variables and chi-square (χ^2) tests for categorical variables.

Repeated-measures analysis of variance (ANOVA) with post hoc Scheffé tests was employed to examine within-group differences across the four measurement time points (baseline, 1 month, 2 months, and 3 months). Analysis of covariance (ANCOVA) was used to compare the magnitude of change between groups at each measurement time point, with baseline values included as covariates. Statistical significance was set at a *p*-value of less than 0.05.

CHAPTER 4

RESULTS

4.1 Participants

A total of 38 participants with knee osteoarthritis (19 participants per group) were included in the study. Most participants were overweight (BMI, 26.67 ± 1.29) females with an average age of 64.66 ± 4.68 years, diagnosed with knee osteoarthritis and concurrent low back and knee pain, and none planned to undergo surgery within the next six months. Moreover, over the three-month period, the experimental group achieved 97.08 ± 1.12 (%) adherence to the dietary plan, while the control group, which did not follow the plan, exhibited 95.41 ± 1.28 (%) Adherence. It experienced deviations due to various factors that included social eating occasions, habitual dietary patterns, limited nutritional knowledge, and difficulties in meal planning. Baseline characteristics showed no significant differences between groups ($p > 0.05$, Table 4.1).

Table 4.1 Demographics of the participants (n = 38)

Variables	Total (n=38)	Control (n=19)	Experimental (n=19)	<i>p-value</i>
Age (years) ^a	64.66 ± 4.68	64.79 ± 4.57	64.53 ± 4.91	0.865
Gender (female), n (%)	27 (71.10)	16 (84.20)	11 (57.90)	0.078
Education, n (%)				0.117
Primary	28 (73.70)	17 (89.50)	11 (57.90)	
Secondary	9 (23.70)	1 (5.30)	8 (42.10)	
Bachelor	1 (2.60)	1 (5.30)	0 (0.00)	
Low back pain (yes), n (%)	32 (84.20)	18 (94.70)	14 (73.70)	0.082
Numeric Rating Scale (4/10)				

Table 4.1 (continued)

Variables	Total (n=38)	Control	Experimental	<i>p-value</i>
		(n=19)	(n=19)	
Knee pain (yes), n (%)	34 (89.50)	18 (94.70)	16 (84.20)	0.305
Numeric Rating Scale (≥ 4)				
Underlying disease (yes), n (%)	28 (73.70)	14 (73.70)	14 (73.70)	1.000
Dyslipidemia (yes), n (%)	18 (47.37)	10 (52.60)	8 (42.10)	0.529
Hypertension (yes), n (%)	20 (52.60)	10 (52.60)	10 (52.60)	0.341
Other (yes), n (%)	11 (28.90)	5 (26.30)	6 (31.60)	0.729
Medicine use (yes), n (%)	23 (60.50)	12 (63.20)	11 (57.90)	0.748
Supplement use (yes), n (%)	13 (34.20)	6 (31.60)	7 (36.80)	0.741
Exercise (yes), n (%)	30 (78.90)	14 (73.70)	16 (84.20)	0.440
Achievement ^a (%)	96.24 $\pm$ 1.46	95.41 $\pm$ 1.28	97.08 $\pm$ 1.12	0.283

Note ^a The data are presented using mean $\pm$ standard deviation. The normal distributions are presented using the Skewness test. Abbreviations: n number, (%) percentage

4.2 Parameter Outcome

4.2.1 Body composition outcome

All participants in the experimental group achieved 97% to the dietary plan (Table 19). After participating program, these participants showed significant improvement in all body composition outcomes after 4-, 8-, and 12-week participation ($p < 0.001$, Table 20), and significant difference in each time ($p < 0.001$, Table 21) except muscle mass, skeletal muscle mass, and basal metabolic rate. However, some outcomes in the control

group that included body mass index showed statistically significant changes, but these changes did not indicate improvement ($p < 0.014$, Table 20). Furthermore, a comparison of the data between the groups showed that the improvement in the experimental group was significantly better than that in the control group ($p < 0.001$, Table 4.2).

4.2.2 Pain and disability outcome

All participants in the experimental group showed a significant and consistent decrease in the visual analog scale from baseline at each time (5.26 to 4.58, $p < 0.001$, Table 4.4). Conversely, the control group showed a significantly and consistently higher VAS scale (6.16 to 6.88, $p < 0.001$, Table 4.4). Meanwhile, a comparison between the groups revealed statistically significant differences ($p < 0.001$, Table 4.4).

The results of 3 components (pain during activity, stiffness, and physical function) and total score of the WOMAC scale showed that the pain (4.58 to 6.26) and physical function (21.05 to 23.00) scores of the control group were significantly negative when compared all time points with before the program ($p < 0.001$, Table 4.4). In the experimental group, there were no significant differences in pain and physical function scores at 3 time points, except for week 4 ($p < 0.05$); nevertheless, scores improved at each time relative to baseline. Conversely, stiffness scores showed significant improvement at all time points, notably at week 12 (mean change 2.68 ± 0.28 , $p < 0.001$; Table 4.4). In addition, within-group comparisons in each time point found statistically significant differences ($p < 0.001$; Table 4.5). When a comparison between the group of the sub scores for the 3 components across all time points revealed significant differences at all assessments, except for the stiffness sub score at week eight, which showed no significant difference (Table 4.4).

Moreover, the results indicate that the total WOMAC scores in the control group increased significantly across all time points, while the experimental group showed pronounced improvement, particularly at week 12 (24.74 to 22.05, $p < 0.001$; Table 4.4). In addition, the study found significant between-group differences in outcomes when comparing the time intervals of weeks 4-8, 4-12, and 8-12 (Table 4.5). This results in a clear between-group difference, especially at week 12 (mean change 7.46 ± 0.51 , $p < 0.001$; Table 4.4).

4.2.3 Physical ability outcome

Physical ability, as measured by the five-times sit-to-stand test (FTSST). All participants in the experimental group showed significant improvement in physical ability, whereas the control group demonstrated progressive deterioration. After the intervention, the experimental group showed marked and progressive reductions in FTSST time at Week 4 (14.95 ± 1.70), Week 8 (13.26 ± 1.61), and Week 12 (12.28 ± 1.71), corresponding to significant improvements when compare from baseline ($p < 0.001$, Table 4.6) and when compared among the experimental group at all follow-up time points, including Week 4 (mean difference = 0.99 ± 0.29 sec, $p = 0.006$), Week 8 (mean difference = 2.86 ± 0.38 sec, $p < 0.001$), and Week 12 (mean difference = 3.95 ± 0.47 sec, $p < 0.001$), indicating progressively greater functional improvements over time.

When comparing the data between the groups, the improvement in the experimental group was significantly better than that in the control group in every follow-up. In the experimental group, with significant differences in Table 4.7 between Week 4 and Week 8 (mean difference = 1.69 ± 0.25 sec, $p = 0.006$), Week 4 and Week 12 (mean difference = 2.67 ± 0.37 sec, $p < 0.001$), and Week 8 and Week 12 (mean difference = 0.98 ± 0.23 sec, $p < 0.001$). Conversely, the control group showed either non-significant changes or significant deterioration over time.

Table 4.2 Body composition of the participants in the control and experimental groups at each measurement time (n=38)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p-value</i> ^b
Weight (kg)						
Pre-test	63.94 $\pm$ 6.10 (61.00-66.88)		61.67 $\pm$ 5.30 (59.12 – 64.23)			
After 4-week	65.05 $\pm$ 7.10 (61.63 – 68.47)	-1.11 $\pm$ 0.48 (-254, 0.33)	58.36 $\pm$ 4.63 (56.13 – 60.59)	3.31 $\pm$ 0.35*** (2.27, 4.35)	4.42 $\pm$ 0.62 (3.16, 5.68)	< 0.001
After 8-week	65.11 $\pm$ 6.89 (61.78 – 68.43)	-1.16 $\pm$ 0.46 (-2.52, 0.19)	56.23 $\pm$ 4.87 (53.88 – 58.57)	5.45 $\pm$ 0.52*** (3.91, 6.99)	6.67 $\pm$ 0.72 (5.12, 8.12)	< 0.001
After 12-week	66.00 $\pm$ 7.25 (62.51 – 69.49)	-2.06 $\pm$ 0.59 (-3.81, -0.31)	54.80 $\pm$ 5.44 (52.18 – 57.42)	6.87 $\pm$ 0.54*** (5.28, 8.46)	8.85 $\pm$ 0.82 (7.18, 10.51)	< 0.001
Body Mass Index (kg/m²)						
Pre-test	27.47 $\pm$ 1.19 (26.89 – 28.04)		25.88 $\pm$ 0.82 (25.48 – 26.28)			
After 4-week	27.93 $\pm$ 1.58 (27.17 – 28.69)	-0.46 $\pm$ 0.20 (-1.04, 0.12)	24.52 $\pm$ 0.98 (24.04 – 24.99)	1.36 $\pm$ 0.13*** (0.99, 1.74)	1.71 $\pm$ 0.30 (1.10, 2.32)	< 0.001
After 8-week	27.94 $\pm$ 1.49 (27.22 – 28.66)	-0.48 $\pm$ 0.19 (-1.03, 0.08)	23.58 $\pm$ 1.27 (22.97 – 24.19)	2.30 $\pm$ 0.20*** (1.71, 2.89)	2.66 $\pm$ 0.35 (1.94, 3.37)	< 0.001

Table 4.2 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) a	Between the groups ^b	p-value ^b
After 12-week	28.36 $\pm$ 1.74 (27.53–29.20)	-0.90 $\pm$ 0.25* (-1.65, -0.15)	22.95 $\pm$ 1.30 (22.33–23.58)	2.93 $\pm$ 0.23*** (2.26, 3.59)	3.67 $\pm$ 0.44 (2.78, 4.56)	< 0.001
Waist-to-hip ratio (cm)						
Pre-test	0.91 $\pm$ 0.04 (0.89 – 0.93)		0.89 $\pm$ 0.06 (0.87 – 0.92)			
After 4-week	0.92 $\pm$ 0.05 (0.90 – 0.94)	-0.01 $\pm$ 0.01 (-0.25, 0.01)	0.87 $\pm$ 0.05 (0.85 – 0.89)	0.02 $\pm$ 0.01** (0.01, 0.04)	0.03 $\pm$ 0.01 (0.02, 0.05)	< 0.001
After 8-week	0.93 $\pm$ 0.05 (0.90 – 0.95)	-0.01 $\pm$ 0.01 (-0.28, 0.00)	0.86 $\pm$ 0.05 (0.84 – 0.89)	0.03 $\pm$ 0.01*** (0.01, 0.05)	0.05 $\pm$ 0.01 (0.03, 0.06)	< 0.001
After 12-week	0.93 $\pm$ 0.05 (0.91 – 0.95)	-0.02 $\pm$ 0.01 (0.04, 0.00)	0.86 $\pm$ 0.05 (0.83 – 0.88)	0.04 $\pm$ 0.01*** (0.02, 0.05)	0.06 $\pm$ 0.01 (0.04, 0.08)	< 0.001
Body fat percentage						
Pre-test	25.98 $\pm$ 3.69 (24.20 – 27.76)		25.81 $\pm$ 1.75 (24.96 – 26.65)			
After 4-week	25.77 $\pm$ 4.58 (23.56 – 27.98)	0.21 $\pm$ 0.66 (-1.75, 2.18)	21.31 $\pm$ 2.11 (20.29 – 22.32)	4.50 $\pm$ 0.57*** (2.82, 6.18)	4.32 $\pm$ 0.87 (2.55, 6.09)	< 0.001

Table 4.2 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) a	Between the groups ^b	p-value ^b
After 8-week	27.92 $\pm$ 4.14 (25.92 – 29.91)	-1.94 $\pm$ 0.85 (-4.47, 0.60)	18.45 $\pm$ 3.30 (16.86 – 20.04)	7.36 $\pm$ 0.88*** (4.74, 9.97)	9.38 $\pm$ 1.14 (7.06, 11.70)	< 0.001
After 12-week	28.47 $\pm$ 4.26 (26.42 – 30.52)	-2.49 $\pm$ 0.91 (-5.17, 0.19)	16.84 $\pm$ 2.76 (15.50 – 18.17)	8.97 $\pm$ 0.73*** (6.82, 11.12)	11.54 $\pm$ 1.08 (9.35, 13.74)	< 0.001
Visceral fat (level)						
Pre-test	11.00 $\pm$ 2.00 (10.04 – 11.96)		10.84 $\pm$ 0.96 (10.38 – 11.30)			
After 4-week	10.79 $\pm$ 2.42 (9.62 – 11.95)	0.21 $\pm$ 0.37 (-0.89, 1.31)	8.63 $\pm$ 1.21 (8.05 – 9.22)	2.21 $\pm$ 0.33*** (1.23, 3.19)	2.04 $\pm$ 0.49 (1.04, 3.03)	< 0.001
After 8-week	11.95 $\pm$ 2.12 (10.93 – 12.97)	-0.95 $\pm$ 0.46 (-2.30, 0.40)	7.26 $\pm$ 1.85 (6.37 – 8.16)	3.58 $\pm$ 0.49*** (2.12, 5.04)	4.62 $\pm$ 0.62 (3.37, 5.86)	< 0.001
After 12-week	12.21 $\pm$ 2.15 (11.17 – 13.25)	-1.21 $\pm$ 0.47 (-2.62, 0.20)	6.37 $\pm$ 1.38 (5.70 – 7.03)	4.47 $\pm$ 0.39*** (3.33, 5.62)	5.77 $\pm$ 0.55 (4.66, 6.89)	< 0.001
Muscle mass (kg)						
Pre-test	35.41 $\pm$ 6.44 (32.31 – 38.52)		33.49 $\pm$ 4.12 (31.50 – 35.47)			

Table 4.2 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95% CI)	Mean change scores (95% CI) ^a	Mean $\pm$ SD (95% CI)	Mean change scores (95% CI) ^a	Between the groups ^b	<i>p</i> -value ^b
After 4-week	36.78 $\pm$ 6.14 (33.82 – 39.75)	-1.37 $\pm$ 0.46* (-2.73, -0.02)	34.48 $\pm$ 4.69 (32.22 – 36.74)	-0.99 $\pm$ 0.54 (-2.58, 0.61)	0.52 $\pm$ 0.72 (-0.94, 1.98)	0.474
After 8-week	33.09 $\pm$ 6.78 (29.83 – 36.36)	2.32 $\pm$ 1.25 (-1.40, 6.03)	35.23 $\pm$ 5.44 (32.60 – 37.85)	-1.74 $\pm$ 0.66 (-3.68, 0.21)	-3.71 $\pm$ 1.42 (-6.60, -0.82)	0.013
After 12-week	33.41 $\pm$ 7.16 (29.95 – 36.86)	2.01 $\pm$ 1.31 (-1.87, 5.88)	5.41 $\pm$ 5.10 (32.95 – 37.87)	-1.92 $\pm$ 0.58* (3.65, -0.19)	-3.60 $\pm$ 1.44 (-6.53, -0.67)	0.018
Skeletal muscle mass (kg)						
Pre-test	20.57 $\pm$ 4.21 (18.54 – 22.60)		19.33 $\pm$ 2.69 (18.03 – 20.62)			
After 4-week	21.27 $\pm$ 4.11 (19.29 – 23.25)	-0.70 $\pm$ 0.30 (-1.60, 0.20)	19.98 $\pm$ 3.07 (18.50 – 21.47)	-0.66 $\pm$ 0.35 (-1.70, 0.39)	0.1 $\pm$ 0.48 (-0.85, 1.08)	0.814
After 8-week	21.68 $\pm$ 6.32 (18.64 – 24.73)	-1.11 $\pm$ 1.18 (-4.61, 2.39)	20.46 $\pm$ 3.55 (18.75 – 22.17)	-1.13 $\pm$ 0.43 (-2.42, 0.16)	0.04 $\pm$ 1.30 (-2.59, 2.67)	0.973
After 12-week	21.92 $\pm$ 6.40 (18.83 – 25.00)	-1.34 $\pm$ 1.18 (-4.48, 2.15)	20.59 $\pm$ 3.33 (18.98 – 22.19)	-1.26 $\pm$ 0.38* (-2.40, -0.12)	0.13 $\pm$ 1.28 (-2.46, 2.73)	0.918

Table 4.2 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95 % CI)	Mean change scores (95 % CI) ^a	Mean $\pm$ SD (95 % CI)	Mean change scores (95 % CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Basal metabolic rate (kcal).						
Pre-test	1,189.26 $\pm$ 149.23 (1,117.34 – 1,261.19)		1,144.68 $\pm$ 95.31 (1,098.75 – 1,190.62)			
After 4-week	1,220.11 $\pm$ 142.28 (1,151.53 – 1,288.68)	-30.84 $\pm$ 10.33 (-61.45, 0.23)	1,168.68 $\pm$ 108.47 (1,116.40 – 1,220.97)	-24.00 $\pm$ 12.29 (-60.4, 12.4)	9.86 $\pm$ 16.31 (-23.25, 42.96)	0.549
After 8-week	1,172.37 $\pm$ 125.37 (1,111.94 – 1,232.80)	16.90 $\pm$ 14.47 (-25.97, 59.76)	1,185.21 $\pm$ 125.88 (1,124.54 – 1,245.88)	-40.53 $\pm$ 15.28 (-85.80, 4.75)	-51.59 $\pm$ 20.99 (-94.20, -8.97)	0.019
After 12-week	1,180.05 $\pm$ 134.53 (1,115.21 – 1,244.89)	9.21 $\pm$ 15.89 (-37.87, 59.29)	1,189.47 $\pm$ 117.52 (1,132.83 – 1,246.12)	-44.79 $\pm$ 13.52* (-84.86, -4.72)	-48.51 $\pm$ 20.89 (-90.92, -6.11)	0.026

Note Abbreviations: *SD*, standard deviation; *CI*, confidence interval; *kg*, kilogram; *kg/m²*, kilogram per square meter; *cm*, centimeter; *kcal*, kilocalorie. Note: The data are presented using mean $\pm$ standard deviation (95% confidence intervals). ^a The data were compared with baseline ability (pre-test), and the data were analyzed using the repeated measure ANOVA and post-hoc (Scheffe) test. ^b The adjusted means from the Analysis of Covariance (ANCOVA). Superscripts indicated significant differences with the *p*-value **p*<0.05, ***p*<0.01, ****p*<0.001.

Table 4.3 Differences among times regarding the mean scores of body composition outcomes in each group (n= 19 per group)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference (I-J)	p-value	Mean Difference (I-J)	p-value
			95% CI		95% CI	
Weight (kg)	After 4-week	After 8-week	-0.06 ± 0.19 (-0.63, 0.52)	1.000	2.14 ± 0.34*** (1.12, 3.16)	< 0.001
		After 12-week	-0.95 ± 0.31* (-1.88, -0.02)	0.043	3.56 ± 0.40*** (2.39, 4.73)	< 0.001
	After 8-week	After 12-week	-0.90 ± 0.24** (-1.60, -0.19)	0.009	1.42 ± 0.25*** (0.68, 2.17)	< 0.001
	Body Mass Index (kg/m²)	After 4-week	After 8-week	-0.02 ± 0.08 (-0.26, 0.23)	1.000	0.94 ± 0.14*** (0.52, 1.35)
After 4-week		After 12-week	-0.44 ± 0.15 (-0.88, 0.00)	0.054	1.56 ± 0.18*** (1.02, 2.11)	< 0.001
		After 8-week	After 12-week	-0.42 ± 0.12* (-0.77, -0.07)	0.012	0.63 ± 0.12*** (0.28, 0.97)

Table 4.3 (continued)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference (I-J) 95% CI	<i>p</i> -value	Mean Difference (I-J) 95% CI	<i>p</i> -value
Waist-to-hip ratio (cm)	After 4-week	After 8-week	0.00 ± 0.00 (-0.01, 0.00)	1.000	0.01 ± 0.00** (0.00, 0.01)	0.005
		After 12-week	-0.01 ± 0.00* (-0.02, 0.00)	0.422	0.02 ± 0.00*** (0.01, 0.02)	< 0.001
	After 8-week	After 12-week	-0.01 ± 0.00* (-0.01, 0.00)	0.11	0.01 ± 0.00*** (0.00, 0.01)	< 0.001
Body fat percentage	After 4-week	After 8-week	-2.15 ± 0.84 (-4.63, 0.34)	0.118	2.85 ± 0.90* (0.20, 5.51)	0.031
		After 12-week	-2.70 ± 0.84* (-5.20, -0.20)	0.029	4.47 ± 0.81*** (2.07, 6.87)	< 0.001
	After 8-week	After 12-week	-0.55 ± 0.25 (-1.29, 0.19)	0.250	1.62 ± 0.33** (0.63, 2.60)	0.001

Table 4.3 (continued)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference (I-J) 95% CI	<i>p</i> -value	Mean Difference (I-J) 95% CI	<i>p</i> -value
Visceral fat level	After 4-week	After 8-week	-1.16 ± 0.47* (-2.54, 0.23)	0.140	1.37 ± 0.52 (-0.17, 2.91)	0.100
		After 12-week	-1.42 ± 0.47 (-2.81, -0.04)	0.04	2.26 ± 0.44*** (0.95, 3.58)	< 0.001
	After 8-week	After 12-week	-0.26 ± 0.15 (-0.71, 0.18)	0.58	0.90 ± 0.17*** (0.39, 1.40)	< 0.001
Muscle mass (kg)	After 4-week	After 8-week	3.69 ± 1.18* (0.19, 7.19)	0.035	-0.75 ± 0.76 (-3.01, 1.52)	1.000
		After 12-week	3.38 ± 1.21 (-0.22, 6.98)	0.074	-0.93 ± 0.67 (-2.91, 1.05)	1.000
	After 8-week	After 12-week	-3.31 ± 0.18 (-0.83, 0.21)	0.176	-0.18 ± 0.24 (-0.99, 0.53)	1.000

Table 4.3 (continued)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference (I-J) 95% CI	<i>p</i> -value	Mean Difference (I-J) 95% CI	<i>p</i> -value
Skeletal muscle mass (kg)	After 4-week	After 8-week	-0.41 ± 1.30 (-4.26, 3.43)	1.000	-0.47 ± 0.49 (-1.94, 0.99)	1.000
		After 12-week	-0.64 ± 1.29 (4.46, 3.18)	1.000	-0.61 ± 0.43 (-1.88, 0.67)	1.000
	After 8-week	After 12-week	-0.23 ± 0.12 (-0.57, 0.11)	0.364	-0.13 ± 0.16 (-0.60, 0.33)	1.000
Basal metabolic rate (kcal)	After 4-week	After 8-week	47.74 ± 17.14 (-3.05, 98.52)	0.073	-16.53 ± 17.60 (-68.68, 35.63)	1.000
		After 12-week	40.05 ± 17.58 (-12.03, 92.14)	0.211	-20.79 ± 15.24 (-65.94, 24.37)	1.000
	After 8-week	After 12-week	-7.68 ± 4.11 (-19.85, 4.49)	0.466	-4.26 ± 5.59 (-20.83, 12.30)	1.000

Note Abbreviations: SD, standard deviation; CI, confidence interval; kg, kilogram; kg/m², kilogram per square meter; cm, centimeter; kcal, kilocalorie. Note: The data are presented using mean $\pm$ standard deviation (95% confidence intervals). The data were analyzed to examine differences between Week 4 and Week 8, Week 4 and Week 12, and between Week 8 and Week 12, and the data were analyzed using the repeated-measure ANOVA and post-hoc (Scheffe) test. Superscripts indicated significant differences with the *p*-value **p*<0.05, ***p*<0.01, ****p*<0.001.



Table 4.4 Pain and disability of the participants in the control and experimental groups at each measurement time (n=38)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Visual analog scale (VAS)						
Pre-test	6.16 $\pm$ 1.20 (5.59, 6.74)		5.26 $\pm$ 0.80 (4.88, 5.65)			
After 4-week	6.42 $\pm$ 1.18 (5.85, 6.98)	0.26 $\pm$ 0.06* (-0.44, -0.06)	4.84 $\pm$ 0.77 (4.47, 5.21)	-0.42 $\pm$ 0.07*** (0.22, 0.62)	0.73 $\pm$ 0.10 (0.53, 0.93)	< 0.001
After 8-week	6.69 $\pm$ 1.13 (6.15, 7.23)	0.53 $\pm$ 0.09* (-0.80, -0.25)	4.74 $\pm$ 0.68 (4.41, 5.07)	-0.52 $\pm$ 0.09*** (0.24, 0.80)	1.19 $\pm$ 0.13 (0.92, 1.47)	< 0.001
After 12-week	6.88 $\pm$ 0.98 (6.41, 7.35)	0.72 $\pm$ 0.14* (-1.14, -0.29)	4.58 $\pm$ 0.63 (4.41, 5.07)	-0.68 $\pm$ 0.14** (0.27, 1.09)	5.91 $\pm$ 0.65 (4.58, 7.23)	< 0.001

Table 4.4 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Total WOMAC score						
Pre-test	28.79 $\pm$ 7.41 (25.22, 32.36)		24.74 $\pm$ 2.08 (23.74, 25.74)			
After 4-week	29.63 $\pm$ 7.48 (26.03, 33.24)	-0.84 $\pm$ 0.21** (-1.45, -0.23)	24.26 $\pm$ 2.02 (23.29, 25.24)	0.47 $\pm$ 0.14 (0.06, 0.89)	1.33 $\pm$ 0.27 (0.78, 1.88)	< 0.001
After 8-week	31.16 $\pm$ 6.89 (27.84, 34.48)	-2.37 $\pm$ 0.29*** (-3.22, -1.51)	24.81 $\pm$ 6.85 (21.50, 28.11)	-0.07 $\pm$ 1.64 (-4.91, 4.78)	2.89 $\pm$ 1.78 (-0.73, 6.50)	0.114
After 12-week	32.79 $\pm$ 6.36 (29.72, 35.86)	-4.00 $\pm$ 0.51*** (-5.50, -2.50)	22.05 $\pm$ 1.54 (21.31, 22.80)	2.68 $\pm$ 0.28*** (1.87, 3.50)	7.46 $\pm$ 0.51 (6.42, 8.49)	< 0.001

Table 4.4 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Pain score						
Pre-test	4.58 $\pm$ 1.61 (3.80, 5.35)		3.63 $\pm$ 0.76 (3.26, 4.00)			
After 4-week	4.95 $\pm$ 1.84 (4.06, 5.83)	-0.37 $\pm$ 0.11 (-0.71, -0.03)	3.63 $\pm$ 0.76 (3.26, 4.00)	0.00 $\pm$ 0.08 (-0.23, 0.23)	0.30 $\pm$ 0.15 (0.01, 0.60)	0.045
After 8-week	5.63 $\pm$ 1.67 (4.82, 6.44)	-1.05 $\pm$ 0.12*** (-1.41, -0.70)	3.32 $\pm$ 0.48 (3.09, 3.55)	0.32 $\pm$ 0.13 (-0.08, 0.71)	1.48 $\pm$ 0.19 (1.10, 1.86)	< 0.001
After 12-week	6.26 $\pm$ 1.19 (5.69, 6.84)	-1.68 $\pm$ 0.19*** (-2.24, -1.13)	3.37 $\pm$ 0.60 (3.08, 3.66)	0.26 $\pm$ 0.17 (-0.24, 0.76)	2.34 $\pm$ 0.21 (1.92, 2.75)	< 0.001

Table 4.4 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Stiffness score						
Pre-test	3.16 $\pm$ 0.60 (2.87, 3.45)		3.16 $\pm$ 0.50 (2.92, 3.40)			
After 4-week	3.11 $\pm$ 0.66 (2.79, 3.42)	0.05 $\pm$ 0.05 (-0.10, 0.21)	2.79 $\pm$ 0.63 (2.49, 3.09)	0.37 $\pm$ 0.11* (0.03, 0.71)	0.32 $\pm$ 0.13 (0.06, 0.57)	0.017
After 8-week	3.47 $\pm$ 0.61 (3.18, 3.77)	-0.32 $\pm$ 0.13 (-0.71, 0.08)	3.96 $\pm$ 7.13 (0.53, 7.40)	-0.81 $\pm$ 1.64 (-5.68, 4.07)	-0.49 $\pm$ 1.66 (-3.87, 2.89)	0.770
After 12-week	3.53 $\pm$ 0.61 (3.23, 3.82)	-0.37 $\pm$ 0.16 (-0.83, 0.10)	1.84 $\pm$ 0.37 (1.66, 2.02)	1.32 $\pm$ 0.13*** (0.92, 1.71)	1.68 $\pm$ 0.16 (1.36, 2.01)	< 0.001

Table 4.4 (continued)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	<i>p</i> -value ^b
Physical function score						
Pre-test	21.05 $\pm$ 5.70 (18.31, 23.80)		17.95 $\pm$ 1.47 (17.24, 18.66)			
After 4-week	21.58 $\pm$ 5.59 (18.88, 24.27)	-0.53 $\pm$ 0.16 ^{**} (-1.00, -0.05)	17.84 $\pm$ 1.38 (17.17, 18.51)	0.11 $\pm$ 0.11 ^{**} (-0.21, 0.42)	0.73 $\pm$ 0.20 (0.32, 1.14)	0.001
After 8-week	22.05 $\pm$ 5.16 (19.57, 24.54)	-1.00 $\pm$ 0.24 ^{**} (-1.72, -0.28)	17.53 $\pm$ 1.43 (16.84, 18.21)	0.42 $\pm$ 0.16 (-0.05, 0.89)	1.76 $\pm$ 0.27 (1.21, 2.31)	< 0.001
After 12-week	23.00 $\pm$ 5.10 (20.54, 25.46)	-1.95 $\pm$ 0.35 ^{***} (-3.00, -0.90)	16.84 $\pm$ 1.42 (16.16, 17.53)	1.11 $\pm$ 0.24 (0.39, 1.82)	3.51 $\pm$ 0.41 (2.67, 4.34)	< 0.001

Table 4.5 Differences among times regarding the mean scores of pain and disability outcomes in each group (n= 19 per group).

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference		Mean Difference	
			(I-J)	P-value	(I-J)	P-value
			95% CI		95% CI	
Visual analog scale (VAS)	After 4-week	After 8-week	0.10 ± 0.06 (-0.07, 0.27)	0.586	-0.27 ± 0.04*** (-0.41, -0.14)	< 0.001
		After 12-week	0.26 ± 0.10 (-0.05, 0.56)	0.136	-0.46 ± 0.11** (-0.78, -0.14)	0.003
	After 8-week	After 12-week	0.16 ± 0.07 (0.06, 0.38)	0.136	-0.19 ± 0.08 (-0.42, 0.04)	0.140
		After 12-week	-0.54 ± 1.66*** (-5.47, 4.39)	1.000	-1.53 ± 0.26*** (-2.29, -0.76)	< 0.001
Total WOMAC score	After 4-week	After 12-week	2.21 ± 0.28*** (1.38, 3.05)	< 0.001	-3.16 ± 0.50*** (-4.65, -1.67)	< 0.001
		After 12-week	-2.75 ± 1.65*** (-2.14, -7.64)	0.676	-1.63 ± 0.28*** (-2.46, -0.81)	< 0.001
	After 8-week	After 12-week				

Table 4.5 (continued)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference		Mean Difference	
			(I-J)	P-value	(I-J)	P-value
			95% CI		95% CI	
Pain score	After 4-week	After 8-week	0.32 ± 0.13 (-0.08, 0.71)	0.177	-0.68 ± 0.13*** (-1.08, -0.29)	< 0.001
		After 12-week	0.26 ± 0.17 (-0.24, 0.76)	0.812	-1.32 ± 0.23*** (-2.00, -0.63)	< 0.001
	After 8-week	After 12-week	-0.05 ± 0.12 (-0.41, 0.30)	1.000	-0.63 ± 0.17*** (-1.15, -0.11)	0.012
Stiffness score	After 4-week	After 8-week	-1.174 ± 1.68 (-6.15, 3.80)	1.000	-0.37 ± 0.11* (-0.71, -0.03)	0.027
		After 12-week	-0.95 ± 0.16 (0.47, 1.43)	< 0.001	-0.42 ± 0.14* (-0.83, -0.01)	0.044
	After 8-week	After 12-week	2.12 ± 1.63 (-2.69, 6.94)	1.000	-0.05 ± 0.12 (-0.31, 0.20)	1.000

Table 4.5 (continued)

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference		Mean Difference	
			(I-J) 95% CI	P-value	(I-J) 95% CI	P-value
Physical function score	After 4-week	After 8-week	-0.47 ± 0.21 (-1.09, 0.14)	0.209	0.32 ± 0.13 (-0.08, 0.71)	0.177
		After 12-week	-1.42 ± 0.32 (-2.36, -0.48)	0.002	1.00 ± 0.22** (0.36, 1.64)	0.001
	After 8-week	After 12-week	-0.95 ± 0.19 (-1.52, -0.37)	0.001	0.68 ± 0.15** (0.23, 1.14)	0.002

Note Abbreviation: SD standard deviation, CI confidence interval. Note: The data are presented using mean ± standard deviation (95% confidence intervals). The data were analyzed to examine differences between Week 4 and Week 8, Week 4 and Week 12, and between Week 8 and Week 12, and the data were analyzed using the repeated-measure ANOVA and post-hoc (Scheffe) test. Superscripts indicated significant differences with the p -value * p <0.05, ** p <0.01, *** p <0.001.

Table 4.6 Physical ability of the participants in the control and experimental groups at each measurement time (n=38)

Variable	Control group (n= 19)		Experimental group (n= 19)		Mean difference	
	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Mean $\pm$ SD (95%CI)	Mean change scores (95%CI) ^a	Between the groups ^b	P-value ^b
Five times sit-to-stand test (sec)						
Pre-test	18.00 $\pm$ 3.46 (16.33, 19.67)		15.65 $\pm$ 2.12 (14.63, 16.67)			
After 4-week	17.94 $\pm$ 3.24 (16.38, 19.51)	-0.53 $\pm$ 0.16* (-1.00, -0.05)	14.95 $\pm$ 1.70 (14.13, 15.77)	0.70 $\pm$ 0.18* (0.18, 1.23)	0.99 $\pm$ 0.29 (0.39, 1.57)	0.006
After 8-week	18.11 $\pm$ 3.42 (16.47, 19.76)	-1.00 $\pm$ 0.24** (-1.72, -0.28)	13.26 $\pm$ 1.61 (12.48, 14.04)	2.39 $\pm$ 0.32*** (1.46, 3.32)	2.86 $\pm$ 0.38 (2.08, 3.62)	< 0.001
After 12-week	18.19 $\pm$ 3.47 (16.52, 19.87)	-1.95 $\pm$ 0.35*** (-3.00, -0.90)	12.28 $\pm$ 1.71 (11.46, 13.10)	3.37 $\pm$ 0.41*** (0.39, 1.82)	3.95 $\pm$ 0.47 (2.99, 4.92)	< 0.001

Note Abbreviation: SD standard deviation, CI confidence interval, sce second. Note: The data are presented using mean $\pm$ standard deviation (95% confidence intervals). ^a The data were compared with baseline ability (pre-test), and the data were analyzed using the repeated measure ANOVA and post-hoc (Scheffe) test. ^b The adjusted means from the Analysis of Covariance (ANCOVA). Superscripts indicated significant differences with the *p*-value **p*<0.05, ***p*<0.01, ****p*<0.001.

Table 4.7 Difference among times regarding the mean scores of physical abilities in each group (n= 19 per group).

Dependent Variable	(I) Group	(J) Group	Control group		Experimental group	
			Mean Difference (I-J) 95% CI	p-value	Mean Difference (I-J) 95% CI	p-value
Five times sit-to-stand test (sec)	After 4-week	After 8-week	-0.47 ± 0.21 (-1.09, 0.14)	0.209	1.69 ± 0.25* (0.94, 2.44)	0.006
		After 12-week	-1.42 ± 0.32** (-0.70, 0.21)	0.002	2.67 ± 0.37** (0.36, 1.64)	< 0.001
	After 8-week	After 12-week	-0.95 ± 0.19*** (-0.24, 0.08)	0.001	0.98 ± 0.23** (0.30, 1.66)	< 0.001

Note Abbreviation: *SD* standard deviation, *CI* confidence interval, *sce* second. Note: The data are presented using mean ± standard deviation (95% confidence intervals). The data were analyzed to examine differences between Week 4 and Week 8, Week 4 and Week 12, and between Week 8 and Week 12, and the data were analyzed using the repeated-measure ANOVA and post-hoc (Scheffe) test. Superscripts indicated significant differences with the *p*-value **p*<0.05, ***p*<0.01, ****p*<0.001.

CHAPTER 5

DISCUSSION

This study was designed as a randomized controlled trial to evaluate the effects of a Whole-Food Plant-Based (WFPB) dietary intervention on body composition, pain, disability, and physical performance in overweight patients with knee osteoarthritis. Participants in the experimental group followed a plant-based dietary program for a duration of 12 weeks.

The findings demonstrated that participants in the experimental group exhibited statistically significant improvements across multiple outcomes when compared with the control group, which followed standard Thai healthy dietary guidelines as recommended by the Ministry of Public Health of Thailand.

In particular, the results showed consistent and statistically significant improvements in body composition among participants in the experimental group. These improvements were observed across several indicators, including body weight, body mass index (BMI), body fat percentage, and visceral fat levels, reflecting an overall reduction in metabolic burden.

These changes occurred concurrently with significant reductions in pain and disability, as evidenced by improvements in the Visual Analog Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores. In addition, significant improvements in physical performance were observed in the experimental group, demonstrated by a reduction in the time required to complete the Five-Times Sit-to-Stand Test (FTSST), a functional measure reflecting lower limb muscle strength and functional mobility.

From a mechanistic perspective, these findings are likely attributable to the combined effects of mechanical and biological factors. Specifically, reductions in body weight may decrease joint loading (mechanical effect), while improvements in metabolic and inflammatory profiles associated with plant-based dietary patterns may contribute to symptom reduction (biological pathways). Both mechanisms are

recognized as key contributors to the pathophysiology and progression of knee osteoarthritis.

5.1 Effect of a Whole-food Plant-based Diet on Body Composition

The present randomized controlled trial demonstrated that a 12-week Whole-Food Plant-Based (WFPB) dietary intervention resulted in significant and clinically meaningful improvements in body composition among overweight patients with knee osteoarthritis. Compared with the control group, the experimental group exhibited significant reductions in body weight, body mass index (BMI), body fat percentage, visceral fat level, and waist-to-hip ratio (WHR), while preserving muscle mass, skeletal muscle mass (SMM), and basal metabolic rate (BMR) (Tables 4.2-4.3). Between-group differences were statistically robust ($p < 0.001$) with narrow confidence intervals, supporting both internal validity and clinical relevance.

A central component of the intervention was limiting total dietary fat intake to <10% of total energy, a strategy previously shown to enhance insulin sensitivity, reduce intramyocellular lipid accumulation, and improve mitochondrial efficiency (Barnard et al., 2015; Kahleova et al., 2017; Walrabenstein et al., 2021). Reduced intracellular lipid deposition restores insulin signaling pathways, promoting increased lipid oxidation and decreased lipogenesis. These metabolic adaptations are particularly relevant for reducing visceral adiposity, a metabolically active fat depot strongly associated with systemic inflammation and osteoarthritis progression (Hunter & Bierma-Zeinstra, 2019).

The dietary pattern, composed primarily of vegetables and fruits (~75%) and legumes, nuts, and seeds (~15%), provided high fiber density and low energy density. According to the energy density–satiety model, diets rich in fiber and water reduce spontaneous energy intake through enhanced satiety signaling without deliberate caloric restriction (Rolls et al., 2006). Fiber stimulates the secretion of glucagon-like peptide-1 (GLP-1) and peptide YY (PYY), promoting appetite regulation and improved glycemic control (Slavin, 2013). Consistent with randomized trials of plant-based diets, weight reduction occurred despite ad libitum intake (Kahleova et al., 2017; Turner-

McGrievy et al., 2015). The present findings extend this literature by integrating body composition metrics with a structured causal framework linking dietary exposure to mechanistic and clinical outcomes.

5.1.1 The energy density and weight reduction (Weight, BMI)

The significant reductions in body weight and BMI observed in the intervention group were explained through the energy density–satiety model, a central mechanism identified in the literature review. WFPB diets were characterized by low energy density due to their high water and fiber content and minimal added fats. This nutritional composition promoted a spontaneous reduction in total caloric intake without intentional energy restriction.

Dietary fiber played a pivotal physiological role by modulating satiety-related hormones, including glucagon-like peptide-1 (GLP-1) and peptide YY (PYY), thereby reducing appetite and enhancing fat oxidation. Joanne (Slavin, 2013) reported that high-fiber diets enhanced satiety signaling and improved glycemic control, contributing to sustainable weight loss. Randomized trials conducted by Hana (Kahleova et al., 2017) further demonstrated that plant-based diets facilitated significant weight reduction without mandated caloric restriction, reinforcing the biological plausibility of the present findings.

From a mediation perspective, weight reduction functioned as a key intermediary mechanism linking dietary intervention to downstream clinical outcomes. Biomechanically, each kilogram of weight loss was associated with an approximate four-kilogram reduction in knee joint compressive load per step, as demonstrated by Stephen (Messier et al., 2004). Therefore, reductions in body weight and BMI not only reflected metabolic improvements but also provided a mechanistic explanation for potential reductions in joint pain and improvements in functional mobility among individuals with knee osteoarthritis.

5.1.2 The lipid metabolism and adiposity reduction (% Body Fat, Visceral Fat, WHR)

The significant reductions in body fat percentage, visceral fat level, and WHR observed in the intervention group indicate substantial improvements in adiposity distribution and metabolic health. WFPB diets have been shown to improve insulin

sensitivity, enhance lipid oxidation, and suppress lipogenesis through multiple cellular mechanisms (Barnard et al., 2015; Kahleova et al., 2017; Walrabenstein et al., 2021).

Improved insulin sensitivity facilitates increased lipolysis and reduced triglyceride accumulation in adipocytes, thereby promoting fat mass reduction. In particular, reductions in visceral adiposity are clinically important, as visceral fat is a metabolically active tissue associated with systemic inflammation, metabolic dysfunction, and osteoarthritis progression (Hunter & Bierma-Zeinstra, 2019). The observed reductions in visceral fat and WHR therefore represent meaningful improvements in both metabolic and inflammatory risk profiles.

5.1.3 The Muscle Preservation Pathway (MM, SMM)

Despite significant reductions in total body weight and fat mass, muscle mass and skeletal muscle mass were largely preserved in the intervention group. This finding is particularly important in older adults with knee osteoarthritis, where sarcopenia risk and functional decline are critical concerns.

The review highlighted that well-planned plant-based diets with adequate protein from legumes, soy products, and whole grains can maintain lean body mass. Improvements in mitochondrial function, reductions in oxidative stress, and enhanced insulin sensitivity collectively support efficient muscle protein synthesis and limit muscle catabolism.

Preservation of skeletal muscle mass may serve as a mediator between adiposity reduction and improved functional outcomes. Maintenance of lean mass contributes to sustained mobility, joint stabilization, and metabolic rate, thereby preventing the functional decline often associated with weight-loss interventions that disproportionately reduce lean tissue.

5.1.4 The Metabolic Adaptation Pathway and Changes in Basal Metabolic Rate (BMR)

The preservation of basal metabolic rate observed in this study reflects favorable metabolic adaptation associated with selective fat loss and maintenance of lean tissue mass. Lean mass is the primary determinant of resting energy expenditure; therefore, preservation of skeletal muscle mass helps prevent the metabolic slowdown commonly observed during conventional weight-loss interventions.

These findings align with the metabolic efficiency model, which proposes that plant-based diets enhance mitochondrial function, improve metabolic flexibility, and support efficient energy utilization (Barnard et al., 2015; Kahleova et al., 2017). By reducing fat mass while preserving lean mass, WFPB dietary intervention may prevent disproportionate reductions in energy expenditure and support long-term weight maintenance and metabolic stability.

Collectively, the present findings support a comprehensive causal pathway linking WFPB dietary intervention to improved body composition outcomes. The intervention promotes spontaneous caloric reduction through low energy density and enhanced satiety, improves insulin sensitivity and lipid metabolism, reduces visceral adiposity, preserves skeletal muscle mass, and maintains metabolic rate. These coordinated metabolic adaptations contribute to improved metabolic health and provide a mechanistic foundation for downstream improvements in pain, functional capacity, and overall clinical outcomes in patients with knee osteoarthritis.

5.2 Effect on Pain Reduction and Disability

Significant reductions in pain severity and disability were observed in the experimental group, whereas the control group demonstrated progressive worsening over the same period (Tables 4.4–4.5). Specifically, Visual Analog Scale (VAS) pain scores in the experimental group decreased significantly from baseline to Week 12, while the control group showed a substantial increase in pain severity, reaching. Between-group comparison confirmed a highly significant difference favoring the intervention (mean difference = 5.91 ± 0.65 ; 95% CI: 4.58–7.23; $p < 0.001$) (Table 4.4), indicating both statistical robustness and clinical relevance.

Similarly, WOMAC total scores improved significantly in the experimental group, declining from baseline, whereas the control group exhibited marked deterioration, increasing. The between-group difference was statistically significant (mean difference = 7.46 ± 0.51 ; 95% CI: 6.42–8.49; $p < 0.001$) (Table 4.5), confirming meaningful improvements across pain, stiffness, and physical function domains. Notably, the WOMAC pain subscale demonstrated a significant between-group

difference of 2.34 ± 0.21 ($p < 0.001$), exceeding established minimal clinically important difference (MCID) thresholds for knee osteoarthritis populations, thereby supporting both statistical and patient-centered clinical significance.

Pain reduction in knee osteoarthritis is mediated through both inflammatory and mechanical pathways. Adipose tissue functions as an endocrine organ, secreting pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and leptin, which contribute to cartilage degradation, synovial inflammation, and pain sensitization (Berenbaum, 2013). Visceral adiposity is particularly implicated in systemic inflammatory burden.

The substantial reductions in visceral fat observed in the experimental group likely attenuated adipokine-mediated inflammatory signaling, thereby reducing joint inflammation and pain perception. These combined anti-inflammatory and vascular benefits, together with biomechanical unloading resulting from weight loss, provide a plausible explanation for the progressive improvements observed in WOMAC pain and stiffness domains over the 12-week intervention period.

These findings are consistent with previous evidence demonstrating that plant-based dietary interventions can reduce chronic musculoskeletal pain and improve functional outcomes (Clinton et al., 2015). They also support the metabolic phenotype model of osteoarthritis, which proposes that metabolic dysfunction associated with obesity contributes to joint degeneration independently of mechanical loading alone (Hunter & Bierma-Zeinstra, 2019).

Although circulating inflammatory biomarkers such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF- α) were not directly measured in this study, the consistent and parallel improvements observed across body composition, pain, disability, and physical function outcomes (Tables 4.2–4.7) support a biologically plausible and integrated mechanistic framework. Visceral adipose tissue plays a central role in this model, functioning as an endocrine organ that promotes systemic inflammation through cytokine secretion. Therefore, the observed reductions in visceral adiposity provide a credible mechanistic link between dietary intervention and improvements in pain, disability, and physical capacity.

Collectively, these findings support an inflammation–adiposity–mechanical pathway, in which diet-induced reductions in visceral fat contribute to decreased

inflammatory burden, reduced joint stress, and improved clinical outcomes. This integrated mechanism strengthens the biological plausibility of the intervention. It underscores the potential of a Whole-Food Plant-Based dietary approach as an effective non-pharmacological strategy for reducing pain and disability in patients with knee osteoarthritis.

5.3 Effect on Physical Abilities

The reductions in pain and improvements in body composition translated into significant enhancements in physical capacity. The experimental group demonstrated significant improvements in the five-times sit-to-stand test (FTSST) performance at Weeks 4, 8, and 12 (Tables 4.6-4.7; $p < 0.001$), whereas the control group exhibited functional decline.

These functional improvements likely resulted from the integration of multiple physiological mechanisms. First, pain reduction enabled greater voluntary movement and improved neuromuscular activation. Second, biomechanical unloading resulting from weight loss reduced joint stress during weight-bearing activities. Third, preservation of skeletal muscle mass maintained muscular strength and joint stability. Finally, improved metabolic efficiency enhanced muscular endurance and overall functional performance.

These findings suggest the presence of a positive feedback cycle in which reduced pain facilitates increased mobility, which in turn improves muscle strength, joint stability, and metabolic health. This trajectory is consistent with international clinical guidelines recommending weight management and lifestyle modification as first-line interventions for knee osteoarthritis (Bannuru et al., 2019).

5.4 Clinical Significance Based on Minimal Clinically Important Difference (MCID)

In addition to reporting statistical significance, the interpretation of the findings in this study requires consideration of clinical significance. This can be achieved using

the concept of the Minimal Clinically Important Difference (MCID), defined as “the smallest change in an outcome that patients perceive as beneficial and that would warrant a change in clinical management” (Tubach et al., 2005). This concept is particularly important in osteoarthritis research, where statistically significant changes do not always translate into meaningful improvements in patients’ quality of life.

In terms of body composition, although MCID thresholds are not clearly established for all parameters (e.g., body fat percentage or visceral fat), clinical evidence generally supports that a weight reduction of at least 5–10% of baseline body weight is considered clinically meaningful, as it is associated with improvements in both metabolic status and osteoarthritis symptoms (Christensen et al., 2007; Messier et al., 2013). In this study, the experimental group achieved a mean weight loss of 6.87 kg from a baseline of 61.67 kg, corresponding to approximately 11.14% of initial body weight. This magnitude clearly exceeds the threshold for clinical relevance. Furthermore, the reduction in BMI (2.93 kg/m²) and visceral fat supports improvements in metabolic profile, which are closely linked to reductions in inflammation and joint loading.

Regarding pain, assessed using the Visual Analog Scale (VAS), previous studies have reported an MCID of approximately 1.5–2.0 points in patients with knee osteoarthritis (Angst et al., 2001; Tubach et al., 2005). In the present study, the between-group difference was 5.91 points, substantially exceeding the MCID threshold. This indicates that the reduction in pain is not merely a statistical change but represents a clinically meaningful improvement that patients are likely to perceive in their daily lives, such as reduced pain during walking, standing up, or performing routine activities.

For disability, assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), MCID values have been reported at approximately 9–12 points or 10–12% of the total score (Angst et al., 2001; Tubach et al., 2005). Although the between-group difference observed in this study was 7.46 points, which may fall slightly below the upper threshold of MCID, the consistent improvements observed across all WOMAC subdomains (pain, stiffness, and physical function), together with the strong statistical significance ($p < 0.001$), support the interpretation

that these changes are clinically meaningful. This is particularly relevant in the context of non-pharmacological interventions, which typically yield moderate effect sizes.

In terms of physical performance, assessed using the Five-Times Sit-to-Stand Test (FTSST), previous evidence suggests that a change of approximately 2 seconds represents the MCID in patients with knee osteoarthritis (Dobson et al., 2013). In this study, the experimental group demonstrated a reduction of 3.37 seconds, clearly exceeding the MCID threshold. This reflects meaningful improvements in functional mobility and lower limb strength, which are directly relevant to daily activities such as rising from a chair, climbing stairs, and performing routine physical tasks.

When considered collectively across all domains—body composition, pain, disability, and physical performance—the observed changes in the experimental group are largely consistent with established MCID thresholds. This supports the conclusion that the WFPB dietary intervention yields clinically meaningful benefits, rather than merely statistically significant outcomes.

Importantly, the application of the MCID framework in this study strengthens the interpretation of the findings by demonstrating that the WFPB intervention not only produces statistically significant improvements but also leads to tangible, patient-relevant benefits. These improvements span multiple domains, including symptom relief, functional capacity, and physical performance, highlighting the potential of WFPB as an effective non-pharmacological treatment strategy for individuals with knee osteoarthritis.

5.5 Behavioral and Contextual Determinants of Adherence to the Dietary Intervention

This study demonstrated a remarkably high level of adherence (achievement) in the experimental group ($96.24 \pm 1.46\%$), reflecting an exceptional degree of compliance compared with typical nutrition interventions. This phenomenon can be plausibly explained by the structured design of the intervention protocol, which functioned as a comprehensive behavioral support system tailored to the participants' real-life context.

First, the intervention included a well-developed dietary manual that comprehensively outlined principles, practical guidelines, and a wide variety of menu options. This approach likely reduced decision burden and enhanced practical feasibility, enabling participants to implement the dietary recommendations more effectively in daily life. Importantly, the menus were culturally adapted and aligned with participants' habitual dietary patterns, which likely increased acceptability and behavioral sustainability. This is consistent with the concept of *culturally tailored interventions*, which have been shown to significantly improve adherence in health behavior interventions (Kreuter et al., 2003).

Second, the intensive follow-up strategy—consisting of telephone monitoring every 2 days and formal assessments every 4 weeks—likely played a critical role in reinforcing accountability and motivation. Such continuous engagement aligns with principles of behavioral reinforcement and self-regulation, as described in Social Cognitive Theory (Bandura, 2004). Empirical evidence supports that frequent monitoring and feedback significantly enhance adherence to dietary and lifestyle interventions (Burke et al., 2011).

In addition, the establishment of a communication platform via a messaging application (e.g., LINE) provided substantial psychosocial support, fostering a sense of community and facilitating social reinforcement. Social support has been consistently identified as a key determinant of sustained behavior change, particularly in long-term lifestyle interventions (Wing & Jeffery, 1999). Peer interaction and the sharing of experiences may also enhance intrinsic motivation and reduce perceived barriers to adherence.

Another critical component was dietary self-monitoring, whereby participants were required to record their daily food intake. Qualitative feedback indicated that some participants developed increased mindfulness in eating behavior, suggesting enhanced awareness of their dietary patterns. This mechanism is strongly supported in the literature, where self-monitoring is consistently associated with improved weight management and behavioral outcomes (Burke et al., 2011), as it facilitates ongoing self-evaluation and behavioral adjustment.

Furthermore, the 4-week follow-up assessments, which highlighted positive changes such as weight reduction and pain improvement, may have functioned as a

positive feedback loop. This likely strengthened self-efficacy, or the belief in one's ability to successfully perform a behavior, a core construct in Social Cognitive Theory (Bandura, 2004). Increased self-efficacy has been shown to predict sustained adherence to health behavior interventions.

In summary, the high level of adherence observed in this study is likely attributable to the integration of multiple synergistic components, including culturally appropriate program design, clear instructional materials, intensive follow-up, social support mechanisms, and behavioral self-regulation strategies. This finding is consistent with the broader evidence base, which indicates that multi-component interventions are more effective in promoting adherence than single-component approaches (Greger, 2020).

5.6 Strengths of the Study

This study possesses several key strengths that enhance the credibility and robustness of its findings. First, the use of a randomized controlled trial (RCT) design represents a high level of evidence in clinical research. This methodological approach minimizes selection bias, reduces confounding, and enhances internal validity, thereby allowing for more reliable causal inferences regarding the effects of the intervention.

Second, the study employed a multi-dimensional outcome assessment, encompassing body composition, pain, disability, and physical performance. This comprehensive evaluation reflects the holistic impact of the intervention and enables a more nuanced interpretation of the underlying mechanisms, integrating both structural (e.g., body composition changes) and functional (e.g., mobility and pain reduction) domains.

Third, the study explicitly incorporated the concept of Minimal Clinically Important Difference (MCID) in interpreting the results. By evaluating outcomes not only in terms of statistical significance but also clinical relevance, the study enhances the translational value of its findings and aligns them more closely with real-world clinical decision-making (Tubach et al., 2005).

Furthermore, the intervention itself represents a pragmatic and scalable behavioral strategy, particularly the Whole-Food Plant-Based (WFPB) dietary approach. This dietary pattern emphasizes minimally processed plant foods, which are generally safe, accessible, and feasible for long-term implementation. Such characteristics increase the potential for integration into routine clinical practice and public health strategies aimed at managing osteoarthritis and related metabolic conditions.

5.7 Limitations and Future Directions

Despite its strengths, this study has several limitations that should be carefully considered when interpreting the findings.

First, the sample size was relatively small, which may limit the statistical power and the generalizability of the results to broader populations. Future studies should include larger and more diverse samples to enhance external validity and ensure broader applicability.

Second, the intervention duration of 12 weeks may not be sufficient to fully evaluate long-term outcomes, particularly regarding the sustainability of behavioral changes, body composition improvements, and clinical benefits. Long-term follow-up studies are warranted to assess the persistence of these effects over time.

Third, adherence to the dietary intervention was assessed in part of self-reported data, which may be subject to recall bias and social desirability bias. Future research should incorporate more objective measures, such as nutritional biomarkers (e.g., plasma carotenoids) or digital tracking systems, to improve the accuracy of adherence assessment (Burke et al., 2011).

Fourth, the study lacked detailed biochemical and clinical laboratory assessments, such as inflammatory markers (e.g., C-reactive protein, interleukin-6), glycemic indices, and lipid profiles. Including such measures in future studies would provide deeper insight into the biological mechanisms underlying the observed clinical improvements.

Fifth, the intervention was not fully supported by a multidisciplinary team, particularly with consistent involvement of nutrition professionals at all stages. Future interventions would benefit from a multidisciplinary approach involving dietitians, physicians, and exercise specialists to optimize intervention design and implementation.

Sixth, the study did not assess participant satisfaction, which is an important determinant of feasibility, acceptability, and long-term adherence. Future research should incorporate validated tools to evaluate patient-reported experience and satisfaction with the intervention.

Finally, other behavioral confounders, such as the consumption of beverages (e.g., tea, coffee, or sugar-sweetened drinks), were not strictly controlled. These factors may influence metabolic outcomes and should be more clearly defined and monitored in future studies.

Despite these limitations, the findings of this study remain consistent and demonstrate both statistical and clinical significance, providing a strong foundation for future research. The results support the potential of WFPB dietary interventions as an effective non-pharmacological strategy and highlight important directions for advancing research in this field.

5.8 Summary of the Discussion

This study demonstrates that a 12-week Whole-Food Plant-Based dietary intervention can produce significant improvements in both statistical and clinical outcomes among overweight patients with knee osteoarthritis. These improvements were observed across multiple domains, including body composition, pain, disability, and physical performance, when compared with a control group receiving standard Thai dietary recommendations.

In terms of body composition, the experimental group exhibited a significant reduction in body weight, accompanied by decreases in body mass index (BMI), percentage body fat, and visceral fat. Notably, there was no significant reduction in skeletal muscle mass ($p = 0.918$), indicating that the observed weight loss was primarily

attributable to fat loss rather than lean tissue depletion. The magnitude of weight reduction—exceeding 10% of initial body weight—is consistent with evidence suggesting that such a degree of weight loss can meaningfully reduce knee joint loading and improve metabolic status (Messier et al., 2013).

Regarding clinical outcomes, the experimental group showed a significant reduction in pain, with a between-group difference in Visual Analog Scale (VAS) scores of 5.91 points ($p < 0.001$), substantially exceeding the reported Minimal Clinically Important Difference (MCID) of approximately 1.5–2.0 points. Similarly, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) demonstrated a between-group difference of 7.46 points ($p < 0.001$), with consistent improvements observed across all subdomains. Although this value approaches the lower bound of the MCID threshold, the consistent directionality of improvement across multiple domains supports its clinical relevance.

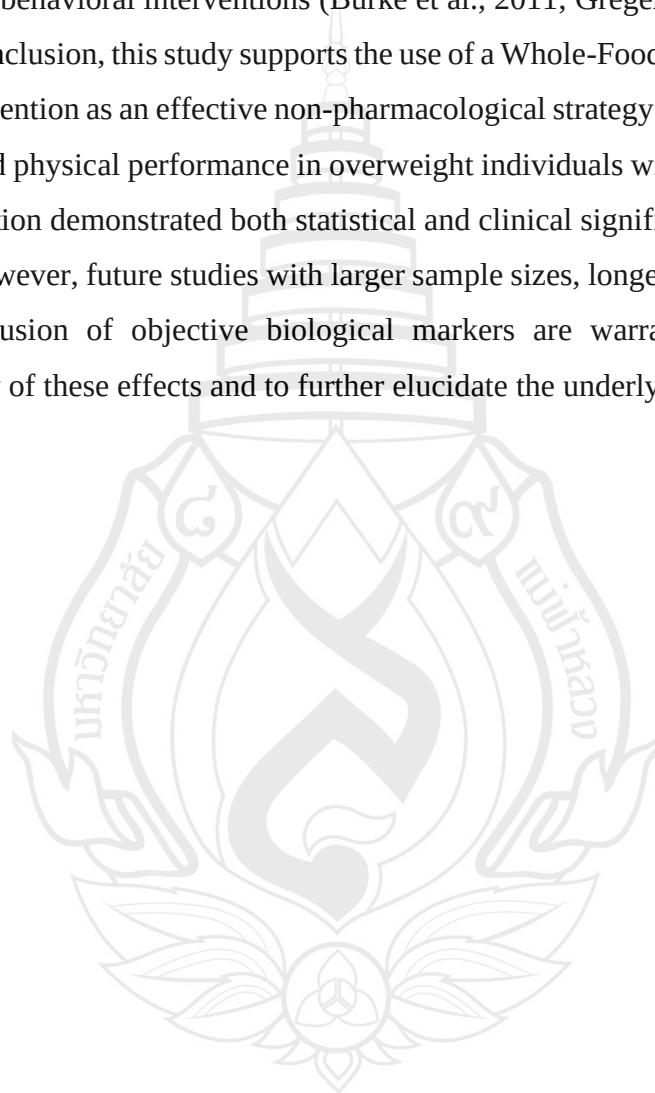
In terms of physical performance, the experimental group exhibited a significant improvement, as evidenced by a reduction in Five Times Sit-to-Stand Test (FTSST) duration from 15.65 ± 2.12 seconds to 12.28 ± 1.71 seconds (a reduction of approximately 3.37 seconds). This exceeds the established MCID (~2 seconds), indicating a meaningful enhancement in functional mobility and lower limb strength relevant to daily activities.

The observed effects are likely attributable to the interaction of both mechanical and biological mechanisms. Weight reduction decreases mechanical loading on the knee joint, thereby alleviating stress on articular structures. Concurrently, the reduction in adiposity—particularly visceral fat—may attenuate the secretion of pro-inflammatory mediators, including cytokines and adipokines, which are implicated in cartilage degradation and joint inflammation. In addition, the WFPB dietary pattern, characterized by low energy density and high intake of dietary fiber, antioxidants, and phytochemicals, may contribute to reductions in oxidative stress and chronic low-grade inflammation. These findings align with the conceptual framework of the metabolic osteoarthritis phenotype, which emphasizes the role of metabolic and inflammatory factors in disease progression.

Another key finding is the exceptionally high level of adherence (achievement $96.24 \pm 1.46\%$), which likely played a critical role in the success of the intervention.

This high adherence may be attributed to several factors, including culturally tailored program design, the provision of structured dietary guidance and diverse menu options, frequent follow-up (every 2 days), social support via group communication platforms, and the promotion of self-awareness through dietary self-monitoring. These components are well-supported in the literature as effective strategies for enhancing adherence to behavioral interventions (Burke et al., 2011; Greger, 2020).

In conclusion, this study supports the use of a Whole-Food Plant-Based (WFPB) dietary intervention as an effective non-pharmacological strategy for improving clinical outcomes and physical performance in overweight individuals with knee osteoarthritis. The intervention demonstrated both statistical and clinical significance across multiple domains. However, future studies with larger sample sizes, longer follow-up durations, and the inclusion of objective biological markers are warranted to confirm the sustainability of these effects and to further elucidate the underlying mechanisms.



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APPENDIX A

DOCUMENT CERTIFYING HUMAN ETHICS



บันทึกข้อความ

หน่วยงาน ส่วนบริหารงานวิจัย สถาบันวิจัยและนวัตกรรมการแพทย์ 7170 (ชาณุณรงค์)

ที่ อว 7742(1)/3735

วันที่ 2 ตุลาคม 2568

เรื่อง แจ้งผลการพิจารณาโครงการวิจัยและเอกสารที่เกี่ยวข้อง ครั้งที่ 3

เรียน นางสาวขวัญศิรินทร์ จันทน์ธวัช

ตามที่ ท่านได้ส่งโครงการวิจัย ฉบับแก้ไขครั้งที่ 3 เรื่อง ผลของของโปรแกรมการให้ความรู้ด้านอาหารจากพืชเป็นหลัก (Whole food plant based diet) ต่อองค์ประกอบทางร่างกาย ความเจ็บปวด ความพิการ และสมรรถภาพทางกายในผู้ป่วยโรคข้อเข่าเสื่อมที่มีภาวะน้ำหนักเกิน: การทดลองแบบสุ่มและมีกลุ่มควบคุม (Effects of whole food plant-based program on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis: A randomized controlled trial) ชื่อเรื่องเดิม ผลกระทบของโปรแกรมการให้ความรู้ด้านอาหารจากพืชเป็นหลัก (Whole food plant based diet) ต่อองค์ประกอบทางร่างกาย ความเจ็บปวด ความพิการ และสมรรถภาพทางกายในผู้ป่วยโรคข้อเข่าเสื่อมที่มีภาวะน้ำหนักเกิน: การทดลองแบบสุ่มและมีกลุ่มควบคุม (Effects of whole food plant-based program on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis: a randomized controlled trial) จากสำนักวิชาการแพทย์บูรณาการ รหัสโครงการวิจัย EC 25153-25 เพื่อขอรับการพิจารณาจริยธรรมการวิจัยในมนุษย์ นั้น

คณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง ได้รับเอกสารครบถ้วน เมื่อวันที่ 23 กันยายน 2568 และได้พิจารณาโครงการวิจัยดังกล่าวเห็นสมควรดังนี้

รับรอง (Approval)

ทั้งนี้ ท่านสามารถติดต่อสอบถามได้ที่ นายชาณุณรงค์ คำแสน เพื่อเข้ารับหนังสือรับรองจริยธรรมการวิจัย (Certificate of Approval) ได้ที่สำนักคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง อาคารบริการวิชาการ (AS) ชั้น 4 หมายเลขโทรศัพท์ (053) 917-170 ถึง 7171 และ (053) 916-551 โทรสาร (053) 917-170 อีเมล rec.human@mfu.ac.th

จึงเรียนมาเพื่อทราบ และดำเนินการต่อไป

(อาจารย์ นพ.จุฬาลักษณ์ อัจฉพงษ์)

ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์
มหาวิทยาลัยแม่ฟ้าหลวง



The Mae Fah Luang University Ethics Committee on Human Research
333 Moo 1, Thasud, Muang, Chiang Rai 57100
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หนังสือรับรองด้านจริยธรรมการวิจัย

COA: 189/2025

รหัสโครงการวิจัย: EC 25153-25

ชื่อโครงการวิจัย:

ผลของของโปรแกรมการให้ความรู้ด้านอาหารจากพืชเป็นหลัก (Whole food plant based diet) ต่อองค์ประกอบทางร่างกาย ความเจ็บปวด ความพิการ และสมรรถภาพทางกายในผู้ป่วยโรคข้อเข่าเสื่อมที่มีภาวะน้ำหนักเกิน: การทดลองแบบสุ่มและมีกลุ่มควบคุม

ชื่อผู้วิจัยหลัก:

นางสาวขวัญศิรินทร์ จันทน์ธวัช

สำนักวิชา:

การแพทย์บูรณาการ

ผู้สนับสนุนการวิจัย:

มหาวิทยาลัยแม่ฟ้าหลวง

การรับรอง :

- | | |
|---|----------------------------------|
| (1) โครงการวิจัย | ฉบับที่ 3 วันที่ 18 กันยายน 2568 |
| (2) เอกสารข้อมูลและขอความยินยอมเข้าร่วมการวิจัย | ฉบับที่ 2 วันที่ 1 กันยายน 2568 |
| (3) แบบบันทึกข้อมูล แบบประชาสัมพันธ์ คำแนะนำอาสาสมัคร | ฉบับที่ 2 วันที่ 1 กันยายน 2568 |
| (4) สมุดบันทึก | ฉบับที่ 1 วันที่ 3 กรกฎาคม 2568 |
| (5) ผู้วิจัย และผู้วิจัยร่วม | |

- นางสาวขวัญศิรินทร์ จันทน์ธวัช

- อาจารย์ ดร.ดลยา พรหมแก้ว

ขอรับรองว่าโครงการดังกล่าวข้างต้นได้ผ่านการพิจารณารับรองจากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง ว่าสอดคล้องกับแนวทางจริยธรรมสากล ได้แก่ ปฏิญญาเฮลซิงกิ (Declaration of Helsinki) รายงานเบลมอนต์ (Belmont Report) แนวทางจริยธรรมสากลสำหรับการวิจัยในมนุษย์ของสภาองค์การสากลด้านวิทยาศาสตร์การแพทย์ (CIOMS) และแนวทางการปฏิบัติกรวิจัยที่ดี (ICH-GCP)

วันที่รับรองด้านจริยธรรมของโครงการวิจัย:

29 กันยายน 2568

วันสิ้นสุดการรับรอง:

28 กันยายน 2569

ความถี่ของการส่งรายงานความก้าวหน้าของการวิจัย:

1 ปี

ลงนาม

(อาจารย์ นพ.จุลพงศ์ อจลพงศ์)

ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง



The Mae Fah Luang University Ethics Committee on Human Research
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ผู้วิจัยที่โครงการวิจัยผ่านการรับรองจากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง
ต้องปฏิบัติตามต่อไปนี้

- (1) ดำเนินการวิจัยตามที่ระบุในโครงการวิจัยอย่างเคร่งครัด
- (2) ใช้เอกสารข้อมูลและขอความยินยอมเข้าร่วมการวิจัย / แบบสอบถาม / แบบบันทึกข้อมูล / เอกสาร
ประชาสัมพันธ์ ที่มีตราประทับของคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยแม่ฟ้าหลวง เท่านั้น
- (3) ผู้วิจัยต้องส่งรายงานความก้าวหน้าของการวิจัย (AP 05/2024) ตามระยะเวลาที่คณะกรรมการฯ กำหนด และ
ภายใน 30 วัน ก่อนหมดอายุการรับรอง ในกรณีที่การวิจัยยังไม่เสร็จสิ้น ผู้วิจัยต้องส่งจดหมายขอต่ออายุ
การรับรอง
- (4) เมื่อมีการแก้ไขเพิ่มเติมโครงการวิจัย ผู้วิจัยต้องส่งรายงานส่วนแก้ไขเพิ่มเติมโครงการวิจัย (AP 06/2024) และ
โครงการวิจัยที่มีการแก้ไขเพิ่มเติม เพื่อแจ้งให้คณะกรรมการฯ พิจารณารับรองก่อนดำเนินการตามที่ได้แก้ไข
เพิ่มเติม (ยกเว้นในกรณีที่การแก้ไขเพิ่มเติมนั้นกระทำเพื่อความปลอดภัยของอาสาสมัคร)
- (5) เมื่อมีเหตุการณ์ไม่พึงประสงค์ร้ายแรง “ในสถาบัน” ผู้วิจัยต้องส่งรายงานเหตุการณ์ไม่พึงประสงค์ชนิด
ร้ายแรง (AP 07/2024) ตามข้อกำหนดของ ICH-GCP
- (6) เมื่อมีการเบี่ยงเบนหรือไม่ปฏิบัติตามโครงการวิจัยที่ได้รับการรับรอง ผู้วิจัยต้องส่งรายงานการการเบี่ยงเบน
หรือไม่ปฏิบัติตามข้อกำหนด (AP 08/2024)
- (7) เมื่อการวิจัยเสร็จสิ้น หรือ มีการยุติโครงการวิจัยก่อนกำหนดเวลาที่กำหนด ผู้วิจัยต้องส่งรายงาน
ปิดโครงการวิจัย (AP 09/2024)

หมายเหตุ สามารถ Download แบบรายงานต่าง ๆ ได้ที่ <https://ethic.mfu.ac.th>

ข้าพเจ้าในฐานะ ผู้วิจัย ยินยอมที่จะปฏิบัติตามข้อกำหนดดังกล่าว

(นางสาวขวัญศิรินทร์ จันทน์ธวัช)

วันที่ ๗/๑๐/๖๕



The Mae Fah Luang University Ethics Committee on Human Research
 333 Moo 1, Thasud, Muang, Chiang Rai 57100
 Tel: (053) 917-170 to 71 Fax: (053) 917-170 E-mail: rec.human@mfu.ac.th

CERTIFICATE OF APPROVAL

COA: 189/2025

Protocol No: EC 25153-25

Title: Effects of whole food plant-based program on body composition, pain, disability, and physical capacity in overweight patients with knee osteoarthritis: A randomized controlled trial

Principal investigator: Miss. Khwansirin Chantawat

School: Integrative Medicine

Funding support: Mae Fah Luang University

Approval:

- | | |
|--|-----------------------------------|
| 1) Research protocol | Version 3 Date September 18, 2025 |
| 2) Information sheet and informed consent documents | Version 2 Date September 1, 2025 |
| 3) Record form, Advertising information sheet and Handbook | Version 2 Date September 1, 2025 |
| 4) Diary | Version 1 Date July 3, 2025 |
| 5) Principal investigator and Co-investigators | |
| - Miss. Khwansirin Chantawat | - Donlaya Promkaew, RPh, Ph.D. |

The aforementioned documents have been reviewed and approved by the Mae Fah Luang University Ethics Committee on Human Research in compliance with international guidelines such as Declaration of Helsinki, the Belmont Report, CIOMS Guidelines and the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use - Good Clinical Practice (ICH - GCP)

Date of Approval: September 29, 2025

Date of Expiration: September 28, 2026

Frequency of Continuing Review: 1 year

(Jullapong Achalapong, M.D.)

Chairperson of the Mae Fah Luang Ethics Committee on Human Research

APPENDIX B

DATA RECORDING FORM (IN THAI)

Version 2 Date 1 กันยายน 2568

AP 02/2024

1

ภาคผนวก ค

2

3

แบบบันทึกข้อมูลการวิจัย

4

ส่วนที่ 1 แบบสัมภาษณ์และบันทึกข้อมูลพื้นฐานส่วนบุคคล และค่าองค์ประกอบของร่างกาย

5

คำชี้แจงการบันทึกข้อมูล ผู้วิจัยเป็นผู้สัมภาษณ์/สังเกตโดยใช้คำถามที่เป็นตัวเลือก และจดบันทึกข้อมูลที่ได้จาก

6

การสัมภาษณ์/สังเกตอาสาสมัครโดยให้กาเครื่องหมายถูก (/) ในช่อง () หน้าตัวเลือกที่ตรงกับข้อมูล มาก

7

ที่สุดเพียงข้อเดียว ส่วนคำถามที่ให้เขียนตอบ กรุณาเขียนตอบด้วยตัวบรรจง

8

9

1. เพศ () 1. ชาย () 2. หญิง อายุ.....ปี

10

2. ระดับการศึกษา

11

() 1. ประถมศึกษา () 2. มัธยมศึกษา

12

() 3. ปริญญาตรีหรือเทียบเท่า () 4. สูงกว่าปริญญาตรี

13

3. ท่านมีอาการปวดรยางค์ส่วนล่าง

14

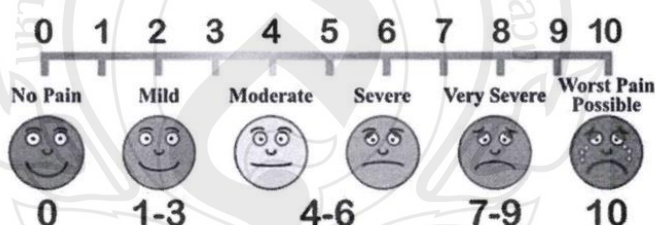
() 1. ไม่ใช่ () 2. ใช่ ระดับความเจ็บปวด.....

15

4. ท่านมีอาการปวดบริเวณเข้าหรือไม่

16

() 1. ไม่ใช่ () 2. ใช่ ระดับความเจ็บปวด.....



17

5. แบบประเมิน Numeric Rating Scale (NRS) อาการปวดข้อเข้า

18

คำชี้แจงสำหรับผู้ป่วย

19

กรุณาประเมินระดับความปวดข้อเข้าของท่าน “ขณะทำกิจกรรม” (เช่น การเดิน การลุกจากเก้าอี้ การขึ้น-ลง

20

บันได หรือกิจกรรมที่ท่านทำในชีวิตประจำวัน) โดยอิงจากอาการในช่วง 48 ชั่วโมงที่ผ่านมา

21

โปรดให้คะแนนความปวดโดยใช้ตัวเลข 0-10:

22

() 0 = ไม่มีอาการปวดเลย

23

() 1-3 = ปวดเล็กน้อย (mild pain)

24

() 4-6 = ปวดปานกลาง (moderate pain; มักเริ่มรบกวนการทำกิจกรรม)

25

() 7-10 = ปวดรุนแรงมาก (severe pain; รบกวนกิจกรรมอย่างชัดเจนหรือทำไม่ได้)



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- 1 6. ท่านมีโรคประจำตัว
 2 () 1. ไม่มี () 2. มี ระบุ.....
 3 7. ท่านรับประทานยาหรือไม่
 4 () 1. ไม่มี () 2. มี ระบุ.....
 5 8. ท่านรับประทานอาหารเสริมหรือไม่
 6 () 1. ไม่มี () 2. มี ระบุ.....
 7 9. ท่านออกกำลังกายหรือไม่ ก็ครั้งต่อสัปดาห์ กิจกรรมที่ทำ 9. ท่านเข้ารับโปรแกรมลดน้ำหนักอื่นๆ หรือไม่
 8 () 1. ไม่มี () 2. มี ระบุ.....
 9

10 ส่วนที่ 2 แบบบันทึกข้อมูลเกี่ยวกับระดับความเจ็บปวด และองค์ประกอบของร่างกาย

ตัวแปร	สัปดาห์ที่ 0	สัปดาห์ที่ 4	สัปดาห์ที่ 8	สัปดาห์ที่ 12
ระดับความเจ็บปวด				
น้ำหนัก (กิโลกรัม)				
ส่วนสูง (เซนติเมตร)				
BMI (กิโลกรัม/เมตร ²)				
สัดส่วนรอบเอว/สะโพก (WHR)				
Body Fat (%)				
Skeletal Muscle Mass (kg)				
Segmental lean analysis				
Visceral Fat Level				
BMR (kcal)				



1 ส่วนที่ 3 แบบบันทึกข้อมูลเกี่ยวกับการทดสอบสมรรถภาพทางกาย

Five times sit-to-stand test (FTSST)	Time 1	Time 2	Time 3	Average
สัปดาห์ที่ 0				
สัปดาห์ที่ 4				
สัปดาห์ที่ 8				
สัปดาห์ที่ 12				

2

3 ส่วนที่ 4 แบบประเมิน Western Ontario and McMaster University Osteoarthritis Index

ส่วนที่ 1: ความเจ็บปวด (Pain)

ข้อ	รายการ	ไม่มีเลย (0)	เล็กน้อย (1)	ปานกลาง (2)	รุนแรง (3)	รุนแรงมาก (4)
1	ขณะเดินบนพื้นเรียบ	☐	☐	☐	☐	☐
2	ขณะขึ้นหรือลงบันได	☐	☐	☐	☐	☐
3	ขณะนอน	☐	☐	☐	☐	☐
4	ขณะนั่งหรือนอนพัก	☐	☐	☐	☐	☐
5	ขณะยืน	☐	☐	☐	☐	☐

4

ส่วนที่ 2: ความฝืดของข้อ (Stiffness)

ข้อ	รายการ	ไม่มีเลย (0)	เล็กน้อย (1)	ปานกลาง (2)	รุนแรง (3)	รุนแรงมาก (4)
6	รู้สึกข้อฝืดในช่วงเช้า (หลังตื่นนอน)	☐	☐	☐	☐	☐
7	รู้สึกข้อฝืดหลังจากนั่ง หรือนอนเป็นเวลานาน	☐	☐	☐	☐	☐

5

ส่วนที่ 3: การทำงานทางกายภาพ (Physical Function)

ข้อ	รายการ	ไม่มีเลย (0)	เล็กน้อย (1)	ปานกลาง (2)	รุนแรง (3)	รุนแรงมาก (4)
8	ขึ้นบันได	☐	☐	☐	☐	☐
9	ลุกจากเก้าอี้	☐	☐	☐	☐	☐
10	ยืนขึ้นหลังจากนั่ง	☐	☐	☐	☐	☐



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ส่วนที่ 3: การทำงานทางกายภาพ (Physical Function)

ข้อ	รายการ	ไม่มีเลย (0)	เล็กน้อย (1)	ปานกลาง (2)	รุนแรง (3)	รุนแรงมาก (4)
11	งอเข้า	☐	☐	☐	☐	☐
12	เดินบนพื้นเรียบ	☐	☐	☐	☐	☐
13	เข้าออกจากรถยนต์หรือรถโดยสาร	☐	☐	☐	☐	☐
14	ทำงานบ้านเบาๆ (เช่น กวาดบ้าน ล้างจาน)	☐	☐	☐	☐	☐
15	ทำงานบ้านหนักๆ (เช่น ถูพื้น ยกของ)	☐	☐	☐	☐	☐
16	ลุกจากที่นอน	☐	☐	☐	☐	☐
17	เข้าออกจากห้องน้ำ	☐	☐	☐	☐	☐
18	ถอดหรือใส่ถุงเท้า	☐	☐	☐	☐	☐
19	ลุกยืนขณะนั่งอยู่บนพื้น	☐	☐	☐	☐	☐
20	รับของจากชั้นสูง	☐	☐	☐	☐	☐
21	นอนบนเตียง	☐	☐	☐	☐	☐
22	เข้าออกจากเตียง	☐	☐	☐	☐	☐
23	ออกไปข้างนอก (เดินทางระยะสั้น)	☐	☐	☐	☐	☐
24	ข้อปั้ง (เดินระยะยาว)	☐	☐	☐	☐	☐

1

สรุปผลการประเมิน WOMAC	สัปดาห์ที่ 0	สัปดาห์ที่ 4	สัปดาห์ที่ 8	สัปดาห์ที่ 12
WOMAC Score (รวม)				
Pain				
Stiffness				
Physical Function				

2

3 คำแนะนำการให้คะแนน

4 - หมวดความเจ็บปวด (Pain): 5 ข้อ (คะแนนรวมสูงสุด 20)

5 - หมวดความฝืดของข้อ (Stiffness): 2 ข้อ (คะแนนรวมสูงสุด 8)

6 - หมวดการทำงานทางกายภาพ (Function): 17 ข้อ (คะแนนรวมสูงสุด 68)

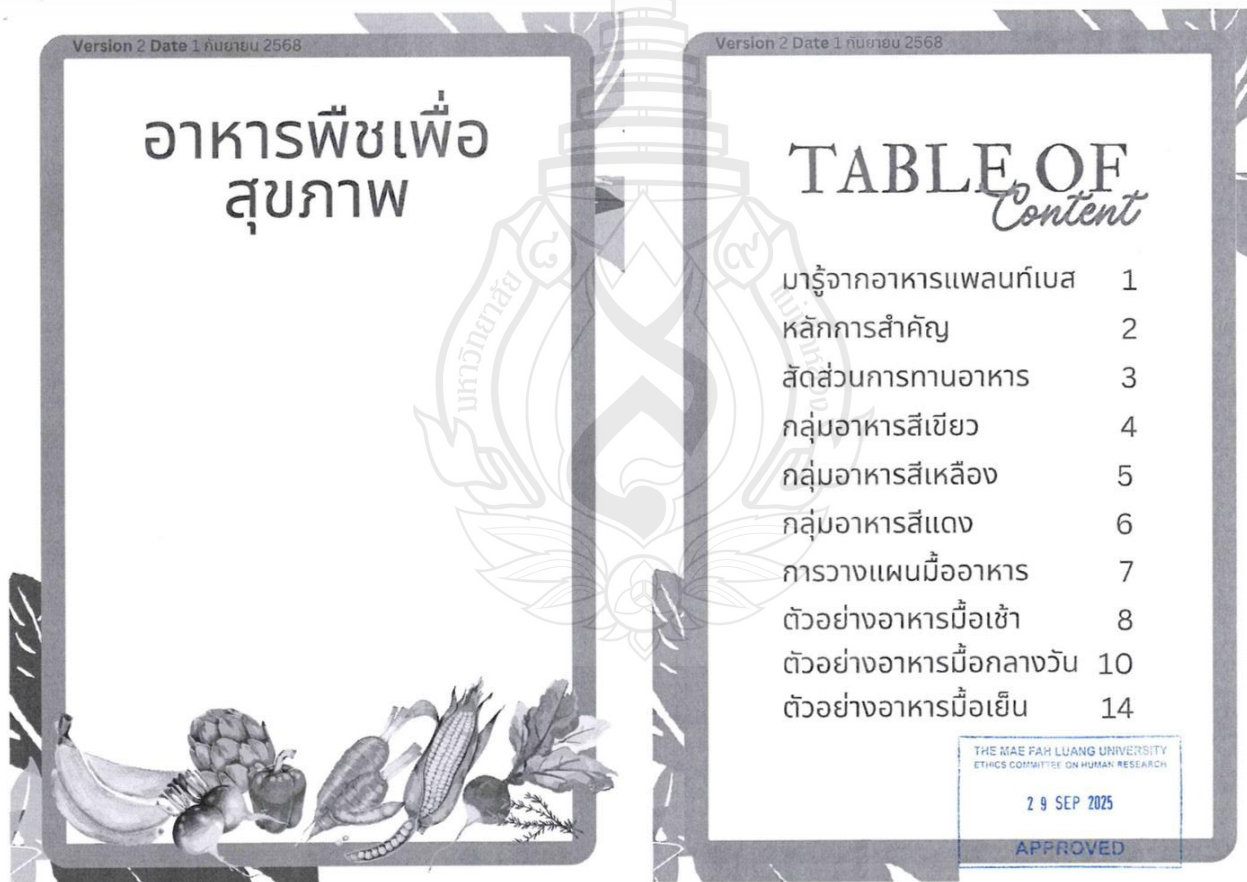
7 - รวมทั้งหมด: 24 ข้อ / คะแนนรวมสูงสุด 96

8



APPENDIX C

WHOLE FOOD PLANT-BASED DIETARY GUIDEBOOK



มารู้จักอาหาร แพลกันเบส

อาหารแพลกันเบส คือรูปแบบ
การทานอาหาร จากพืชเป็นแหล่ง
พลังงานหลัก และอยู่ในรูปแบบที่ ไม่
ผ่านการแปรรูปมาก และยังคงอยู่ใน
สภาพใกล้เคียงธรรมชาติมากที่สุด
เช่น ข้าวกล้อง ผักสด ผลไม้ ถั่ว
ต่างๆ โดยไม่มีการขัดสี เติมน้ำตาล
หรือสารปรุงแต่ง โดยลดหรืองด
อาหารที่มาจากสัตว์และอาหาร
แปรรูปทั้งหมด



หลักการสำคัญ

- ไม่แปรรูป : หลีกเลี่ยงอาหารที่ผ่านการขัดสีหรือแปรรูป เช่น ข้าวขาว น้ำตาลทราย แป้งขัดขาว อาหารมัจฉวีรติแปรรูป เช่น เนื้อเทียม อาหารทอด และขนมขบเคี้ยว
- งดผลิตภัณฑ์จากสัตว์ : งดเนื้อสัตว์ ผลิตภัณฑ์นม ไข่ และอาหารทะเล
- ใช้น้ำมันให้น้อยที่สุด: ลดการใช้น้ำมันในการปรุงอาหาร เลือกใช้น้ำมันดีต่อสุขภาพ (น้ำมันมะกอก น้ำมันมะพร้าว น้ำมันงา) ให้ใช้ในปริมาณน้อย
- เน้นความหลากหลาย: บริโภคผักหลากสี ผลไม้หลากชนิด พืชตระกูลถั่ว และธัญพืช เต็มเมล็ด เพื่อรับสารอาหารครบถ้วน



THE MAE FAH LUANG UNIVERSITY
ETHICS COMMITTEE ON HUMAN RESEARCH

29 SEP 2025

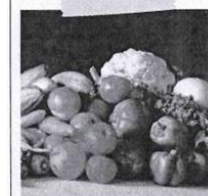
APPROVED

สัดส่วนการ ทานอาหาร



- ทานผักและผลไม้เป็นหลัก
- อาหารจากโปรตีนถั่ว และพืชไขมันสูง
ให้ทานเสริมในปริมาณที่พอเหมาะ
- น้ำมันพืช และเครื่องปรุงให้ทานใน
ปริมาณน้อยที่สุดเท่าที่จะทำได้

กลุ่มอาหาร สีเขียว 75%



อาหารธรรมชาติที่ไม่ผ่านการแปรรูป

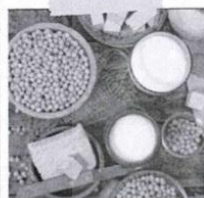
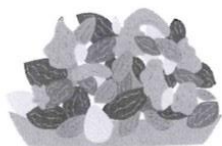
1. ผักใบเขียวชนิดแข็งดำ เช่น ผักคะน้า ผักกวางตุ้ง ผักกาดขาว ผักกาดฮ่องเต้ ผักบุ้ง ผักกูด ผักเชียงดา ผักตำลึง กะหล่ำปลี ดอกกะหล่ำ บล็อกโคลี่ มะเขือเทศ แตงกวา เป็นต้น
2. ผักหัว และผักมีแป้ง เช่น เผือก ฟักทอง มันไทย มันฝรั่ง ข้าวโพด แครอท หัวไชเท้า เป็นต้น
3. เห็ดทุกชนิด เช่น เห็ดนางฟ้า เห็ดโคน เห็ดฟาง เห็ดหูหนู เห็ดหอม เห็ดเข็มทอง และเห็ดอื่นๆ
4. ผลไม้ เช่น กล้วยน้ำว้า กล้วยหอม มะละกอ สับปะรด แตงโม สับปะรด มังคุด ทุเรียน มะม่วง ชมพู เงาะ ลำไย ลิ้นจี่ แก้วมังกร สาลี่ ฝรั่ง ลูกหม่อน เป็นต้น
5. ธัญพืชเต็มเมล็ด (ไม่ขัดสี) เช่น ข้าวกล้อง ข้าวไรซ์เบอร์รี่ ข้าวเหนียวดำ ข้าวบาร์เลย์ ลูกเดือย ข้าวโอ๊ต เป็นต้น
6. ถั่วเปลือกอ่อน เช่น ถั่วแดง ถั่วเขียว ถั่วดำ ถั่วลันเตา เป็นต้น
7. สมุนไพร เช่น พริก ขมิ้น ขิง ข่า ตะไคร้ ลูกมะกรูด ใบมะกรูด กระเพรา ยี่หระ สารแหน่ ใบเตย ใบชะพลู เป็นต้น

THE WU FAH LUANG UNIVERSITY
ETHICS COMMITTEE ON HUMAN RESEARCH

29 SEP 2025

APPROVED

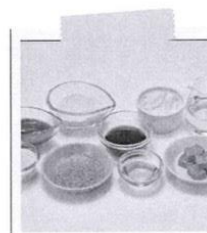
กลุ่มอาหาร สีเหลือง 15%



อาหารธรรมชาติที่แปรรูปเล็กน้อย
พืชไขมันสูง หรือผ่านการแปรรูปเล็กน้อย

1. ข้าวขาว- ข้าวเหนียว ลูกเดือยขาว
2. พืชที่มีไขมันสูง เช่น อะโวคาโด เนื้อมะพร้าว
3. ถั่วเปลือกแข็ง เช่น ถั่วลิสง เม็ดมะม่วงหิมพานต์ เมล็ดทานตะวัน เมล็ดฟักทอง เมล็ดแตงโม ถั่วอัลมอนต์ ถั่วพิสตาชิโอ ถั่วแระแคดเมย์ งา คุกกี้ เป็นต้น
4. เนยถั่ว และ ดาร์กช็อกโกแลต
5. ถั่วเหลือง และผลิตภัณฑ์ถั่วเหลือง เช่น ถั่วเหลือง ถั่วแระ เต้าหู้ ฟองเต้าหู้ โยเกิร์ตถั่วเหลือง
6. นมพืชทุกชนิด เช่น นมถั่วเหลือง (น้ำเต้าหู้) นมอัลมอนต์ นมพิสตาชิโอ นมโอ๊ต และนมพืชอื่นๆ
7. น้ำมันผลไม้พร้อมกากที่ไม่เติมน้ำตาล เช่น น้ำมันมะพร้าว น้ำมันปาล์ม
8. ผลไม้อบแห้งที่ไม่ใส่น้ำตาลเพิ่ม เช่น ลูกพรุน ลูกเกด มะเขือเทศอบแห้ง อีเกะฟาล์ม เป็นต้น
9. เส้นบางชนิด เช่น เส้นบุก เส้นแกว
10. ของหมักดอง (โพรไบโอติก) เช่น กิมจิ ข้าวหมาก ผักกาดดอง เป็นต้น

กลุ่มอาหาร สีแดง 10%



อาหารพืชที่ผ่านการแปรรูปมาก
และเครื่องปรุงต่างๆ

1. น้ำมันพืช เช่น น้ำมันรำข้าว น้ำมันมะพร้าว น้ำมันงา
2. เครื่องปรุงให้ความหวาน เช่น น้ำตาลทรายแดง น้ำตาลอ้อย น้ำตาลมะพร้าว น้ำตาลหญ้าหวาน น้ำตาลหล่อหึงก๊วย
3. เครื่องปรุงให้ความเค็ม เช่น เกลือทุกสี กะปิ ปลาร้า น้ำปลา (โซเดียมต่ำ) ซอสถั่วเหลือง ซีอิ๊วหวาน น้ำส้มสายชู เต้าเจี้ยวซอสเห็ดหอม ผงปรุงรสเห็ดหอม
4. ของแปรรูป เช่น ผงโกโก้ เนย เส้นบะหมี่ เส้นใหญ่ เส้นเล็ก รันเส้น ผักอบกรอบ กะทิ
5. เบเกอรี่ เช่น ขนมปังโฮลวีต



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การวางแผน มื้ออาหาร

7

- เตรียม ตารางเมนู 7 วัน ล่วงหน้า
- เตรียมอาหารไว้เป็นชุด เช่น หุงข้าวกล้อง ต้มถั่วชนิดต่างๆ และแช่แข็งไว้, เตรียม ซุปผักหรือซอสโฮมเมดในตู้เย็น เพื่อ สะดวกต่อการปรุงอาหาร
- เขียนรายการซื้ออาหาร แยกหมวดหมู่:
 - ผักสด ผลไม้ ธัญพืช ถั่ว
 - เลือกวัตถุดิบสดใหม่: เน้นผักผลไม้ ตามฤดูกาล
 - เลือกข้าวกล้องแกนข้าวขาว, ขนมนึ่ง โฮลวีตแทนขนมปังขาว



เคล็ดลับ และคำแนะนำ

- ปรีกษานักกำหนดอาหารสำหรับการปรับเมนู ตามภาวะสุขภาพเฉพาะบุคคล
- อ่านฉลากอาหารเสมอ หลีกเลี่ยงน้ำตาล/ไขมัน ช้อนเร้น
- แนะนำให้เสริม วิตามิน B12 และ วิตามิน D หากจำเป็น
- ดื่มน้ำสะอาดเพียงพอ

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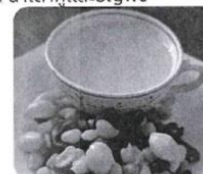
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ตัวอย่างเมนูอาหารเช้า

8

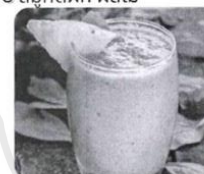
1 น้ำเต้าหู้และธัญพืช



2 โจ๊กเห็ดหอม¹



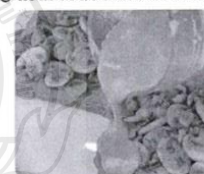
3 สมูทตี้ผัก ผลไม้³



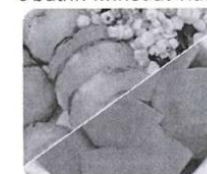
4 สมูทตี้ถั่วและธัญพืช⁴



5 แซนวิชขนมปังโฮลวีตใส่ผักและเห็ด¹



6 บันเทศ ฟักทองนึ่ง ผลไม้สด



7 พุดดิ้งเมล็ดเจีย ผลไม้²



8 ข้าวต้มเห็ด



ที่มา: 1. หนังสือจาก PHIT TO PLANT (ใช้ก่อนวันที่ 2 กรกฎาคม 2568)

2. YOUTUBE: ครัวบ้านเฮา (ใช้ก่อนวันที่ 2 กรกฎาคม 2568)

ที่มา: 1. หนังสือ KAPOOK COOKING (ใช้ก่อนวันที่ 2 กรกฎาคม 2568)

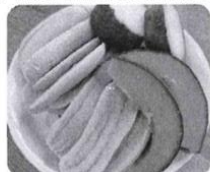
4. หนังสือจาก บ้านดีใจ (ใช้ก่อนวันที่ 2 กรกฎาคม 2568)

Version 2 Date 1 กันยายน 2568

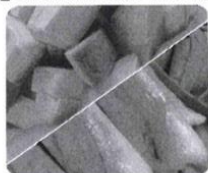
ตัวอย่างเมนูอาหารเช้า

9

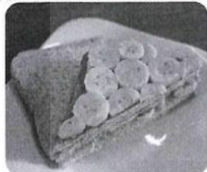
9 กล้วย ฟักทองและมันเทศนึ่ง



11 ข้าวต้มมัดใส่กล้วย และผลไม้



10 ขนมปังโฮลวีต แยมกล้วยหอม



12 ข้าวโอ๊ต น้ำเต้าหู้และผลไม้



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ตัวอย่างเมนูอาหารกลางวัน

10

1 ต้มจืดผักใส่เต้าหู้



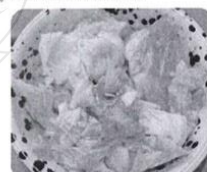
3 ผัดผักบุ้งกับข้าวกล้อง



5 เห็ดรวมผัดกระเพรา



7 กระหล่ำปีชีอิ้วขาว



2 สุกียากี้ใส่ผักและเห็ด



4 สมูทตี้กล้วยและธัญพืช



6 ผัดคะน้ากับเห็ดหอม⁵



8 เต้าหู้ผัดบิง



ที่มา: 5. 100 EASY COOKING MENU (ฉบับแก้ไข 2 กรกฎาคม 2568)

Version 2 Date 1 กันยายน 2568

ตัวอย่างเมนูอาหารกลางวัน 11

9 ถั่วงอกผัดเต้าหู้



10 ผัดผักรวมใส่เห็ดหอม



11 ผัดลืออกโคสสีซิวขาว



12 ผัดโก เต้าหู้



13 ราดหน้าฟองเต้าหู้ ผักรวม¹



14 ยำเห็ดรวม



15 ก๋วยเตี๋ยวหลอดเห็ดรวม¹



16 ส้มตำไทยไม่ใส่ปูและกุ้ง



ที่มา: 1. เพจเพจ PIN TO PLANT (ถ่ายเมื่อ 2 กรกฎาคม 2568)

Version 2 Date 1 กันยายน 2568

ตัวอย่างเมนูอาหารกลางวัน 12

17 ข้าวผัดเต้าหู้¹



18 ผัดซีอิ้วผักรวม³



19 ต้มจืดมะระ



20 ก๋วยเตี๋ยวลุยสวนเต้าหู้³



21 ข้าวผัดสันปะรด¹



22 ผัดพริกแกงหัวเต้าหู้



23 แกงเห็ดใบย่านาง¹



24 แกงโห้ผักรวม



ที่มา: 1. เพจเพจ PIN TO PLANT (ถ่ายเมื่อ 2 กรกฎาคม 2568)
6. YOUTUBE: ครัวแม่ BEE HAPPY KITCHEN (ถ่ายเมื่อ 2 กรกฎาคม 2568)

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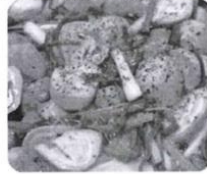
Version 2 Date 1 กันยายน 2568

ตัวอย่างเมนูอาหารกลางวัน 13

25 น้ำพริกอ่องเต้าหู้



26 ผัดเห็ดฟางใส่แครอท



27 ผัดกระเพราเต้าหู้



28 ผัดมะเขือยาว



29 สลัดไก่ทอดข้าวโพด



30 ถั่วแขกผัดพริกกระเทียม



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ตัวอย่างเมนูอาหารเย็น 14

1 ต้มยำเห็ดน้ำใส



2 ขนมนจีนน้ำยาเห็ด¹



3 ผักนึ่งกับน้ำพริกหน่อ



4 เห็ดย่างกับน้ำจิ้มซีฟู้ด¹



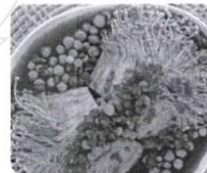
5 แกงส้มผักรวม



6 ผักกาดขาวพื้เห็ดเห็บทอง¹



7 เห็ดเห็บทองนึ่งซีอิ๊ว¹



8 ลาบเต้าหู้



รูป 1. ผักพอง P.N TO PLANT (ใช้ตั้งแต่ 2 กันยายน 2568)

Version 2 Date 1 กันยายน 2568

ตัวอย่างเมนูอาหารเย็น

15

9 เต้าหู้ราดซอสมะขาม¹



10 บั้วพริกมะเขือเทศกับบั้ง



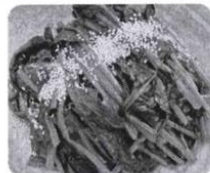
11 จอผักกาดใส่เห็ด¹



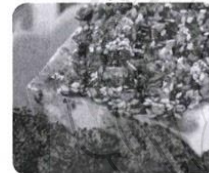
12 เต้าหู้ผัดเปรี้ยวหวาน³



13 ผัดผักปวยเล้งงาขาว



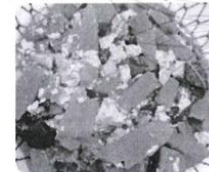
14 ผักกับเต้าหู้นึ่งซีอิ๊ว¹



15 เต้าหู้นึ่งเห็ดหอม⁷



16 ผัดผักกอกใส่เต้าหู้



ที่มา: 1. เพจเฟซบุ๊ก PIN TO PLANT (เข้าถึงเมื่อ 2 กรกฎาคม 2568)
2. YOUTUBE: ครัวแม่บ้าน BEE HAPPY KITCHEN (เข้าถึงเมื่อ 2 กรกฎาคม 2568)

ที่มา: 3. เว็บไซต์ KAPOOK COOKING (เข้าถึงเมื่อ 2 กรกฎาคม 2568)
4. เว็บไซต์ WON-ONAI RECIPES (เข้าถึงเมื่อ 8 กรกฎาคม 2568)

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16

17 แกงเลียงผักรวม



18 เต้าหู้พะโล้³



19 ตับจับฉ่ายใส่เต้าหู้⁸



20 เห็ดลูกเขย¹



21 แกงแค



22 กระเจี๊ยบเขียวซอสเห็ดหอม¹



23 ยำหับปัสใส่เต้าหู้¹



24 ลาบอีสานเห็ดรวม



ที่มา: 1. เพจเฟซบุ๊ก PIN TO PLANT (เข้าถึงเมื่อ 2 กรกฎาคม 2568)
2. เว็บไซต์ WON-ONAI RECIPES (เข้าถึงเมื่อ 8 กรกฎาคม 2568)

ที่มา: 3. เว็บไซต์ KAPOOK COOKING (เข้าถึงเมื่อ 2 กรกฎาคม 2568)
4. เว็บไซต์ WON-ONAI RECIPES (เข้าถึงเมื่อ 8 กรกฎาคม 2568)

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ตัวอย่างเมนูอาหารเย็น

17

25 ตับจืดสาหร่ายใส่เต้าหู้



26 แกงขนุนใส่เห็ด



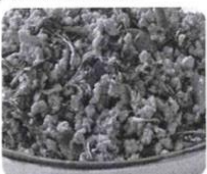
27 ตำขบถอ่อน



28 เห็ดหอมคั่วซีอิ๊ว¹



29 ผักกระเพราโปรตีน⁹



30 เห็ดหอมผัดพริกเกลือ⁹



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รูป: 1. เพาะเต้าหู้ PIN TO PLANT (ภาพถ่าย 2 กรกฎาคม 2568) รูป: 9. (รูปถ่าย NESTLEPROFESSIONAL ภาพถ่าย 2 กรกฎาคม 2568)

Version 2 Date 1 กันยายน 2568

เอกสารประกอบงานวิจัย

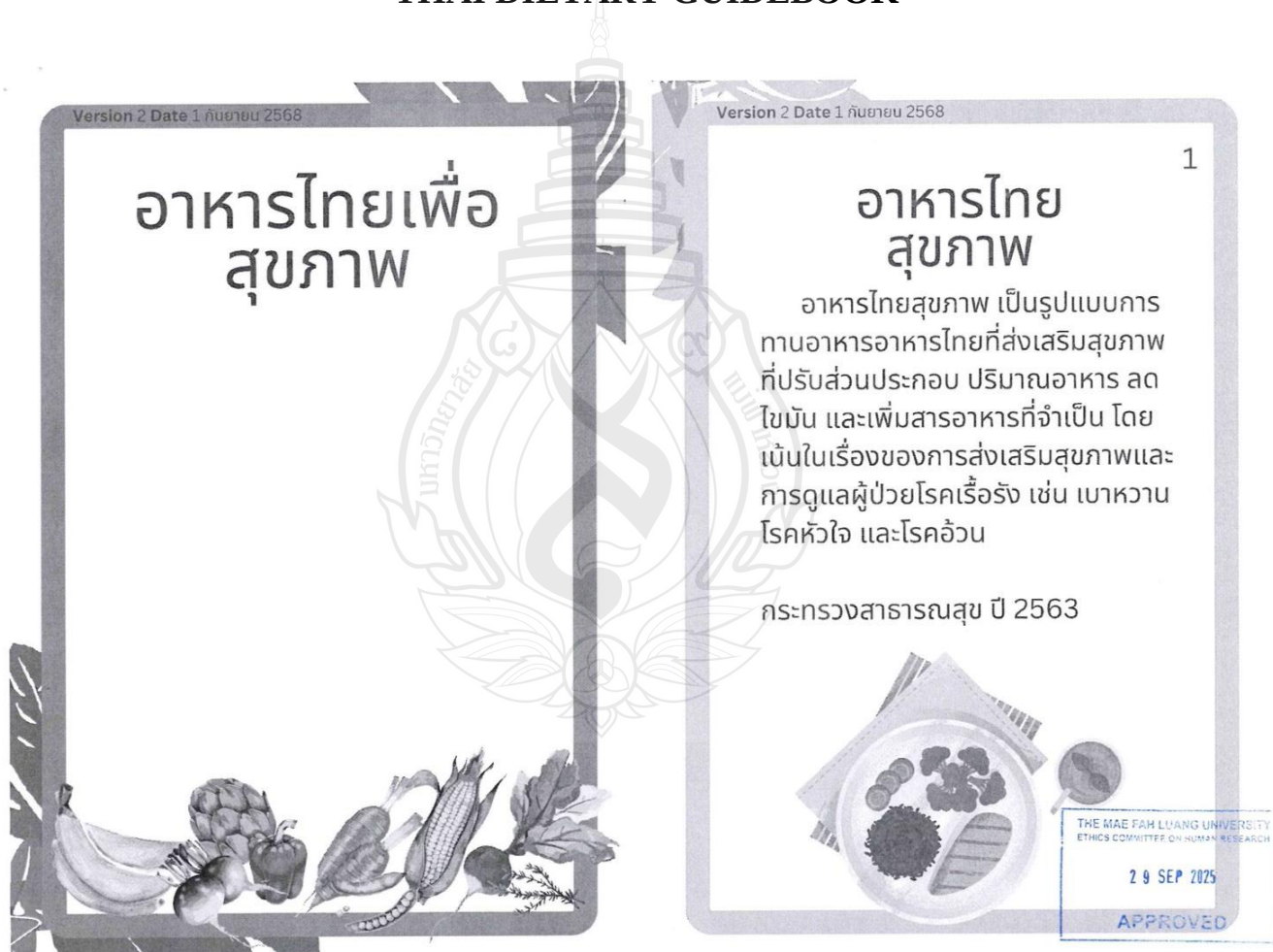
Reference

1. <https://www.facebook.com/Pintoplants/>
2. https://www.youtube.com/watch?v=jD5_vuDvLio
3. <https://cooking.kapook.com/view231890.html>
4. <https://www.facebook.com>
5. <https://www.facebook.com/easycokingmenu>
6. <https://www.youtube.com/watch?v=XcNjb4SfD90>
7. <https://www.youtube.com>
8. <https://www.wongnai.com/recipes/vegetarian-chinese-vegetable-stew>
9. <https://www.nestleprofessional.co.th/trends-insights/jae-menu>



APPENDIX D

THAI DIETARY GUIDEBOOK



หลักการสำคัญ

- กินอาหารให้หลากหลายครบ 5 หมู่ ในสัดส่วนที่เหมาะสม
- กินข้าวเป็นอาหารหลักสลับกับอาหารประเภทแป้งเป็นบางมื้อ
- กินผักให้มากและกินผลไม้เป็นประจำ
- กินปลา เนื้อสัตว์ไม่ติดมัน ไข่ และถั่วเมล็ดแห้งเป็นประจำ
- ดื่มนมให้เหมาะสมตามวัย
- กินอาหารที่มีไขมันแต่พอควร
- หลีกเลี่ยงการกินอาหารรสหวานจัด เค็มจัด และมันจัด
- กินอาหารที่ปรุงสุกใหม่ และสะอาด
- จดหรือลดเครื่องดื่มแอลกอฮอล์

สัดส่วนการทานอาหาร



- ทานอาหารให้ครบ 5 หมู่
- ½ ของจาน: ผักที่ไม่ให้แป้ง (ผักใบเขียว ผักไทยต่างๆ)
- ¼ ของจาน: ข้าวหรือแป้งที่ไม่ขัดสี (เช่น ข้าวกล้อง ข้าวไรซ์เบอร์รี่)
- ¼ ของจาน: โปรตีนไขมันต่ำ (เช่น เต้าหู้ ปลา ถั่ว)

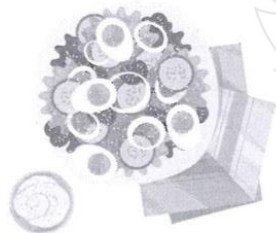
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เคล็ดลับ และคำแนะนำ

- เน้นวิธีทำแบบ ต้ม ลวก นึ่ง และหลีก
เลี่ยงผัดน้ำมันเยอะหรือน้ำแกงใส่กะทิ
- เลือกเมนูที่ไม่ใส่น้ำตาลเพิ่ม เช่น น้ำ
พริกตาแดงไม่ใส่น้ำตาล ส้มตำไม่ใส่น้ำตาล
- ลดหวาน มัน เค็ม
- ดื่มน้ำสะอาดเพียงพอ



เอกสารประกอบงานวิจัย

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APPENDIX F

FORM DIARY

Version 1 Date 3 กรกฎาคม 2568

แบบบันทึก
การรับประทานอาหาร
รายสัปดาห์

Version 1 Date 3 กรกฎาคม 2568

ข้อมูลการทานอาหารของ
อาสาสมัคร รหัส

ข้อมูลส่วนตัว

ประวัติการเจ็บป่วย

คำแนะนำอื่นๆ

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Version 1 Date 3 กรกฎาคม 2563

แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 1

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 2

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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ETHICS COMMITTEE OF HUMAN RESEARCH

29 SEP 2025

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 3

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 4

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 5

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 6

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 7

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 8

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 9

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 10

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 11

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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แบบบันทึกอาหาร ประจำสัปดาห์ ที่ 12

	มือเช้า	มือเที่ยง	มือเย็น	น้ำดื่ม
MON				
TUE				
WED				
THU				
FRI				
SAT				
SUN				

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