Physical Rehabilitation and Recreational Health Technologies

Vol. 10, No 1 (2025)

ISSN 2522-1914 (Online)
ISSN 2522-1906 (Print)

Parallel title: Fìzična reabìlìtacìâ ta rekreacìjno-ozdorovčì tehnologìï
Parallel title: Фізична реабілітація та рекреаційно-оздоровчі технології

DOI: 10.15391/prrht

Foundation year: 2016
Founder: Kharkiv State Academy of Physical Culture
Frequency: 6 times a year
Publication language – English

The materials of the scientific journal are of theoretical and practical interest for doctoral students, post-graduate students, masters, rehabilitation specialists, physical therapists, occupational therapists, physical medicine and rehabilitation doctor, medical doctor, sports doctors, massage therapists, scientific and pedagogical workers.

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Journals website: https://phrir.com

ISSN (print) 2522-1906, ISSN (online) 2522-1914
FIZICNA REABILITACIA TA REKREACIJNO-OZDOROVCI TEHNOLOGII
Vol. 10 No. 1, 2025

CONTENT

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Original Scientific Article
DOI: 10.15391/prrht.2025-10(1).01

Protein supplementation on muscle recovery and soreness after intense badminton training sessions

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Abstract

Purpose. This study aimed to investigate the impact of protein supplementation on muscle recovery and delayed-onset muscle soreness (DOMS) in male badminton players following intense training sessions.

Material & Methods. Thirty-six male badminton players, aged 18 to 25, were randomly divided into three groups: a high-protein group (1.6 g/kg body weight), a moderate-protein group (0.8 g/kg body weight), and a placebo group. Participants consumed their respective supplements within 30 minutes after each training session over a six-week period. Muscle soreness was assessed using the Visual Analog Scale (VAS) at 24, 48 and 72 hours post-exercise, and recovery was measured through the Perceived Recovery Status (PRS) scale. Statistical analyses, including two-way ANOVA, were performed to assess the effects of protein supplementation and the recovery time on muscle soreness and recovery.

Results. The high-protein group showed significantly faster recovery and reduced muscle soreness than the moderate-protein and placebo groups ($p<0.001$). Furthermore, regression analysis indicated a strong negative correlation between protein intake and muscle soreness, highlighting the benefit of higher protein levels in improving recovery.

Conclusions. Protein supplementation, especially at a higher dose of 1.6 g/kg body weight, significantly aided in muscle recovery and reduced muscle soreness in male badminton players. This suggests that adequate protein intake is key to enhancing recovery and performance in sports that require quick bursts of intense activity.

Keywords: Protein, muscle recovery, soreness, badminton, sports nutrition.

Introduction

Badminton requires a high level of physical intensity, blending agility, strength, endurance, and quick reaction times (Rossi et al., 2022). The sport's demands often lead to muscle fatigue and delayed-onset muscle soreness (DOMS), which can hinder athletes' ability to perform consistently (Molaeikhaletabadi et al., 2022). Unlike in sports where continuous endurance or heavy lifting are key, badminton players face a unique challenge due to their fast, high-intensity movements and bursts of sprinting, followed by rest periods. This intense stop-and-go style of play leads to greater muscle strain and rapid buildup of metabolic byproducts, which contribute to muscle soreness and fatigue. These effects underscore the need for efficient recovery strategies to sustain performance levels and maintain consistent training schedules (Phomsoupha & Laffaye, 2015; Gasibat et al., 2023; Phomsoupha & Laffaye, 2020).

Nutrition, and specifically protein intake, is widely recognized as essential to muscle recovery

and performance in various sports. Protein aids in muscle repair, reducing soreness, and promoting recovery (Papadopoulou, 2020; Danh et al., 2023; Hulland et al., 2024). Extensive research on endurance and strength sports has confirmed that protein supplementation after exercise can improve recovery times and reduce muscle soreness. These findings, however, have focused on sports with different physical requirements than badminton, leaving an important gap in understanding how protein might help badminton athletes, who face unique movement patterns and physiological demands (Jayawardena et al., 2024; Klein et al., 2021; Muwonge et al., 2017).

Recovery-focused research suggests that high-protein intake (typically between 1.6-2.2 grams per kilogram of body weight) is generally effective for muscle repair, yet there is limited insight on the ideal protein intake specifically for badminton players (Phillips, 2006; Pourabbas et al., 2021). Given the sport's combination of anaerobic and aerobic demands, determining the ideal type and timing of protein intake for optimal recovery remains an open question. Additionally, research has shown varied results on whether immediate post-exercise protein intake or consistent intake throughout the day has the greatest impact on recovery, suggesting a need to explore timing strategies that could specifically benefit badminton players (Karp et al., 2006; Amiri et al., 2019; Chang et al., 2020).

Current studies into protein's effect on DOMS have yielded mixed results. Some studies indicate that protein may reduce DOMS by facilitating muscle repair and anti-inflammatory effects, while other studies report no significant impact. These differing results may be due to inconsistencies in sample sizes, exercise types, and protein dosages (Molaeikhaletabadi et al., 2022). For badminton athletes, who experience muscle soreness from the sport's explosive demands, investigating whether protein intake can specifically alleviate DOMS symptoms is highly relevant. The potential for protein to improve recovery would not only benefit players' performance but also reduce downtime due to soreness and fatigue, enabling more consistent training (Lau et al., 2013; Laurent et al., 2011).

The purpose of this study is to investigate the effects of protein supplementation on muscle recovery and soreness reduction in college-level male badminton players. By assigning participants to high-protein, moderate-protein, and control groups, the study aims to determine whether protein supplementation can improve recovery and reduce muscle soreness at various time points post-exercise.

Material and methods

Participants

This study included 36 competitive college-level male badminton players aged between 18 and 25 years (21.4±1.773), all from SRM Institute of Science and Technology, India. These players, chosen for their minimum of two years of competitive experience and consistent training routines, reflect a skilled demographic relevant to badminton performance. Participants were randomly allocated into three groups, each containing 12 members: a high-protein group, a moderate-protein group, and a control group. Informed consent was obtained from each participant to ensure voluntary involvement in the study.

Methods

The intervention lasted six weeks, during which participants consumed their designated post-training supplementation after each training session. Group 1 (high-protein) received 1.6 grams of protein per kilogram of body weight, while Group 2 (moderate-protein) consumed 0.8 grams per kilogram of body weight. To meet these protein requirements, both groups were given cow milk, a widely available and natural protein source in India. The high-protein group drank approximately 470 ml of milk daily, while the moderate-protein group consumed around 230 ml per day. Group 3, the control group, received a calorie-matched, non-protein placebo drink. All participants consumed their supplements within 30 minutes post-training to maximize recovery. Additionally, they followed a well-structured training routine that included exercises to improve agility, strength, and endurance, tailored specifically for badminton.

Procedure

Intervention and data collection occurred over six weeks in a controlled lab setting to ensure consistency. Key measures included muscle soreness, recovery rate, and weekly feedback on well-being. Muscle soreness was assessed using the Visual Analog Scale (VAS) at 24, 48 and 72 hours post-training, allowing players to rate discomfort on a 0-10 scale in a quiet, focused environment (Lau et al., 2013). The recovery rate was measured with the Perceived Recovery Status (PRS) scale captured each player's recovery perception data on recovery progression (Laurent et al., 2011). Weekly questionnaires collected participants' feedback on fatigue, soreness, and any side effects to enrich the primary data, documenting broader well-being and any training impacts.

Statistical analysis

Statistical analysis was performed using SPSS software, focusing on evaluating the effects of protein supplementation on muscle soreness and recovery. A two-way ANOVA was applied to analyse differences across groups and time points for both recovery and soreness variables, considering both main effects and interactions. Significant differences between specific groups were examined using post hoc analysis (Tukey's HSD test). Re-

gression analysis further explored the relationship between protein intake levels and both recovery rates and soreness reduction over time. A significance level of $p<0.05$ was used throughout the analysis.

Results

The Two-Way ANOVA results highlighted significant effects of group (protein intake) and time (post-exercise period) on both recovery and muscle soreness. Players in the high-protein group experienced improved recovery and reduced soreness compared to the moderate-protein and control groups ($F=15.72$, $p<0.001$ for recovery; $F=18.96$, $p<0.001$ for soreness). Significant time effects ($F=23.61$, $p<0.001$ for recovery; $F=26.42$, $p<0.001$ for soreness) showed gradual improvements, with interaction effects ($F=8.45$, $p=0.001$) emphasizing the long-term benefits of protein.

The post hoc test results show that high-protein supplementation significantly improved both recovery and reduced muscle soreness in badminton players. Compared to the moderate-protein and control groups, the high-protein group had a much faster recovery (mean difference = 0.65, $p=0.0002$) and experienced less soreness (mean difference = -2.50, $p<0.001$). The moderate-protein group also performed better than the control group, though the differences were smaller (recovery: mean difference = 0.35, $p=0.03$; soreness: mean difference = -0.70, $p=0.04$). When looking at the time points, recovery and soreness were significantly better after 48 hours (recovery: mean difference = -0.50, $p=0.02$; soreness: mean difference = -1.20, $p<0.001$), with the most improvement seen by 72 hours post-exercise (recovery: mean difference = -1.20, $p<0.001$; soreness: mean difference = -2.10, $p<0.001$).

The regression analysis results show how protein intake and time affect both recovery and muscle soreness. For recovery, protein intake had a significant negative relationship (coefficient = -0.15, $p=0.003$), meaning that higher protein consumption contributed to a faster recovery. Time also played an important role, with a negative coefficient (-0.08, $p=0.015$), suggesting that recovery improves as more hours pass after exercise. With an R^2 value of 0.78, the model explains 78% of the variation in recovery, indicating a strong relationship between these variables. When it comes to muscle soreness, the analysis showed that protein intake significantly reduced soreness (coefficient = -2.50, $p<0.001$), with higher protein intake leading to lower soreness levels. Time also had a notable impact, with soreness decreasing over time (coefficient = -1.00, $p=0.002$). The R^2 value of 0.82 indicates an even stronger relationship, with protein intake and time accounting for 82% of the variation in muscle soreness.

Table 1. Two-way ANOVA results for recovery and muscle soreness analysis

Source of Variation	df	F-value (Recovery)	p-value (Recovery)	F-value (Soreness)	p-value (Soreness)
Main Effect: Group	2	15.72	<0.001	18.96	<0.001
Main Effect: Time	3	23.61	<0.001	26.42	<0.001
Interaction (Group × Time)	6	8.45	0.001	9.82	<0.001

Table 2. Post hoc test results for recovery and muscle soreness analysis

Comparison	Mean Difference (Recovery)	p-value (Recovery)	Mean Difference (Soreness)	p-value (Soreness)
High-Protein vs. Moderate-Protein	0.65	0.0002	-2.50	<0.001
High-Protein vs. Control	1.00	<0.001	-3.20	<0.001
Moderate-Protein vs. Control	0.35	0.03	-0.70	0.04
Pre-Test vs. 24h Post-Test	-0.20	0.12	-0.50	0.11
Pre-Test vs. 48h Post-Test	-0.50	0.02	-1.20	<0.001
Pre-Test vs. 72h Post-Test	-1.20	<0.001	-2.10	<0.001

Table 3. Regression analysis results for recovery rate and muscle soreness in relation to protein intake and time

Group	Variable	Coefficient	Standard Error	t-value	p-value	R^2
Recovery Rate and Protein Intake	Intercept	4.35	0.95	4.58	<0.001	0.78
	Protein Intake (g/kg)	-0.15	0.05	-3.00	0.003	
	Time (Hours)	-0.08	0.03	-2.67	0.015	
Muscle Soreness and Protein Intake	Intercept	45.00	1.20	37.50	<0.001	0.82
	Protein Intake (g/kg)	-2.50	0.50	-5.00	<0.001	
	Time (Hours)	-1.00	0.30	-3.33	0.002	

Discussion

The present study aimed to investigate the effects of protein supplementation on muscle recovery and soreness reduction in competitive male badminton players. The findings clearly highlight the beneficial role of protein supplementation, particularly in the high-protein group, which showed faster recovery and significantly reduced muscle soreness compared to both the moderate-protein and control groups. The results of this study are consistent with previous research that suggests protein plays a vital role in muscle repair and recovery following intense physical activity. However, despite these encouraging findings, there are several limitations that should be considered when interpreting the results (Castillo et al., 2022; Iwasa-Madge & Sesbreno, 2023; Ihsan et al., 2024).

The results of this study are consistent with previous research highlighting the benefits of protein supplementation for muscle recovery and soreness reduction after intense physical activity. Research has consistently shown that increased protein intake post-exercise aids in the repair of muscle fibres damaged during strenuous activity and facilitates muscle rebuilding. In this study, the group that consumed 1.6 grams of protein per kilogram of body weight showed superior recovery and less muscle soreness compared to both the moderate-protein group (0.8 grams per kilogram) and the placebo group. This finding reinforces the idea that higher protein consumption can significantly enhance recovery, supporting the recommendations for athletes involved in high-intensity or endurance sports. The statistical analyses conducted, including the two-way ANOVA and regression analysis, further reinforced the significance of protein supplementation in improving recovery and reducing soreness. The results of the two-way ANOVA indicated that protein intake and time significantly impacted both recovery and soreness, with high-protein supplementation showing the most favourable results. The regression analysis also confirmed a negative relationship between protein intake and both recovery rate and soreness, underscoring the importance of protein in the recovery process. These findings align with other studies suggesting that protein intake can effectively mitigate the muscle damage associated with intense training and hasten recovery times (Molaeikhaletabadi et al., 2022; Wickham & Spriet, 2024; Alcantara et al., 2019).

From a practical perspective, the results of this study have important implications for athletes, particularly those involved in intermittent sprint sports like badminton, where rapid recovery is essential for maintaining performance across multiple training sessions or competition days (Lau et al., 2013; Alcantara et al., 2019). Athletes and coaches may consider incorporating protein supplementation into their training regimens to enhance recovery and minimize muscle soreness, especially following intense exercise sessions. Additionally, as the high-protein group demonstrated the greatest improvements, athletes may benefit from adhering to protein intake recommendations that approach or exceed 1.6 grams per kilogram of body weight (Chang et al., 2020; Palani et al., 2024; Wickham & Spriet, 2024).

This study offers important insights into how protein supplementation impacts muscle recovery and soreness. While the sample size was limited, it provided a controlled examination of the effects, and future studies could involve a larger, more varied group to enhance generalizability. The six-week intervention effectively highlighted short-term effects, and extending the duration would allow for analysis of long-term outcomes (Gilson et al., 2010; Hasanpouri et al., 2023; Krushynska, et al. 2023). Exploring different protein types and integrating objective measures, such as creatine kinase levels, would further deepen our understanding of protein's role in muscle recovery (Sembaiyan et al., 2024; Jeoung & Kim, 2021; Babov et al. 2023).

Conclusions

The present study clearly demonstrates the significant benefits of protein supplementation on muscle recovery and soreness reduction in competitive male badminton players. The high-protein group, consuming 1.6 grams of protein per kilogram of body weight, exhibited the fastest recovery and the greatest reduction in muscle soreness compared to the moderate-protein and control groups. Statistical analyses, including two-way ANOVA and regression analysis, confirmed the strong relationship between protein intake, recovery rate, and soreness reduction.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).01

Acknowledgements
We thank all participants for their valuable contribution to the study and the research team for their dedicated support.

Conflict of interest
The authors declare no conflict of interest in relation to this study.

Funding Statement
This study was conducted without any external funding.

Received: January 12, 2025; Accepted: January 25, 2025
Published: February 28, 2025

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Conceptualization, B.P. and C.S.; methodology, B.P. and C.S.; software, C.S., I.P. and S.S.; check, C.S., I.P. and S.S.; formal analysis, A.M. and S.S.; investigation, B.P.; resources, B.P.; data curation, B.P.; writing - rough preparation, B.P.; writing - review and editing, S.S., I.P. and A.M.; visualization, S.S., I.P. and A.M.; supervision, C.S.; project administration, B.P. and C.S. All authors have read and agreed with the published version of the manuscript..

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Original Scientific Article
DOI: 10.15391/prrht.2025-10(1).02

Readaptation of functional capabilities of special unit servicemen with long-term hypodynamia caused by peripheral neuromuscular system damage

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Abstract

Purpose. To study the efficiency of readaptation of the functional capabilities of special unit servicemen with prolonged hypodynamia caused by neuromuscular system damage during long-term rehabilitation.

Material & Methods. A study was conducted on 30 special unit servicemen, aged 25±1.6 years, who required immediate readaptation of their functional capabilities caused by prolonged hypodynamia lasting 45±4.7 days. The study participants were divided into three groups (10 people in each). Members of the first group were instructed to follow standard physical therapy protocols during the initial 70-day phase of their long-term rehabilitation. Participants in the second and third groups followed experimental training models for readapting functional capabilities. The heart rate variability (HRV) method was used to assess the adaptive and compensatory responses of the special unit servicemen to stress stimuli throughout the study.

Results. All study participants showed high tension in heart rhythm regulation following the previous rehabilitation. In response to test loads, sympathetic regulation activity increased, and the central mechanism of sinus rhythm control was enhanced in special unit servicemen. The HRV indicators observed in the group of military personnel showed no changes after 70 days of following standard long-term rehabilitation protocols. In response to the test load, there was a shift in the vegetative balance towards sympathetic regulation due to the weakening of the high-frequency spectrum of the heart rhythm power. In members of the other two groups who followed experimental training models, an increase in vagal influence on the sinus node was observed. The results after the load showed a shift in autonomic balance toward parasympathetic regulation, indicating the activation of short-term adaptation processes. The most significant functional readaptation was observed in special unit servicemen who combined isolated exercises with high-intensity training under creatine phosphokinase energy supply conditions.

Conclusions. The results confirm the effectiveness of the proposed system for restoring the functional capabilities of special unit servicemen experiencing hypokinesia caused by peripheral neuromuscular system damage during long-term rehabilitation. The use of standard physical therapy protocols in long-term rehabilitation is ineffective for the readaptation of functional capabilities in special unit servicemen. The proposed mechanism, which maximally engages synergistic muscle groups while minimizing the load on injured agonists and avoiding additional stabilizer activity, enables selective muscle fatigue without disrupting adaptation. Ap-

plying this combined approach, integrating isolated exercises from power fitness and MMA, effectively enhances the readaptation of special unit servicemen during long-term rehabilitation.

Keywords: special unit servicemen, readaptation, long-term rehabilitation, hypokinesia, heart rhythm regulation.

Introduction

The ongoing pursuit of effective mechanisms to enhance the physical rehabilitation system for military personnel necessitates an in-depth, comprehensive study of this issue by scientists (Biggs et al., 2019; Conkright et al., 2020). One of the least explored, yet highly relevant areas, is the study of the readaptation of functional capabilities in special unit servicemen after prolonged hypodynamia. This issue is particularly pressing in long-term rehabilitation due to the varying degrees of damage to the peripheral components of the neuromuscular system. The practical application of this issue causes the development of an innovative method for restoring the body's adaptive reserves following the completion of rehabilitation phases (acute and post-acute) (Klymovych et al., 2020; Miyatsu et al., 2023; Uphill et al., 2025). The absence of an adequate level of exercise during prolonged hypodynamia in this rehabilitation results in pronounced hypokinesia (Chernozub et al., 2024; Potop et al., 2024). The prolonged impact of pronounced hypokinesia, particularly when exercise intensity does not match the resistance level, will lead to persistent compensatory reactions, followed by increased maladaptation (Collins et al., 2018; McFadden et al., 2024).

The effectiveness of implementing standard rehabilitation protocols for special unit servicemen, considering their previous high level of body resistance, is a highly debated issue (Gancitano et al., 2021; Vine et al., 2024). Thus, using most methods, tools, and rehabilitation training programs during the readaptation may be ineffective or worsen the situation (Salonen et al., 2019). This problem can be solved by developing an experimental methodology based on the physiological mechanisms of selective recruitment of agonist, synergist, and stabilizer muscles (Potop et al., 2023). The proposed mechanism is especially relevant when performing isolated exercises, considering the initial hypokinesia and the condition of the neuromuscular system (Olkhovyi et al., 2016). Load regimes, energy supply mechanisms, and the kinematic characteristics of the exercise technique are important factors in adjusting the stress stimulus during the readaptation of military personnel (Chernozub et al., 2023). Optimizing the integrated system for controlling the readaptation processes of special unit servicemen with hypokinesia is a vital component of long-term rehabilitation. The development of a system for the readaptation of functional capabilities in special unit servicemen following neuromuscular system damage remains one of the unresolved challenges in rehabilitation.

Purpose of the Study. To explore the efficiency of readaptation of the functional capabilities of special unit servicemen after prolonged hypodynamia caused by neuromuscular system damage during long-term rehabilitation.

Materials and Methods

Participants

The study involved 30 special unit servicemen aged 25±1.6 years, who needed prompt readaptation of functional capabilities after prolonged hypodynamia (45±4,7 days). Previously, the examined servicemen who had neuromuscular system damage due to mine-explosive injuries used standard medical protocols during the acute and post-acute rehabilitation periods. Random sampling divided the study participants into three groups (10 people in each group). Using this sampling method is justified by the high level of resistance, which all examined military personnel had before injuries. The studies were conducted in 2024 based on the Research Center of Modern Kinesiology "KINEZUS" and its branches (Odesa and Mykolaiv, Ukraine). The ethics committee of Lesya Ukrainka Volyn National University approved the study design. After explaining the risks and benefits of the study, the participants signed an informed consent form prepared following the ethical standards of the Declaration of Helsinki.

Measurements

Heart rate variability (HRV)

A Polar V800 heart rate monitor (Polar Electro Oy, Kempele, Finland) was used to measure RR intervals. Heart rate and raw RR intervals were recorded using a sensor mounted on a chest strap (H10, Polar Electro Oy, Finland). The Polar Flow web service was used to download RR interval data to a computer. Kubios HRV Standard 3.5.0 software (University of Eastern Finland) calculated HRV parameters in the time and frequency domains. The most informative indicator for short-term analysis from the time domain was selected as the standard deviation of RR intervals (SDNN, ms). Fast Fourier transform was selected for spectral analysis in the frequency domain. During the

analysis of HRV power spectral characteristics, the following frequency ranges were identified: low-frequency (LF, %), very-low-frequency (VLF, %), and high-frequency (HF, %). The LF/HF ratio was determined as an indicator of autonomic balance. The RR interval signals were recorded in the subjects seated at rest, before (baseline) and after acute physical exertion. To standardize HRV studies with short recordings, an optimal recording duration was 5 minutes. The temperature was 22–24°C.

Research Design

The research was conducted in several stages during 2024.

In the first stage, the medical records of special unit servicemen were analyzed. These servicemen participated in the study after completing the acute and post-acute rehabilitation periods (60–75 days). The protocols were assessed for the effective implementation of standard physical rehabilitation programs during each rehabilitation period. The protocols of biochemical blood tests conducted in medical institutions during this period were also analyzed. The obtained results enabled an assessment of the adaptive body changes in the examined servicemen during the acute and post-acute rehabilitation periods. After analyzing the data provided by medical institution representatives and the research findings (Miyatsu et al., 2023; Uphill et al., 2025), the key issues in the rehabilitation system across different periods were identified. One of the ways to solve this problem is to develop a system for readapting the functional capabilities of special unit servicemen after prolonged hypodynamia. This system is important for military personnel experiencing hypokinesia due to damage to the peripheral parts of the neuromuscular system during long-term rehabilitation.

In the second stage, the heart rhythm regulation tension was determined using the spectral characteristics of HRV in the examined groups of servicemen at rest (before exercise). To assess the functional body capabilities at the beginning of the study, a test load was developed to evaluate the nature of adaptive and compensatory reactions to a stressful stimulus. During the test load, four isolated auxiliary exercises were employed to target muscle groups that act as synergists for those requiring readaptation. The intensity of the external stimulus, or resistance to external stimulus, was set at 65-70% of 1 RM. Exercises are performed with partial amplitude, moderate pace (2/2), and minimal involvement of muscle groups of body position stabilizers. The number of repetitions in these conditions should not exceed 8-10 until the active muscle groups of synergists are fully fatigued. The creatine phosphokinase energy supply mechanism and the onset of anaerobic glycolysis were used to conduct the training. Rest intervals between test exercises were within 50-60 seconds.

The characteristics of changes in spectral heart rate indicators during the performance of the developed test task were examined. A comparative analysis of the studied indicators at rest before and after exercise was carried out. Based on the study results, two experimental models of functional readaptation classes for special unit servicemen were created for long-term rehabilitation. Representatives of the first group were offered standard protocols in physical therapy during the first period (70 days) of long-term rehabilitation. The participants in the second group followed experimental class model 1 for functional readaptation. The servicemen in the third group were instructed to use experimental model 2 during the long-term rehabilitation.

In the third stage, we examined the impact of standard physical therapy protocols for long-term rehabilitation and the experimental class models on the functional readaptation of the participants. The control over the functional readaptation of the participants using the proposed class models was conducted in two stages: at the beginning and the end of the 70-day readaptation period. The dynamics of spectral HRV indicators in the participants of the examined groups at rest and in response to an acute test load were studied. The results were processed.

Statistical Analysis

The study results were statistically analyzed using the IBM SPSS*Statistics 26 software package (StatSoftInc., USA). The G-Power 3.1.96 program (Germany) was used to determine the minimum sample size for the study through statistical power calculation. Nonparametric statistical analysis methods were used to calculate the median (Me) and interquartile range (IQR). The Mann-Whitney U test was applied to compare the initial parameters among the three groups of examined servicemen. The Wilcoxon T-test was used to compare two dependent samples.

Results

Figure 1 illustrates the system designed to restore the functional abilities of special unit servicemen experiencing hypokinesia caused by peripheral neuromuscular damage during extended rehabilitation.

To develop a system for restoring servicemen's functional capabilities, the stages' characteristics and control methods were thoroughly analyzed. The study outlines the gradations of key informative markers used to evaluate both the short-term and long-term adaptation of participants to

ISSN (print) 2522-1906, ISSN (online) 2522-1914
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Vol. 10 No. 1, 2025

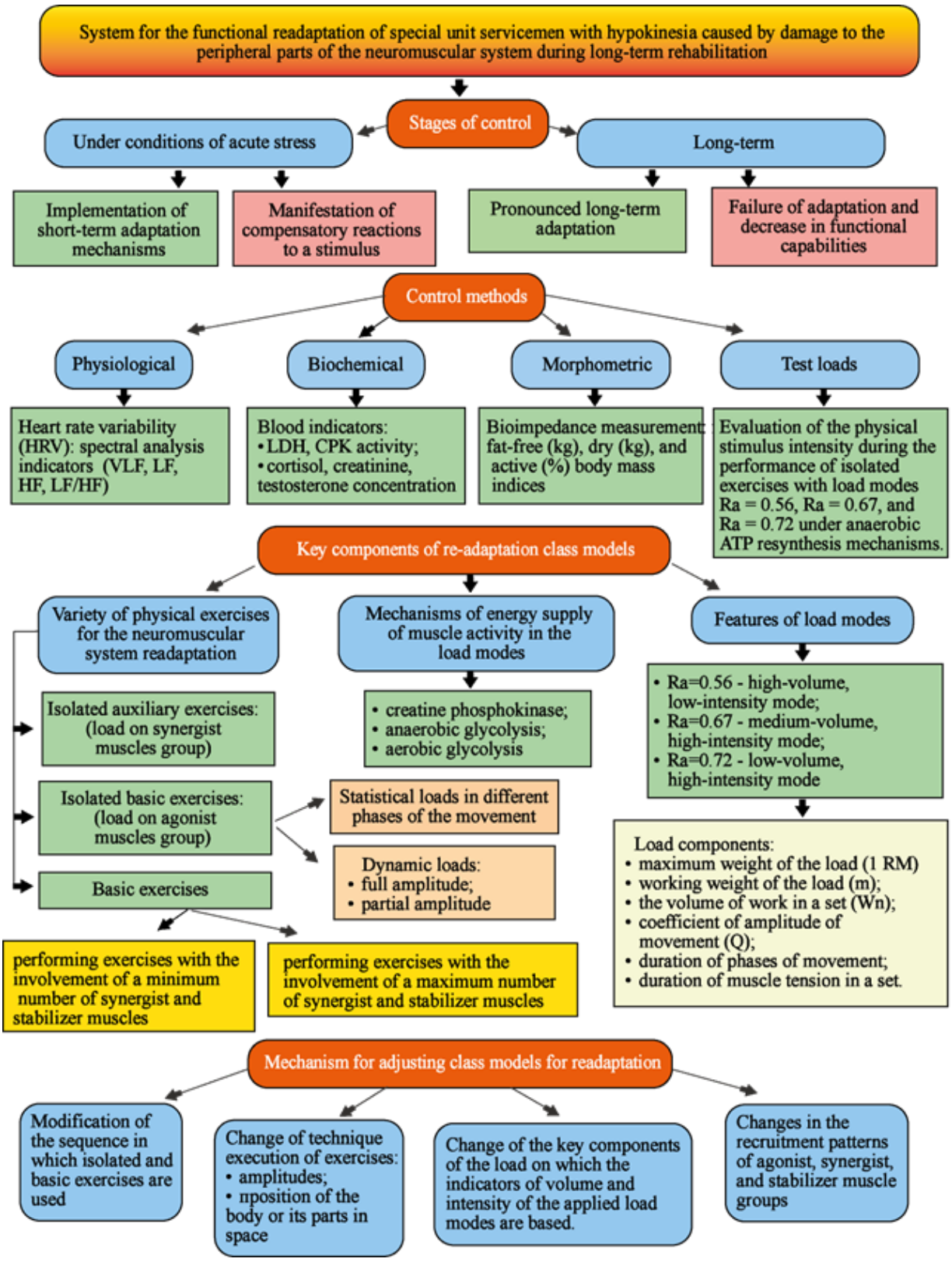

Fig. 1. System for the functional readaptation of special unit servicemen with hypokinesia caused by damage to the peripheral parts of the neuromuscular system during long-term rehabilitation.

a stressful stimulus. A scientifically substantiated integral mechanism for combining physiological, biochemical, and morphometric control methods is proposed. The mechanism will allow for determining the dynamics of functional capabilities during readaptation. The developed test tasks enable the design of an appropriate stressful stimulus based on the individual functional capabilities and the condition of the examined person's neuromuscular system. The effective development

Table 1. Experimental class models for functional readaptation proposed for special unit servicemen during long-term rehabilitation

Class model 1	Class model 2
Features of physical exercises	
Mainly basic power fitness exercises are used with the simultaneous involvement of agonist, synergist, and stabilizer muscle groups: – free-weight exercises: the load correction is carried out by altering the body position and shifting the center of gravity, which affects the number of muscle groups engaged simultaneously; – exercises with dumbbells: load correction is achieved by modifying the technique (movement amplitude, pace), the duration of muscle activity, and the number of stabilizer muscle groups involved, which results from changes in the position of body parts in space; – exercises involving resistance from another person: load correction is achieved by increasing the partner's muscle efforts, altering the biomechanics of movements, and reducing the activation of stabilizer muscle groups.	Isolated exercises (auxiliary and basic) are used to consistently involve mainly synergist, stabilizer, and partially agonist muscle groups: – a combined set of special isolated exercises (exercises involving resistance from another person, machine exercises) of power fitness and MMA for readaptation of affected muscle groups; – an algorithm for using auxiliary isolated exercises (with resistance from another person) for premature fatigue of stabilizer muscles and partly synergists; – a set of isolated machine exercises designed to load agonist muscles following prior fatigue of synergist muscles; – isolated exercises (with resistance from another person) resembling technical elements of MMA, aimed at loading agonist muscles after prior fatigue of synergist muscles.
Features of load modes	
A high-volume, low-intensity training load regime (R_a=0.56) is used; in some cases, a medium-volume, low-intensity regime (R_a=0.67) is used.	A low-volume, high-intensity training load regime is used (R_a=0.72).
Mechanisms of energy supply for muscle activity	
Under the specified training load conditions, anaerobic glycolysis mechanisms were activated. Muscle glycogen is the main energy source for ATP resynthesis.	Under this training load regime, the creatine phosphokinase energy supply mechanism is used. Creatine phosphate is the main energy source for ATP resynthesis.
Periodization of loads	
Load parameters vary within 55-68% of 1 RM. The number of repetitions in a set is within 7-8 to 10-12 in most cases. The total number of exercises in a set is 8-10. The set duration is about 60-70 minutes. Rest intervals between a series of sets are 48 hours. The main assessment criterion is quantitative indicators within the specified limits of 1 RM.	Load parameters vary within 70-75% of 1 RM. The number of repetitions in a set is within 5-6 until the working muscle groups fatigue. The total number of exercises in a set is 8-10. The set duration is about 35-40 minutes. Rest intervals between a series of sets are 24 hours. The main evaluation criterion is the magnitude of the stimulus (% of 1 RM).

and adjustment of a stressful stimulus rely on the use of various load mode combinations along with different energy supply mechanisms for muscular activity.

An important aspect of long-term rehabilitation is the selection of key components while developing re-adaptation exercise models. We proposed a non-standard variation of exercise model components compared to conventional physical therapy protocols due to hypokinesia caused by peripheral neuromuscular damage in servicemen. One component is a peculiar variety of using isolated (subtractive and basic), basic strength exercises, and special exercises for this category of military men. Creating individualized exercise combinations and a prioritized engagement algorithm directly influences the pace of re-adaptation processes. This algorithm is based on neuromuscular damage and the involvement of synergists, agonists, or stabilizer muscle groups. An important structural component in this process is a clear understanding of the necessity to apply an appropriate load regime based on the conditions and the body's adaptive reserves. Considering the ability to effectively apply load regimes of varying volumes and intensities under both anaerobic and aerobic energy supply mechanisms is essential.

Developing an optimal mechanism for adjusting class models to restore the functional capabilities of servicemen with prolonged hypodynamia requires processing much physiological and biochemical data collected during rehabilitation. The effectiveness of the correction process relies on the timely adjustment of the variability in using isolated or basic exercises to prioritize the activation of the relevant muscle groups. Modifying the kinematic characteristics of performing technique and load parameters effectively impacts the en-

ergy supply system.

Table 1 presents experimental models of classes for functional readaptation offered to servicemen of special units with prolonged hypodynamia caused by damage to the neuromuscular system.

Each experimental class model for functional readaptation is based on key components. These components include a series of physical exercises, load regimes, mechanisms of muscle activity energy supply, and load periodization.

A comparative analysis of the sets of physical exercises used in the presented models reveals a notable difference. Model 1 contains mainly basic power fitness free-weight exercises, exercises with dumbbells, and exercises involving resistance from another person. The key feature of implementing such exercises is the simultaneous activation of muscle groups of agonists, synergists, and stabilizers. This strategy enables the execution of the exercise even with only a 30% recovery of the agonists after prior rehabilitation periods, thanks to the increased activity of the synergists and stabilizers (Potop et al., 2023). However, prolonged use of only basic exercises in rehabilitation will lead to hypertrophy of mainly synergist and stabilizer muscle groups (Chernozub et al., 2023). These changes will only complicate the readaptation of damaged agonist muscle groups by reducing their activity during loads. Model 2 offers the option of using isolated exercises to sequentially engage primarily synergist, stabilizer, and partially agonist muscle groups, which may address this issue. Specifically, implementing a combined set of special isolated strength fitness exercises and MMA is crucial for the readaptation of damaged muscle groups in special unit servicemen.

The effectiveness of applying the developed exercise sets for each experimental class model relies on the balance between the combination of load modes and energy supply mechanisms. Under the conditions of using basic exercises, it was suggested to apply a high-volume, low-intensity load mode within anaerobic glycolysis conditions. This combination was chosen due to the low level of adaptation reserves in the study participants and their limited resistance to stress stimuli. It was assumed that performing isolated exercises with a low-volume, high-intensity load mode, under the creatine phosphokinase energy supply mechanism, would positively impact the readaptation processes. Considering the specific features of the developed training class models for the readaptation of servicemen's functional capabilities, classic power fitness options for load periodization were proposed.

Figures 2 and 3 visually display changes in the spectral indicators of heart rate in the participants of the examined groups using the proposed training models for readapting functional capabilities. The 70-day study was conducted during the long-term rehabilitation of special unit servicemen following prolonged physical hypodynamia caused by damage to the neuromuscular system.

An analysis of the results shown in Figure 2 indicates that the initial spectral indicators (LF and HF) of the participants did not reveal any intergroup differences. This suggests that the servicemen in the examined groups had an identical initial heart rhythm regulation tension at rest. However, in response to the test load, a reduction in the influence of autonomic regulation was observed in participants across all three groups, with HF decreasing by an average of 7.8%. At the same time, a decrease in sympathetic tone was also observed in examined group 2, with LF decreasing by 9.9% in response to the stressful stimulus. In the servicemen of group 1, an increase in the low-frequency spectrum of the heart rhythm power (LF +3.1%) was detected after the test load.

The results obtained after 70 days of using the proposed class models for readapting functional capabilities during long-term rehabilitation revealed the following findings. In a resting state, the heart rhythm regulation tension in group 1 remained unchanged after using standard training protocols in rehabilitation. At the same time, an increase in the activation of the parasympathetic branch of the autonomic nervous system was observed in servicemen of groups 2 (HF +9.4%) and 3 (HF +23.3%). A decrease in sympathetic tone was observed after an extended period of using the experimental models, with representatives of group 2 showing a reduction of LF by 4.1% and group 3 – by 15.7%. This finding indicates an increase in vagal influence on the sinus node during the readaptation of functional capabilities, particularly among group 3.

The results of the spectral indices LF and HF obtained at the end of the study, in response to the test load, showed opposing changes. Servicemen in group 1 increased their sympathetic tone (LF +4.7%) in response to the test load, while the influence of autonomic regulation decreased (HF -7.6%). Representatives of the other two groups showed different changes in the studied HRV indices in response to the stressful stimulus. An increase in parasympathetic activity was observed in the participants of groups 2 (HF +13.7%) and 3 (HF +10.2%). A decrease in sympathetic tone after exercise was noted in representatives of groups 2 (LF -11.5%) and 3 (LF -14.2%).

Analysis of the results presented in Figure 3 shows that initial vegetative balance in representatives of all groups shifted towards sympathetic regulation. The obtained results indicate high tension in heart rate regulation at rest, which may

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

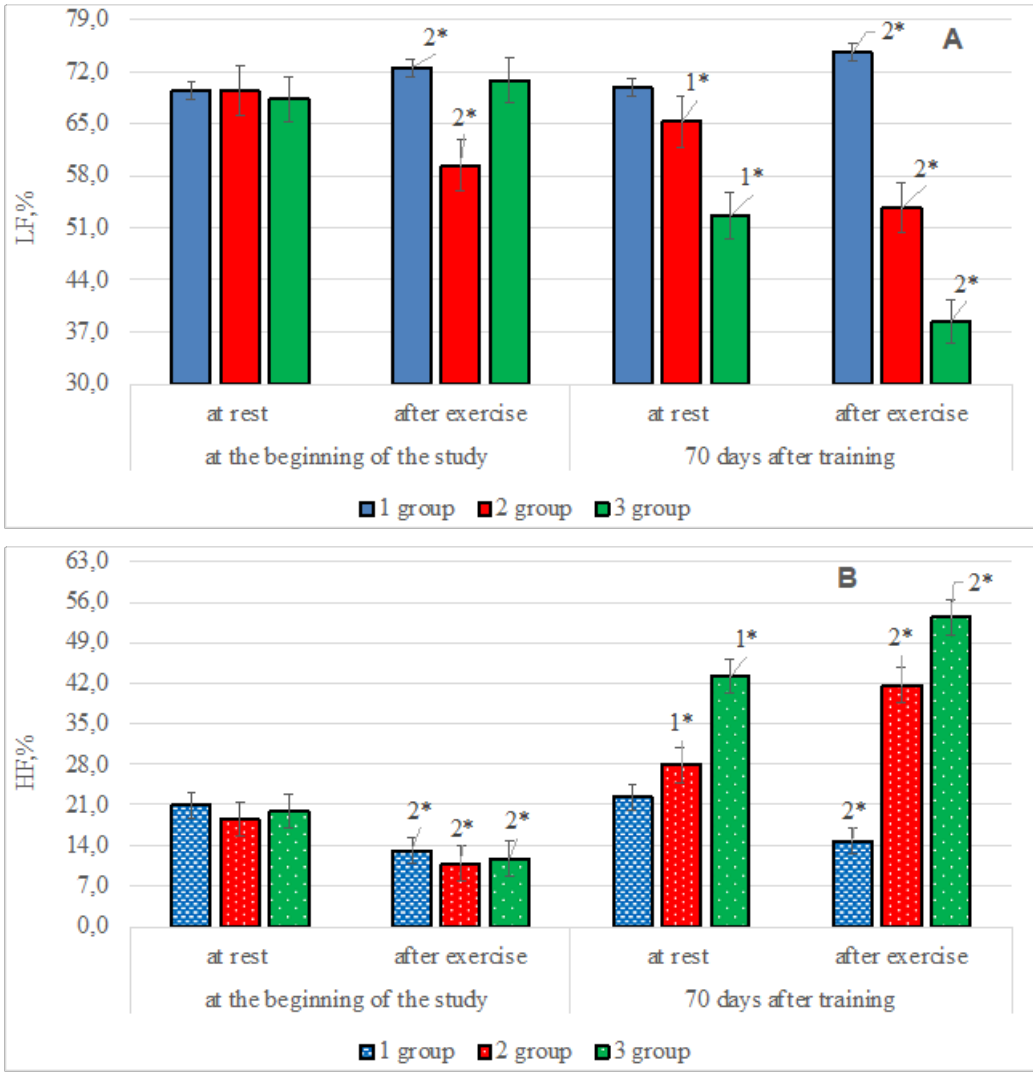

Fig. 2. Results of changes in spectral heart rate indices LF (A) and HF (B) of the examined servicemen during long-term rehabilitation in response to test loads, n=30.

Note: 1 – p<0.05 compared to the indices at the beginning of the study in a state of rest; 2* – p<0.05 compared to the indices before the load.*

be a consequence of prolonged hypodynamia. In response to the test load, an increase in the LF/HF index parameters was observed among participants in all groups, indicating the activation of the humoral and sympathetic regulatory mechanisms (Korobeinikova et al., 2024). Group 2 servicemen showed the greatest increase in the central circuit of sinus rhythm regulation (VLF +17.6%) to a stressful stimulus.

After using the proposed models of re-adaptation exercises there was a varied change in the indicators of vegetative balance and the activity of the central circuit. The initial (at rest) parameters of the HRV indicators in group 1 servicemen did not change after 70 days of using standard rehabilitation protocols. The vegetative balance (LF/HF) decreased in servicemen of group 2 (-37.7%) and 3 (-64.5%). These changes indicate a balance between the mechanisms of vagal and sympathetic tone during the re-adaptation of functional capabilities, particularly in representatives of group 3. After using the proposed class models during rehabilitation, group 1 servicemen had the highest level of tension in heart rhythm regulation.

At the end of the study, group 1 servicemen shifted the autonomic balance towards sympathetic regulation in response to the test load. Representatives of this group also showed an increase in the central circuit of sinus rhythm regulation (VLF +2.9%) in response to the stimulus. In servicemen of the other two groups, a shift in the autonomic balance towards parasympathetic regulation was observed in response to the test load. The most pronounced implementation of short-term adaptation and an increase in the level of resistance to loads was recorded in servicemen of group 3.

Discussion

The results presented in this study highlight

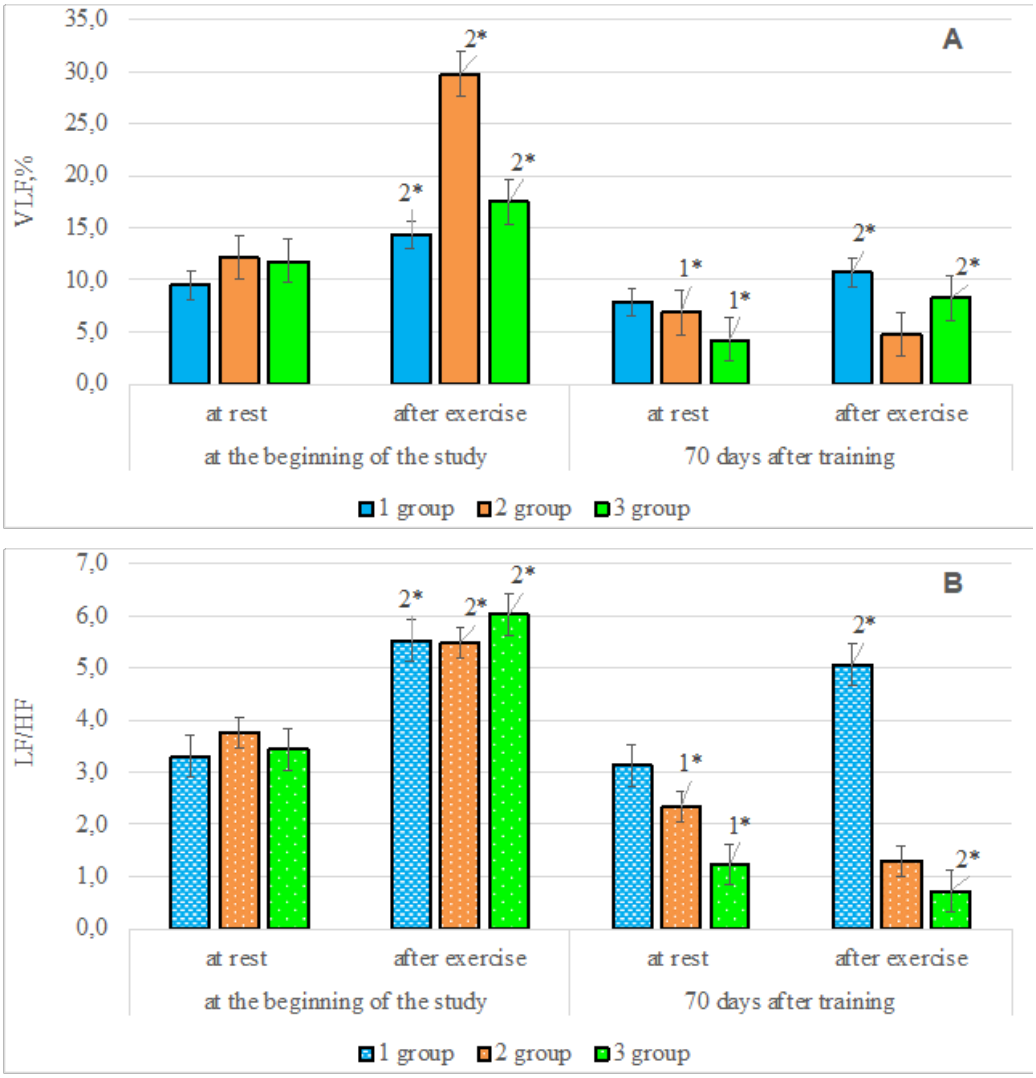

Fig. 3. Results of changes in spectral heart rate indices VLF (A) and LF/HF (B) of the examined servicemen during long-term rehabilitation in response to test loads, n=30.

Note: 1 – p<0.05 compared to the indices at the beginning of the study at rest; 2* – p<0.05 compared to the indices before the load.*

one possible solution to the problem of readaptation for servicemen who sustained neuromuscular system damage due to mine-explosive injuries. We examined the mechanisms of readaptation of functional capabilities during long-term rehabilitation, with the primary challenge being the development of hypokinesia resulting from prolonged hypodynamia (Chernozub et al., 2024; Uphill et al., 2025). A system for the readaptation of functional capabilities in special unit servicemen with hypokinesia, caused by damage to the peripheral parts of the neuromuscular system during long-term rehabilitation, was developed. A key issue in the research was determining the optimal class models for readaptation, considering the high previous level of resistance to loads in special unit servicemen. There is a lack of scientific studies evaluating the effectiveness of standard physical therapy protocols during the long-term rehabilitation of this category of servicemen (Collins et al., 2018; McFadden et al., 2024). Most scientists (Gancitano et al., 2021; Vine et al., 2024) in physical rehabilitation primarily focus on studying issues related to enhancing recovery processes during the acute period. At the same time, ongoing debates among scientists persist regarding the effectiveness of most physical rehabilitation protocols and the existing mechanisms for their adjustment (McFadden et al., 2024). The key issue is identifying informative indicators in rehabilitation to assess the effectiveness of readaptation of functional capabilities, particularly in special unit servicemen (Collins et al., 2018, Olkhovyi et al., 2020).

The results indicate that using standard physical therapy protocols during the long-term rehabilitation of military personnel is ineffective in the readaptation of functional capabilities. Despite their high resistance level, special unit servicemen lack the repeated restoration of adaptive re-

serves. However, using experimental class models during this rehabilitation helps balance the vagal and sympathetic tone mechanisms. The level of resistance to loads increased, indicating the effectiveness of readaptation of functional capabilities following prolonged hypodynamia (Chernozub et al., 2023). The results introduce a new approach for implementing the readaptation system for special unit servicemen, focusing primarily on functional capabilities during long-term rehabilitation. The identified data will improve the control system for restoring adaptive reserves in this contingent during long-term rehabilitation using the HRV method.

All study participants exhibited high tension in heart rhythm regulation following the previous rehabilitation periods. In response to the test loads, sympathetic regulation activity increased, and the central mechanism of sinus rhythm regulation was strengthened in special unit servicemen. These changes suggest the manifestation of compensatory reactions and low body resistance to stressful stimuli (Potop et al., 2024). This indicates low body adaptive reserves in special unit servicemen, negatively impacting the effectiveness of using functional capabilities under necessary conditions (Biggs et al., 2019; Conkright et al., 2020). The issue arises from the fact that, in developing training protocols, physical therapy specialists primarily focus on creating combinations of physical exercises (Gancitano et al., 2021; Korobeinikova et al., 2024). However, this category of researchers tends to overlook the optimization of load regimes in combination with energy supply mechanisms, depending on the level of adaptive reserves.

The HRV indicators studied in the group of servicemen after 70 days of using standard protocols during long-term rehabilitation showed no change. In response to the test load, the vegetative balance shifted towards sympathetic regulation, indicated by the weakening of the high-frequency spectrum of heart rhythm power. These HRV changes during long-term rehabilitation lack readaptation of functional capabilities in special unit servicemen (Vine et al., 2024). The vagal influence on the sinus node was enhanced in the other two groups that used experimental training models. The results after the test load show a shift in the vegetative balance towards parasympathetic regulation, indicating the activation of short-term adaptation processes (Chernozub et al., 2024). The most pronounced readaptation of functional capabilities was observed in the group of servicemen who used isolated exercises combined with high-intensity loads under creatine phosphokinase energy supply. Sequential engaging muscle groups of synergists, stabilizers, and partial agonists in isolated exercises enables selective muscle fatigue without disrupting adaptation (Uphill et al., 2025). These actions focus on maximizing the involvement of synergist muscle groups with minimal load on damaged agonists, without engaging stabilizers. The long-term implementation of such a mechanism in readaptation will enhance adaptive reserves and promote selective hypertrophy of damaged muscle groups (Potop et al., 2023). Combining isolated strength exercises with special MMA exercises is crucial during the long-term rehabilitation of special unit servicemen.

Conclusions

The results confirm the efficiency of the proposed system for restoring the functional capabilities of special unit servicemen experiencing hypokinesia caused by peripheral neuromuscular system damage during long-term rehabilitation. The use of standard physical therapy protocols during long-term rehabilitation of servicemen of this category is ineffective in the readaptation of functional capabilities. The study showed that combining isolated exercises with high-intensity loads under creatine phosphokinase energy supply was effective. The proposed mechanism, which maximizes the involvement of synergist muscle groups with minimal load on damaged agonists and no additional activity of stabilizers, enabled selective muscle fatigue without disrupting adaptation. Implementing this combined mechanism of isolated fitness and MMA exercises effectively influences the readaptation processes of special forces servicemen during long-term rehabilitation. The results obtained will help address the challenge of finding an effective rehabilitation mechanism for servicemen who sustained neuromuscular system damage from mine and explosive injuries.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).02

Conflict of interest
The authors declare that there is no conflict of interest.

Funding Statement
This article did not receive financial support from the state, public or commercial organizations.

Received: January 07, 2025; Accepted: January 22, 2025
Published: February 28, 2025

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ISSN (print) 2522-1906, ISSN (online) 2522-1914
FIZICNA REABILITACIA TA REKREACIJNO-OZDOROVCI TEHNOLOGII
Vol. 10 No. 1, 2025

Original Scientific Article DOI: 10.15391/prrht.2025-10(1).03

Evaluation of the effectiveness of a corrective and rehabilitation program using gravity postisometric relaxation exercises, self-massage and myofascial release on the biogeometric profile of posture and cardiovascular system parameters of women of the second period of mature age

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Abstract

Purpose. To scientifically substantiate, develop and experimentally verify the impact of a correctional and rehabilitation program using gravitational postisometric relaxation exercises, self-massage and myofascial release on the state of the biogeometric profile of posture and parameters of the cardiovascular system of women in the second period of adulthood.

Material & Methods. The 'School of Women's Health' was organized. The total number of 79 people were women aged 36-45 years. The study involved two groups of women with complaints of chronic pain in the cervical spine and fluctuations in the parameters of the cardiovascular system: A group of women aged 36-40 years (n=16) and women aged 41-45 years (n=15). Study procedure: heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured. Posture examination was performed in the frontal and sagittal planes using the REEDCO posture scale. Measurement of the depth of the physiological cervical bend (cervical point) was performed according to the method of Z.P. Kovalkova. With correct posture, the depth of the cervical spine curve is within 5-5.5 cm. Statistical data processing was performed using the statistical package STATISTICA 13.0 (StatSoft).

Results. A correctional and rehabilitation programme was developed for the subjects of the 'School of Women's Health', which consisted of three blocks: means of physical culture and sports rehabilitation, psychocorrection, and educational part. In the first block, it was proposed to perform isometric gymnastic exercises aimed at relaxing and strengthening the neck muscles; myofascial release using a massage roll. The aim of the educational component of the programme was to teach women how to perform self-massage of the neck on their own. The research and work on the correctional and rehabilitation programme lasted 3 months. The women spent 21 days in the School of Women's Health under the supervision of a rehabilitation specialist. Subsequently, the women worked independently under the programme, contacting the rehabilitation specialist through online communication in Viber, WhatsApp and Telegram messengers. During the initial communication, all the women complained of recurrent headaches, dizziness, palpitations, and high blood pressure. The results of the formative experiment showed a significant improvement in all parameters of the cardiovascular system ($p<0.05$). After the implementation of the correctional and rehabilitation programme, the scores on the REEDCO posture scale statistically significantly increased in women aged 36-40 years by 1.04 times ($p<0.05$), and in women aged 41-45 years by 1.12 times ($p<0.05$). The introduction of myofascial release into the correctional and rehabilitation programme in women of the second period of mature age had a positive effect on changes in the cervical spine: the depth of spinal curvature according to the method of Z.P. Kovalkova in women aged 36-40 years statistically significantly increased by 1.12 times

(p<0.05), in women aged 41-45 years by 1.29 times (p<0.05).

Conclusions. Training in the 'School of Women's Health' according to the developed correctional and rehabilitation programme had a positive effect on the parameters of the cardiovascular system, namely, normalization of heart rate, blood pressure, and blood pressure. The use of gravitational post-isometric relaxation, self-massage of the cervical spine, myofascial release significantly improved the biogeometric profile according to the REEDCO posture scale, positively influenced the change in the depth of spinal curvature according to the method of Z.P. Kovalkova.

Keywords: biogeometric profile of posture, arterial hypertension, post-isometric relaxation, self-massage, myofascial release.

Introduction

Due to the urbanisation of the population, the prevalence of chronic back pain, in most cases in the cervical region, and/or arterial hypertension is increasing worldwide. Back in the twentieth century, such problems were most often diagnosed in the elderly, but today they are much younger (Peng et al., 2015; Luhova et al., 2021; Kovalyova et al., 2022; Samoiliuk et al., 2024).

The presence of changes in the biogeometric profile in women in the second period of adulthood provokes the development of arterial hypertension. There is a relationship between the two problems: blood pressure levels depend on the presence and severity of degenerative changes. Insufficient mobility in the joints of the cervical spine leads to headaches, dizziness, and high blood pressure. Due to degenerative changes in the vertebrae, the spinal arteries are compressed, which in turn leads to an increase in pressure; due to the compression of the vertebral vessels, their walls are constantly in tone, which leads to oxygen deprivation, resulting in the development of hypertension (Bruehl et al., 2005; Altaraqji et al., 2020; Ruban et al., 2021).

Peng et al. (2015) hypothesised that vertebral artery insufficiency due to cervical spondylosis may lead to dizziness. However, the mechanisms of dizziness caused by cervical spondylosis are not fully understood. One of the reasons is a decrease in vertebral artery blood flow during head rotation and hyperextension. The second reason indicates that hypertension may be associated with cervical spondylosis as a secondary disease. Due to the fact that degenerative discs are always inflammatory discs, that is, degeneration is always accompanied by pain. Blood pressure levels, even at rest, can be elevated with persistent pain in the cervical spine (Peng et al., 2015).

A retrospective study by Bruehl et al. (2005) showed that chronic pain may be associated with an increased risk of developing hypertension. The authors proved that in patients with chronic spinal pain, over time, a higher prevalence of clinically diagnosed hypertension will result in a higher prevalence of hypertension compared to patients without pain (Bruehl et al., 2005). Our study suggests a possible link between reduced spinal curvature in the cervical spine and hypertension. If chronic pain in the cervical spine is reduced by decreasing spinal curvature, it can lead to hypertension due to sympathetic arousal and failure of normal homeostatic mechanisms of pain regulation. At the same time, early rehabilitation intervention followed by post-isometric relaxation exercises (Honcharov et al., 2020) and independent performance of myofascial release techniques can have a beneficial effect on restoring spinal curvature in the cervical spine and reducing the risk of developing hypertension in women of the second period of adulthood.

A generalized analysis of the scientific literature shows that, despite the close attention of specialists to the comorbidity of chronic spinal pain with arterial hypertension, the issue of correction of biogeometric posture profile disorders in women of the second period of adulthood with recurrent high blood pressure is not covered.

Purpose – to scientifically substantiate, develop and experimentally test the effect of a correctional and preventive programme using gravitational post-isometric relaxation exercises, self-massage and myofascial release on the state of the biogeometric posture profile and parameters of cardiovascular system assessment in women of the second period of mature age.

Material and methods

Participants

The 'School of Women's Health' was organized based on the State Enterprise 'Clinical Sanatorium "Roshcha" of the Ukrprofozdorovnytsia. The total number of participants was 79 women aged 36-45 years. The study involved two groups of women with complaints of chronic pain in the cervical spine and fluctuations in cardiovascular parameters: A group of women aged 36-40 years (n=16) and a group of women aged 41-45 years (n=15). The study was conducted in compliance with all relevant national regulations and institutional policies, the principles of the Declaration of Helsinki adopted by the General Assembly of

the World Medical Association (1964-2000), the Council of Europe Convention on Human Rights and Biomedicine (1997).

Procedure

Study procedure: heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured. Posture examination was performed in the frontal and sagittal planes using the REEDCO posture scale. The scale consists of 10 items, according to which posture must be assessed from 0 to 10 points for each item. The total score on the REEDCO posture scale ranges from 0 to 100 points. The higher the score, the better the posture (Ruban et al., 2021).

Measurement of the depth of the physiological cervical bend (cervical point) was performed according to the method of Z.P. Kovalkova. With correct posture, the depth of the cervical spine curve is in the range of 5-5.5 cm (Ruban et al., 2021).

Statistical analysis

Statistical data processing was performed using the statistical package STATISTICA 13.0 (StatSoft). The arithmetic mean – X; standard deviation – δ; variance – D; error of the arithmetic mean – ±m. To determine significant differences, the parametric Student's test was used; differences at $p<0.05$ were considered statistically significant.

Results

A correctional and rehabilitation programme was developed for the subjects of the 'School of Women's Health', which consisted of three blocks: means of physical culture and sports rehabilitation, psychocorrection, and educational part. In the first block, it was proposed to perform isometric gymnastic exercises aimed at relaxing and strengthening the neck muscles; myofascial release using a massage roll. The educational component of the programme aimed to teach women how to perform self-massage of the neck on their own.

The research and work on the correctional and rehabilitation programme lasted 3 months. The women spent 21 days in the School of Women's Health under the supervision of a rehabilitation specialist. Later, the women worked independently under the programme, and kept in touch with the rehabilitation specialist through online communication in Viber, WhatsApp and Telegram messengers.

Neck self-massage technique: sitting on the edge of a chair, back straight. *Gravitational post-isometric relaxation (GPR)* of the neck muscles. Starting position – sitting on a chair, torso slightly forward, head down and in a state of extension. Take a deep breath to the count of 1-4, relax the neck muscles as much as possible. Slowly exhale through the lips, which are closed for a count of 5-12. A sign of correct performance of this exercise is a noticeable increase in the forward tilt of the head. The number of repetitions is no more than 3-4 times.

Self-massage of the neck. The starting position is sitting on a chair, resting your back against the back of the chair, head back by 200. Using the pads of the fingers of both hands, knead the paravertebral muscles simultaneously on both sides of the spinous processes in a circular and spiral motion. Next, rub the attachment points of the cervical muscle tendons on the base of the back of the head with the thumbs, working out the occipital tubercles in a circular motion, for 5-7 minutes.

Myofascial release was performed using a manual massage roll. Starting position – standing or sitting on a chair, head tilted forward, neck muscles relaxed as much as possible, all muscle tissues tensioned along the posterior surface under the weight of the head. With both hands, we hold the massage roll by the handles, which makes it possible to lower the roll as low as possible. Alternately roll the massage roll over the neck muscles on both sides, 15-20 times. Next, use the massage roll to work out the attachment points of the neck muscle tendons along the entire length of the base of the back of the head, for 3-5 minutes (Fig. 1).

At the end of the *self-massage procedure, the stretching of subcutaneous tensions* was performed by pulling the skin on the surface of the back of the head. Grasp the hair with the fingers of both hands and make a fist. Then, without releasing the hair, perform 3-4 circular movements in both directions. A sign that this exercise has been performed correctly is a feeling of warmth in the back of the head.

After the exercises and self-massage, the women wore the Chance collar for 1-2 hours, which helps to maintain the effect of the exercises and massage.

During the initial interview, all women complained of recurrent headaches, dizziness, palpitations, and an increase in blood pressure up to 135-140/85-90 mmHg (Table 1).

After the implementation of the correctional and rehabilitation programme, a formative experiment was conducted. Women of both groups had no complaints of headaches and high blood pressure. Thus, in women aged 36-40 years, the heart rate parameter tended to decrease significantly ($p>0.05$); the BPc parameter statistically significantly decreased by 0.93 times ($p<0.05$) compared to the initial one; the BPd parameter statistically significantly decreased by 0.93 times ($p<0.05$) compared to the initial one. Women aged 41-45 years showed statistically significant

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Fig. 1. An example of the myofascial release technique.

Table 1. Features of cardiovascular system parameters in women aged 36-40 years (n=16) and women aged 41-45 years (n=15)

CVS parameters	Women aged 36-40 (n=36)		Women aged 41-45 (n=43)	
	before the programme X±m	after the programme X±m	before the programme X±m	after the programme X±m
Heart rate, post. per min	73,18±1,74	69,68±0,97	74,46±1,59	69,93±1,01
	t=1,76; p>0,05		t=2,40; p<0,05	
SBP, mmHg	131,31±1,22	122,51±1,37	134,33±1,48	122,66±1,45
	t=4,80; p<0,05		t=5,63; p<0,05	
SBP, mmHg	76,87±1,57	72,18±1,01	79,33±1,45	72,06±1,06
	t=2,51; p<0,05		t=4,05; p<0,05	

improvement in all parameters: Heart rate decreased by 0.94 times (p<0.05); BPc decreased by 0.91 times (p<0.05); and DBP decreased by 0.90 times (p<0.05).

In women of both groups of the second period of mature age, after three months of work under the correctional and rehabilitation programme, there were observed changes in the biogeometric profile according to the REEDCO posture scale. Thus, in women aged 36-40 years, the primary indicators were within 78.06±1.34 points out of 100 points according to the norm. In the initial measurements, the indicators of the biogeometric profile in women aged 41-45 years were 72.87±1.05 points. That is, it can be argued that negative changes in posture occur over the years. The results of the formative experiment indicated a positive impact of the programme on women's posture (Fig. 2).

After the implementation of the correctional and rehabilitation programme, the REEDCO posture scale scores statistically significantly increased in women aged 36-40 years by 1.04 times (p<0.05), in women aged 41-45 years by 1.12 times (p<0.05).

With correct posture, the depth of spinal curves in the cervical spine is within 5-5.5 cm. In women of the second period of adulthood, the variation in the cervical spine ranged from 3 cm to 4 cm. That is, according to the method of Z.P. Kovalkova, a tendency to straighten physiological lordosis in the cervical spine was observed. Reducing the curvature of the spine in the cervical spine reduces the shock absorption capacity and provokes fluctuations in blood pressure. The introduction of myofascial release into the correctional and rehabilitation programme in women of the second period of mature age had a posi-

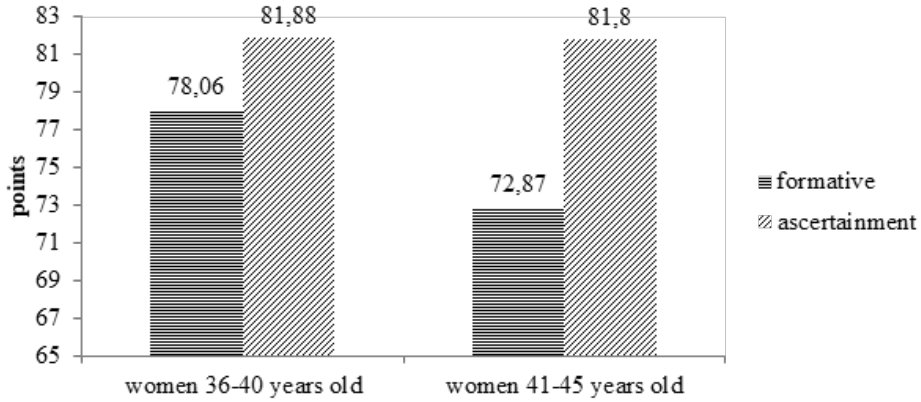

Fig. 2. Changes in the biogeometric profile of posture according to the REEDCO scale in women aged 36-40 years and women aged 41-45 years under the influence of a correctional and rehabilitation programme.

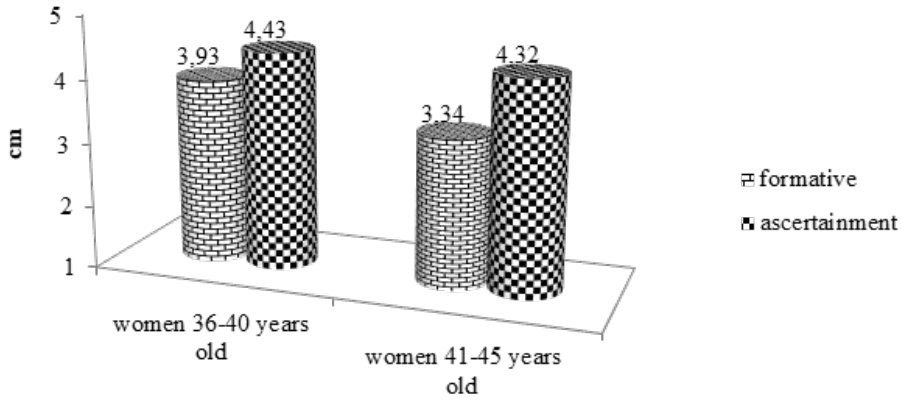

Fig. 3. Changes in the depth of spinal curvature according to the method of Z.P. Kovalkova in women aged 36-40 years and women aged 41-45 years under the influence of a correctional and rehabilitation programme.

tive effect on changes in the cervical spine: the depth of spinal curvature according to the method of Z.P. Kovalkova in women aged 36-40 years statistically significantly increased by 1.12 times ($p<0.05$), in women aged 41-45 years by 1.29 times ($p<0.05$) (Fig. 3).

Discussion

Chronic spinal pain is a progressive disease with periods of remission and exacerbations, which causes severe neurological and orthopaedic disorders. Luhova & Tymchyk (2021) note that the problem is particularly relevant, according to medical statistics, about 50% of the population has pathology in the cervical spine. It is believed that physical rehabilitation methods can increase the effectiveness of basic drug therapy, including isometric exercises, post-isometric muscle relaxation, proprioceptive neuromuscular perception, postural exercises and special massage. We support the authors' opinion that the development of wellness programmes correlates with the diagnosis of spinal biomechanics, understanding of the main means and methods of rehabilitation for cervical osteochondrosis.

A literature review by Kovaleva et al. (2022) systematised the available information on the etiology and pathogenesis of fibromyalgia, as well as the classification and causes of hypertension, and considered possible links between these two pathologies. The authors identified the main areas of fibromyalgia research and evaluated further prospective studies of the relationship between fibromyalgia and hypertension.

Ruban (2021) noted that one of the most important conditions for postural disorders is relative muscle weakness in some parts of the musculoskeletal system, which manifests itself as a result of heavy loads. The results of our study confirmed previous research.

Based on their's study's results, Hulens et al. (2018) discussed possible pathophysiological links between idiopathic intracranial hypertension, fibromyalgia, and chronic fatigue syndrome. Our study's results of support the hypothesis (Altaraqji et al., 2020) that chronic headache in fibromyalgia may be a manifestation of idiopathic intracranial hypertension.

Kashuba et al. (2019) found that with age there is an increase in the number of postural

disorders in men of the first period of adulthood. Timely detection and differentiation of changes in the spatial organisation of the human body will allow to plan corrective and preventive health measures. To this end, it is necessary to conduct an express assessment of the musculoskeletal system by indicators of the state of the biogeometric profile of posture in the frontal and sagittal planes, as well as by the indicator of the generalized total assessment of its biogeometric profile.

Samoiliuk et al. (2024) found that the most common type of posture among women in the first period of adulthood is the round back type, which is found in 44.4% of women, while normal posture and scoliotic posture occur with the same frequency of 27.8% each. To summarise, normal posture was found to be associated with health-promoting habits in women in the first period of adulthood. Impaired posture, regardless of the type of impairment, was marked by a lower frequency of morning gymnastic exercises and a lower habit of doing gymnastics between work. When it comes to the motives for health fitness classes, according to the data from the total sample, the most important for women was health improvement with an average ranked value of 1.44. It was in the first place for 72.2% of the respondents. Aesthetic appearance was also an important motivator, with an average rank of 1.97, and 22.2% of women considered it the main fitness's goal.

Honcharov et al. (2020) concluded that one of the tasks of kinesiotherapy in the training motor regime is to facilitate the functional recovery of patients with chronic back pain. The main means of kinesiotherapy is exercise. When selecting physical exercises, it should be borne in mind that they should not only improve blood and lymph circulation in the spinal segment, but also reduce the emotional stress of athletes with chronic pain. The use of post-isometric relaxation is the main feature of relieving paravertebral muscle tension in vertebrogenic reflex syndromes. The results of our study confirmed the conclusions of the authors regarding the use of gravitational post-isometric relaxation.

Conclusions

The study suggests that women in the second period of adulthood have changes in the biogeometric profile of posture and fluctuations in the parameters of the cardiovascular system. Classes at the 'School of Women's Health' according to the developed correctional and rehabilitation programme had a positive effect on the parameters of the cardiovascular system, namely, normalisation of heart rate, blood pressure, and blood pressure. The use of gravitational post-isometric relaxation, self-massage of the cervical spine, myofascial release significantly improved the biogeometric profile according to the REEDCO posture scale: statistically significant increase in women aged 36-40 years by 1.04 times ($p<0.05$), in women aged 41-45 years by 1.12 times ($p<0.05$). The change was also positively influenced by the depth of spinal curvature according to the method of Z.P. Kovalkova, namely, in women aged 36-40 years it statistically significantly increased by 1.12 times ($p<0.05$), in women aged 41-45 years by 1.29 times ($p<0.05$).

Prospects for further research are related to the study of the impact of the correctional and rehabilitation programme on the adaptive potential of the subjects of the 'School of Women's Health'.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).03

Conflict of interest
The authors declare that there is no conflict of interest.

Funding Statement
This article did not receive financial support from the state, public or commercial organizations.

Received: January 12, 2025; Accepted: February 15, 2025
Published: February 28, 2025

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Conceptualization, V.K. and L.R.; methodology, L.R. and P.Y.; software, O.K.; check, L.R. and P.Y.; formal analysis, V.K.; investigation, O.G.; resources, O.K.; data curation, O.K; writing - rough preparation, O.G.; writing - review and editing, V.K. and L.R.; visualization, O.G.; supervision, L.R.; project administration, L.R. All authors have read and agreed with the published version of the manuscript.

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Original Scientific Article DOI: 10.15391/prrht.2025-10(1).04

Justification of the role of rehabilitation assistance in lymphedema of the upper extremities based on foreign experience (a literature review)

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Abstract

Purpose. Lymphedema is a chronic condition of the lymphatic system that results from impaired lymphatic drainage. In adult practice, secondary lymphedema, which arises as a consequence of the treatment of oncological diseases, notably breast cancer, is predominant. One of the most common types is upper limb lymphedema. This condition is characterized by swelling, a sensation of heaviness in the limb, pain, and limited range of motion. According to various statistics, regardless of the chosen treatment methods, edema develops in 10% to 80% of breast cancer patients. The issue of timely rehabilitation for patients with lymphatic edema of the extremities remains relevant due to the widespread prevalence of this condition and its severe complications.

Material & Methods. General scientific: analysis, synthesis, generalization. The search was conducted in electronic databases PubMed/MedLine, PEDRo, International Clinical Trials Registry Platform, Cochrane Library.

Results. The rehabilitation program for lymphedema was developed quite a long time ago, and today there are many rehabilitation methods. However, discussions about the main components of oncological rehabilitation are still ongoing. Clinical studies from different countries of the world were included in the review. A total of 10 completed studies and one ongoing study were analyzed. The most points on the PEDRo scale were obtained by studies related to physical exercises and various elements of complex therapy. Two studies scored an overall score of 8 out of 10, five studies scored 7 out of 10, and the other studies scored 6, 5, and 4, respectively.

Conclusion. In recent years, the number of studies on the topic of lymphedema is increasing. New and established rehabilitation methods are being tested in research. There is a tendency to use only proven and effective means and methods of rehabilitation.

Keywords: lymphedema, physical exercises, manual lymphatic drainage, bandaging.

Introduction

Lymphedema is a chronic disorder of lymph circulation within lymphatic vessels due to their damage. Lymphatic load exceeding its transport capacity is the cause of lymphedema (Lawenda et al., 2009). According to the codes of the International Classification of Diseases, lymphedema belongs to the following sections: Other non-infectious diseases of lymphatic vessels and lymph nodes (189.0 – lymphedema, not classified elsewhere; lymphangiectasia), Postmastectomy lymphedema syndrome. Elephantiasis. Oblitera-

tion of lymphatic vessels caused by mastectomy (197.2), and Hereditary lymphedema or congenital lymphedema (Q82.0) (ICD-10). The chronic course of the disease leads to progressive swelling, which, in turn, reduces healthy blood flow to tissues, hinders wound healing, and increases the risk of tissue infection (Lawenda et al., 2009).

Lymphedema is considered incurable, so the only physiological way to reduce swelling is by removing excess plasma proteins from tissues through the lymphatic vessels. E. Vodder developed a method of manual lymphatic drainage, later validated by J. Asdonk, who determined the indications and contraindications for this technique. The next step was the integration of manual lymphatic drainage, physical exercises, skin care, and limb bandaging into a comprehensive anti-edema physical therapy program developed by M. Földi. Specialized centers for the treatment of lymphedema first emerged in Europe and then spread to the United States and Canada. Over the years, researchers and scientists such as J. Asdonk, M. Földi, A. Gregl, E. Kuhnke, S. Kubik, J. Casley-Smith, E. Vodder, A. Leduc, and others have made invaluable contributions to the search for and development of methods and treatments for lymphedema (Lee, 2008; Norton & Zuther, 2012; Morgan, 2008).

As part of the American Lymphedema Framework Project, a survey of professionals working with patients suffering from lymphedema was conducted. Physical therapists reported that in 80% of cases, secondary lymphedema was the reason for patients seeking their care. The majority of respondents were physical therapists and occupational therapists who indicated that they use complex decongestive therapy (CDT) (Anderson et al., 2019). This is a type of intervention aimed at reducing swelling. According to a review of the literature, the most commonly used approach is comprehensive decongestive therapy, also known as combined physical therapy or comprehensive anti-inflammatory physical therapy. Research demonstrates the effectiveness and success of this therapy. In European countries, this therapy has been applied since the 1970s, and in the United States, since the 1980s. Another form of rehabilitation intervention for lymphedema is complex anti-edema therapy (CAET). It involves a two-stage or two-phase intervention program. CAET includes manual lymphatic drainage, bandaging, physical exercises, skin care, compression garments, and self-management programs (Norton & Zuther, 2012; Morgan, 2008).

Regardless of the therapy's name, it consists of two distinct phases of intervention. The primary goal of the first, intensive phase is to reduce swelling, restore daily activities, and prevent infection. It is recommended to have five sessions per week throughout 3 to 4 to 6 weeks, but for maximum symptom relief, it may require 8 weeks or more. The second phase aims to optimize and maintain the results achieved in the first phase and, if possible, improve the dynamics of swelling reduction. Patients receive guidance on self-monitoring methods, skin care, compression therapy, self-massage, weight control, and the specifics of performing exercises for lymphedema. In the second phase, patients independently monitor their condition, and typically, after 6 to 9 months, a specialist evaluates the therapy and may adjust the program as needed (Morgan, 2008; Thiadens et al., 2010).

Oncological diseases are the most prevalent in the world, but the increased survival rates after cancer can be attributed to advanced technologies and the progress of medicine. Nevertheless, the proportion of patients experiencing complications after oncological diseases is steadily rising worldwide. This raises the question of what combination of physical therapy tools and methods is the most effective, as an optimal approach to organizing rehabilitation will lead to efficient resource allocation, reduce the economic burden, and improve the quality of life for patients (Muñoz-Alcaraz et al., 2020).

Purpose of the study is to analyze approaches to the rehabilitation of patients with lymphedema of the upper extremities through the analysis of evidence-based literature.

Material and methods

General scientific methods including analysis, synthesis, and generalization were employed. The search was conducted using keywords in reputable electronic databases, including PubMed/MedLine, PEDRo, the International Clinical Trials Registry Platform, and the Cochrane Library. The search results were limited to publications from 2017 to 2022. In the database, 349 scientific studies were found using the keywords. Out of these, 84 studies were analyzed. Ten studies that met the inclusion criteria were included in the analysis. Inclusion criteria for the review randomized clinical trials (RCT), quasi-randomized trials, crossover randomized controlled trials, pilot studies, and other clinical research with publications in the English language, focusing on the topic of upper extremity lymphedema and/or breast cancer-related lymphedema (unilateral and/or bilateral). Exclusion criteria involved studies related to the prevention of lymphedema or publications in languages other than English.

Results

The management of lymphedema differs worldwide (Anderson et al., 2019). Therefore,

Table 1. Evaluation of research according to the PEDRo scale

№	Author, year	EC*	1	2	3	4	5	6	7	8	9	10	In general
1	Ligabue M. et al., 2019	–	+	+	+	–	–	+	+	+	+	+	8/10
2	Kilbreath S. et al., 2020	+	+	+	+	–	–	+	+	+	+	+	8/10
3	Torres-Lacomba M. et al., 2020	+	+	+	+	–	–	+	+	–	+	+	7/10
4	Deacon R. et al., 2019	+	+	+	+	–	–	+	–	+	+	+	7/10
5	Omar M. et al., 2020	+	+	+	+	–	–	+	+	–	+	+	7/10
6	Sen E. et al., 2021	+	+	+	+	–	–	+	+	–	+	+	7/10
7	Tantawy S. et al., 2019	–	+	+	+	–	–	+	+	–	+	+	7/10
8	Forner-Cordero I. et al., 2021	+	+	–	+	–	–	+	+	–	+	+	6/10
9	Bahtiyarca Z. et al., 2019	–	+	–	+	–	–	+	–	–	+	+	5/10
10	Pasyar N. et al., 2019	–	+	–	+	–	–	+	–	–	+	+	5/10

** Eligibility criteria; 1 – Random allocation; 2 – Concealed allocation; 3 – Baseline comparability; 4 – Blind subjects; 5 – Blind therapists; 6 – Blind assessors; 7 – Adequate follow-up; 8 – Intention-to-treat analysis; 9 – Between-group comparisons; 10 – Point estimates and variability.*

clinical studies from various countries around the world were analyzed. The review included 10 completed studies and one ongoing study (Table 1). The quality of the studies was assessed using the PEDRo scale. During the analysis of the studies, factors considered included whether subjects were randomized into control and experimental groups and whether blinding of assessors occurred in the study. If the studies did not meet the specified criteria, their results were considered less reliable and subject to doubt (Guyatt et al., 1993). Such studies were not included in the review and were excluded during the analysis. Among the analyzed studies, two had an overall score of 8 out of 10, while the other studies received scores of 7, 6, 5, and 4, respectively.

In the study by Ligabue et al. (2019) intervention period 1 month. There were two intervention groups in the study EG[1] (manual lymphatic self-drainage + self-bandaging + physical exercises) and CG[2] (standard CDT care). In the experimental group, after 6 months, pain decreased by 70% from 4 to 2 on the pain scale. In the majority of patients in the experimental group (50%), the swelling decreased by 230 ml. Assessment methods include Numerical Pain Rating Scale (NPRS) and arm asymmetry (Excess Limb Volume (ELV).

In the study by Kilbreath S. et al. (2020) experimental group contained combined aerobic and resistance training program. The control group was without exercise. EG a significant reduction in symptom severity. Both groups had significant reductions in symptoms and physical performance by the end of the 12-week intervention period. Assessment methods include bioimpedance spectroscopy, Lymphedema Symptom Intensity and Distress Survey (LSIDS) questionnaire and EORTC BR23 questionnaire (European Organisation of Research and Treatment Collaboration Quality of Life Breast Cancer Module), and ultrasound.

All participants had the same intervention, except for the bandaging in the study by Torres-Lacomba M et al. (2020). After 3 weeks of study the most effective were simplified multilayer bandages (59.5%, IQR = 28.7) and cohesive bandages (46.3%, IQR = 39). In all groups, there was a reduction in the circumference. Assessment methods include volume of the limb measurement (perimeter), evaluation of the comfort of the dressing on a numerical scale from 0 to 10: 0 – comfortable, 10 – very uncomfortable.

Research Deacon R. et al. (2019) was ongoing from July 2014 to February 2016. There were two groups. Group 1 (low-speed aquatic exercise Ai Chi+diaphragmatic breathing+ymph node massage) and Group 2 (conventional aquatic exercise +lymph node massage, diaphragmatic breathing+ warm ups+ stretches+ small component of aerobic activities+cool down period). The results of the study were that 72% of Group 1 had a reduction in arm circumference immediately after the intervention compared to 28% of the Group 2. The volume of lymphedema decreased for Group 1 compared to Group 2 by 140 ml immediately after the intervention, but the difference was not maintained 1 hour after the intervention There were no differences between the groups in terms of bioimpedance. Assessment methods include arm volumetry, bio-impedance, and feedback form.

The study by Omar et al. (2020) was ongoing for 8 weeks (three times a week). No statistically significant changes in relative volume and DASH were observed. Assessment methods include limb Volume Measurement, symptoms of pain, severity and tension – visual analog scale (VAS), measurement of active shoulder range of motion (ROM), disabilities of the arm, shoulder, and hand (DASH) questionnaire, daily self-assessment (Adherence to Exercises and Compression Garment).

Methods research by Sen et al. (2021) includes circumference measurements, visual an-

1 experimental group
2 control group

alogue scale (VAS), Quick Disabilities of Arm, Shoulder, and Hand (Quick-DASH) questionnaire, Lymphoedema Functioning, Disability and Health questionnaire (Lymph-ICF). After 3 weeks excessive hand volume was reduced in both the Group 1 CDT[3] (compressive multilayer bandaging + exercise training + MLD[4]+ one-session educational program) (56.3%, p<0.001) and ST[5] (compression multilayer bandaging + exercise training + one-session educational program) (54.8%, p<0.001) groups. The VAS discomfort and severity scores showed better improvement in Group 1 (CDT) than in Group 2 (ST) (p=0.015 and p=0.014). However, there was no significant difference in post-intervention changes in VAS edema scores (p=0.074) between the groups. The Quick-DASH and Lymph-ICF scores were significantly reduced in the groups.

In the study by Tantawy et al. (2019) girth, SPADI scores, dynamometry and all aspects of quality of life were significantly improved in group 1 (kinesio taping + home exercise programme) at the end of the intervention (P<0.05) compared with group 2 (pressure garment + home exercise programme). The intervention period of the study 3 weeks.

There were several groups studied by Forner-Cordero et al. (2021): group 1 (manual lymphatic drainage + intermittent pneumatic compression + bandaging); group 2 (pneumatic lymphatic drainage with the Lymphapress Plus device + intermittent pneumatic compression + bandaging); group 3: (intermittent pneumatic compression + bandaging). Period of study 4 weeks. Reduction in circumference in all groups, one month after therapy, the results were maintained and no differences were found between the groups.

Research Bahtiyarca et al. (2019) intervention period 5-6 weeks. There were two groups in the study: CB[6] group (intensive phase of CDT: MLD, compression bandaging + information about lymphedema + skincare + physical exercises) and CB/SLD[7] group (intensive phase of CDT without MLD, including self-lymphatic drainage + compression bandaging information about lymphedema + skincare + physical exercises). The circumference in both groups achieved at the end of treatment did not change after 6 months. DASH Q scores (p<0.001) and SF-36 physical and mental subscale scores (p=0.004 and p<0.001) at the end of treatment and six months after treatment were significantly different from baseline in both groups. HADS scores did not differ significantly.

In the study by Pasyar et al. (2019) intervention period 8 weeks. At 4 weeks post-intervention, there was a significant difference between the intervention (yoga exercises + standard therapy) and control groups (standard therapy) on the EORTC QLQ-C30 role functioning subscale (P=0.03). However, the other four functional scales of the EORTC QLQ-C30 were similar between groups (P>0.05). At 8 weeks after the intervention, a significant difference was found between the groups in physical and emotional functioning of the EORTC QLQ-C30 (P<0.05). There was no significant difference between the groups in the reduction of upper limb edema at 4 and 8 weeks after the intervention (P>0.05).

Discussion

Comprehensive conservative treatment for lymphedema is effective (Greene & Goss, 2018; Mercier et al., 2019; Patel et al., 2015). Regardless of the names of the interventions, all programs include manual lymphatic drainage, as it is an essential component. However, it should not be applied in isolation in the treatment of lymphedema but rather as one of the components in an individualized program. A session typically requires a minimum of 45 to 60 minutes, depending on the size of the limb or body part and the severity of symptoms. There are several methods of manual lymphatic drainage (M. Földi, J. Casley-Smith, E. Vodder, A. Leduc), each with its own advantages. Self-manual lymphatic drainage or simple lymphatic drainage is a simplified form that can help maintain the results of manual lymphatic drainage. Patients themselves, their family members, or caregivers can apply self-manual lymphatic drainage massage after being taught the techniques by a physical therapist (Morgan, 2008).

The question of intervention effectiveness is raised by Bahtiyarca et al. (2019) study. Because the therapy involves a combined effect, there are not enough studies that have evaluated the effectiveness and contribution of each individual component. The authors claim that manual lymphatic drainage, which should be applied before compression therapy, should be considered time-consuming and expensive. Therefore, the study proposes adding self-manual lymphatic drainage to the therapy and indirectly assessing its impact. It was found that adding self-manual lymphatic drainage to the treatment did not affect the functions of the upper extremities. Compression therapy provides a significant reduction in swelling during the intensive phase of complex decongestive therapy. However, self-manual lymphatic drainage does not offer an additional advantage in treatment. According to the PEDRo scale, the study received a score of 5 out of 10.

The short-term effectiveness of manual lymphatic drainage was investigated in Sen et al.'s study. Standard therapy, which consisted of multi-

3 complex decongestive therapy
4 manual lymphatic drainage
5 standard therapy
6 compression bandaging
7 self-lymphatic drainage

layer compression bandaging and exercise, was compared to comprehensive therapy with manual lymphatic drainage. Both approaches were found to be effective in reducing swelling, increasing joint mobility, and improving the quality of life. Therefore, manual lymphatic drainage does not have an advantage or additional effect. However, when it comes to improving subjective symptoms such as heaviness and discomfort, the use of manual lymphatic drainage in the initial phase of complex decongestive therapy may have an additional benefit (Sen et al., 2021).

Forner-Cordero et al. (2021) also analyzed optimal approaches to lymphedema treatment. Performing manual lymphatic drainage requires qualified professionals who are proficient in the technique, and it consumes a significant amount of time, making it one of the most costly components of therapy. In a randomized controlled trial, it is suggested that periodic pneumatic compression and bandaging in the intensive phase of therapy are not inferior to the classical approach based on the principle of trimodality, which includes manual lymphatic drainage, intermittent pneumatic compression, and bandaging. According to the PEDRo scale, the study received a score of 6 out of 10.

External compression (bandaging or pneumatic compression) complements any exercise program developed for each patient. Compression is not intended to "squeeze out" fluid from the limb but rather acts as a counterforce to muscular activity, thus creating higher pressure on tissues during contractions. This provides the most potent stimulus for lymphatic drainage. Compression also restricts capillary filtration, opposing capillary pressure and thus reducing swelling from excessive fluid overload. Compression is not effective without physical exercises (Thiadens et al., 2010). As low-intensity resistance exercises (or low-intensity resistance training) do not exacerbate lymphedema or worsen symptoms, they instead reduce swelling, leading to increased joint mobility. It was also found that resistance exercises are effective whether they are combined with compression garments or not (Omar et al., 2020).

Since the elasticity of the skin is partially lost in lymphedema, hydrostatic pressure on the tissues must be maintained with external support (external compression). This support should be continuous until the reduction in volume stabilizes (Morgan, 2008).

Bandaging is an important step within the framework of complex decongestive therapy. The results of the study by Torres-Lacomba et al. (2020) showed that simplified multilayer bandaging was the most effective in reducing swelling. Kinesio tape was the most comfortable but the least effective in reducing swelling. The simplified multilayer bandage is more effective in reducing swelling and more convenient than traditional multilayer bandaging.

In the study by Tantawy et al. (2019) the use of kinesio tape in lymphedema is discussed. The authors recommend replacing compression garments with kinesio taping. Patients performed the same home exercise programs, with the group using kinesio taping showing significant improvements in reducing limb circumference, dynamometry values, and shoulder pain index, as well as improved quality of life compared to the group receiving compression garments. However, in contrast to this study, another single-blinded controlled pilot study, which was not included in the review, contradicts this idea, indicating that kinesio taping cannot replace bandaging (Smykla et al., 2013).

In the study by Ligabue et al. (2019) a program was developed and tested to enhance the effect of complex decongestive therapy. Women in the experimental group were taught self-manual lymphatic drainage and self-bandaging techniques, breathing exercises, mobilization exercises, muscle strengthening exercises, treatment for muscle contracture, and an understanding of the changes that occur in lymphedema. The developed program for self-complex decongestive therapy demonstrated its effectiveness and can be used to enhance complex decongestive therapy or as self-management.

According to Lee et al. (2011) and Morgan (2008), physical exercises, as one of the components of therapy, improve lymphatic drainage and stimulate the circulatory system. It is well known that physical exercises and movement are crucial for lymphatic drainage. Exercises enhance cardiovascular function, muscle strength, functional capacity, and endurance. A combination of resistance exercises, aerobic activities, and endurance training can be beneficial in addressing lymphedema and helping patients with mobility limitations.

An additional element recommended for lymphedema management is yoga. According to the study, practicing yoga does not reduce swelling in lymphedema, but it should be used when the intervention's goal is symptom reduction. Yoga sessions can improve functional performance and quality of life, as demonstrated by randomized controlled studies (Pasyar et al., 2019).

Aquatic therapy exercise offers therapeutic effects on a swollen limb due to hydrostatic pressure. In the study by Deacon et al. (2019) patients were offered water exercises using the Ai Chi method to reduce pain and swelling. In contrast to regular water exercises, they performed exercises according to the Ai Chi method. Ai Chi

is done in deep water in rhythm with breathing. It's a slow, relaxing, and gentle exercise routine. There were no additional benefits to Ai Chi water exercises, and the immediate effect of these exercises disappeared within an hour.

Ali et al. (2021) found that aqua therapy-resistance exercise programs can provide additional benefits when combined with other physical therapy methods, specifically reducing swelling and pain intensity, which, in turn, helps increase the range of motion.

It has been proven that a combined aerobic and resistance training program is safe for women with lymphedema. Confirmation of this can be found in the study by Kilbreath et al. (2020), where a 12-week combined aerobic program with strength exercises not only did not exacerbate lymphedema but was also more effective in reducing lymphedema symptoms compared to standard care.

Ongoing research is proposing new concepts for lymphedema treatment. These studies aim to design new cost-effective approaches, do not require extensive resources, and improve patients' daily activity. For example, Muñoz-Alcaraz et al. (2020) introduced a new activity-oriented proprioceptive antiedema therapy (TAPA) as an alternative to comprehensive anti-lymphedema therapy. The study emphasizes the social integration of patients with breast cancer-related lymphedema during rehabilitation, as it should include not only physical therapy but also occupational therapy. Functional abilities, patient needs, and limitations in daily activities affect a patient's quality of life. This research is still ongoing. The costs associated with the new program are expected to be half of those of traditional therapy and more effective in reducing swelling, but, according to the PedRo scale, the study overall received only 4 out of 10 points.

In addition to conservative treatment for lymphedema, there are also surgical and other methods. However, surgical interventions will not completely eliminate the consequences of lymphedema. Rehabilitation is needed not only for patients with lymphedema who are not suitable for surgery but also for those both before and after surgical procedures. Most studies focus on the role of each individual means or physical therapy method within the treatment of lymphedema or investigate the combined effect or addition of a new additional means to an established program to enhance the existing effect. Many studies often address the issue of the economic feasibility of a program, its effectiveness, and the impact of interventions on a patient's overall quality of life. Since lymphedema is a chronic condition, treatment strategies need to be oriented towards the management of chronic diseases (Damstra, 2011; de Sire et al., 2022).

The development and creation of modern rehabilitation programs for lymphedema are based on foreign experience, taking into account the region's specific characteristics, and standardization will allow for an increase in the effectiveness of conservative treatment, which, in turn, will fully meet the needs of this group of patients (Greene & Goss, 2018).

Conclusions

In recent years, the number of studies on the topic of lymphedema has been increasing. These studies focus on developing new and evaluating established rehabilitation methodologies aimed at preventing the progression of this condition. Since rehabilitation is the best way to control and manage lymphatic swelling, there is a consensus on the use of only evidence-based and effective rehabilitation means and methods. The analyzed studies aimed to determine the role and assess the effectiveness of each individual element of comprehensive therapy.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).04

Conflict of interest
The authors declare that there is no conflict of interest.

Funding Statement
This article didn't receive financial support from the state, public or commercial organizations.

Received: November 26, 2024; Accepted: February 15, 2025
Published: February 28, 2025

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Conceptualization, S.K. and O.B.; methodology, S.K. and O.B.; check, S.K. and O.B.; formal analysis, S.K., O.B., A.H, A.V., M.H; investigation, S.K. and O.B.; data curation, S.K. and O.B., A.H; writing –rough preparation, S.K. and O.B., M.H.; writing –review and editing, M.H., A.H, A.V.; supervision, A.V.; project administration, S.K. All authors have read and agreed with the published version of the manuscript.

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Original Scientific Article DOI: 10.15391/prrht.2025-10(1).05

Biomechanical impact of foot pronation on anterior knee pain – case controlled study

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Abstract

Purpose. The purpose of the study was to investigate the biomechanical difference and relationship between pronated foot posture and AKP in the Abu Dhabi region. Structural abnormalities of the foot can disrupt the normal lower extremity biomechanics, leading to abnormal kinematics and affecting the musculoskeletal health of individuals with anterior knee pain(AKP). In-depth research on the biomechanical link between tibial kinematics and pronated foot posture is crucial for clinical interventions.

Material & Methods. Involving 50 participants clinically diagnosed with AKP with or without pronated feet. The Kujala patellofemoral score for functional limitations, the foot posture index (FPI) for foot posture, and the dynamic valgus index (DVI) for the knee valgus angle were used as outcome measures. The studies were conducted in compliance with the requirements of the Helsinki Declaration of the World Medical Association "Ethical principles for medical research involving human subjects". A case-controlled study was conducted at a tertiary Hospital, in Abu Dhabi, UAE. The significance was set at $p<0.05$.

Results. Participants in the case group AKP with pronated feet (mean: 50.20±5.28) had statistically significant ($p <0.001$) lower Kujala scores as compared to the control group participants with neutral and supinated feet (mean: 83.90± 8.36). In addition, the correlation ($p = 0.04$) between the variables DVI and FPI was found to cause the altered foot pronation position that led to AKP.

Conclusions. The study findings indicated that the unusual loading among AKP participants on their patellofemoral joint may be influenced by the pronated foot. While managing the participants with AKP, musculoskeletal practitioners should consider foot posture, especially pronation, while evaluating individuals with AKP.

Key words: Pronated foot, anterior knee pain, Kujala score, foot posture, musculoskeletal health risk.

Introduction

Anterior knee pain (AKP) is one of the most prevalent musculoskeletal conditions and significantly affects the adolescent population(Piva et al., 2006; Van Linschoten et al., 2006). The understanding of the Healthcare professional about AKP may become unclear in a clinical setting, as it involves numerous factors, notably the determination of foot position(Austermuehle, 2001; Fredericson & Powers, 2002;).Foot alignment or posture plays an important role in maintaining optimal biomechanics functions of the lower limb(Alderink, 2001). Pronated foot alignment is simply described as collapsing or flattening of the medial longitudinal arch, which interns leads to abnormal foot alignment.This abnormal align-

ment of the foot can lead to greater stress on the soft tissue structures around the knee and foot segments. Mechanically alter the kinetics of the talonavicular joint leads to a significant navicular drop, and it is directly linked to the overall function of the foot (Arndt et al., 2007). The previous literature supports the hypothesis that excessive foot pronation at the subtalar joint has a biomechanical link with the knee complex (Duffey, Martin, Cannon, Craven, & Messier, 2000). Excessive subtalar pronation leads to altering or delaying the normal tibial torsion and may cause compensatory motions at the tibiofemoral joint. As a result of that, it simultaneously increases the knee valgus angulation and decreases the contact surface of the patella and femur, leading to abnormal tracking of the patella, which is the reason for the excessive compression at the lateral patellar facet contributing to the anterior knee pain symptoms (Kaufman, Brodine, Shaffer, Johnson, & Cullison, 2011).

Based on the research evidence, it is further hypothesised that foot alignment plays a crucial role in the prevention of various musculoskeletal injuries in the lower limbs. (Chung, Lee, & Lee, 2016) Frequently researchers reported that muscle length tensions are a common target & treatment goal for anterior knee pain syndrome. However, the studies did not explain the relationship between Muscle length tension and AKP in their treatment approaches (Post, 2005; Pourahmadi et al., 2016; Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000). Hence, the physiotherapy intervention needs to address the altered kinematic chain relations of the foot has an apparent biomechanical association with knee functions.

Musculoskeletal clinicians well know that the etiology of AKP is multifactorial; at the same time, it is crucial to the screening of foot posture, and it may help the clinicians to understand the musculoskeletal risk factors and rule out the biomechanical influence on AKP. Clinicians should consider several clinical reasons before the interventions to achieve their outcome in the management of AKP (Kuru, Dereli, & Yaliman, 2010; Powers, 2003).

Currently, available literatures lacks in-depth exploration of the specific biomechanical factors for foot pronation and it is an association with AKP to the local population. In addition to existing knowledge of biomechanical contributing factors, this study considered the diverse population specifically within the Abu Dhabi region by including cultural and diversity factors, activity levels, and ethnic background to provide a more detailed understanding of the comprehensive biomechanical associations and influences of the AKP to address the research gap and provide the valuable insights for musculoskeletal clinical practice.

Interestingly, this study will help young musculoskeletal practitioners understand the importance of the comprehensive biomechanical assessment to identify the multifactorial risk factors and explore the biomechanical kinematic link between the pronated foot postures in subjects with anterior knee pain syndrome. Therefore, this study aimed mainly to address the difference between pronated feet and neutral/supinated feet and its biomechanical association with AKP in Abu Dhabi region.

Material and methods

Design

This cross-sectional study is a phase -1 part of our research work which invites 50 participants with AKP who visited for rehabilitation as a convenience sample. The studies were conducted in November 2023 onwards for 6 weeks compliance with the requirements of the Helsinki Declaration of the World Medical Association "Ethical Principles for Medical Research Involving Human Subjects". A case-controlled study was conducted at a tertiary Hospital, in Abu Dhabi, UAE.

Before recruiting the participants, this study method was approved by the Clinical Research Ethical Committee (reference number MCME. CR.310.MNOO.2023). The main trial (phase -2) study has been registered on ClinicalTrials.gov under the trial registration number NCT05917080.

Participants

Before the data collection, subjects were explained the purpose of the study and signed an informed consent form. In total, 50 participants of both genders (male and female) aged between 18 and 35 years with AKP accepted our invitation for this study. All participated AKP subjects, age, gender, and body mass index (BMI-kg/m^2) were marked in the data sheet. The severity of the AKP condition of the recruited participants was screened using the Kujala Patellofemoral Questionnaire (KPQ) according to inclusion and exclusion criteria. Participants who had KPQ scores 40 and above were included in this study(Willson & Davis, 2009). Among the included 50 participants, 30 AKP participants (n=26 Males and 4 Females) with pronated feet were grouped as case groups and 20 AKP participants (n=17 males and 3 females) without pronated feet were grouped as a control group (Figure 1). Subjects were excluded from the study according to the following criteria: history of meniscus or joint injury, surgery in and around the knee, participants under non-steroidal anti-inflammatory drugs or corticosteroids within 24 hours before the clinical assessment, positive patellar apprehension test, congenital or traumatic deformity, concomitant diagnosis of pre-patellar bursitis or tendonitis, Plica syndrome

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

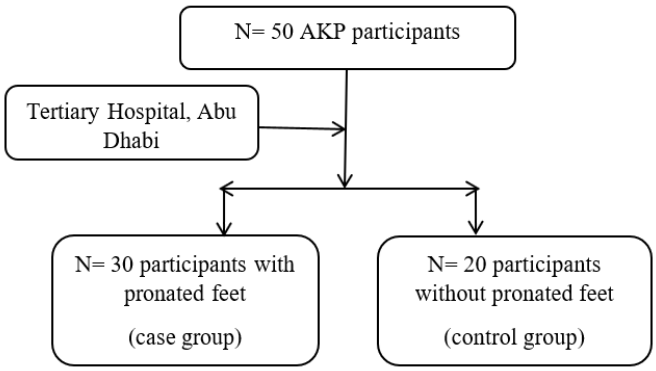

Figure 1. Distribution of subjects in the study. "AKP" and "N" were referred to Anterior knee Pain and the number of subjects.

& Osgood Schlatter's disease, malignancy & skin infection, Pregnant woman or lactating woman.

Outcome measures

The Kujala anterior knee pain scoring questionnaire was formulated in 1993, specifically for the AKP, with reliability, validity, and sensitivity of this scoring (Crossley, Bennell, Cowan, & Green, 2004). It consists of 13 items categorized to evaluate various levels of knee function. The response of each participant to each item and their cumulative score were added to a comprehensive index that ranges from 0 to 100 points. The maximum score of 100 signifies 'no impairment', while the lowest score of zero signifies 'maximum impairment'.

Version-6, Foot Posture Index (FPI-6) was used to assess foot pronation. FPI-6 is a user-friendly clinical assessment tool to assess the foot posture in all 3 planes without any special instruments. It has good reliability and validity. The individual item is assigned a score ranging from −2 to +2 points, with −12 indicating significant supination and +6 and +12 representing substantial pronation (Redmond et al., 2006). The score, "0 and +5" represents the neutral position. In a weight-bearing posture on both feet, the following six measurements were recorded by the researcher: antero-posterior foot alignment, medial longitudinal arch, supra- and infralateral malleolar curvature, head of talus palpation, talonavicular prominence, and calcaneal angle (Barton et al., 2011).

The Dynamic Valgus Index (DVI) is used to measure dynamic knee valgus angulation. The measurement analysis was performed using image analysis with suitable, cost-effective software. Measurements captured by mobile phone camera (iPhone 14 Pro, Apple, USA, 2023), recorded by two-dimensional data from 3 meters of distance and a height of 45 cm in front of the subjects. The DVI is derived by adding the frontal plane projection angle (FPPA) of the knee joint to the hip FPPA. The hip FPPA is calculated as 90° minus the angle (α) between the pelvis segment and thigh segment. Furthermore, the knee joint FPPA is computed by subtracting the angle (β) between the thigh and shank segment from 180°. The knee projection angle generally increased by 10° or greater in a single leg squat with the knee flexion posture (Harris-Hayes et al., 2014; Salsich et al., 2012). The tool reported measurement reliability (ICC) ranges from 0.68 to 0.8 (Boling et al., 2006; Mølgaard et al., 2018; Scholtes & Salsich, 2017).

Statistical analysis

The Minitab Version 21.1.0 programme was used for the data analysis. Descriptive statistics were used to report the demographic data of the participants. The data was tested for normality using Shaprio-Wilk tests. Since the data was not normally distributed ($p>0.05$), the non-parametric Mann-Whitney U test was applied to analyze the Kujala scores between the case and control groups. Besides, the relationship with the severity of AKP participants's discomfort and pronated foot in the case group was tested using the chi-square test. The significance was set at $p<0.05$.

Results

The descriptive statistics presented in Table 1 show that the overall participants in the case and control groups were 28.62±4.75 years old with a BMI of 27.28±1.83. In the case group, participants with AKP (mean: 50.20±5.28) had more severe symptoms and physical limitations than people in the control group (mean: 83.90± 8.36) who had neutral and supinated feet. The difference was statistically significant (U = 0.000, $p<0.001$). Furthermore, the lowest mean rank of Kujala scores in pronated feet ($\bar{x}$ −15.50) compared to neutral/supinated feet ($\bar{x}$ −40.50) indicates that foot position plays a significant role in the severity of AKP symptoms. The DVI of most of the participants in the case group presented moderate knee valgus (56.7%) and severe knee valgus (43.3%). However, the majority of participants in the case group were overweight and presented with moderate knee valgus and severe knee valgus. The participants with AKP in the case group were found to have a significant relationship between the variables DVI and FPI, X^2 (1, N=30) = 4.22, $p<0.04$. Whereas, no significant relationship was observed between DVI and gender X^2 (1, N=30) = 0.632, $p=0.43$, BMI X^2 (1, N=30) = 1.35, $p=0.25$, Kujala score severity X^2 (1, N = 30) = 2.04, $p=0.15$. This finding indicates that pronated feet have a relationship with biomechanical changes in the knee valgus angle of participants in AKP.

Table 1. Participants demographic data

Variables	Case group (pronated foot) n=30	Control group (neutral and supinated foot) n=20	Overall n=50
Age	28.0±5.4	29.5±3.53	28.62±4.75
Gender			
Male	26 (86.7%)	18 (90%)	44(88%)
Female	4 (13.3%)	2 (10%)	6(12%)
Weight	56±79.37	74.3±7.79	77.34±9.67
Height	169.37±8.88	166.25±5.86	168.12±7.89
BMI	27.58±1.85	26.84±1.74	27.28±1.83
Healthy weight	1 (3.3%)	-	
Overweight	29(96.7%)	20 (100%)	
Kujala Scores	50.20±5.28	83.90±8.36	63.68±17.94
Mild	-	17 (85%)	
Moderate	14 (46.7%)	3 (15%)	
Severe	16(53.3%)	-	
DVI			
No Valgus	-	15 (75%)	
Moderate Knee Valgus	17 (56.7%)	5 (25%)	
Severe Knee Valgus	13 (43.3%)	-	
FP1			
Pronated feet	8 (26.7%)	-	
Highly Pronated feet	22 (73.3%)	-	
Supinated feet	-	8 (40%)	
Normal feet	-	12 (60%)	

**Note: The variables are presented in Mean ±Standard deviation (Mean±SD) and Frequency (%)*

Discussion

The present study was aimed at investigating the biomechanical difference between pronated and neutral/supinated foot posture. In addition, pronated feet and their relationship with AKP in the Abu Dhabi region. Based on the study results, participants in the case group AKP with pronated feet had significantly lower Kujala Patellofemoral Score compared with participants without pronated feet. Besides, the AKP participants's FPI scores and DVI were found to have altered foot posture and knee angles compared to the participants in the control group. In line with the findings of this study, past studies concluded that anterior knee pain has multifactorial causes in clinical conditions (Akarcali et al., 2000).

Kosashvili et al. (2008) conducted a study that identified the pronated foot as a risk factor among multifactorial causes, biomechanically linked to lower extremity malalignment and anterior knee pain. Additionally, a study among runners found a significant association between pronated foot posture and anterior knee pain (Smith et al., 2018). This indicates biomechanical changes that affect both the atheletic and non-atheletic communities that suffer from AKP. Similar to these findings, the present study found that pronated feet have a relation with the DVI of AKP participants and confirms that foot posture alignment issues, especially pronated feet, cause AKP.

On the other hand, among the adolescent population, the study reported no significant correlation between pronated foot and anterior knee pain(Starkey & Brown, 2015). This indicates that the biomechanical impacts between the adolescent and adult ages were different, and that does not cause AKP. However, the assessment of foot posture plays a significant role in gait parameters and injury prevention (Alderink, 2001). On the other side, optimal foot posture is necessary to gain adaptability in different terrains to equally distribute the body weight and shock-absorbing functions (DeLisa, 2001) The altered foot posture, such as pronated feet, would cause biomechanical dysfunctions to influence greater stress on the proximal joints of the lower extremities.

Our study results showed that participants's gender and BMI did not directly have a relationship with the AKP. Recent studies have explored the impact of gender and BMI on AKP and its rela-

tionship with foot posture. According to Zumwalt et al. (2023), in female genders, biomechanical factors such as Q-angle and wider pelvis contributed to the exacerbated effects of pronated foot posture (Zumwalt, 2023). This does not align with our findings since the majority of participants were male (88%), and it is recommended that gender-specific biomechanical assessment be advocated for further exploration.

In addition, Davis et al. (2020) found a positive correlation between a higher BMI and an increased risk of knee pain and altered foot biomechanics (Davis et al., 2020). Even though the statistical relation was not found in the present study, the majority of participants were overweight, had changes in knee angle DVI, and reported AKP. Biomechanical evaluation for participants with a higher BMI may contribute to pronated foot posture, which leads to abnormal shearing force on the knee and a higher risk of anterior knee pain.

According to Haddad et al. (2020), the Kujala score, FPI, and DVI have moderate evidence in evaluating patients with anterior knee pain. However, there are variations in the supportive literature used as primary assessment tools. Although Smith et al. (2018) strongly relied on the FPI and visual gait analysis, our study was more detailed in biomechanical assessment through the DVI, providing a more detailed understanding of dynamic knee valgus. This comprehensive approach is strongly recommended for evaluating and correcting biomechanical dysfunctions contributing to AKP (Smith et al., 2018). Although previous studies may have adopted a more segmented approach, focusing on isolated factors such as foot posture or knee alignment, our study emphasises the interconnectedness of biomechanical factors and the need for a holistic assessment strategy.

This study will be an eye-opener for musculoskeletal clinicians. It will help them to develop critical skills in the biomechanical basis of an evaluation to effectively manage the AKP subjects and critically explore the association between excessive subtalar joint pronation and abnormal compression at the patellofemoral joint. At the same time, musculoskeletal specialists can focus on the biomechanical intervention to correct the subtalar joint pronation.

Conclusion

This study supports the biomechanical relationship between pronated foot posture and anterior knee pain. It indicates that the pronated foot posture biomechanically influences on subjects with AKP. Hence, this study strongly advocates that, before any targeted interventions, musculoskeletal clinicians need to use the comprehensive assessment tools of the Kujala score, foot posture index, and dynamic valgus index in clinical practice with detailed biomechanical evaluation and correction in the management of anterior knee pain.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).05

Acknowledgements
We would like to thank the entire Physiotherapy Team members

& Patient Administrators at Mediclinic Tertiary Hospital, Abu Dhabi, UAE for their support in facilitating this research study..

Conflict of interest
All the authors declare that they have No Conflict of interests.

Ethical approval and consent to participate
Participants was signed a written informed consent before the participation. Participants signed a written informed consent before intervention. The study was approved by the Clinical Research Ethical Committee under reference number MCME. CR.310.MNOO.2023.

Funding Statement
This article did not receive financial support from the state, public or commercial organizations.

Received: September 15, 2024; Accepted: January 22, 2025
Published: February 28, 2025

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ISSN (print) 2522-1906, ISSN (online) 2522-1914
FIZICNA REABILITACIA TA REKREACIJNO-OZDOROVCI TEHNOLOGII
Vol. 10 No. 1, 2025

Original Scientific Article DOI: 10.15391/prrht.2025-10(1).06

The Effect of Yoga Combined Elastic Band Exercise Program on Health - Physical Fitness and Balance in Older Adults

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Abstract

Purpose. The study and compare the effects of yoga combined elastic band training programs on health, - physical fitness, and balance in older adults.

Material & Methods. The sample group consisted of 32 older adults aged 60–69 years in Ban Mek Yai, Nong Mek Subdistrict, Nong Han District, Udon Thani Province, Thailand. They were divided into 2 groups, 16 people per group: the exercise group trained with yoga combined elastic band training programs and the control group for 6 weeks, 3 days a week, 40 minutes a day. The tests were conducted pretest and posttest. Data on muscle strength and endurance were collected using the Chair Stand Test and arm curl test, Flexibility was collected using the Chair Sit and Reach test and balance using the single leg stance and time up and go test. Data were analyzed using the mean, standard deviation, and t-test with a statistical significance level of .05.

Results. The Physical fitness (Arm Curl Test, Chair Stand Test, Chair Sit and Reach Test) and balance (Time up and Go test and Single Leg Stance Test) statistically had significant differences between the pre- and post-six weeks in the exercise group but the control group was not statistically significant and posttest statistically had significant differences between the control group and the exercise group, but the pretest was not statistically significant.

Conclusions. However, after six weeks of combined yoga with elastic band training programs, the order adults had improved muscle strength, endurance, flexibility, and balance. Consequently, this exercise regimen is considered a healthy alternative for older adults.

Keywords: Yoga, Elastic band, Heath-physical fitness, Balance, Older adults.

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). This causes physical instability that is at risk of injury and accidents in the elderly. There should be preparation to cope with physical changes. Therefore, it is necessary to promote the health of the elderly more. As the World Health Organization (2023) recommends that a long-life expectancy alone is not enough, it is necessary to have good health as well. If the elderly have sufficient physical activity, it will be the foundation of good health (World Health Organization, 2023; Xiong, Ye, Wang, Zheng, 2021;

Cotman Berchtold, 2007).

Exercise for the elderly is mainly found to be beneficial by helping to reduce blood pressure, especially systolic blood pressure, reduce peripheral vascular resistance, increase HDL-C system, reduce body fat, increase heart efficiency, increase insulin sensitivity, improve muscle size and joint movement, increase muscle strength, reduce bone loss rate, increase blood volume to the brain, increase brain efficiency (Singhacharu, 2016), and increase balance and balance, reduce the risk of falls and accidents in the elderly (Atwinijtrakarn, 2019). The mechanism that transmits falls and balance depends on many factors, including gender, age, deterioration of vision, hearing, joint movement, muscle strength, and flexibility. Therefore, while walking or changing postures, the body cannot maintain the center of mass of the body in a balanced base and falls occur (Atwinijtrakarn, 2019). Therefore, exercise for the elderly should be activities that promote balance and weight-bearing exercises that are appropriate for the individual, are safe, and do not cause harm or injury to muscles and joints, such as walking or running slowly, cycling, swimming, physical exercise, Chinese boxing, yoga, etc. (Siripanich, 2012).

Yoga is a physical and mental exercise. Physical exercise is the practice of various yoga postures. Mental exercise is the conscious focus on inhaling and exhaling while holding a pose, changing poses, or practicing breathing in various forms. It can be practiced with a variety of equipment, such as yoga belts, elastic bands, blankets, pillows, chairs, and blindfolds (Chanthasorn, 2022). Practicing yoga has many health benefits, such as increasing strength and flexibility, increasing the efficiency of the respiratory system, and reducing stress. It uses asana training techniques, physical posture training, breathing, and meditation together to treat diseases by stretching and relaxing alternately. This causes physical instability, which can lead to injury and accidents in older adults (Wongrachit, 2018).

Resistance exercise is a form of exercise that uses weight resistance or pressure on striated muscles. Striated muscles contract during resistance exercise. Muscle contraction occurs by using energy from the body's chemical processes. Chemical energy is then converted into mechanical energy, namely force or tension muscle contraction against weight (Hoeger & Hoeger, 2012; Sharkey & Gaskill, 2013). Elastic bands are convenient, economical, and safe for the elderly. Every time they are stretched, there is a reflex that affects the development and treatment of muscle function (Chaiyodsilp, 2022). It was found that the highlight of exercising with elastic bands is a reflex or pulling force from being pulled to stretch, called the Stretch reflex. Every time the rubber is stretched, which is a special property of such elastic bands, it affects the nervous system that senses muscle and joint tension (Proprioception) to react and respond to the tensile force of the rubber being stretched (Boonlert, 2021). Therefore, it helps protect and restore the muscular system, joints and bones, and enhances physical fitness. Exercises using elastic bands help increase muscle strength and improve flexibility and balance (Karbunrat, 2015).

Since previous studies have used only one yoga program and elastic bands, there have been no studies done on combining yoga with elastic bands. Therefore, to promote health, increase strength, endurance, flexibility and better balance, researchers have designed a training program combining yoga with elastic bands to help develop physical fitness, balance and quality of life in the elderly.

Material and methods

Study participants

Participants were recruited from Ban Mek Yai, Nong Mek Subdistrict, Nong Han District, Udon Thani Province, Thailand. The sample size was determined from Cohen's table (Cohen, 1988) by setting the alpha value at the significance level of 0.05, the effect size at 0.80 and the power of the test at 0.75. The sample size was 23 people. To prevent missing, the researcher increased the sample size to 25 people per group, divided into an experimental group and a control group.

Inclusion criteria were elderly people aged 60–69 years who Time up and Go test at a level greater than up to 20 seconds, can help themselves, pass the Physical Activity Readiness Assessment (PAR-Q) and agreed to participate in the research and sign the consent form to join the program.

Exclusion criteria were a history of cardiovascular or respiratory illness, neuromuscular or musculoskeletal diseases affecting postural control or vision deficits influencing the study's outcome, and injuries that occurred during the training program. Participants completed less than 80% of the study period, and subjects requested to discontinue training.

Approval for this experiment was obtained from the ethics human in Nakhon Ratchasima Rajabhat University (the approval number is HE 140/2024; 27 September 2024). 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.

Study organization

Participants underwent a 2-week, 3-day fa-

miliarization program of yoga combined with an elastic band exercise program conducted by the instructor before the testing session. The exercise group engaged in a 60-minute yoga combined with an elastic band exercise program consisting of: 10 poses (Tree pose, Swin tree pose, Forward stretch pose, Cow face pose, Head to knee pose, sitting bending pose, Knee pressing to chest pose, Leg lifting pose, Modified pier pose and dead body pose in figure 1), performed 3 breaths, 4 times divided into a 10-minute warm-up phase, a 40-minute exercise phase, and a 10-minute cool-down phase. The control group did not engage in any exercise activities. Throughout the 6-week, 3 d·wk-1, 60 min·d-1 study.

Outcome measurements

The tests were carried out as established by Jones and Rikli (2013) details as follows:

1. The Chair Stand Test reflects lower body strength. The Participants were asked to sit on the chair with arms crossed over their chest, and they were encouraged to complete as many stand-ups as possible in 30 seconds. Scoring was based on the total repetitions completed in 30 seconds. The number of stands is recorded.

2. The Biceps Curl Test reflects upper body strength. The participants were asked to perform as many bicep curls as possible in 30 seconds, using a 5-pound dumbbell for females and an 8-pound dumbbell for males. Scoring was based on the total repetitions completed in 30 seconds.

3. The Chair Sit and Reach Test is measured in distance (cm) and reflects lower body flexibility. The participants were asked to sit on the edge of a chair with the left knee bent at 90o and the left foot flat on the floor while keeping the right knee straight and the right leg extended forward. Participants were instructed to attempt to touch their toes using both hands. The most flexible side of an individual was used for assessment. The distance in centimeters between the fingers and toes was measured. Overlap of the fingers was measured in positive increments, while the distance between untouched fingers was measured in negative increments.

4. The single-leg stance test is measured in time (seconds) and reflects static balance. The Participants were timing the moment the subject began to stand on one leg, with arms at the sides of the body and eyes open, and stopping the timer if the foot touched the floor or handgrips.

5. The Time Up-and-Go test is measured in time (seconds) and reflects agility and dynamic balance. The Participants measured the time it takes the test subject to stand up from a chair, walk a distance of 3 meters, and return to sit on the chair.

Statistical Analyses

The mean and ±SD were used to present the statistical data. An independent t-test was used to analyze the differences in height, weight, age, and body mass index between the 2 Groups. An independent t-test was used to compare the flexibility, muscle strength and endurance, and bal-

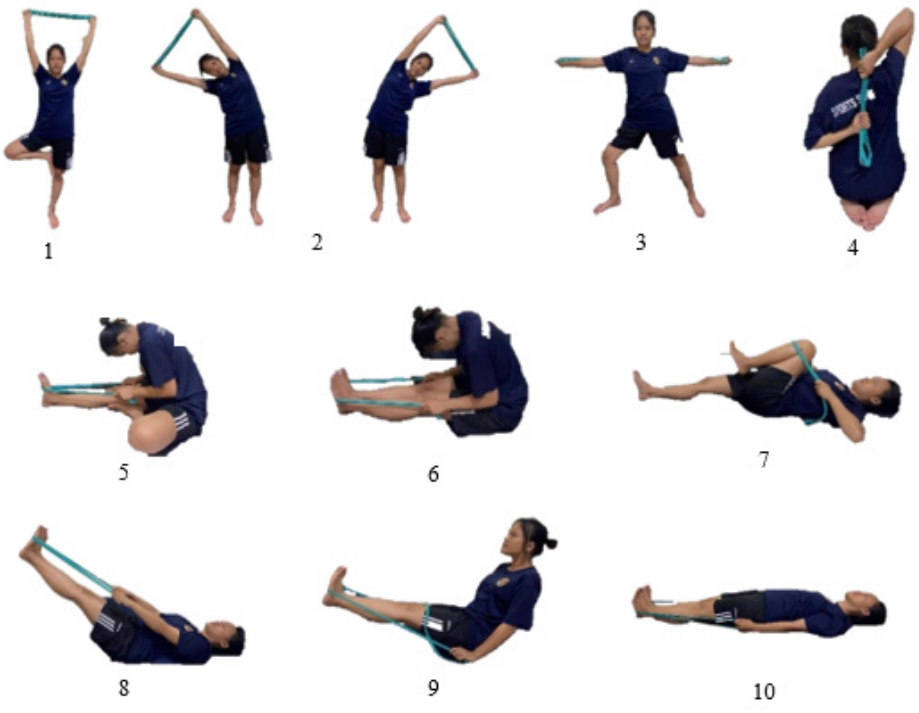

Figure 1. **Yoga combined Elastic Band Exercise**

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
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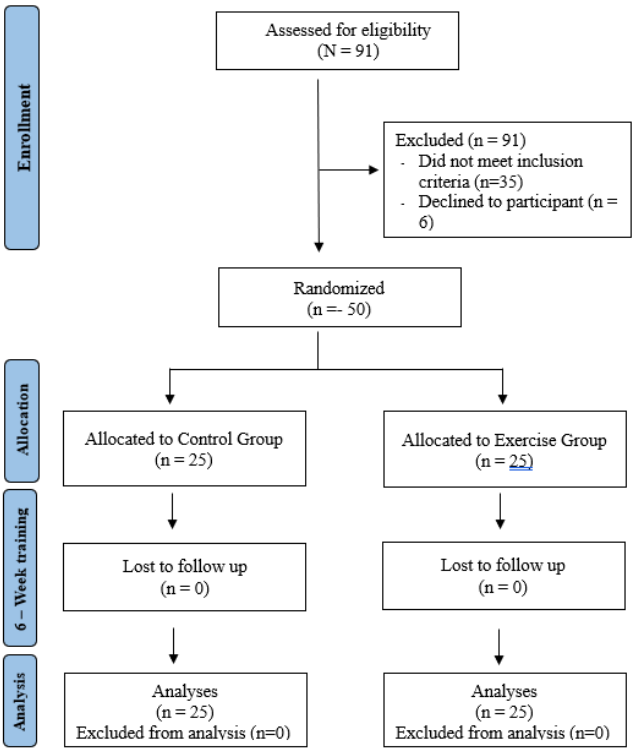

Figure 2. **CONSORT flow diagram of participants through the intervention.**

ance of the 2 Groups both at baseline and after 8 weeks. Flexibility, muscle strength and endurance, and balance at baseline and after 8 weeks were compared using a paired t-test to determine the changes within the 2 Groups. A type I error of 5% was used to determine statistical significance. The data were analyzed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., 2012).

Results

The analysis covered the baseline characteristics of the 36 older adults, as outlined in Table 1. Age, gender, body weight, height, and BMI showed no significant differences between the two groups after a 6-week training period.

In Table 2 and Figure 3, the results show improvements in all measured variables of post-intervention in the exercise group. The physical fitness and balance in the exercise group showed statistically significant differences between pre- and post-intervention (six weeks). Specifically, muscle strength, as measured by the arm curl test ($p<.001$) and chair stand test ($p<.001$), demonstrated a substantial increase, highlighting enhanced muscular strength in both the upper and lower body. Flexibility also improved ($p<.001$), suggesting enhanced extensibility of the hamstrings and lower back. Additionally, both static balance ($p<.001$) and dynamic balance ($p<.001$) improved, indicating enhanced movement efficiency. In contrast, the control group showed no statistically significant changes, including in muscle strength as measured by the arm curl test ($p=0.157$), a decrease in the chair stand test ($p=0.319$), a decrease in flexibility ($p=0.928$), and no significant changes in static balance ($p=0.402$) or dynamic balance ($p=0.063$). Furthermore, the posttest showed statistically significant differences between the exercise group and the control group, but the pretest did not. The exercise group had significantly higher mean values for muscle strength, flexibility, and balance compared to the control group. However, there were no differences between the two groups at the pretest.

Discussion

It was found that the flexibility in the sitting bending posture of the elderly group practicing yoga postures had a statistically significant change at the 0.05 level because the nature of yoga practice with elastic bands is stretching, bending, leaning, arching, twisting joints, tendons, and muscles, it affects the properties of connective tissue, especially tendons and fascia, causing changes in Collagen remodeling, resulting in more flexible tissue. It also helps reduce the muscle's tension by adjusting the function of sensory receptors in the muscles spindle and Golgi tendon organ, increasing the range of motion of the joints that is consistent with many past research studies

Table 1. **The measures of basal characteristics in control and exercise groups**

Variables	Control Group (n=25)	Exercise Group (n=25)
Gender		
Male	3	3
Female	22	22
Age (Years)	66.50 ± 2.82	64.43 ± 2.75
Weight (Kilometer)	54.75 ± 12.27	56.68 ± 8.12
Height (Centimeter)	156.12 ± 9.58	155.18 ± 8.18
BMI (kilometer / Meter^2)	22.53 ± 3.56	23.61 ± 4.35

Data are expressed as mean ± SD. BMI: body mass index; *Significant $p < 0.05$ control group vs. exercise group

ISSN (print) 2522-1906, ISSN (online) 2522-1914
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Table 2. The measures of physical fitness were assessed during pre- and post-six weeks in control and exercise groups

Variables	Control Group (CO) (n=25)		p-value	Exercise Group (EX) (n=25)		p-value	p-value CO vs EX	
	Pretest	Posttest		Pretest	Posttest		pretest	posttest
Arm Curl Test (reps)	14.92±4.54	14.16±4.10	0.157	16.12±2.93	18.92±4.19	<0.001#	0.273	<0.001*
Chair Stand Test (reps)	14.24±3.53	13.80±3.39	0.319	14.32±3.94	15.84±4.29	<0.001#	0.940	0.033*
Chair Sit and Reach Test (Centimeter)	1.22±6.03	1.12±5.07	0.928	1.47±2.72	7.27±4.05	<0.001#	0.852	<0.001*
Time up and Go test (Second)	19.78±1.68	20.91±1.86	0.063	20.23±1.75	19.19±1.48	<0.001#	0.365	0.001*
Single Leg Stance Test (Second)	11.43±4.98	11.24±4.56	0.402	10.38±3.89	12.39±5.08	<0.001#	0.413	0.050*

Data are expressed as mean ±SD. #Significant p<0.05 pretest vs. posttest period, *Significant p < 0.05 control group vs. exercise group

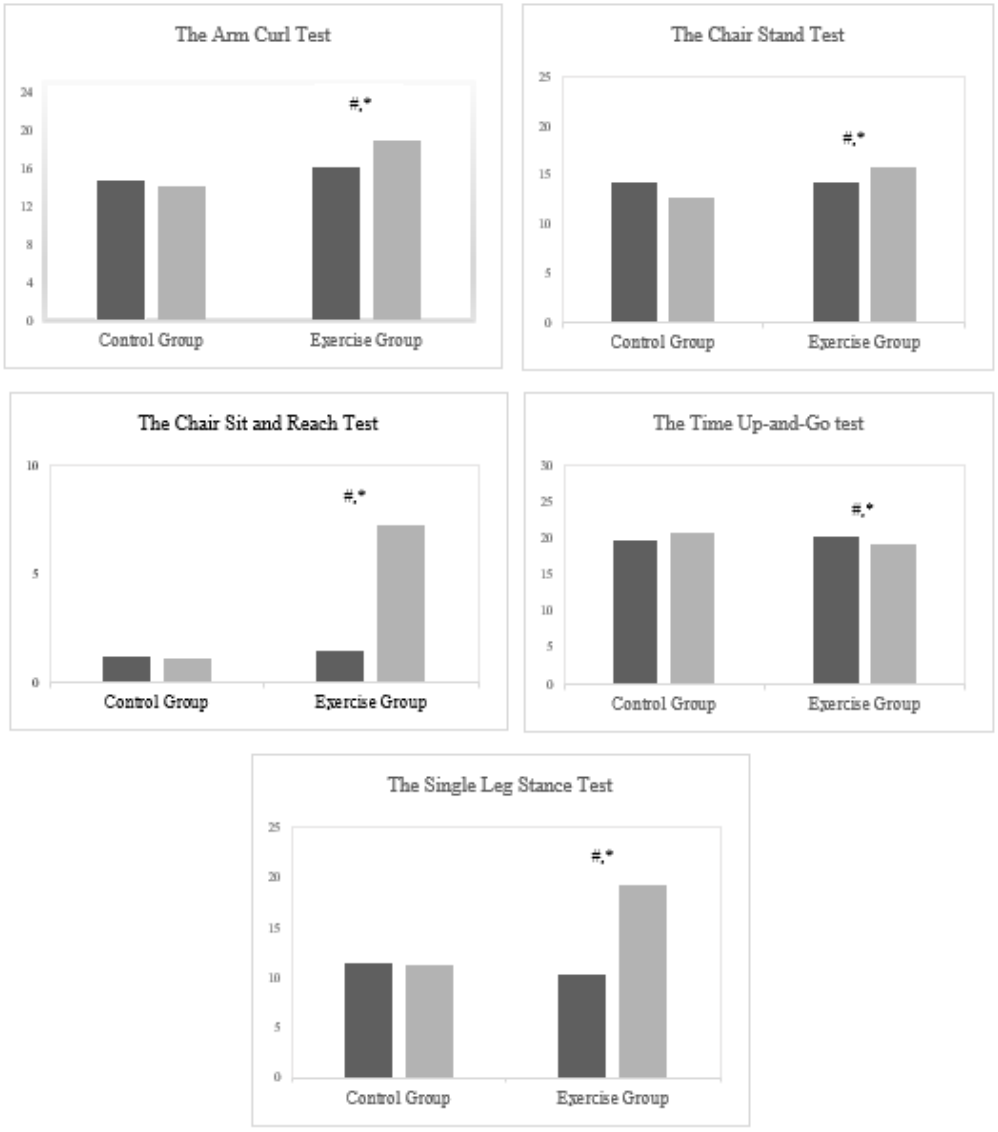

Figure 3. Physical fitness during pre- and post-six weeks in control and exercise groups.
*#Significant p<0.05 pretest vs. posttest period, *Significant p<0.05 control group vs. exercise group.*

that accept that yoga practice can develop muscle flexibility (Amin & Goodman, 2014; Donahoe-Fillmore & Grant, 2019; Tiffany Field, 2016; Mears et al., 2019; Mears et al., 2018, Gothe & McAuley, 2016; Noradechanunt et al., 2017).

It was found that the muscle strength and endurance in the arm curl and Chair Stand of the elderly group practicing yoga combined elastic band had a statistically significant change at the 0.05 level because yoga combined elastic band is mainly an isometric type of exercise, it helps in the improvement of muscular strength as it is found in any resistive exercise. Yoga combined elastic band training among the participants in this study has helped to improve muscular strength by better neural drive from the brain involving both the mechanisms of recruitment and rate coding of muscle contraction to achieve greater force which resulted in greater muscular strength which is consistent with many past research studies that accept that yoga practice can develop muscle strength and endurance (Gothe & McAuley, 2016; Noradechanunt, Worsley, & Groeller, 2017).

It was found that the balance in the static and dynamic balance of the elderly group practicing yoga combined elastic band had a statistically significant change at the 0.05 level because yoga practice of poses such as Tree pose, Swin tree pose, Forward stretch pose, Cow face pose and others can benefit the body in many ways. Starting with strengthening the core muscles, which are important for supporting the spine and maintaining balance in the body. These yoga poses also help develop joint stability, allowing for better weight-bearing and reducing the risk of injury. In addition, yoga practice helps develop concentration and awareness of different parts of the body, especially in the Dead body pose, which helps train the perception and control of body movement. Meanwhile, poses such as the Cow face pose and sitting bending pose help increase muscle flexibility, which is an important factor in movement and maintaining balance in the body. Practicing the Leg lifting pose and the Knee pressing to chest pose play an important role in developing the sensory nervous system, allowing the body to be more aware of position and movement while the Tree pose and the Swin tree pose help to strengthen the leg muscles, which are the foundation of good balance which is consistent with many past research studies that accept that yoga practice can develop balance (Gothe & McAuley, 2016; Wooten et al., 2018; Okubo et al., 2017, Ni et al., 2014; Nick et al., 2016; Noradechanunt et al., 2017).

Yoga is a multimodal activity that improves muscle strength, balance, and flexibility in the elderly, and physical activity policies should continue to promote yoga as an activity that enhances physical and mental well-being in these older adults.

Conclusion

After six weeks of combined yoga with elastic band training programs, the order adults had improved muscle strength, endurance, flexibility, and balance.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).06

Acknowledgement
We would like to express our sincere gratitude to all the participants who generously dedicated their time and effort to this study. Additionally, we extend our appreciation to the community leaders who facilitated the smooth conduct of the intervention sessions and data collection procedures.

Conflict of interest
The authors declare no conflict of interest regarding the publication of this research study.

Funding Statement
This article did not receive financial support from the state, public or commercial organizations.

Received: January 11, 2025; Accepted: January 27, 2025
Published: February 28, 2025

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Author's contribution
Conceptualization, T.T., P.B., P.S., and P.J.; methodology, T.T., P.B., and P.J.; software, T.T., and P.B.; check, T.T., P.B., and P.J.; formal analysis, T.T., P.B., P.S. and P.J.; investigation, T.T., P.S., and P.J.; resources, T.T., and P.J.; data curation, T.T., P.B., and P.J.; writing - rough preparation, T.T., P.B., and P.J.; writing - review and editing, T.T., P.S., and P.B.; visualization, T.T., and P.J.; supervision, T.T., and P.J.; project administration, T.T., P.S., and P.J.; receiving funding, T.T., P.B., P.S., and P.J. All authors have read and agreed with the published version of the manuscript.

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Original Scientific Article
DOI: 10.15391/prrht.2025-10(1).07

Comparative assessment of Barthel index and functional independence measure in providing rehabilitation care for military personnel with combined injuries

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Abstract

In the structure of military traumatism, the number of multiple and combined wounds and injuries has increased significantly due to the expansion in the destructive properties of modern weapons. Establishing the correct rehabilitation diagnosis and subsequent stage-by-stage assessment of the results of rehabilitation therapy should be based on adequate functional assessment tools. The Barthel Index is the most widely used measure for assessing the ability to perform activities of daily living. However, recently, many authors have proposed using the Functional Independence Measure (FIM) for this purpose.

Purpose. The study aims to investigate the possibility of using the Barthel Index and Functional Independence Measure to assess the effectiveness of rehabilitation of military personnel with combined injuries over a long period.

Material & Methods. We conducted a retrospective study of 807 wounded military personnel with complex injuries of varying severity. Our examination included a meticulous analysis of medical records, a comprehensive physical examination, and a survey using the Barthel Index and FIM scale. Due to the nature of the injuries, the servicemen were provided with standard rehabilitation programs.

Results. All patients were classified as lightly injured and moderately injured according to the Abbreviated Injury Scale. The initial data in evaluating functioning on the FIM scale made it possible to identify subgroups of patients with a predominance of motor function impairment and a predominant impairment of cognitive functions. Patients with combined TBI should receive more rehabilitation measures to improve cognitive and mental functions, socialization, and communication skills.

Conclusions. The inclusion of the FIM scale in the recommended toolkit for assessing the effectiveness of rehabilitation will allow for additional objectification of rehabilitation care and the formulation of individual recommendations for achieving the best results.

Keywords: Rehabilitation, combined wounds, Barthel Index, Functional Independence Measure.

Introduction

In the structure of military traumatism, the number of multiple, combined wounds and injuries has increased significantly due to the expansion in the destructive properties of modern weapons (Khomenko et al., 2022; Chernozub et al., 2024). Most blast wounds are characterized by multiple damage to blood vessels, nerve fibers, and significant defragmentation of muscles and skin (Shakargy et al., 2023). The treatment of

contemporary combat trauma and restoration of the combat capability of wounded soldiers largely depends on adequate rehabilitation measures. Military personnel with multiple craniocerebral injuries, amputations, burns, etc., need long-term rehabilitation care. Therefore, the standardized approach to the rehabilitation process is of particular importance. The research of various aspects of the organizational and methodological foundations of the military personnel rehabilitation system in different countries demonstrates the need to improve methods for monitoring the effectiveness and quality of the rehabilitation (Olkhovyi et al., 2020, Babov, 2023; Klyce et al., 2024). Establishing the correct rehabilitation diagnosis and subsequent stage-by-stage assessment of the results of rehabilitation therapy should be based on adequate functional assessment tools (Lurin et al., 2023; Belrose et al., 2019). The Barthel Index is the most widely used measure for assessing the ability to perform activities of daily living (ADL). (Barros et al., 2022; Dos Reis et al., 2022; Gao et al., 2021). However, recently, a significant number of authors have proposed using the Functional Independence Measure (FIM) for this purpose as more differentiated one (García-Rudolph et al., 2024;. Maritz et al., 2022; Mellick, 2023). Simultaneously, there is virtually no data on using these scales to assess the ability to perform everyday activities in patients with complex injuries. So, this idea formed the basis of this work.

The study aims to investigate the possibility of using the Barthel Index and Functional Independence Measure to assess the effectiveness of rehabilitation for military personnel with combined injuries over a long period of time.

Material and methods

Participants

We conducted a retrospective study of 807 wounded patients in 2023 who were admitted to the Arcadia Clinical Sanatorium of the State Border Service of Ukraine, Odesa. The examination included an analysis of medical records, an examination, and a survey using the FIM scale. A statistical analysis of the nature, localization, severity, and prevalence of injuries was performed. These studies were conducted following the principles of bioethics set out in the Helsinki Declaration and the General Declaration on Bioethics and Human Rights (UNESCO). The studies were approved by the Biomedical Ethics Committee of the State Institution "Ukrainian Research Institute of Medical Rehabilitation and Resort Therapy of the Ministry of Health of Ukraine", (Protocol No. 4 dated 05/23/2024). Before being involved in the study, patients gave informed written consent to participate.

Inclusion criteria: combined injuries of the musculoskeletal system, traumatic brain injury, and injury of the musculoskeletal system.

Exclusion criteria: combined injuries of the musculoskeletal system and internal organs.

Study design

Due to the nature of the injuries, the servicemen were provided with standard rehabilitation programs, the effectiveness of which was assessed using recommended rehabilitation tools (Potcovaru et al., 2024).

Rehabilitation treatment was carried out by a multidisciplinary team, including a physical and rehabilitation medicine physician, a physical therapist and his assistants, a traumatologist, a neurologist, a psychologist, and, if necessary, other specialists. In most cases, rehabilitation treatment lasted 30 days. The rehabilitation complex was based on physical therapy, the tasks of which were formed according to the specific rehabilitation goal of each patient. Thus, with the prevailing consequences of TBI, the main tasks were to reduce headaches, improve motor skills and coordination, and normalize the tone of the muscles of the trunk and limbs. In the case of neuropathies, post-traumatic, and post-mobilization contractures, the main thing was to improve motor skills, both general and in the affected limbs, increase the range of motion in the joints, and increase muscle strength.

The rehabilitation complex included classes on various exercise equipment, namely a roller trainer, an exercise bike, a treadmill, and soft and balancing platforms. Devices for continuous passive development of movements in the joints of the limbs were actively used. Hardware physiotherapy treatment was prescribed to all patients depending on the manifestations of the TBI symptom complex and the type of limb damage: magnetotherapy, low- and high-intensity laser therapy, electrical myostimulation, sinusoidal modeled current therapy, and darsonvalization.

The rehabilitation treatment complex also included balneological procedures in the form of baths and showers. All patients received classical therapeutic massage, general or in local areas. Psychological rehabilitation was carried out in the form of psychotherapy sessions using individual or group methods.

Additionally, the effectiveness of the rehabilitation was assessed using the Barthel Index and FIM scale. The initial functional status of patients was assessed one week after admission to the sanatorium, after the adaptation period.

The Barthel Index consists of 10 activity indicators: Eating, Bathing, Personal hygiene (washing, brushing teeth, shaving, combing hair), Dressing, Bowel control, Urinary control, Toilet

use, Moving (from bed to chair and back), Ability to move on level ground, Climbing stairs. Each item is assessed from 0 to 10 points. A total score of 45-50 points corresponds to severe disability and dependence on outside help, 50-75 points indicate moderate dependence and 75-100 points indicate minimal limitation or restoration of lost neurological functions. The Barthel Index consists of 10 activity indicators: Eating, Bathing, Personal hygiene (washing, brushing teeth, shaving, combing hair), Dressing, Bowel control, Urinary control, Toilet use, Moving (from bed to chair and back), Ability to move on level ground, Climbing stairs. Each item is assessed from 0 to 10 points. A total score of 45-50 points corresponds to severe disability and dependence on outside help, 50-75 points indicate moderate dependence, and 75-100 points indicate minimal limitation or restoration of lost neurological functions (Wang et al., 2023; Lee et al., 2022).

The FIM scale consists of 18 items assessing 6 functional categories. The elements are divided into two groups: motor (13 parts) and cognitive (5 parts) (Granger et al., 1993). The FIM scale was used to assess the following areas of activity: self-care (eating, hygiene, bathing, dressing the upper body, dressing the lower body, using the toilet), sphincter control, transfer (bed/chair/wheelchair, toilet, bath/shower), ambulation (walking/moving in a wheelchair, walking upstairs), communication (understanding, expression) and social awareness (activities: social relations, problem-solving, memory). Each area of activity involves the performance of specific tasks, the quality of which is assessed in points from 1 to 7. The value of each point is given in Table 1.

Interpretation of results: the possible total score is (18-126); the scores are distributed between (13-91) for motor and (5-35) for cognitive categories. A higher score indicates greater patient independence. The minimum score (18) indicates complete patient dependence on others, while the maximum score of 126 indicates complete patient independence (Weinrebe et al., 2020).

Statistical analysis

Statistical data processing was performed using the XLSTAT 2016 statistical software package. The compliance of the clinical trial data distribution with the normal distribution law was checked using the Shapiro-Wilk test. To compare the quantitative data of the two groups, the Student's t-test was used. The Pearson correlation coefficient (r-Pearson) was calculated to study the relationship between two variables. The mean value and the error of the mathematical mean (M±m) were used to describe the data. The results of comparisons were considered reliable if the error probability value was less than $p<0.05$.

Results

All patients under our observation were classified as lightly injured and moderately injured according to the Abbreviated Injury Scale (AIS) (Table 2), which allows for determining the severity of the injury, the prognosis for life, justifying the choice of surgical treatment tactics and organizational and medical features of surgical care at the initial stage of medical evacuation (Rapsang et al., 2015). The initial severity of the injury is of great importance since it has the most significant impact on the effectiveness of further rehabilitation (Van Ditshuizen et al., 2021).

Table 1. FIM Scoring Criteria

	Description	Points
Patient does not need help	Full independence	7
	Modified independence (patient requires assistance using additional means, but not physical assistance)	6
Needs help (moderate dependence)	Supervision or accommodation	5
	Minimal assistance (patient can independently perform 75% or more of tasks)	4
	Moderate assistance (patient can independently perform 50% to 74% of tasks)	3
Patient does not need help	Maximum assistance (patient can do 25% to 49% of tasks independently)	2
	Totally requires assistance (patient can do less than 25% of tasks independently or requires assistance from more than one person)	1
	Patient is unable to perform daily activities	0

Table 2. Distribution of injuries depending on the severity of the injury according to the AdTS, n, %

Injury severity	Points	Number of injured	
		n	%
Non-severe	Less than 5	372	46,1
Moderate	5–7	435	53,9

Under the treatment, there was damage to the integrity of tissues, organs and systems due to specific morphological manifestations (brain damage, slaughter, crushing, enlargement, wound, dislocation, fracture, injury, injury, frostbite, etc.). According to the definition, combined injuries were considered simultaneous injuries to the head and the musculoskeletal system, several injuries within different anatomical and functional areas. Multiple trauma is several injuries (by one or more projectiles) within one anatomical area of the body. Combined trauma is several injuries (by one or more projectiles) to two or more anatomical regions of the body (head, neck, chest, abdomen, pelvis, spine, limbs).

Patients were admitted for treatment and rehabilitation from hospitals and clinics' surgical, traumatology, and neurology departments. Mine-blast wounds and gunshot wounds of the musculoskeletal system predominated among the total number. The following groups were distinguished: closed craniocerebral trauma and uncomplicated spinal trauma (without damage to the spinal cord, spinal roots, or blood vessels); combined spinal trauma (several parts of the spine); uncomplicated spinal trauma and closed chest trauma; open chest trauma and upper limb trauma; gunshot fracture of the upper limbs; combined trauma of the upper and lower limbs; chest and pelvic trauma (Table 3).

The following results were obtained for various groups depending on the nature of the damage during the examination of patients according to the Barthel scheme (Table 4).

As Table 4 shows, the total score in all study groups was within 68-77 points, which indicates moderate dependence on outside help.

Table 3. Distribution of servicemen by type of injury, n, %

Nature of injuries	Absolute number, n.	Percentage of the total number, %
Closed TBI and uncomplicated spinal trauma	116	14,4
Combined spinal trauma	121	15,0
Uncomplicated spinal trauma and closed chest trauma	104	12,9
Open chest trauma and upper extremity trauma	96	11,9
Chest and pelvic trauma	100	12,4
Combined upper and lower extremity trauma	160	19,8
Closed TBI and limb trauma	110	13,6

Table 4. Bartell Index indicators in different groups of wounded, M±m

Bartell Index indicators / Nature of lesions	Eating	Bathing	Toileting	Dressing	Bowel control	Urinary control	Toileting	Transfer	Ability to move on level ground	Climbing stairs	Total
Closed TBI and uncomplicated spinal trauma	6,6±1,1	3,6±0,8	4,1±0,6	6,1±1,1	8,0±1,7	7,9±1,6	7,5±1,1	10,3±2,5	10,1±2,1	6,1±1,9	70,3±2,5
Combined spinal trauma	6,4±1,0	3,5±0,9	3,9±0,7	6,2±1,4	7,9±2,0	7,7±1,6	7,4±1,1	9,8±1,7	9,6±1,7	5,8±1,9	68,2±2,0
Uncomplicated spinal trauma and closed chest trauma	7,9±1,1	4,1±0,9	4,4±1,1	6,5±1,2	8,7±2,1	8,5±1,8	8,3±1,7	11,2±1,9	10,2±2,0	6,2±1,8	76,0±2,1
Open chest trauma and upper extremity trauma	7,6±1,0	3,9±0,7	4,2±0,8	6,0±1,1	8,9±1,9	8,8±1,9	8,6±1,9	10,8±2,3	11,2±2,6	7,2±2,1	77,2±2,6
Chest and pelvic trauma	7,2±1,1	3,4±0,6	4,5±0,9	7,8±1,9	7,2±1,6	7,0±2,0	6,9±2,1	9,9±2,2	9,1±2,3	6,1±1,9	69,1±2,3
Combined upper and lower extremity trauma	8,4±1,6	2,9±0,7	3,9±1,0	6,3±1,2	9,1±2,0	8,8±1,5	7,7±2,4	9,7±2,1	9,4±2,2	6,2±2,5	72,4±2,5
Closed TBI and limb trauma	6,8±1,0	3,9±0,6	4,0±0,9	6,5±1,4	8,6±1,9	8,4±1,9	7,9±2,2	9,8±2,1	9,7±2,6	6,7±2,1	72,3±2,6

ISSN (print) 2522-1906, ISSN (online) 2522-1914
PHYSICAL REHABILITATION AND RECREATIONAL HEALTH TECHNOLOGIES
Vol. 10 No. 1, 2025

Table 5. FIM score indicators in different groups of wounded, M±m

FIM categories / Nature of lesions	Self-care	Bowel control	Transfer	Ambulation	Communication	Social cognition	Total
Closed TBI and uncomplicated spinal trauma	28,4±1,5	13,6±1,8	9,1±1,4	6,3±2,1	8,2±1,9	10,9±1,6	76,5±8,1
Combined spinal trauma	24,9±1,6	8,8±1,9	12,2±1,6	8,6±1,9	11,4±2,1	15,3±1,8	81,2±6,1
Uncomplicated spinal trauma and closed chest trauma	26,6±1,4	11,7±1,9	14,4±1,6	8,2±1,8	12,1±2,1	14,3±1,7	87,3±6,3
Open chest trauma and upper extremity trauma	22,1±1,8	13,8±1,8	17,2±1,8	11,9±1,8	12,3±1,9	13,6±1,6	90,9±3,9
Chest and pelvic trauma	24,2±1,6	8,9±1,9	9,4±2,2	8,1±2,4	12,6±1,8	15,2±1,8	78,4±6,1
Combined upper and lower extremity trauma	15,5±2,1	13,8±1,7	9,7±1,9	6,8±2,2	14,1±2,1	19,2±1,4	79,1±4,4
Closed TBI and limb trauma	23,3±1,6	12,9±1,6	7,8±2,1	6,6±2,4	8,3±1,8	10,2±1,6	69,1±6,2

The following results were obtained during the initial rehabilitation examination of the wounded using the FIM scale (Table 5).

In this case, the total score was within 69–90 points, which, like the Bartell index, indicates a moderate dependence of patients on others. Analysis of motor and cognitive skill levels is an important prognostic factor when assessing and monitoring the patient's condition. With an FIM value of <5 for such categories as self-care, movement, and ability to move, we can talk about the patient's complete dependence and form a rehabilitation prognosis and directions for restorative treatment. The FIM score ≥6 for each indicator of the motor (self-care (eating, hygiene procedures, bathing, dressing, bowel control, movement) and cognitive (acoustic/visual comprehension, verbal/nonverbal expression, social behavior, and problem-solving) categories are assessed as modified independence (the patient requires assistance with the use of additional means, but not physical assistance). Among the servicemen under our observation, no one had an FIM score <5. All the examined wounded had an initial assessment of more than 6 points on the FIM scale. The initial data in evaluating functioning on the FIM scale made it possible to identify subgroups of patients with a predominance of motor function impairment and a predominant impairment of cognitive functions, respectively (Chumney et al., 2010; Izumi, 2019).

Discussion

One of the most important conditions for successful patient rehabilitation is an adequate assessment of the physical and functional state to determine the direction and extent of the necessary interventions. Due to the severity and complexity of modern injuries, this is especially true for combat victims. One tool for such an assessment is the Functional Independence Measure (Chokshi et al., 2021; Colomer et al., 2023). The Functional Independence Measure (FIM) is part of the Uniform Data System for Medical Rehabilitation (UDSMR). It was developed to measure disability for various populations and is not specific to any diagnosis. The FIM scale is one of the methods of testing social and everyday skills, widely used in rehabilitation medicine that offers a unified system for determining the independence of the patient based on the International Classification of Impairments, Disabilities and Social Deficiencies for use in the medical system (Ann Peleg & Justo, 2024). The level of the patient's disability justifies the necessary level of care, the elements of the scale specify what kind of assistance a person needs to carry out everyday activities. FIM scores determine the degree of disability subjectively experienced by patients and their progress through medical rehabilitation programs (Çerezci & Boneval, 2023). This scoring system is most often used for patients who have had a stroke (Güp et al., 2023; Kakehi et al., 2023). However, recently FIM has increasingly begun to be successfully used in patients with severe injuries: hip fractures, spinal fractures, spinal cord injury (Pozin et al., 2024; Harvey et al., 2021; Hoenig et al., 1999).

Traditionally, the Barthel Index is used to assess daily living activities, which is a reliable indicator of disability (Collin et al., 1988; Katano et al., 2021). Simultaneously, subsequent studies, especially in recent years, have shown greater sensitivity of the FIM scale compared to the Barthel Index (Alookaran et al., 2022; Hachisuka et al., 1997). In addition, the FIM's resistance to Differential Item Functioning is higher than that of the Barthel Index (Caronni & Scarano, 2024; Lee et al., 2022).

In our study, we considered that standard tools for assessing the effectiveness of rehabilitation in military personnel with combined injuries may be insufficient. Combined injuries are complex pathological conditions, so patients with this type of injury need a more differentiated approach to determining functional capacity at all stages of rehabilitation. It is essential to consider the differentiation of functional disorders by the motor and cognitive components depending on the nature of the combined injury, adaptive and readaptive capabilities of the organism (Olkhovyi et al., 2016). The FIM scale is appropriate as a tool for assessing functional independence to more effectively determine the amount of necessary assistance and objectively assess rehabilitation results. Determining the level of functional abilities can also be considered an additional method of sorting regarding the direction to a certain stage of rehabilitation. Since one of the critical components of high-quality rehabilitation is the establishment of effective communication between hospitals and rehabilitation centers that carry out rehabilitation in the subacute and long-term periods of rehabilitation, including in the form of permanent supportive rehabilitation care, in our opinion, the standardization of medical care and the use, in particular, of the FIM scale, would contribute to increasing the effectiveness and quality of rehabilitation measures in different periods of rehabilitation. Thus, further directions of rehabilitation intervention in patients with certain combined injuries should be formed, taking into account the prevalence of motor or cognitive impairments. This will allow individualization of rehabilitation programs and increase their effectiveness.

Conclusions

Using the functional independence scale as a tool for assessing the long-term effectiveness of rehabilitation for military personnel with combined injuries allows for a more effective determination of the amount of necessary assistance and objectification of rehabilitation results. The inclusion of the FIM scale in the recommended toolkit for assessing the effectiveness of rehabilitation will allow for additional objectification of rehabilitation care and the formulation of individual recommendations for achieving the best results.

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Supplementary Information

Article details

The online version available at
https://doi.org/10.15391/prrht.2025-10(1).07

Conflict of interest
The authors declare that there is no conflict of interest.

Funding Statement
The materials presented in the article were obtained as a result of the research work "Development of the organizational and methodological foundations of the system of early rehabilitation of military personnel with the consequences of modern combat injuries", which is financed by the Ministry of Health of Ukraine from the state budget in the period 2023-2024 (state registration number 0123U100216)..

Received: February 2, 2025; Accepted: February 24, 2025
Published: February 28, 2025

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