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Intervention Effect of Combined Exercise in Individual with Type 2 Diabetes Mellitus

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Abstract. Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and relative insulin deficiency that severely affects an individual's health and quality of life. In this paper, we investigated the effectiveness of combined exercise as an intervention for patients with T2DM based on the World Health Organization's International Classification of Functioning, Disability and Health (ICF framework). The findings of this paper show that combined aerobic and resistance training combined exercise is considered a superior intervention strategy that is effective in improving insulin resistance by decreasing HbA1c levels and increasing insulin sensitivity. This article emphasizes how combined exercise can target physical functional and structural impairments, activity limitations, and participation restrictions, thereby reducing the severe disability and functional impact of type 2 diabetes. Combined exercise can improve mobility and balance, metabolic and endocrine processes, address comorbidities including obesity, and can also help address participation limitations (e.g., social isolation) and activity limitations (e.g., walk-ing limitations). In addition, this paper recommends multidisciplinary rehabilitation and emphasizes the importance of individualized intervention strategies, and combined exercise is considered a key strategy to reduce the complex impairment load of type 2 diabetes, promote functional independence, and mitigate the socioeconomic impact of the disease.

Keywords: T2DM, ICF Framework, Combined Exercise.

1. Introduction

In recent years, the prevalence of diabetes has risen dramatically worldwide, with 11.1% of adults (aged 20-79 years) having diabetes by 2025, and more than 40% being unaware of their condition, with type 2 diabetes accounting for 95% of all diabetes cases [1,2]. Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by high blood sugar caused by insulin resistance and relative insulin deficiency. It has a significant impact on individu-als' health and quality of life, as well as posing substantial challenges to healthcare systems [1]. Type 2 diabetes af-fects many major organs including the heart, blood vessels, nerves, eyes, and kidneys, and symptoms such as localized nerve twitching, nausea and vomiting, diarrhea and constipation, visual disturbances, obstructive sleep apnea, and memory loss are common in daily life [1]. In patients

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with type 2 diabetes, exercise is the primary intervention and combined exercise is superior to other types of exercise [2]. A combined exercise program that combines frequency, intensity, type, and duration (FITT) includes resistance training, which is a type of strength training that uses re-sistance or tension, and aerobic exercise, which is repetitive and continuous movement of large muscle groups when there is an adequate supply of oxygen [3]. In contrast to aerobic or resistance training alone, combined exercise that combines both types of exercise can be effective in improving insulin resistance status by simultaneously decreasing HbA1c levels and increasing insulin sensitivity. By activating several muscle fiber types and metabolic pathways at the same time, this mode of exercise more thoroughly supports glycemic management and metabolic activity [2].

In recent years, there has been a steady increase in domestic and international research on the use of combined exer-cise (combining weight training and aerobic exercise) in the treatment of type 2 diabetes mellitus (T2DM). Most of the research conducted abroad has been on how exercise habits enhance glucose regulation, insulin sensitivity, and problems. For example, the American Diabetes Association emphasized the benefits of varied exercise in reducing HbA1c levels and enhancing metabolic processes [4]. In addition, this study showed that mixed exercise significantly improved insulin sensitivity by enhancing mitochondrial function and GLUT4 transport [4]. On the other hand, do-mestic studies have focused more on a complete intervention model combining TCM theories with modern exercise therapy to investigate its potential to improve patients' physical function and quality of life [3]. However, most stud-ies have focused on short-term treatments, and customized strategies and long-term compliance need to be studied extensively, with only 35% of patients able to continue exercising for more than six months [5].

The ICF framework not only allows for a comprehensive assessment of the impact of type 2 diabetes on a patient's physical function, mobility skills, and social participation, but also emphasizes health and function, not just impair-ment. The use of the World Health Organization ICF framework in this paper provides a methodical approach to com-bined exercise interventions, making it easier to analyze how exercise enhances patients' physical function, activity levels, and participation. It also serves as a basis for developing customized intervention plans and interdisciplinary teamwork [6].

Based on the effectiveness of combined exercise (aerobic exercise plus resistance training) as the main intervention measures for type 2 diabetes, this paper conducted in-depth research on this discussion within the framework of com-prehensive rehabilitation [2, 3]. At the same time, through the use of the ICF framework, we will study how joint ex-ercise specifically targets the damage, activity restriction and participation restriction of body function and structure to reduce the serious disability and functional impact of type 2 diabetes on people [7].

2. The discussion of injury assessment and functional recovery based on the ICF framework

2.1. Incidence, prevalence and social burden

The fact that T2DM is classified as a chronic progressive metabolic disease emphasizes the fact that it systematically affects multiple ICF regions [1]. In 2021, diabetes affects 537 million people aged 20 to 79 years globally, and this number is projected to increase to 783 million by 2045 [8]. In the UK alone, 4.3 million people are diagnosed with T2DM, 90% of whom have T2DM [9]. The obesity epidemic, sedentary lifestyles and an ageing population are the main modifiable risk factors contributing to the rising prevalence [2]. Type 2 diabetes often manifests itself subtly, with symptoms such as fatigue, neuropathy and polyuria only becoming apparent after years of insulin resistance [1]. This condition can lead to severe disability and functional effects: mainly affecting

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sensory function, damaging the kidneys (nephropathy), nerves (peripheral neuropathy) and retinal vessels (retinopathy) [1]. Daily activities (e.g. walking and lifting) are limited by reduced mobility caused by joint stiffness and muscle weakness (hydatidiform fleas) (ICF), and co-morbidities and overexertion leading to hopelessness, social isolation, and absenteeism (ICF) also participate in the limitation [10, 11]. Type 2 diabetes costs the healthcare system an estimated 966 billion dollars globally, which underscores the urgent need for effective rehabilitative treatments [8]. However, by improving body structure and function in people with type 2 diabetes, combined exercise can reduce the risk of diabetic complications and improve blood glucose levels. At the same time, by improving body function, combined exercise can significantly alleviate activity and participation limitations in people with type 2 diabetes.

2.2. Impact of body function regulation on glycemic control and its potential mechanisms

Achieving and maintaining ideal blood glucose levels is the cornerstone of managing type 2 diabetes. The microvascular (retinopathy, nephropathy, neuropathy) and macrovascular (cardiovascular disease, stroke) consequences of damaging organ systems are caused by uncontrolled hyperglycemia [1]. Combined exercise clearly has a more effective synergistic effect on glycemic control than other modalities [3]. Aerobic exercise (e.g., brisk walking or cycling) primarily improves mitochondrial function and increases the transport of glucose transporter protein 4 (GLUT4) to the cell membrane, which improves skeletal muscle insulin sensitivity and facilitates glucose uptake, thereby lowering blood glucose levels [4]. Resistance training (e.g., weight lifting) increases lean body mass or muscle mass, which increases the amount of metabolic tissue available for glucose uptake, which effectively lowers fasting and postprandial blood glucose levels and decreases important indicators of long-term glucose regulation [4]. Patients with type 2 diabetes who participate in combined exercise have significantly greater reductions in HbA1c than (typically 0.5-1.0% or more) patients who engage in aerobic exercise only, resistance exercise only, or controls [3]. This is especially true for patients who are overweight or obese. Reduced impairment of body functions, especially metabolic and endocrine functions, by the structural domains of ICF is a direct result of this improvement. This evidence could greatly assist in research and the development of long-term, individualized glycemic improvement plans for patients with type 2 diabetes, suggesting that modulation of multiple body functions through combined exercise has a significant improvement in various glycemic indicators.

2.3. Reducing functional limitations and improving physical fit-ness

Because type 2 diabetes not only affects glycemic control but also has a severe impact on physical function, it has a significant impact on disability. Common disorders include cardiovascular disease, decreased muscle strength and mass, peripheral neuropathy, and stiff joint function. Difficulties in walking, climbing stairs, lifting objects, or doing household chores are examples of how these impairments manifest themselves in activities that ultimately limit participation, and these functional losses can be directly counteracted by joint practice [10,11]. Rehabilitation is essential to improve muscle strength and mass as well as to reverse sarcopenia and weakness prevalent in type 2 diabetes. The ability to perform routine tasks involving force generation can be immediately improved by increasing strength. Aerobic exercise makes it possible to be active for long periods of time without overexertion, increasing endurance and reducing fatigue by improving cardiorespiratory fitness (e.g. walking longer distances and doing chores more easily). In addition, both types of exercise contribute to better proprioception and balance. Resistance training strengthens muscles critical for

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postural control, while aerobic activities such as Tai Chi or controlled walking challenge and improve the balance system, directly addressing instability due to neuropathy and reducing the risk of falls - a major problem in the population [5,12]. Integration within the ICF framework is clear by targeting impairments in physical function (muscle strength, cardiac or respiratory health, balance), combined exercise directly improves mobility (mobility, carrying, walking) and promotes greater participation in life roles and social activities. For example, combining resistance and aerobic training in a combined exercise program can successfully increase lower extremity muscle strength, which is critical for weight maintenance and maintaining stability and balance while walking. Patients with type 2 diabetes who engage in mixed exercise have a significantly lower BMI, suggesting that mixed exercise helps to reduce body fat content, which in turn reduces joint tension during walking, improves walking efficiency, and reduces walking activity limitations[3]. Guidelines from the National Institute for Health and Care Excellence strongly support structured exercise programs (including co-training) as a core component of diabetes management to improve physical function and quality of life, suggesting that co-exercise has a significant positive impact on the way the body operates, including increased muscle strength and cardiovascular capacity [9]. It also has an important targeting and ameliorative effect on participation limitations (e.g. lack of social interaction) and functional limitations (e.g. walking limitations) caused by complications in people with type 2 diabetes.

2.4. Critical appraisal of joint training

Although joint exercises have demonstrated effectiveness, there are 3 key barriers to their implementation. First, only 35% of people with type 2 diabetes maintain exercise over time due to socioeconomic constraints, comorbidities, or motivational deficits [5]. Secondly, there are safety risks; cardiovascular autonomic neuropathy requires rigorous pre-exercise assessment, and neuropathy increases the risk of falls during resistance training and therefore may lead to worsening of the condition [4]. The third is dose-response uncertainty; individual differences require customized titration for optimal FITT parameters, such as 150 minutes of aerobic activity plus two days of weight training per week. However, without a differentiated formulation, it may even have negative consequences [3].

The term “multidisciplinary rehabilitation” describes rehabilitation services provided by a team of medical, nursing and therapeutic specialists. The team develops a customized rehabilitation plan and goals for each patient based on the results of a joint assessment. Through frequent coordination meetings, the team modifies intervention strategies, and multidisciplinary rehabilitation can bridge these gaps. Physical therapists customized activities (e.g. hydrotherapy and seated resistance bands) to reduce the risk of neuropathy, thereby reducing the need for assessments and safety risks [9]. Dietitians combine exercise and nutrition to improve blood glucose management.

Psychologists treating depression through cognitive behavioral techniques to improve exercise adherence, which would promote long-term adherence to a mix of exercises for people with type 2 diabetes. Equally important are the ways in which national plans are integrated with public health strategies, and these pillars are incorporated into national plans such as the NHS Diabetes Prevention Plan for England, which integrates individual rehabilitation into public health strategies. This demonstrates how multidisciplinary rehabilitation can bridge the challenges facing joint motion, taking full advantage of multidisciplinary collaboration to mitigate or address issues such as safety hazards, compliance issues and uncertainty in joint motion measurement responses [13].

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3. Conclusion

This study shows that the key strategy to reduce the complex injury load of type 2 diabetes is structured joint exercise, which combines resistance and aerobic training. When using the World Health Organization ICF framework for rigor-ous examination, this method simultaneously addresses physical functional/structural impairments, activity limita-tions, and participation limitations. In terms of physical function/structural impairment, it directly counteracts meta-bolic dysfunction by increasing insulin sensitivity (through GLUT4 translocation) and lean body weight, leading to clinically significant HbA1c reduction (0.5-1.0%). At the same time, it can enhance cardiovascular endurance, propri-oception, and balance, while reversing fatigue and sarcopenia. Regarding activity restrictions, improvements in cardi-ovascular health and muscle strength can lead to significant functional improvements, such as reduced risk of falls, safer mobility, and reduced fatigue in daily activities such as walking and carrying. The stability of blood sugar and the improvement of physical ability together promote more participation in social, entertainment and professional responsibilities, thus reducing depression and isolation related to diabetes. Despite strong evidence (according to the World Health Organization and NICE guidelines) that it is more desirable than single-mode exercise, there are still significant implementation barriers. Long term compliance is hindered by socio-economic constraints, comorbidities such as neuropathy, and motivational deficits, with only 35% of patients continuing their plans for more than six months. For safety reasons, especially cardiovascular stress and injury risk, personalized FITT prescriptions (such as 150 minutes of aerobic exercise+2 endurance training per week) and thorough pre assessments are needed, highlight-ing the importance of interdisciplinary integration. Nutritionists synchronize nutrition with activities, psychologists use cognitive techniques to overcome behavioral disorders, and physical therapists modify activities for neurological safety. This holistic approach is demonstrated by initiatives such as the NHS diabetes Prevention Program, which in-corporates rehabilitation into public health policies. Therefore, although joint movement is still undoubtedly essential to reduce the disability associated with type 2 diabetes, its effectiveness will be maximized when it is carried out in a customized and professional way, ultimately promoting long-term functional independence and reducing the expected global socio-economic impact of the disease. With the continuous progress of technology and the in-depth develop-ment of medical research, exercise is expected to have a broader expansion prospect in the field of type 2 diabetes intervention. On the one hand, patients can benefit from customized combination exercise plans implemented by cut-ting-edge digital technologies such as wearable technology, virtual reality, motion tracking applications, and metaverse, which will help patients better adhere to their training regimen, making exercise more enjoyable and com-pliant. However, in the future, additional long-term research on joint exercise is needed to clarify its significant im-pact on all aspects of type 2 diabetes and lay a solid foundation for formulating more specific exercise recommenda-tions. In addition, a key pathway for the future is the thorough integration of interdisciplinary research. By promoting the cooperation of endocrinology, exercise physiology, nutrition, psychology and other disciplines, we can further analyze the internal relationship between the pathogenesis of type 2 diabetes and exercise intervention. This will optimize the intervention mode combined with exercise, improve its application value in the comprehensive management of type 2 diabetes, and help patients to obtain better health results and improve their quality of life.

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