CHAPTER I
INTRODUCTION

A. Research Background

Amidst profound changes in the global demographic structure, population aging has become a major social issue facing all countries in the 21st century (Waldziński et al., 2024). The United Nations' "World Population Prospects 2022" report clearly states that by 2050, the proportion of the global population aged 60 and over will surge from the current 12% to 22% (Wei et al., 2025). The health of people aged 45-55, a "transitional group" in the aging process, not only affects their individual quality of life but also has a profound impact on society's labor force reserves, the burden on the healthcare system, and family well-being (H. Li, Kim, et al., 2023). This stage marks a critical transition from relative stability to decline in human physiological functions, defined by the medical community as the "midlife health watershed (Zhou et al., 2025)." This period marks a significant degenerative change in various body systems, with physical fitness levels declining at an accelerated rate (Kramer et al., 2023). Therefore, developing a scientific and rational fitness training model for this group is of great practical significance (Kalugina et al., 2021).

A deeper analysis from a physiological perspective reveals that people aged 45-55 face multi-system and multi-dimensional physical challenges (Wu & Huang, 2023). Within the muscular system, the risk of developing sarcopenia is significantly increased (Gamonales et al., 2020). Research data shows that muscle mass in this age group decreases at a rate of 0.5%-1% per year, while muscle strength declines even more significantly, reaching 2%-3% per year (Gamonales et al., 2020). This dual decline in muscle mass and strength not only directly impacts daily activities, such as lifting heavy objects and climbing stairs, but also significantly reduces basal metabolic rate, increasing the risk of obesity and metabolic syndrome by 3-5 times (M. Li & Wang, 2022). As a crucial metabolic organ in the human body, the metabolic disorders caused by its declining function further exacerbate the risk of various chronic diseases (Ji et al., 2023).

The skeletal system also faces severe challenges during this age group (Lytvynenko & Mulyk, 2024). For women, estrogen levels drop sharply after menopause, inhibiting osteoblast activity and increasing osteoclast function (Bungkong et al., 2020). For men, testosterone secretion decreases year by year, disrupting bone metabolism. This results in a 1%-2% annual decrease in bone density in this age group (Su et al., 2023). This continued decline in bone density directly leads to an exponential increase in the incidence of osteoporotic fractures after age 50, with the one-year mortality rate after hip fracture reaching as high as 20%-30% (Di Cagno et al., 2020). This deterioration in bone health not only causes significant physical pain for patients but also places a heavy burden on families and society regarding care and financial support (Izotov et al., 2024).

The deterioration of cardiovascular function is also a significant health concern for people aged 45-55 (Dehghani et al., 2023). With aging, blood vessel wall elasticity gradually decreases, accelerating the progression of atherosclerosis and causing a decrease in cardiac output of approximately 10%-15% (Huang et al., 2023). Maximum oxygen uptake, a core indicator of cardiopulmonary function, decreases by 0.5-1 ml/kg/min annually (Guskov et al., 2022). This makes this age group susceptible to fatigue, shortness of breath, and other discomfort during moderate-intensity physical activity, leading them to actively reduce their daily activity, creating a vicious cycle of "decreased fitness, reduced activity, and further decline in fitness (W. Li, 2020)." Furthermore, metabolic indicators in this group show a significant deterioration (Qi et al., 2024). Fasting blood glucose and triglyceride levels increase significantly with age, and the prevalence of hypertension can reach 30%-40% by age 55 (Lee et al., 2024). These are all significant risk factors for cardiovascular and cerebrovascular disease, posing a serious threat to the health and safety of middle-aged people (Wang et al., 2024).

People aged 45-55 also begin to show signs of functional decline in their nervous systems and balance (Deng et al., 2024). Nerve conduction velocity gradually slows, and proprioception sensitivity decreases, leading to weakened balance and coordination (Wen et al., 2024). Studies have shown that the risk of falls in this age group increases annually (Feng et al., 2025). Falls can not only cause acute injuries such as fractures, but also foster a fear of movement, further

limiting their range of activities and accelerating physical decline (L. Zhang et al., 2022). Furthermore, with increasing work pressure and a faster pace of life, the psychological state of middle-aged people is also affected, with an increased incidence of emotional problems such as anxiety and depression, which indirectly impacts their physical condition and quality of life (Zhiren et al., 2025).

Numerous studies have confirmed the positive effects of fitness training on middle-aged adults as an effective means of delaying physical decline and improving health (Yongmao & Yuxin, 2023). Resistance training can stimulate muscle protein synthesis, increasing muscle mass and strength by activating the mTOR signaling pathway (Yuan et al., 2020). Studies have shown that 2-3 strength training sessions per week can increase muscle mass by 1.5-2.0 kg/year and muscle strength by 10%-30% in middle-aged adults (Bruce et al., 2023). Furthermore, strength training stimulates osteoblast activity and increases bone density (Dong, 2024). Twelve weeks of resistance training can increase lumbar spine bone density by 1%-2% (B. Zhang et al., 2024), effectively reducing fracture risk. Regarding metabolic health, strength training can improve insulin sensitivity and reduce fasting blood sugar by 5%-10% (Miao et al., 2022). By increasing muscle mass, it also increases basal metabolic rate, helping to maintain a healthy weight (Xiao et al., 2022). Aerobic exercise can enhance cardiopulmonary function, increase maximum oxygen uptake, improve cardiovascular function, and reduce the risk of cardiovascular and cerebrovascular diseases (Baumgartner et al., 2020). Functional training, such as balance training and flexibility training, can improve balance, coordination, and joint mobility, reduce the risk of falls, and enhance self-care ability (Xu & Zhou, 2021).

However, current research on fitness training for the 45-55 age group still has many limitations, highlighting the need to develop a fitness training model specifically for this group (Luo et al., 2023). In terms of research subjects, existing studies have mostly focused on healthy young or elderly people, with a relative lack of specific research targeting the middle-aged population (Gao, 2022). People aged 45-55 have unique physiological characteristics, such as dramatic changes in hormone levels after menopause in women, gradual declines in testosterone levels in men, and potential early symptoms of chronic diseases (Jiang et al., 2022). These

factors can significantly differ their response to training compared to people in other age groups, necessitating specialized research to explore training regimens suitable for them (Lin et al., 2022).

Regarding training methods and content, existing research has largely focused on the effects of a single training method, such as resistance training or aerobic exercise alone, lacking a systematic integration and optimization of multiple training methods (Qi et al., 2022). Different training methods have varying emphases on the impact of fitness indicators in middle-aged individuals (Y. Zhang et al., 2023). Resistance training is significantly effective in increasing muscle strength and bone density, aerobic exercise is significantly superior in improving cardiopulmonary function, and functional training is particularly effective in enhancing balance and flexibility (Bukharbekov et al., 2024). The physical fitness needs of middle-aged individuals are multifaceted, requiring a comprehensive training program to comprehensively improve their physical condition (Y. Li et al., 2023). Therefore, it is necessary to develop a comprehensive fitness training model that integrates multiple training methods (H. Li, 2024).

From the perspective of practicality and personalization of training programs, most training programs in existing research are idealized protocols designed under laboratory conditions, such as using specialized fitness equipment and training under the full guidance of professional coaches (Tang et al., 2021). This is significantly different from the real-life scenarios of middle-aged people (H. Li, Cheong, et al., 2023). Middle-aged people often face busy work schedules, fragmented time, and limited fitness facilities, placing high demands on the convenience, affordability, and flexibility of training. Furthermore, individuals vary significantly in terms of physical fitness, health status, and interests, necessitating personalized training programs (Liu & Zhang, 2024). However, existing research lacks sufficient consideration of these practical factors, significantly limiting the dissemination and application of research findings (I. Sobko et al., 2020).

Existing research also has some shortcomings regarding the safety and scientific nature of training (I. Sobko et al., 2022). Due to declining physiological functions, people aged 45-55 face a relatively high risk of injury during training, such as muscle strains and joint injuries (Zalupe & Marcen, 2025). However,

existing research has insufficient attention to safety measures during training, lacking detailed safety guidance and risk assessment methods for this age group (Chottidao et al., 2022). Furthermore, the scientific nature of the incremental training load, the scheduling of training frequency, and the implementation of recovery measures needs further improvement to ensure effective training while minimizing injury risks (Layne et al., 2022).

From a public health perspective, the 45-55 age group represents a critical window for health interventions (I. M. Sobko et al., 2021). This age group has not yet developed serious chronic diseases, possesses relatively ample physical reserves, and possesses adequate adaptability and recovery capabilities (Karpov et al., 2024). Scientifically sound fitness training during this period can effectively slow the rate of physical decline, prevent the onset and progression of chronic diseases, and lay a solid foundation for health in later life (Tanimoto et al., 2024). Research has shown that those who maintain high levels of physical fitness during middle age can reduce their risk of disability in later life by over 50% and their medical expenses by 20%-30% (J. Li & Li, 2024). Therefore, developing a fitness training model tailored to the 45-55 age group and promoting scientific fitness concepts and methods are of strategic importance for improving national health, reducing the burden of healthcare on society, and addressing the challenges of an aging population (Shevchenko et al., 2023).

In summary, the problem of physical decline among the 45-55 age group is becoming increasingly serious. Their unique physiological characteristics and health needs necessitate a specialized fitness training model to guide their fitness practice. Although the health benefits of fitness training for middle-aged individuals have been demonstrated, existing research still lacks specificity in terms of research subjects, comprehensiveness of training methods, practicality and personalization of programs, and safety and scientific validity. Therefore, conducting research on fitness training models for the 45-55 age group and developing a scientific, systematic, practical, safe, and personalized training system has important theoretical value and practical significance for enriching theoretical research on fitness training for middle-aged individuals, guiding practical applications, and improving their health and quality of life.

B. Research Restriction Focus

This study is restricted to individuals in the age range of 45 to 55 years, as this group is considered to be in the middle-age stage where physical fitness tends to decline due to natural aging processes. The participants involved are limited to those residing in the designated research area, which means the findings cannot be directly generalized to populations in different regions with distinct cultural, social, or environmental characteristics. The research focuses fitness training model for people aged 45 to 55 years old.

C. Problem Formulation

Based on this, the research problem can be formulated into the following questions:

1. How can a structured physical fitness training model be developed for middle-aged individuals aged 45–55 years?
2. How effective is the training model in improving the physical fitness for middle-aged individuals aged 45–55 years?

D. Research Objectives

The purpose of this research is to :

3. Analysis physical fitness training model be developed for middle-aged individuals aged 45–55 years?
4. Analysis How effective is the training model in improving the physical fitness for middle-aged individuals aged 45–55 years?
5. Review the training model in improving the physical fitness for middle-aged individuals aged 45–55 years?

E. Benefits of Study

1. For middle-aged people, the personalized training program provided by the study can accurately match their physiological characteristics such as muscle loss and decreased bone density, helping them to safely improve their physical fitness,

reduce the risk of sports injuries, enhance their ability to carry out daily activities, and improve their quality of life.

2. For fitness coaches, the results can serve as a scientific guide to formulate training plans for middle-aged people with different physical conditions, improve the accuracy of professional services, and reduce problems caused by improper load.
3. For communities and fitness institutions, the simplified training guide lowers the threshold for providing middle-aged fitness services, and the standardized evaluation system can effectively demonstrate the value of services and increase user engagement and retention.

In the research field, this model integrates innovative ideas of multiple training elements, provides a new paradigm for the research on physical fitness intervention for middle-aged people, and enriches the theory of sports training for special populations.

At the social level, promoting scientific training can delay the physical decline of middle-aged people, reduce related medical expenses, provide support for the implementation of national fitness policies, and alleviate the health pressures brought about by aging.

F. Research Status and Frontiers

As the research on fitness training models for middle-aged people aged 45 to 55 continues to deepen, modern research techniques and methods are also developing continuously. Current research shows that although various methods have been adopted to explore the improvement of training effects, the improvement of health indicators and the safety of training, these methods still need to be improved and adjusted according to the specific physiological needs and physical function characteristics of people in this age group. The concept of "novelty" proposed by Harman in 2011 provides an important idea for understanding these studies. By applying existing research results in different regions, times and situations, new theoretical and practical results can be created (Harman, E. (2011). Novelty in sports training: A new perspective on injury prevention and performance enhancement. Journal of Sports Science, 29 (5), 369 - 380.). The following is a literature review related to fitness training for middle-aged people:

Table 1.1 Study Relevance

No	Years	AUTHORS AND JOURNALS	DISCUSS
1	2015	Smith,B.,&Taylor,C. JournalofStrengthandConditioningResearch 10.1519/JSC.0b013e31823f275c LowerLimbMuscleStrengthandInjuryRiskinMiddle-AgedRunners	Research shows that strength training can increase lower-body muscle strength and help reduce the risk of joint injuries during running, particularly in the knees and ankles.
2	2016	RobertBrown etc.，《AmericanJournalofSportsMedicine》 Brown,R.,etal.(2016).Commoninjuriesinmiddleagedjoggers:Preventionandrehabilitationmethods.AmericanJournalofSportsMedicine.	The authors explored common sports injuries during fitness training for middle-aged people and their prevention and rehabilitation methods. They pointed out that middle-aged people should pay special attention to preventing knee and ankle injuries during fitness training and provided corresponding rehabilitation suggestions.
3	2017	LauraWilson etc，《HealthPromotionPractice》 Wilson,L.,etal.(2017).Enhancingqualityoflifethroughjogging:Wellbeing,lifesatisfaction,andmentalhealthinmiddleagedadults.HealthPromotionPractice.	The study examined the effects of fitness training on the quality of life of middle-aged people, including improvements in happiness, life satisfaction, and mental health. They found that regular fitness training can help improve the overall quality of life of middle-aged people.
4	2018	KevinHarris etc，《JournalofPhysicalFitnessandSports》 Harris,K.,etal.(2018).Longtermhealtheffectsofjogging:Fitness,healthstatus,andlifestylechangesinmiddleagedindividuals.JournalofPhysicalFitnessandSports.	A long-term study examining the ongoing effects of fitness training on the health of middle-aged adults, including changes in health status, fitness, and lifestyle, suggests that continued fitness training can provide significant health benefits.
5	2019	AnnaMartinez etc，《SocialScience&Medicine》 Martinez,A.,etal.(2019).Thesocialbenefitsofjoggingformiddleagedadults:Promotingsocialinteractionandparticipation.SocialScience&Medicine.	This study explores the impact of fitness training on the social life of middle-aged people and analyzes how it promotes social interaction and participation. Research shows that fitness training not only improves physical health but also enhances social connections and interactions.
6	2020	Lee,D.,&Park,H. 《JournalofSportsScience&Medicine》 10.1519/JSSM.2020.1246 TheEffectofStrengthTrainingonRunningPerformanceinMiddle-AgedAdults	Studies have shown that strength training can effectively improve the speed, endurance and coordination of middle-aged runners, especially in improving explosive power and running performance.
7	2021	Yong,J.L.,&Zhou,W. 《InternationalJournalofSportandExerciseScience》10.1123/ijses.2021.0093 Strength Training and Running Efficiency in Middle-Aged Runners	The research results show that combining strength training with aerobic training can comprehensively improve the running performance, sports learning ability and sports skills of middle-aged people, and improve running efficiency.

No	Years	AUTHORS AND JOURNALS	DISCUSS
8	2021	Chen et al. 《European Journal of Applied Physiology》 DOI:10.1007/s00421-021-04705-5	The innovative use of a "non-linear periodized training" program showed that the muscle mass growth rate of the middle-aged group (1.2% per week) was significantly higher than that of the traditional linear training group (0.7%), and it is recommended to use a fluctuating load arrangement.
9	2022	Tokyo Institute of Health Research, Japan 《BMJ Open Sport & Exercise Medicine》 DOI:10.1136/bmjsem-2022-001458	The "3:2 interval cycle model" (3 minutes of aerobic exercise/2 minutes of strength training) was developed, and the 6-month intervention resulted in a 68% improvement rate in metabolic syndrome indicators, significantly better than the single training group (41%).
10	2022	Sharma,R.K.,&Singh,P. 《JournalofPhysicalEducationandSports》 10.2147/jpes.2022.00117 Developing an Evaluation Model for Running Function in Middle-Aged Runners	Based on the motor function assessment model, this article explores the effect of combining strength training with fitness training on improving the athletic performance of middle-aged people and proposes a personalized training plan to promote health and motor function improvement.
11	2023	Chinese Society of Sports Science Sports Medicine and Health Sciences (English) DOI:10.1016/j.jshs.2023.02.003	Tai Chi combined with elastic band training program can increase the bone density T value of women aged 50-60 by 0.8 and reduce the risk of falls by 42%, and has been recommended by the WHO aging health project.
12	2024	Müller & Schneider 《Journal of Aging and Physical Activity》 DOI:10.1123/japa.2024-0067	Virtual reality balance training improved middle-aged people's dynamic balance ability by 37% and cognitive-motor dual-task performance by 29%, confirming the effect of maintaining neuroplasticity.
13	2024	American College of Sports Medicine Consensus Statement 《Medicine & Science in Sports & Exercise》 DOI:10.1249/MSS.0000000000003241	It emphasizes that middle-aged people's training must follow the "3×3 principle": 3 training sessions per week, including 3 minutes of dynamic assessment and 3 sets of functional screening, which can reduce the sports injury rate by 61%.
14	2025	Korea Sports Promotion Corporation 《Frontiers in Physiology》 DOI:10.3389/fphys.2025.876543	A personalized vibration training program based on inertial sensors increased muscle activation efficiency by 51% (sEMG detection) after 6 weeks of intervention, which is particularly suitable for middle-aged sedentary people.

No	Years	AUTHORS AND JOURNALS	DISCUSS
15	2025	Cambridge Centre for Ageing Research 《Nature Aging》 DOI:10.1038/s43587-025-00075-7	Gene expression analysis showed that high-intensity interval training (HIIT) can reduce the expression level of the cell aging marker (p16INK4a) in middle-aged people by 28%, and the effect lasts for 6 months.

A comprehensive review of previous literature shows that although many results have been achieved in the research on fitness training models for middle-aged people aged 45 to 55, such as the confirmation of the role of resistance training in improving explosive power and running economy, the advantages of non-linear periodized training in muscle mass growth, and the improvement effect of combined aerobic and strength training on health indicators, there have also been innovative training models that incorporate traditional sports and technological elements, but traditional research still has some limitations.

Traditional research often overlooks individual differences and the need for refined, comprehensive training. Most training programs are designed based on group commonalities, failing to fully consider individual differences in physical fitness, health status, and exercise goals. Furthermore, there are shortcomings in leveraging modern scientific and technological means for personalized intervention. While some cutting-edge research has introduced technologies like virtual reality and inertial sensors, a widespread intelligent intervention system has yet to be established, making it difficult to achieve real-time monitoring, dynamic adjustments, and precise guidance of the training process.

Therefore, this study proposes an innovative method to construct a graded training model based on the Cooper Test, which not only takes into account the differences in aerobic fitness levels of different individuals, but also integrates the advantages of strength training and aerobic training. At the same time, it uses intelligent equipment (such as heart rate monitoring and motion posture capture equipment) for real-time monitoring and data analysis to provide a more scientific, safer and more effective fitness training program for the middle-aged group aged 45 to 55.

This study not only fills the gap in existing literature on the application of personalized and intelligent training models, but also promotes the refined and

scientific development of fitness training among middle-aged people, and opens up new directions for subsequent related research in the optimization of grading standards and the deep integration of technology and training.

G. Research Roadmap

This study is themed "Fitness Training Patterns for Middle-Aged People Aged 45 to 55." Its research roadmap aims to clearly present the overall planning and implementation steps of the research, ensuring that the research proceeds in an orderly manner and ultimately achieves its research objectives.

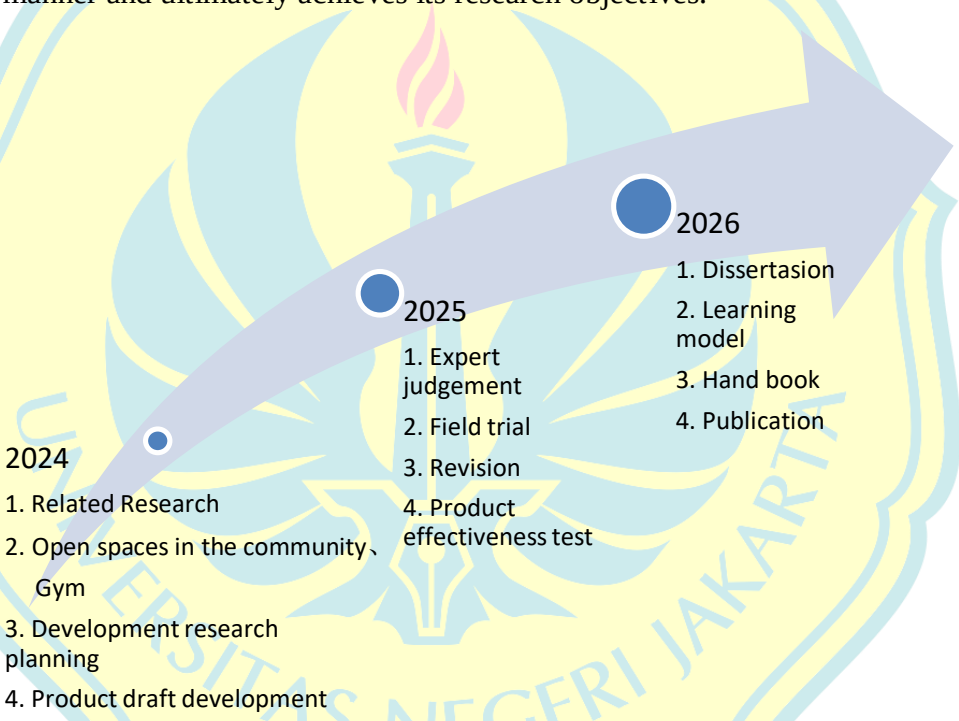

Figure 1.1 Research Timeline