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Elastic Resistance Exercise Effects in Gait Kinematic Characteristics and Lower Limb Functional Rehabilitation

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thera-band;

Abstract

Background: Elastic resistance exercise is a popular type of exercise. Elastic bands are widely used in pre-competition preparation and for sports performance improvement. Purpose: The purpose of the present review is the study of the effect using exercise with elastic resistance bands, in walking kinematics and functionality level after surgical repair of low extremity degenerative diseases. Methodology: A systematic literature review was carried out at Advanced Scholar Google, Cochrane, PubMed and Embase databases, a chronological range from 1999 to 2022. Terms used in the search were as follows: “elastic resistance exercise”, “elastic resistance bands”, “Thera-band”, “arthropathy”, “hip replacement”. Results: Systematic elastic resistance exercise in the frame of a rehabilitation program lasting 8-12 weeks, provides results comparable to an isotonic exercise program, using free weights or constant resistance devices. Elastic resistance bands are commonly used for increasing muscle strength and range of motion and also for static and dynamic balance, walking ability and functionality level improvement. Important benefits observed in metabolic biochemical health biomarkers in the elderly.

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Contents

1 Introduction

Resistance exercise is associated with maintaining or improving fitness and cardiovascular function, increasing muscle strength and muscle mass, functional rehabilitation (increasing range of motion, restoring trophic of degenerated muscle groups), athletic rehabilitation after injury or injury, and maximizing strength (Rhyu et al., 2015). It is an extremely popular type of exercise with significant advantages: low cost of the exercise tool (elastic straps, rubber "tubes" in various colors representative of the different sizes of the resistance applied), ease of use, ease of carry everywhere, and provides the ability to perform exercise in any size of resistance providing exercise intensity control as a determinant of safety and effectiveness, even as an inexpensive substitute for conventional resistance machines (Motalebi et al., 2018; Iversen et al., 2017; Uchida et al., 2016; Colado et al., 2014).

Elastic resistance training (ERT) was a popular clinical "tool" in the 1980s, and is widely used nowadays as a means of increasing muscle strength (an 8-week exercise program was observed to contribute to increasing muscle strength by 14%-26%), in athletic rehabilitation, functional rehabilitation, improvement of balance and proprioception, while effects on prevention of chronic pain and injury are reported, as well as pain reduction in patients with rheumatoid arthritis (Kim et al., 2020; Lopez et al., 2019; Kang et al., 2016).

The purpose of the present study is to the effect of elastic resistance on the kinematic characteristics of gait, the degree of strengthening and functional rehabilitation of the lower extremity in hip pathologies and after surgical replacement.

2 Materials and Methods

A literature review was conducted on online data platforms Pubmed, Google Scholar, Cochrain, and Medline. Research and review studies in chronological range from 1999 to 2022. The terms used during the search were: "elastic resistance exercise", "exercise straps", "Thera-band", "arthrosis", "hip arthroplasty".

3 Results and Discussions

Comparison between elastic resistance exercise and constant resistance exercise

The usual means of resistance exercise (free weights and various devices), despite the benefits they provide, sometimes have as disadvantages the high cost of purchase, the risk of injury during use, difficulty in using them, or restricted access for the population (Colado et al., 2020). Supervised exercise programs do not seem to be particularly superior to home rehabilitation programs (Mikkelsen et al., 2019).

Compared to conventional means of resistance exercise, exercise with elastic bands is safer (presents less risk of injury) and is, therefore, the most popular type of exercise in the field of functional rehabilitation in older age groups, it provides the advantage of fluctuating resistance intensity, a variety of exercises (using a single "tool") and for many is a more acceptable (or even fun) type of exercise, while, it does not seem to lag to

the use of free weights and conventional fixed resistance machines, in terms of muscle strengthening (Lopez et al., 2019; Aloui et al., 2019; Vafaeenasab et al., 2019).

Isotonic sustained resistance strengthening exercise and elastic resistance strengthening exercise generally show similar benefits concerning upper and lower limbs. Studies so far show equal results in strengthening and improving functionality, between exercise with elastic bands and conventional fixed resistance delivery machines, provided that the magnitude of resistance matches both means of exercise (Iversen et al., 2017; Turban et al., 2014).

The comparison, however, between elastic resistance strengthening programs (as the only means of resistance) and isotonic exercise programs for concentric and eccentric strengthening providing fixed resistance, is a topic that has not been studied extensively in the international bibliography.

In purpose to detect differences in effectiveness between isotonic and elastic resistance exercise concerning muscle activity level, Aboodarda et al. (2016), in their review study, concluded that elastic resistance training provides the same level of activation for each muscle as isotonic exercise, refuting the older notion that using elastic exercise straps does not produce comparable levels of muscle activation as fixed resistance machines. To investigate the effect of a 4-week isotonic strength training program (at 85% 1RM), compared to an exercise program of equal duration, using elastic resistance straps, for shoulder external rotation, hip abduction and elbow flexion, 20 healthy women (non-athletes) aged 19-21 years were recruited and divided into two groups. The results demonstrated equal levels of strength training for all muscle groups that underwent the strengthening process (Lee et al., 2021). The increase in muscle strength in the first 4 weeks resulted mainly from neural adaptations (improved neuron recruitment and nervous system activation, motor unit activation mechanisms improvement) (Folkins et al., 2021).

To study electromyographic activity during exercise with elastic bands and exercise with stable resistance machines, Iversen et al. (2017), recruited 29 healthy subjects (men and women aged 22-28 years). Participants were asked to perform 4 lower limb exercises of 10 1RM repetitions in attempting to apply equal resistance to both types of exercises. In conclusion, similar electromyographic activity was observed using the constant resistance machine, in the final range of each movement, with the elastic belt at maximum voltage, while somewhat reduced levels of muscle activity were observed in the phase of each exercise in the elastic strap was loose.

Silva et al. (2016), were engaged in comparing the elastic resistance exercise and fixed resistance exercise (using machines) effect on muscle strength, quality of life and dyspnoea in patients with chronic obstructive disease, in their research. 19 patients aged 45-65 years were divided into 2 groups: the elastic band group (9 people) and the conventional exercise group (10 people).

After a 12-week program of resistance exercises, all participants were assessed in isometric strength (using a digital dynamometer), quality of life (Chronic Respiratory Disease Questionnaire - CRQ) dyspnea level (the Dyspnea Scale - MRC). The results showed that both resistance programs were equally effective in terms of dyspnoea (according to the MRC assessment). However, the constant resistance exercise group showed improvement in dyspnoea level (according to CRQ) and also, the correlation between the strength benefits of upper limb movements and the level of dyspnoea (according to MRC).

Influence on gait kinematic characteristics and lower limb functionality

Muscle strength is a key factor in maintaining balance (static and dynamic). During the lifetime of the non-working population (under normal conditions) the strength retention "curve" remains constant until the age of 50, while after the age of 60, there is a dramatic decrease (Patel et al., 2007). In the international bibliography it is reported that systematic resistance exercise, results in gait analysis changes in the synergy ratios of different muscle groups, while resistance training using elastic bands increases muscle strength levels and improves explosive strength. Also, evident is the effect of elastic resistance exercise in increasing the range of motion, the flexibility of movement, walking ability (effect on kinematic parameters in gait analysis) and the promotion of various skills of everyday life (Jafarnezhadgero et al., 2021; Rhyu et al., 2015; Heiden, 2008).

In their research, Vafaeenasab et al. (2019), studied the effect of an 8-week elastic resistance training program using straps, on static and dynamic balance, walking speed, and muscle strength in a sample of 50 women aged 60-66 years old. Romberg's test was used for static balance assessment, TUG was used for

dynamic balance assessment, 10 Meter Walking Test was used for assessing the effect of walking speed, and the 30 Second Chair Stand test was used to measure muscle strength. Research has shown that elastic resistance training provides significant benefits in increasing balance, which leads to increased walking speed and muscle strength.

Studying the effect of elastic resistance exercise, Kang et al. (2016), used TUG to assess dynamic balance, SLJ to assess agility, and Schober's test to assess the elasticity of motion in the hip joint in healthy individuals aged 19-23 years; As a result, there was an increase in the range of motion, flexion and abduction of the hip, thus contributing to increasing joint stability.

To study the effect of elastic resistance exercise on balance, walking, mobility, and fall prevention, Kwak et al. (2016), recruited 45 participants aged 65-75 who were divided into 2 groups. The first group followed an 8-week program (3 times a week, duration 30' per session) consisting of 8 elastic resistance exercises for the lower limbs. The second group followed a conventional program that included hot compress application, kneading, stretching and exercises to increase the range of motion, for a corresponding period (3 times a week, duration 30' per session). Pre-intervention and post-intervention assessments included SRT, FRT functionality test and TUG. Research has shown an increase in balance capacity due to muscle strength increase after elastic resistance exercises performance in the lower extremities. In conclusion, an exercise program using elastic bands in combination with conventional physiotherapy is indicated for the elderly.

The evaluation of electromyographic activity in the research of Jakobsen et al. (2013), revealed that targeted elastic resistance exercise for hip and knee muscles in healthy individuals induces levels of muscle activity comparable (for knee extensors) or higher (for hip and lower dorsal extensors) than activity levels occurring when using conventional fixed resistance machines. Exercise with elastic bands appears to be an easy and feasible method for high levels of neuromuscular activity in large hip muscles.

The comparison of electromyographic muscle activity levels in the abduction and adduction movement of the hip, using elastic bands and isotonic exercise machines, was the subject of research by Brandt et al. (2013). Specifically, the electromyographic activity of 11 muscles in the hip, thigh and trunk was recorded in 16 women 40-53 years old who do not exercise regularly. After a 10-minute warm-up (performing 10 moderate-intensity repetitions for each exercise), each subject in the sample performed 3 repetitions for each of 4 levels of predefined resistance (provided by the exercise machine, by its factory settings, and the exercise straps, by the elongation rate required according to color and according to the specifications given by the construction company). Between tests, an interval time of 5 minutes was set. Results showed that elastic resistance exercise appears to be equally effective in activating the muscle activity of the hip adductors, by exercising on the isotonic resistance machine. However, elastic resistance training was able to demonstrate a greater level of muscle activation in the hip abductor group than exercise in the stable resistance delivery machine (Wolburg et al., 2016).

Annular elastic bands are generally used in conjunction with free weights and isotonic exercise machines to facilitate hip muscles and enhance proprioception. To evaluate the effectiveness of annular elastic bands at various positioning heights, performing the "deep sitting" exercise, Martins et al. (2022), measured the myoelectric activity of the gluteal, hamstring, medial and lateral flat, and LDT, in 35 healthy subjects aged 21-29 years. The greatest myoelectric activity was found when resistance was applied to the metatarsal region, with a 24% increase for LDT, 83% for gluteus medial, and 68% for gluteus major, when performing "deep squats" in combination with an annular elastic band, to performing the exercise without the use of the strap.

Benefits in childhood, adolescence and middle age

According to the international literature, the various protocols of elastic resistance exercises are effective in improving muscle strength, functional capacity and various health-related parameters, at any age. In childhood, this type of exercise works decisively in increasing motivation and participation in various physical activities, providing more security than using free weights, being a more appropriate one for childhood, stimulus for neuromuscular adjustments and improvements (Aloui et al., 2019).

In adolescents, the effect of elastic resistance training has been evaluated primarily in terms of muscle strength. A significant increase in muscle strength was observed when the use of elastic bands was combined with free weights or various machines, compared to using only free weights or only elastic straps. Also, in cases of a combination of elastic resistance exercises with PNF techniques, significant improvement in joint

mobility was observed, with reported benefits in the development of muscle strength and improving balance through better response of the musculoskeletal system (Jafarnezhadgero et al., 2021).

In middle age, the use of elastic resistance contributes to the improvement of body composition (fat mass loss), at bioelectrical analysis evaluation, at a higher level than the use of conventional resistance devices. A program of moderate-intensity elastic resistance exercises can positively affect metabolic rate, lead to a decrease in diastolic blood pressure, and improve motor function (Davis et al., 2022).

Benefits for the elderly

In the elderly, 10%-20% experience falls related to balance problems and gait disorders. 32% of people aged 65-74 and 51% of those over 85 experience at least one fall within a year. According to literature data, women have poorer levels of balance than men and tend to have a greater risk of falls and accidents, with more serious injuries, given the lower ratio of the female population in muscle mass compared to men Approximately 20-30% of people having a fall, a fracture of the hip joint and damage to the head of the hip occurs, resulting in a decrease in the level functionality of the area and pain. Also, a decline in muscle strength and balance in old age results in walking problems and a decrease in the level of autonomy in functionality and physical activity (Choi et al., 2020; Yeun, 2017).

Various studies focus on the effect of elastic resistance exercise on functional capacity, reporting an improvement of 20% - 25%, while in some studies an increase in muscle strength of 15% - 20% is reported for the lower or upper limbs. Reduction of systolic blood pressure by 14% can be achieved following a systematic program of elastic resistance exercises of moderate intensity. This type of exercise seems to be beneficial either for healthy individuals or patients in the elderly (Colado et al., 2020). It is also a valuable means for reducing exercise overload, reviewing exercise intensity and reducing the risk of causing structural damage in the elderly and an important tool in designing and executing systematic exercise programs with safety and progressivity, for muscle strength maintaining and balance improvement, to prevent and avoid falls in the elderly (Kim et al., 2020). Taking exercise as for fun (and not as something compulsive), also socialization, and the effectiveness of various physical activity programs execution, are prospects and motivation factors in deciding to adopt exercise as a lifestyle in the elderly (Davis et al., 2022; Kwak et al., 2016; Vafaeenasab et al., 2019).

The effect of a 12-week elastic resistance exercise program on functional capacity and blood pressure parameters in the elderly was the subject of research by Choi et al. (2020), 27 healthy seniors 73-77 years old were divided into 2 groups.

The exercise group (15 people) followed a 3 months program of elastic resistance exercises for general fitness, lasting 60 minutes, three times a week. The control group (12 people) did not follow any specific intervention. Participants' functional and cardiovascular fitness were assessed before and after the end of the intervention. According to the results, conception, one-leg balance and SRT scores showed significant improvement in the experimental group individuals, while no significant improvement was observed in the TUG scores. Cardiorespiratory parameters including systolic, diastolic, mean blood pressure, and heart rate (pulse rate) presented a significant decline, compared to the control group (Pidhaietskyi et al., 2021).

A strong muscular system and flexible joints in the lower extremities play a key role in dynamic balance performance. To study the effectiveness of a program of progressive resistance exercises using elastic bands, for the elderly, in dynamic balance and functional capacity level, 45 people aged 60 years and over, participated in a program of elastic resistance exercises (low intensity in the first 2 weeks and moderate with progressive increase in intensity, going into greater difficulty band every 2 - 4 weeks, for the rest of the intervention) lasting 12 weeks (2 days a week). The results demonstrated the adequacy and effectiveness of a simple and inexpensive intervention program for improving dynamic balance and joint function, as well as increasing quadriceps strength (Motalebi et al., 2018).

The effect of elastic resistance on biochemical metabolic markers (glucose, cholesterol, triglycerides, etc.) in elderly people was studied in their research by Stojanovic et al. (2021). 68 women followed a program of elastic resistance, low load, from a sitting position, lasting 12 weeks (2 times a week), at 40-60% 1RM intensity. According to the findings of the research, elastic resistance exercise can contribute to a significant improvement in physical condition in the elderly, given that the values of biochemical metabolic markers (including glucose in the blood, total cholesterol and HDL, LDL) showed improvement. In a similar study,

Azamian Jazi et al. (2022), concluded that a 12-week elastic resistance band program leads to a significant increase in atropine serum levels in the body, as a consequence of changes in some cardiometabolic risk factors (decrease in insulin levels, body fat percentage).

The effectiveness of elastic resistance exercise in muscular strength of the lower limbs and walking ability, in individuals of the elderly with Alzheimer's disease, was the item of study by Ahn & Kim (2015). The experimental group of 23 individuals followed a 5-month exercise program with elastic bands for the upper and lower limbs (3 times a week).

Fitness was assessed with CLS, One-leg Stance, TUG, 2-minute Waking Test and walking ability before and after exercise. As the results of the research showed, static balance (one-leg stance, with eyes open and with eyes closed) improved significantly, while dynamic balance (TUG) did not improve significantly. Significant improvement was observed in cardiorespiratory function and walking speed (Sendzik et al., 2009; Pulles et al., 2017).

Functional benefits after total hip arthroplasty surgery

Diagnosed advanced degeneration of the hip joint (degenerative arthropathy) and diagnosis of symptomatic osteoarthritis (inflammation of the hip joint) are the primary indications for total hip arthroplasty (THA) surgery. Severe arthropathy and hip osteoarthritis are common chronic pathological situations responsible for severe pain and functional

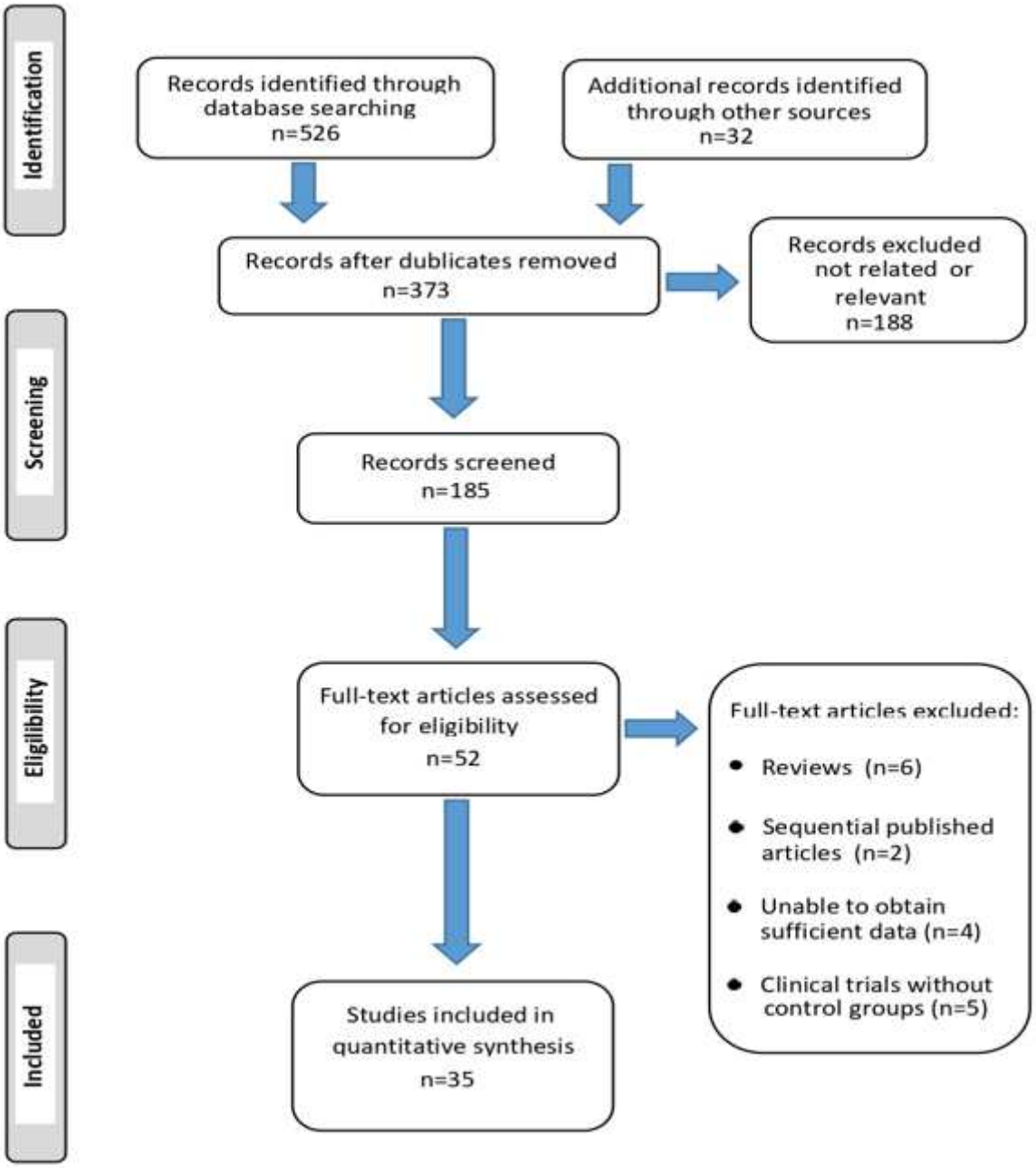
Table 1
Characteristics of the include studies

Study	Characteristics of the participants	Exercise protocol	Intervention	Outcomes
Brandt et al., 2013	N=16 females (age: 40-53 years)	2 EMG evaluation sessions	CRT: 3 reps of 4 levels of predefined resistance ERT: reps of 4 levels of predefined resistance	CRT=ERT (hib adductors EMG activity)
Jacobsen et al., 2013	N=42 males, females (age: 26-67 years)	1 EMG evaluation sessions	CRT: controlled exercises with dumbells 33%, 66%, 100% of 10 RM ERB: ballistic exrtcises using ERB 33%, 66%, 100% of 10 RM	CRT=ERB (in inducing high lkevel activity)
Kwak et al., 2016	N=45 males, females (age: 65-75 years)	8 weeks 3 sessions/week	CG: kneading stretching ROM ecercises EG: 8 lower limb ERB exercises (10 1RM reps)	CG=EG ⬆ Balance ⬆ Muscle strength
Silva et al., 2016	N=19 males, females with chronic obstructive disease (age: 45-65 years)	12 weeks 3 sessions/week	CRT: (weeks 1-3): 2x15 RM reps (weeks 4-6): 3x15 RM reps	CRT=ERT terms of dyspnea (MRC assessement)

Study	Characteristics of the participants	Exercise protocol	Intervention	Outcomes
			ERT: (weeks 7-9): 3x10 RM reps (weeks 10-12): 4-6 RM reps	CRT: Dyspnea ⬇ (CRQ assessement)
Iversen et al., 2017	N=29 males, females healty (age: 22-28 years)	2 EMG evaluation session	CRT: 4 lower limb exercises 10 1RM reps ERT: 4 lower limb exercises	CRT=ERT (EMG activity
MRC: Medical Research Council dyspnea scale			CRQ: Chronic Respiratory Desease 10 1RM reps	
Vafaeenasab et al., 2019	N= 50 females (age: 60-66 years)	8 weeks 3 sessions/week	CG: 6 lowe limb exercises 10 1RM reps	ERT: ⬆ Balance ⬆ Walking ⬆ Muscle strength
Choi et al., 2020	N= 27 males, females (age: 73-77 years)	3 months 3 sessions/week	CG: no specific intervention ERT: wlole bodyfitness exercises	ERT: ⬆ Conception ⬆ One-leg balance ⬇ Blood pressure ⬇ Heart rate
Folkins et al., 2021	N= 20 females (age: 19-21 years)	4 weeks 3 sessions/week	CRT: 3 lower/upper limp exercises (4-6 1RM reps) ERT: 3 lower/upper limp exercises (4-6 1RM reps)	CRT=ERT (muscle strength) (neural adaptation)

CRT: Conventional Resistance Training
CG: Control Group
RPE: Rate of Perceived Exertion
ERT: Elastic Resistance Training
EG: Experimental Group
reps: repetitions
HR: Heart Rate
ERB: Elastic Resistance Bands
1RM: 1 Resistance Maximum

Table 2
Selection process of included studies



problems in 4-9% of adults over the age of 45 years old, showing changes in gait biomechanics. Total hip arthroplasty is a successful hip replacement technique that guarantees good functionality and quality of life, with long-term transplant survival, up to 75% of cases 35 years later (Buehler et al., 2021; Bahl et al., 2018; Van Houcke et al., 2017).

Information derived from studies on hip joint biomechanics can be used to design intervention programs to reduce the joint burden level and the intensity of symptoms and possibly delay joint degeneration and pathology (Lim et al., 1999).

Total hip replacement surgery is an effective method for treating many hip pathologies and improving patients' life quality. After surgery, the functionality of the area fully returns, and the muscle strength of the operated limb remains reduced by 10% - 18% compared to the healthy limb, even 1 year after surgery. The minimally invasive method of hip arthroplasty (SuperPATH) inspired by Dr. Chow in September 2011, in which the transplant is placed through the gluteus minor and piriformis, without surgical incision of any muscle of the hip area, guarantees the integrity of the area soft tissues and bursa, and the faster functional rehabilitation of the involved lower extremity (Ge et al., 2021; Flevas et al., 2022; Meng et al., 2021).

The majority of studies demonstrate the effectiveness of various resistance exercise programs to restore lower limb muscle strength after total hip arthroplasty. However, most of the postoperative programs were under a professional therapist's supervision and carried out using expensive laboratory equipment (Chang et al., 2017).

The effect of an elastic resistance exercise program combined with the range of motion exercises and intense pace walking at home, lasting 12 weeks, on 30 patients aged 55 years and more, diagnosed with severe arthropathy, who underwent total hip replacement surgery was the subject of research by Chang et al. (2017). The assessments, performed at 2, 6 and 12 weeks of postoperative intervention, included the UGT, the Timed Walking Distance Test and the Quality of Life Questionnaire (SF-36). The results demonstrated that a home exercise program with elastic bands is safe, feasible and effective in restoring functionality and muscle strength of the operated limb, comparable to supervision programmes, and interventions that use laboratory equipment

4 Conclusion

Exercise using elastic bands in various colors for choosing the level of resistance is a practical and safe means of improving the kinematic parameters of gait and restoring strength and functionality in pathological situations and following surgical operations of the lower extremities; A systematic program of elastic resistance exercises for home (using bands) is equal to the expectations of a supervised laboratory program, using free weights or fixed resistance machines.

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Abbreviations
CLS : Chair Leg Squat
CRQ : Chronic Respiratory Disease Questionnaire
ERT : Elastic Resistance Band
FRT : Functional Reach Test
HDL : High-Density Lipoprotein
PNF : Proprioceptive Neuromuscular Facilitation
LDL : Low-Density Lipoprotein
LDT : Latissimus Dorsi Tendon
MRC : Medical Research Council dyspnoea scale
SLJ : Standing Long Jump Test
SRT : Sit and Reach Test
SuperPATH: Supercapsular Percutanously Assisted Total Hip
THA : Total Hip Arthroplasty
TUG : Timed Up and Go test
UGT : Up and Go Time test
1RM : 1 Repitition Maximum
TFL : Tensor Fascia Latae

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