Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

EXPLORING THE IMPACT OF COMBINED THAI YOGA AND ELASTIC BAND EXERCISE ON PHYSICAL FITNESS AND EXERCISE CAPACITY IN OLDER PATIENTS WITH TYPE 2 DIABETES

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: December 12, 2023
Published: December 22, 2023

DOI: 10.17309/tmfv.2023.6.11

Abstract

Study purpose. Although it is acknowledged that exercise can positively affect both physical and biochemical markers in older individuals with type 2 diabetes (T2DM), there are still uncertainties about the specific impacts of combining Thai yoga with an elastic band exercise in this population. The objective of the study was to assess the impact of a 12-week program involving Thai yoga combined with an elastic band exercise on the physical fitness and functional exercise capacity among older individuals with T2DM.

Materials and methods. A total of 42 participants, consisting of 20 men and 22 women with T2DM and a mean age of 64.6±3.6 years, were randomly assigned to two groups: the control group and the exercise group. The exercise group engaged in a daily regimen of Thai yoga combined with an elastic band exercise for 40 minutes, 5 days a week, over a 12-week period. In contrast, the control group maintained their regular routines. Physical fitness and functional exercise capacity were assessed both before and after the 12-week intervention.

Results. The exercise group showed significant reductions in body weight (58.7±11.9 vs. 58.0±12.0 kg), body mass index (24.2±3.0 vs. 23.9±3.0 kg/m^2), waist circumference (33.6±3.6 vs. 33.1±3.6 in), and waist-hip ratio (0.90±0.06 vs. 0.89±0.06) ($p < 0.001$). Additionally, there were notable improvements in physical fitness parameters, including hand grips, back strength, leg strength ($p < 0.01$), and trunk flexibility ($p < 0.001$). Functional exercise capacity, indicated by the 6-minute walk test and estimated peak oxygen consumption ($p < 0.01$), also improved significantly.

Conclusions. Thai yoga combined with an elastic band exercise enhances physical fitness and functional exercise capacity in older individuals with T2DM. This improvement has the potential to enhance their cardiopulmonary performance. Consequently, this exercise regimen is considered a health alternative for older individuals with T2DM.

Keywords: exercise, yoga, resistance training, diabetes mellitus, exercise tolerance.

Introduction

Aging is a natural process that unfolds in living organisms over time. The musculoskeletal system undergoes physiological changes in aging, including a decline in muscular strength, muscle endurance, flexibility, and balance, along with functional alterations in cardiopulmonary endurance. These changes contribute to reduced adaptability and an increase in functional impairment (Howe et al., 2011). Various techniques are available to assess the physical fitness and exercise capacity of elderly individuals, encompassing muscle strength testing with dynamometry (Kim et al., 2022; Parraca et al., 2022), trunk flexibility assessment (Duray et al., 2020), the 6-minute walk test (6MWT) (American Thoracic Society, 2002), cardiopulmonary exercise testing (American Thoracic Society & American College of Chest Physicians, 2003), and the 2-minute step test (Poncumhak et al., 2023). Additionally, the elderly population may develop chronic diseases due to organ degeneration, particularly type 2 diabetes mellitus (T2DM). T2DM, a prevalent lifestyle disease driven by insulin resistance and insulin insufficiency, leads to persistent hyperglycemia and various cardiovascular consequences (Balaji et al., 2011).

Research indicates that exercise, coupled with a healthy diet, serves as a non-pharmacological treatment for older individuals with T2DM. Results show improvements in hemoglobin A1c (HbA1c), balance ability, body flexibility, and muscular strength (Xiao et al., 2017), suggesting that exercise can enhance the overall clinical characteristics and fitness levels of elderly T2DM patients. Lifestyle modification, particularly regular exercise, is recommended as a non-pharmacological therapeutic strategy for managing T2DM (Leite et al., 2020). The underlying principle is that working muscles enhance insulin sensitivity and promote glucose metabolism (Mogharnasi et al., 2019), positively affecting glycemic control, body composition, endothelial function, physical fitness, functional capacity, and self-reported well-being (Balaji et al., 2011; Barrows & Fleury, 2022; Fuentes-Lopez et al., 2021; Honda et al., 2021).

Yoga, a low-impact, weight-bearing exercise suitable for the elderly, has demonstrated benefits in enhancing muscle strength, body balance, flexibility, and cardiovascular endurance (American College of Sports Medicine, 2013; Phoosuwan et al., 2021). It also regulates hormone production, promoting movement (McCaffrey et al., 2014; Posadzki et al., 2009), increasing metabolism, and lowering blood pressure (Satyanarayana et al., 2013). Yoga has been reported to improve bone health, and reduce body mass index (BMI), body fat, and blood sugar (Balk & Bernardo, 2011; Chen et al., 2007; Hovsepian et al., 2013), enhance flexibility, muscle strength, blood circulation, and oxygen uptake, and reduce blood glucose levels, particularly in chronic diseases like T2DM (Angadi et al., 2017). Previous studies suggest that yoga is a non-pharmacological therapeutic option for improving the quality of life in older adults with T2DM (Balk & Bernardo, 2011; Phoosuwan et al., 2021).

Resistance training, utilizing muscular strength against resistance, is another form of exercise (Bauer et al., 2021). Elastic bands, cost-effective and space-efficient, are suitable for home or group use. Band characteristics, such as elongation and thickness, influence the force produced (Church et al., 2010). Research indicates that resistance exercise with elastic bands can lower HbA1c, enhance insulin sensitivity (Phillips & Winett, 2010), boost strength (Church et al., 2010; García et al., 2019), and improve the quality of life (Reid et al., 2010) in T2DM patients, making them a valuable alternative exercise for elderly individuals with T2DM.

While previous studies have separately explored the benefits of yoga or resistance training with an elastic band in T2DM patients and the elderly (Balaji et al., 2011; Leite et al., 2020; Pratiwi & Hasinuddin, 2018), the combination of these exercises on physical fitness and functional exercise capacity remains understudied. The present study aims to investigate the impact of a 12-week Thai yoga combined with an elastic band exercise on anthropometry, physical fitness, and functional exercise capacity in older individuals with T2DM.

Materials and methods

Study participants

Participants were recruited from diverse community areas in Phayao Province, Thailand. Approval for this experiment was obtained from the University of Phayao Human Ethics (the approval number is 2/153/62). Before participation, each individual provided written informed consent after being informed about the study protocols, risks, and benefits. The Declaration of Helsinki guided the conduct of this investigation.

A total of 42 T2DM patients (20 men and 22 women, age range: 60-72 years, mean age: 64.6±3.6 years) were recruited. Selection criteria included age between 60-80 years, either gender, a diagnosis of T2DM (fasting blood sugar levels ≥ 126 mg/dL), no previous experience with elastic band exercise or other exercise programs for at least 6 months before the study, no history of acute medical problems or emergency department visits, no hospitalizations resulting from T2DM complications in the past 3 months, and no surgery on the cardiovascular system or at least three falls in the 12 months before enrolling. Exclusion criteria were a history of cardiovascular or respiratory illness, neuromuscular or musculoskeletal diseases affecting postural control, pain of more than 3 degrees, or vision deficits influencing the study's outcome. The participant flow through the study is illustrated in Fig. 1.

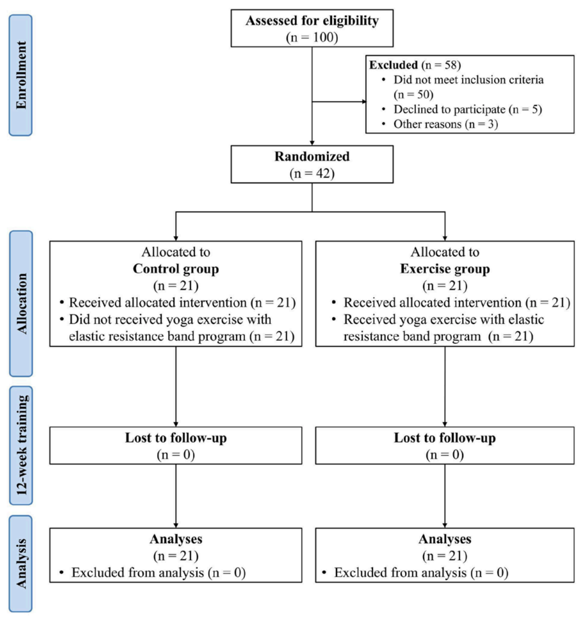

Fig. 1. CONSORT flow diagram of participants through the intervention

Study organization

Participants underwent a 2-week, 3-day familiarization program of Thai yoga combined with an elastic band exercise program conducted by the instructor before the testing session. The participants were randomly assigned to either the control group (n = 21) or the exercise group (n = 21). The exercise group engaged in a 40-minute Thai yoga combined with an elastic band exercise program following the procedure outlined in the previous study (Promsrisuk et al., 2023), divided into a 5-minute warm-up phase, a 30-minute exercise phase, and a 5-minute cool-down phase. The control group did not engage in any exercise activities. Throughout the 12-week study, all patients continued their diabetes medications regularly.

Outcome measurements

Anthropometric profiles

Anthropometric data, including height, weight, waist circumference (WC), hip circumference (HC), and waist-hip ratio (WHR), were directly gathered by the researcher. Body weight was assessed without shoes and in light clothing using Tanita electronic scales, and height was measured with a Stadiometer. BMI was calculated using the standard formula: weight (kilograms)/height (meters) squared.

Back and leg strength test

A strength dynamometer measured back and leg isometric strength according to a standard assessment protocol (Bandinelli et al., 1999). In brief, participants were instructed to stand on the dynamometer's base with feet shoulder-width apart and both hands on the mid-thigh handle (knee flexion angle of roughly 110 degrees) (Dawes et al., 2019). Then, the participants attempted to straighten the legs and keep the arms straight without bending the back, while pulling as hard as possible on the chain. The highest test score from two trials was recorded.

Trunk flexibility test

Trunk flexibility was measured by the sit and reach test (Clark, 1989). Participants sat on the floor with their feet against the testing box, reaching forward along the measuring board while holding their legs straight. The highest test score from two trials was recorded.

The 6-minute walk test

The 6MWT, recommended by the American Thoracic Society, evaluated functional exercise capacity (Carter et al., 2003; Enright et al., 2003; Rocha et al., 2022). Participants were instructed to sit for 10 minutes while vital signs were recorded. Leg fatigue and dyspnea scores were measured at the start and completion of the walk using the Borg rating of perceived exertion. Participants were instructed to walk as far as possible along a flat hallway designated with a 30-meter track pathway without running within the allocated 6 minutes (Whittaker et al., 2019). The total distance of the 6MWT (6MWD) was calculated and used for estimating peak oxygen uptake (VO_2peak). The estimated VO_2peak was determined using the formula: estimated $VO_2peak = 4.948 + (0.023 \times 6MWD)$ (Ross et al., 2010).

Statistical analysis

The statistical analysis was performed using STATA version 14.0. Data are presented as means ± standard deviation. Normality was assessed using the Shapiro–Wilk test. Paired t-tests compared data within control and exercise groups before and after 12 weeks, while unpaired t-tests compared control and exercise groups. Non-normally distributed data within groups were evaluated with the Wilcoxon signed-rank test and between groups with the Wilcoxon rank-sum test. The significance level was set at $p < 0.05$.

Results

The analysis covered the baseline characteristics and anthropometry of the 42 elderly patients with T2DM, as outlined in Table 1. Age, gender, body weight, height, BMI, WC, HC, WHR, and oxygen saturation (SpO_2) showed no significant differences between the two groups. After a 12-week training period, the exercise group exhibited a substantial reduction in body weight (58.7 ± 11.9 vs. 58.0 ± 12.0 kg, $p < 0.001$), BMI (24.2 ± 3.0 vs. 23.9 ± 3.0 kg/m^2, $p < 0.001$), WC (33.6 ± 3.6 vs. 33.1 ± 3.6 in, $p < 0.001$), and WHR (0.90 ± 0.06 vs. 0.89 ± 0.06, $p < 0.001$) (Table 1). Furthermore, neither the control nor the exercise group demonstrated any significant changes in HC compared to their baseline.

The physical fitness and functional exercise capacity in the control and exercise groups are presented in Table 2. Physical fitness (hand grips, back and leg strength, and trunk flexibility) and functional exercise capacity (6MWD and estimated VO_2peak) did not exhibit statistically significant differences between the control group and the exercise group at the baseline (Table 2). Following the 12-week training period, the exercise group exhibited a statistically significant improvement in physical fitness, as evidenced by their hand grips (21.9 ± 5.6 vs. 25.3 ± 5.7 kg, $p < 0.01$), back strength (52.0 ± 15.4 vs. 55.4 ± 15.5 kg, $p < 0.01$), leg strength (63.2 ± 19.6 vs. 66.2 ± 18.7 kg, $p < 0.01$), and trunk flexibility (17.2 ± 2.4 vs. 20.2 ± 2.2 cm, $p < 0.001$) (Table 2, Fig. 2). Similarly, the exercise group demonstrated a significant increase in functional exercise capacity, including 6MWD (344.3 ± 38.8 vs. 372.9 ± 60.0 m, $p < 0.01$) and estimated VO_2peak (28.7 ± 2.7 vs. 28.3 ± 2.8 ml/kg/min, $p < 0.01$) (Table 2, Fig. 3). However, there were no significant differences in any physical fitness or functional exercise capacity between the two groups after the 12-week duration. In the control group, there were also no significant differences between the baseline and after 12 weeks (Table 2).

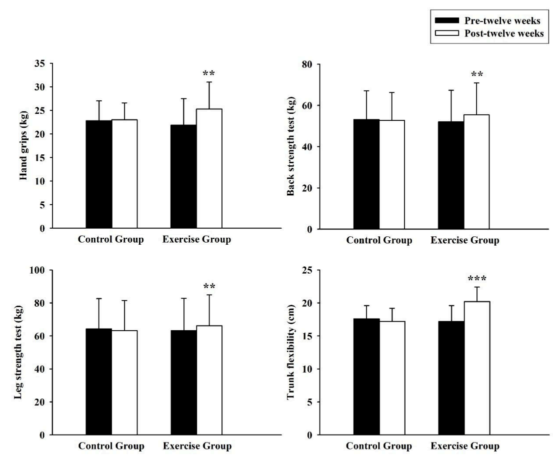

Fig. 2. Physical fitness during pre- and post-twelve weeks in control and exercise groups. **p < 0.01 and ***p < 0.001 to within-group comparison (before vs. after the 12-week period)

Discussion

The present study indicated that the combination of Thai yoga and elastic band exercise significantly improves body weight, BMI, WC, and WHR in elderly patients with T2DM.

Table 1. The measures of basal characteristics and anthropometry profiles were assessed during pre- and post-twelve weeks in control and exercise groups

Variables	Control group (n = 21)		Exercise group (n = 21)	
	Pre-	Post-	Pre-	Post-
Genders:				
Male	10		10	
Female	11		11	
Age (years)	64.90 ± 3.6		64.3 ± 3.7	
Height (cm)	155.10 ± 5.6		155.1 ± 9.01	
Weight (kg)	57.50 ± 8.5	57.80 ± 8.6	58.7 ± 11.9	58.00 ± 12.0***
BMI (kg/m^2)	23.80 ± 2.7	23.90 ± 2.7	24.2 ± 3.0	23.90 ± 3.0***
WC (in)	33.40 ± 2.9	33.60 ± 2.8	33.6 ± 3.6	33.10 ± 3.6***
HC (in)	37.90 ± 1.9	37.90 ± 2.1	37.2 ± 2.4	37.20 ± 2.5
WHR	0.88 ± 0.1	0.88 ± 0.0	0.9 ± 0.1	0.89 ± 0.1***
SpO_2 (%)	98.10 ± 0.8	98.30 ± 0.6	98.2 ± 0.8	98.40 ± 0.6

Data are expressed as mean ± SD. BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-hip ratio; SpO_2: pulse oxygen saturation. ***Significant $p < 0.001$ before vs. after the 12-week period

Table 2. The measures of physical fitness and functional exercise capacity were assessed during pre- and post-twelve weeks in control and exercise groups

Variables	Control group (n = 21)		Exercise group (n = 21)	
	Pre-	Post-	Pre-	Post-
Hand grips (kg)	22.8 ± 4.2	23.0 ± 3.6	21.9 ± 5.6	25.3 ± 5.7**
Back strength test (kg)	53.1 ± 14.0	52.7 ± 13.6	52.0 ± 15.4	55.4 ± 15.5**
Leg strength test (kg)	64.2 ± 18.4	63.2 ± 18.3	63.2 ± 19.6	66.2 ± 18.7**
Trunk flexibility (cm)	17.6 ± 2.0	17.2 ± 2.0	17.2 ± 2.4	20.2 ± 2.2***
6MWD (m)	342.9 ± 36.8	340.5 ± 40.0	344.3 ± 38.8	372.9 ± 60.0**
VO_2peak (ml/kg/min)	28.7 ± 2.7	28.3 ± 2.8	28.3 ± 3.5	30.1 ± 4.2**

Data are expressed as mean ± SD. 6MWD: six-minute walk distance; VO_2peak: peak oxygen uptake. **Significant $p < 0.01$, $p < 0.001$ before vs. after the 12-week period

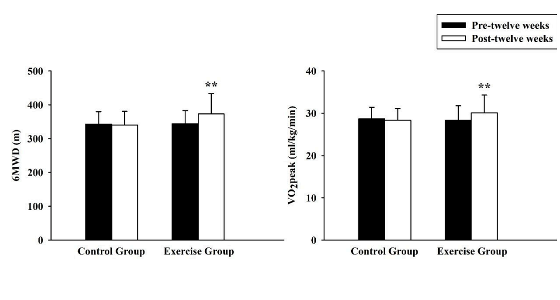

Fig. 3. Six-minute walk distance (6MWD) and peak oxygen uptake (VO_2peak) during pre- and post-twelve weeks in control and exercise groups. **$p < 0.01$ to within-group comparison (before vs. after the 12-week period)

The findings of this study align with earlier research, such as the implementation of yoga asanas and pranayama for 60 minutes daily over a consecutive 12-week period, resulting in reductions in body weight, BMI, and WHR in T2DM patients (Balaji et al., 2011; Barrows & Fleury, 2022). The mechanisms underlying the effects of yoga on body weight, BMI, WC, and WHR remain unclear, but potential explanations include direct rejuvenation or regeneration of pancreatic beta cells (Raveendran et al., 2018; Raveendran et al., 2018; Shantakumari et al., 2013), neuroplasticity promotion affecting the hypothalamic-pituitary-pancreas axis (Subba et al., 2021), and redistribution of fat from the waist to central abdominal fat during yoga practice (Shantakumari et al., 2013). Furthermore, increased total blood flow during yoga may influence glucose uptake in muscle cells, contributing to reduced lean body mass and skin fold thickness and subsequent reductions in WHR (Balaji et al., 2011). Elastic band exercise has shown benefits for T2DM patients by improving anthropometry, including body weight, BMI, WC, and WHR (Barrows & Fleury, 2022; Oh et al., 2017; Park et al., 2016). Elastic band exercise training for 40 to 60 minutes per session, 2 daily for 5 days per week over 12 weeks, has demonstrated positive effects on anthropometry and body composition in women with short-long-duration T2DM (Park et al., 2016).

The integration of yoga and elastic band exercise has shown positive effects in reducing HbA1c levels, managing blood sugar and lipids (García et al., 2019), and improving cardiovascular health along with the metabolism-lipolysis process (Barrows & Fleury, 2022). Moreover, elastic band resistance exercise with modified Thai yoga in T2DM patients has shown reductions in blood glucose, HbA1c, oxidative stress, and increases in antioxidants and pulmonary function (Promsrisuk et al., 2023). The possible mechanism may be related to proinflammatory cytokines, specifically tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), released by visceral fat, which may contribute to obesity-related insulin resistance (Kirwan et al., 2017). Decreased insulin resistance, associated with changes in adiposity, cholesterol levels, and increased expression of glucose transporter type 4 (Amanat et al., 2020), may improve disease status and quality of life (Stanford & Goodyear, 2014). Additionally, increased muscle mass has been shown to help reduce insulin resistance in elderly adults with diabetes and cardiovascular disease (Stanford & Goodyear, 2014). Furthermore, it diminishes oxidative stress, elevates antioxidant markers, and improves cardiopulmonary function in individuals with T2DM (Promsrisuk et al., 2023).

This study revealed a significant improvement in physical fitness following the 12-week regimen of Thai yoga and elastic band exercise, with hand grip strength, back strength, leg strength, and trunk flexibility increasing by 15.5%, 6.5%, 4.7%, and 17.7%, respectively. Moreover, the exercise program enhanced functional exercise capacity, with an 8.3% increase in the 6MWD and a 6.4% increase in estimated VO_2peak compared to baseline. These findings are in line with earlier research by Herriott and colleagues (Herriott et al., 2004), demonstrating that 8 weeks of combined resistance and flexibility training (50-70% 1RM of resistance, three days per week, three sets of 8-12 repetitions for each of the eight exercises), along with standard flexibility exercises (10-30 seconds for each), improved joint range of motion without affecting VO_2peak in elderly patients with T2DM (Herriott et al., 2004). Interestingly, compared to either aerobic or resistance exercise alone, combination training demonstrated a more positive impact on glycemic control (Raveendran et al., 2018; Raveendran et al., 2018). Several studies have reported that strength exercise with elastic bands and aerobic exercise can enhance anthropometric and biochemical variables by improving muscle mass, glycemic control, and intra-myocytic fat accumulation (Amanat et al., 2020; García et al., 2019; Kirwan et al., 2017). Furthermore, a previous study indicated that combining aerobic and resistance exercise holds greater therapeutic potential for improving insulin sensitivity than aerobic exercise alone in T2DM patients (AminiLari et al., 2017). Therefore, it demonstrates that combined training is an effective exercise approach for enhancing physical fitness and contributing to optimal functional exercise capacity (VO_2peak) in older individuals with T2DM.

This exercise combination offers an additional option for improving the health and well-being of elderly individuals with T2DM. However, it is important to acknowledge certain limitations in the study, such as the lack of detailed information on individual dietary variances, nutritional knowledge, lifestyle choices, and dietary modifications, which should be addressed in future research.

Conclusions

The present study indicates that a 12-week regimen of Thai yoga combined with an elastic band exercise emerges as a health-promoting routine capable of significantly enhancing physical fitness, functional exercise capacity, and anthropometric parameters in elderly patients with T2DM. Consequently, the results suggest that integrating Thai yoga with an elastic band exercise holds promising health benefits and may serve as a viable alternative exercise program for older individuals with T2DM.

Acknowledgment

The authors express their sincere appreciation to all the participants who took part in the study. Financial support for this research was provided by the Thailand Science Research and Innovation funds and the University of Phayao (Grant No. FF66-RIM049).

Conflict of interest

The authors affirm that they do not have any conflicts of interest.

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ВИВЧЕННЯ ВПЛИВУ КОМБІНОВАНИХ ВПРАВ ІЗ ТАЙСЬКОЇ ЙОГИ ТА ВПРАВ ЗІ СТРІЧКОВИМ ЕСПАНДЕРОМ НА ФІЗИЧНУ ПІДГОТОВЛЕНІСТЬ І ЗДАТНІСТЬ ПЕРЕНОСИТИ ФІЗИЧНЕ НАВАНТАЖЕННЯ В ЛІТНІХ ПАЦІЄНТІВ ІЗ ЦУКРОВИМ ДІАБЕТОМ 2 ТИПУ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 2 табл., 3 рис., 51 джерело.

Мета дослідження. Незважаючи на загальне визнання факту, що фізичні вправи можуть позитивно впливати як на фізичні, так і на біохімічні показники в людей похилого віку із цукровим діабетом 2 типу (ЦД2Т), досі існує невизначеність щодо конкретних наслідків комбінованого виконання вправ із тайської йоги та вправ зі стрічковим еспандером для цієї популяції. Метою цього дослідження було оцінити вплив 12-тижневої програми, яка включає вправи з тайської йоги в поєднанні з вправами зі стрічковим еспандером, на фізичну підготовленість і функціональну здатність переносити фізичне навантаження в літніх осіб із цукровим діабетом 2 типу.

Матеріали та методи. У дослідженні брали участь загалом 42 учасники, серед яких було 20 чоловіків та 22 жінки із ЦД2Т середнім віком 64,6±3,6 року, яких випадковим чином розподілили на дві групи: контрольну групу та групу фізичних вправ. Група фізичних вправ займалася за розпорядком дня, що передбачав виконання вправ із тайської йоги в поєднанні з вправами зі стрічковим еспандером протягом 40 хвилин, 5 днів на тиждень, протягом 12 тижнів. На відміну від них, контрольна група дотримувалася свого звичайного розпорядку дня. Фізичну підготовленість і функціональну здатність переносити фізичне навантаження оцінювали як до, так і після 12-тижневого втручання.

Результати. У групі фізичних вправ спостерігалося статистично значуще зниження показників маси тіла (58,7±11,9 проти 58,0±12,0 кг), індексу маси тіла (24,2±3,0 проти 23,9±3,0 кг/м^2), окружності талії (33,6±3,6 проти 33,1±3,6 дюйма), а також співвідношення окружності талії та окружності стегон (0,90±0,06 проти 0,89±0,06) ($p < 0{,}001$). Крім того, спостерігалося помітне покращення параметрів фізичної підготовленості, включаючи силу стиснення кисті, силу спини, силу ніг ($p < 0{,}01$) і гнучкість тулуба ($p < 0{,}001$). Функціональна здатність переносити фізичне навантаження, яку показує тест на 6-хвилинну ходьбу та розрахункове пікове споживання кисню ($p < 0{,}01$), також статистично значуще покращилася.

Висновки. Тайська йога у сполученні з вправами зі стрічковим еспандером покращує фізичну підготовленість і функціональну здатність переносити фізичне навантаження в літніх людей із цукровим діабетом 2 типу. Це покращення має потенціал для покращення їхньої серцево-легеневої діяльності. Отже, цей режим фізичних вправ вважається спортивно-оздоровчою альтернативою для літніх осіб із ЦД2Т.

Ключові слова: вправа, йога, тренування зі спротивом, цукровий діабет, здатність переносити фізичне навантаження.

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Cite this article as: Muangritdech, N., Promsrisuk, T., Kongsui, R., Sriraksa, N., Thongrong, S., & Srithawong, A. (2023). Exploring the Impact of Combined Thai Yoga and Elastic Band Exercise on Physical Fitness and Exercise Capacity in Older Patients with Type 2 Diabetes. *Physical Education Theory and Methodology, 23*(6), 894-901. https://doi.org/10.17309/tmfv.2023.6.11

Received: 03.11.2023. Accepted: 12.12.2023. Published: 22.12.2023