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Combined kinesiotherapy in the rehabilitation of osteoarthritis patients after COVID-19

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Abstract

Purpose. Osteoarthritis (OA) remains the most prevalent musculoskeletal disorder globally. Patients with OA and concomitant post-COVID syndrome may exhibit a more severe disease course, characterized by frequent exacerbations and enhanced joint inflammation. This study aimed to improve the effectiveness of rehabilitation in patients with osteoarthritis of large joints who had previously experienced COVID-19 by developing and implementing differentiated methods of combined kinesiotherapy.

Materials & Methods. The study cohort included 72 patients (aged 36–62 years) with knee and hip osteoarthritis who had a history of COVID-19 and presented with post-COVID syndrome. Patients were randomly assigned to two groups: the control group (Group I, n=36) received basic therapy combined with standard therapeutic physical activity, while the intervention group (Group II, n=36) underwent a specialized, differentiated combined kinesiotherapy program alongside basic therapy. The comprehensive examination algorithm included clinical assessment, the Lequesne algofunctional index, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the EuroQol-5D-5L (EQ-5D-5L) questionnaire, and the Post-COVID-19 Functional Status (PCFS) scale.

Results. Evaluation of the personalized combined kinesiotherapy course revealed functional capacity, quality of life, and post-COVID status improvements in both groups. However, the intervention group demonstrated a highly significant therapeutic advantage across all evaluated parameters ($p<0.001$). Specifically, pain scores on the WOMAC scale decreased 4.5-fold, joint physical function improved nearly threefold, and the Lequesne index regressed to minimal manifestations (median (Me): 2.0 points). According to the EQ-5D-5L questionnaire, patients in the intervention group achieved a complete absence of limitations (Me: 1.0 point) across both everyday functional and psycho-emotional domains. Furthermore, analysis of the PCFS scale revealed that 83.3% of patients in the intervention group achieved a complete recovery of functional status (Grade 0), whereas in the control group, this outcome was observed in only 33.3% of cases ($p<0.001$).

Conclusions. The utilization of a personalized, differentiated course of combined kinesiotherapy within the complex rehabilitation of osteoarthritis patients who have suffered from COVID-19 significantly enhances overall rehabilitation efficacy, systematically mitigates post-COVID functional limitations, and substantially improves their long-term quality of life.

Keywords: combined kinesiotherapy, osteoarthritis, large joints, post-COVID syndrome, rehabilitation, quality of life.

Introduction

Among the pathologies of the musculoskeletal system, osteoarthritis (OA) remains the most prevalent disease, affecting approximately 10% of the world's population [1, 2]. According to the World Health Organization (WHO) Global Initiative for 2021–2030, OA is classified as a primary public health concern due to its debilitating impact on patients' functional capacities and overall quality of life [2]. Recent epidemiological projections indicate a sharp rise in global disease burden: by 2050, the incidence of knee OA is expected to increase by 74.9%, hand OA by 48.6%, hip OA by 78.6%, and other forms of the disease by 95.1% compared to 2020 statistics [2]. Furthermore, recent clinical trends demonstrate a noticeable shift toward an earlier onset of OA. This trend extends the cumulative years lived with disability, contributing to a substantial economic burden on healthcare systems and society [3].

The ongoing impact of coronavirus disease (COVID-19) compounds this issue, presenting a persistent global challenge that disproportionately affects individuals with chronic comorbidities, including OA [4]. Currently, scientific attention is heavily focused on the manifestations and long-term outcomes of post-COVID syndrome. Emerging data across virology, epidemiology, and clinical medicine have provided deeper insights into the nature of this systemic condition caused by the SARS-CoV-2 virus [5]. Recent studies investigating the intersection of SARS-CoV-2 infection, joint aging, and OA progression indicate that the long-term sequelae of COVID-19 accelerate degenerative joint processes. Specifically, the infection perpetuates low-grade systemic inflammation, thereby exacerbating the clinical course of osteoarthritis [6]. Consequently, patients with osteoarthritis (OA) who suffer from post-COVID syndrome present a significantly worse prognosis regarding disease progression and experience profound functional limitations compared to OA patients without a history of SARS-CoV-2 infection [4, 6]. The clinical course of OA in this cohort is characterized by frequent exacerbations and intensified intra-articular and systemic inflammatory processes [7]. Several complex pathogenetic pathways are implicated in prolonged COVID-19, including viral persistence, immune dysregulation, mitochondrial dysfunction, complement activation, endothelial inflammation, and microbiome dysbiosis; these mechanisms cumulatively exert a detrimental impact on the pathomorphology and clinical manifestations of OA [5]. Furthermore, psychological comorbidities associated with post-COVID syndrome, such as anxiety and depression, synergistically exacerbate chronic pain pathways in OA patients, thereby further deteriorating their clinical outcomes and quality of life [8].

Despite the significant heterogeneity of clinical manifestations, standard OA treatments are frequently prescribed using a non-individualized approach, which inherently limits their therapeutic efficacy. Conventional interventions, including intra-articular injections and pharmacological management, continue to demonstrate suboptimal long-term outcomes [3]. Consequently, there is an urgent need for targeted, effective interventions designed to restore the functional status of individuals with OA compounded by prolonged COVID-19 symptoms [9]. While numerous studies currently explore restorative strategies for this population, the considerable heterogeneity of post-COVID syndrome manifestations—particularly in patients with pre-existing chronic musculoskeletal disorders—remains a critical challenge [4, 10, 11]. This complexity necessitates the development of optimized rehabilitation protocols, specifically through evidence-based physical therapy modalities. Integrating diverse physical therapy methods into comprehensive rehabilitation schemes has been shown to enhance the quality of life, as well as the socioeconomic status, of this patient cohort [11, 12, 13]. In particular, therapeutic exercise regimens serve as a cornerstone of multimodal rehabilitation, aimed at restoring joint kinematics, enhancing muscular endurance, improving postural control and balance, and ultimately increasing overall physical capacity [10, 12, 13]. However, optimizing the selection and implementation of a differentiated approach to physical therapy—including specialized kinesiotherapy programs — remains insufficiently defined for OA patients navigating the long-term sequelae of COVID-19 and post-viral syndrome [9].

Aim. This study aimed to enhance the efficacy of rehabilitation outcomes in patients with osteoarthritis of the large joints who have suffered from COVID-19 by developing and implementing differentiated methods of combined kinesiotherapy.

Materials and methods

Study Design and Participants

A prospective, randomized, controlled, parallel-group study was conducted with two assessments: before the intervention and upon completion of the therapeutic rehabilitation complex (TRC). The study involved 72 patients with knee and hip osteoarthritis who met the predefined inclusion criteria. Among them, 52 patients suffered from gonarthrosis (72.2%) and 20 from coxarthrosis (27.8%). The majority of patients with both localizations exhibited unilateral joint involvement, including unilateral gonarthrosis in 32

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cases (44.4%) and unilateral coxarthrosis in 16 cases (22.2%). The patients' ages ranged from 36 to 62 years. The study cohort comprised 48 women (66.7%) and 24 men (33.3%) (Table 1). According to the Kellgren–Lawrence radiological classification, most patients were diagnosed with stage I osteoarthritis (46 individuals, 63.9%), 23 patients (31.9%) had stage II, and the remaining patients presented with stage III manifestations. Patients with stage IV osteoarthritis were excluded from the study (Table 1).

Table 1. Baseline clinical and demographic characteristics of the studied patients (n=72)

Parameter		Patient Cohort (n=72)
Age, years, *M±SD*		52.5±8.4
Gender, *n* (%)		
Men		24 (33.3)
Women		48 (66.7)
Joint Localization and Involvement, *n* (%)		
coxarthrosis	Unilateral	16(22.2)
	Bilateral	4 (5.6)
	Total	20(27.8)
gonarthrosis	Unilateral	32(44.4)
	Bilateral	20(27.8)
	Total	52(72.2)
Osteoarthritis Stage (Kellgren–Lawrence), *n* (%)		
coxarthrosis	stage I	12(16.7)
	stage II	7(9.7)
	stage III	1(1.4)
gonarthrosis	stage I	34(47.2)
	stage II	16(22.2)
	stage III	2(2.8)

Note: Data are presented as M±SD, where M means value, SD — standard deviation, for continuous variables, and as n (%), where n is the number of patients and % is the percentage for categorical variables.

Inclusion criteria were as follows: voluntary informed consent to participate in the study; age between 18 and 65 years; diagnosed knee or hip osteoarthritis (stages I–III according to the Kellgren–Lawrence classification) in the remission phase; a history of COVID-19 infection documented more than 12 weeks before enrollment with persistent manifestations of post-COVID syndrome; and the patients' preserved ability to self-care and perform physical exercises.

Exclusion criteria included: age under 18 or over 65 years; stage IV osteoarthritis; the acute period of COVID-19; severe course of post-COVID syndrome, including post-exertional malaise (PEM); decompensated chronic comorbidities; and the inability to self-care or participate in physical rehabilitation; concomitant medical treatment: the regular use of non-steroidal anti-inflammatory drugs (NSAIDs), analgesics, or chondroprotectors within 2 weeks prior to enrollment or during the study period (to eliminate pharmacological confounding factors).

Informed consent was obtained from all subjects involved in the study.

Methods

Using simple randomization, all patients were equally divided into two parallel observation groups (n=36, 50.0% each) depending on the TRC. The movement of participants through all phases of a randomized controlled trial is presented in Figure 1 in accordance with the CONSORT recommendations.

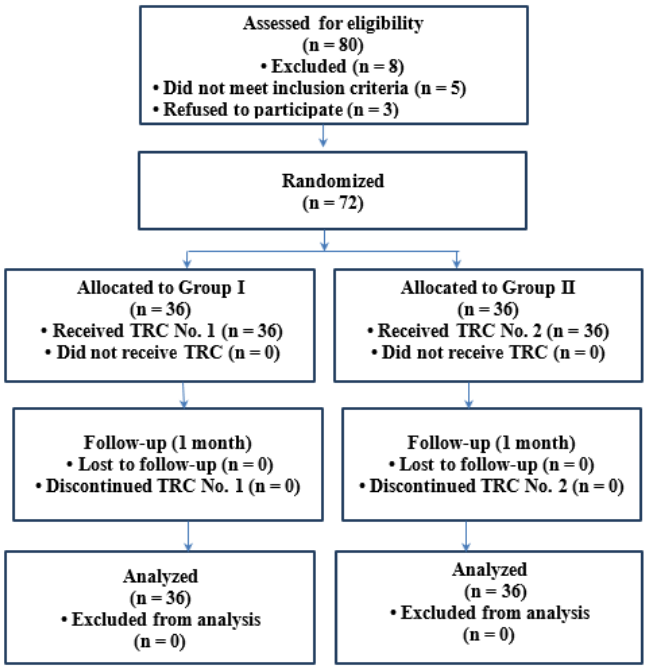

Figure 1. CONSORT flowchart: screening, randomization, allocation, follow-up, and analysis of patient outcomes.

In addition, the study utilized an assessor-blinded design; baseline and follow-up assessments using the WOMAC, Lequesne, EQ-5D-5L, and PCFS scales were conducted by independent experts who were not involved in the rehabilitation interventions, remained blinded to group allocation, and strictly followed a standardized interviewer approach. Subsequent statistical analysis of the baseline characteristics confirmed no significant differences between Group I and Group II regarding the anatomical site of joint involvement (the ratio of coxarthrosis to gonarthrosis cases was homogeneous, $p>0.05$). This minimizes any potential bias stemming from specific joint biomechanics. Patients in the control group (Group I) received TRC No. 1, which consisted of basic therapy (orthopedic regimen, massage) combined with standard therapeutic physical activity, including a set of training exercises performed in a sitting or lying position aimed at

strengthening the lower extremity muscles and improving joint functional activity. Patients in the intervention group (Group II) received TRC No. 2, which featured a customized complex of differentiated combined kinesiotherapy implemented against the background of basic therapy. To eliminate potential confounding effects on pain score outcomes, patients in both groups (Group I and Group II) did not receive any concomitant medical treatment (including non-steroidal anti-inflammatory drugs [NSAIDs], analgesics, or chondroprotectors) throughout the study period. The systematic use of these medications within 2 weeks before the intervention served as an exclusion criterion.

Clinical outcomes were evaluated in two stages: an intragroup analysis (comparing baseline parameters with post-intervention indicators within each group after 1 month) and an intergroup analysis (comparing the outcomes between the intervention and control groups upon completion of the TRC course). The comprehensive examination algorithm included general clinical, orthopedic, neurological, and radiological assessments (MRI and CT), alongside functional and quality-of-life evaluations using the Lequesne algofunctional index, the WOMAC scale, the EQ-5D-5L questionnaire, and the PCFS scale.

The orthopedic assessment comprised a clinical examination, functional testing, and evaluation of instrumental data. We assessed pain severity and the functional status of the joints, specifically recording pain upon palpation, the range of active and passive movements, signs of inflammation, and joint deformities. Conventional radiography was performed for all patients at baseline using a unified testing protocol. When necessary to clarify the diagnosis, computed tomography (CT) or magnetic resonance imaging (MRI) was utilized.

To evaluate the severity of knee and hip osteoarthritis, the Lequesne algofunctional index was applied to assess pain characteristics or discomfort, maximum pain-free walking distance, and activities of daily living. While the index structure is identical for both osteoarthritis localizations, specific items differ based on joint anatomy: the gonarthrosis questionnaire specifically targets pain when rising from a chair, climbing stairs, and knee stiffness, whereas the coxarthrosis version focuses on pain when putting on socks (hip flexion), cane usage, and prolonged sitting discomfort. Each of the three sections is scored from 0 to 8 points, yielding a maximum total score of 24 points [14].

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a self-administered questionnaire, was employed to evaluate the functional status of the musculoskeletal system across three subscales: pain intensity (5 items), stiffness (2 items), and physical function (17 items). Patients rated their condition on a 5-point Likert scale: 0 (none), 1 (mild), 2 (moderate), 3 (severe), and 4 (extreme). Outcomes were classified by the total score as excellent (0–14 points), good (15–28 points), satisfactory (29–38 points), or unsatisfactory (more than 38 points) [15].

Health-related quality of life and the multi-domain impact of post-COVID syndrome were assessed using the standardized EuroQol-5D-5L (EQ-5D-5L) questionnaire. This instrument measures health status across 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is evaluated on 5 severity levels, ranging from 1 (no problems) to 5 (extreme problems), to compute the total health profile score [16].

Additionally, the overall severity of post-COVID functional impairment was monitored using the Post-COVID-19 Functional Status (PCFS) scale, as described above, grading patients from Grade 0 (no symptoms) to Grade 4 (severe functional limitations) [17].

Procedure

The combined kinesiotherapy technique was a complex of general strengthening exercises and special active and static exercises for joints on an inclined plane, under conditions of unloading of joints and spine, selected individually, depending on the stage of the disease, the severity of pathological disorders, comorbidity, the results of functional testing of patients, and their functional capacity. The intervention was carried out according to a structured, personalized protocol. The combined kinesiotherapy program was implemented with a frequency of 3 sessions per week for a total duration of 1 month (4 weeks), consisting of 12 sessions. Each session lasted exactly 40 minutes. To ensure methodology reproducibility, the detailed parameters of the basic exercises, inclination angles, dosing, and progression criteria are provided in Table 2. Patient tolerance and workload progression during the sessions were monitored using the Borg CR10 scale, with the target intensity maintained within the light-to-moderate range (2–4 points). An important aspect in the formation of a personalized combined kinesiotherapy program was the phasing of loads, taking into account the degree of tolerance to physical activity, which is inherent in patients with post-COVID syndrome.

Statistical Analysis

An a priori sample size calculation was performed using G*Power software (version 3.1.9.7) based on an independent samples t-test. To detect a statistically significant difference between

Table 2. Protocol of basic exercises of combined kinesiotherapy for Group II

Exercise Example	Inclination Angle	Dosage & Volume	Progression Criteria
Passive-active joint decompression (Traction-assisted hip/knee extension)	15°–20° (Head end elevated)	3 sets of 10 – 12 repetitions per session	Increase the end-range holding time by 5 seconds weekly.
Guided heel slides (Active slides on a low-friction inclined surface)	20°–30° (Foot end elevated)	4 sets of 10 – 12 repetitions per session	Add light ankle weights (0.5 kg) once 15 reps are pain-free.
Isometric quadriceps sets (Static contraction under joint unloading)	15° (Horizontal-to-inclined transition)	3 sets of 10 holds (5 seconds hold / 5 seconds rest)	Increase isometric contraction duration to 10 seconds per hold.

Note: All exercises are performed smoothly without pain provocation. Patient progression is monitored weekly using the Borg CR10 scale to ensure the perceived exertion remains within the light-to-moderate range (2–4 points).

the two parallel groups with a medium-to-large expected effect size (Cohen's d=0.67), a significance level (α) of 0.05, and a statistical power (1-β) of 0.80, a minimum sample size of 32 patients per group was required. To account for a potential attrition rate of approximately 10% over the 1-month intervention period, the final target sample size was increased to 36 patients per group (n=72 in total). Data accumulation and primary processing were performed using MS Excel 2010, and statistical analysis was conducted using the Statistica software package (version 6.1). The normality of quantitative data distribution was assessed using the Shapiro–Wilk test. WOMAC scores (total and individual subscales) exhibited a normal distribution and were expressed as mean ± standard deviation (M±SD). The statistical significance of intragroup changes was evaluated using the paired Student's t-test, while intergroup differences were analyzed using the independent samples t-test. To assess both statistical significance and the clinical magnitude of the treatment effect, 95% confidence intervals (95% CIs) for the difference in means between the groups after treatment were calculated. Data from individual subscales and questionnaire items followed a non-normal distribution and were expressed as median and interquartile range (Me [Q1; Q3]). Intragroup comparisons of these variables over the course of treatment were performed using the Wilcoxon signed-rank test, and intergroup analysis was conducted using the Mann–Whitney U test. Categorical variables and frequency distributions (PCFS scale) were compared using Pearson's chi-squared test (χ^2). Given the exploratory nature of this study, statistical significance was set at $p<0.05$ for all analyses, and no formal correction for multiple comparisons was applied.

Results

The assessment of the therapeutic and TRC efficacy demonstrated positive clinical outcomes in both observation groups. However, the integration of differentiated combined kinesiotherapy approaches into the multimodal management of patients with large-joint osteoarthritis (OA) who had suffered from COVID-19 contributed to a significantly greater improvement in their clinical status.

Arthrological status was comprehensively evaluated using the Lequesne algofunctional index and Index WOMAC.

Dynamics of Lequesne algofunctional index. Baseline evaluation of coxarthrosis and gonarthrosis severity via the Lequesne index before the TRC implementation revealed moderate pathological impairments across all questionnaire categories in both groups. Patients consistently reported moderate nocturnal pain, as well as pain exacerbated by prolonged walking and static positions (sitting for coxarthrosis; standing for gonarthrosis), which collectively led to diminished mobility and restricted daily activities (Table 2). Following the TRC intervention, patients in both cohorts demonstrated a reduction in pain intensity and an objective improvement in the functional mobility of the affected joints. Nevertheless, the outcomes achieved through the differentiated combined kinesiotherapy approach were significantly superior to those obtained via conventional physical therapy. Post-treatment total scores on the Lequesne index for the second group (differentiated kinesiotherapy) shifted to reflect only mild pathological disorders. Specifically, the pain and discomfort section revealed a more pronounced reduction in nocturnal, walking, and sitting pain. Furthermore, the maximum pain-free walking distance significantly increased, accompanied by a substantial enhancement in daily functional activity scores. Conversely, in the first group (conventional therapy), the severity of coxarthrosis remained classified as moderate despite minor improvements across all parameters. The only statistically meaningful advancement within the first group was observed in the category of functional activity (Table 3).

The integration of combined kinesiotherapy into the complex rehabilitation regimen yielded

Table 3. Dynamics of Lequesne algofunctional index scores in patients with osteoarthritis and post-COVID syndrome before and after complex rehabilitation, Me [Q_1; Q_3] (n=72)

Joint localization	Control Group (I, n=36)			Intervention Group (II, n = 36)			
	before TRC	after TRC	p1	before TRC	after TRC	p1	p2
Knee osteoarthritis, *points*	6.5[6.5;7.0]	4.0[4.0;5.0]	<0.001	6.5[6.0;7.0]	2.0[2.0;2.75]	<0.001	<0.001
Hip osteoarthritis, *points*	7.0[7.0;8.0]	5.5[5.0;7.0]	<0.001	7.0[7.0;7.5]	2.0[2.0;3.0]	<0.001	<0.001

Notes:
1. P1indicates statistical significance of differences within a group (calculated using the non-parametric Wilcoxon signed-rank test);
2. p2 indicates statistical significance of differences between the main and control groups after treatment (calculated using the non-parametric Mann–Whitney U test);
3. TRC — therapeutic rehabilitation complex;
4. Data are presented as Me [Q_1; Q_3] — where Me — median, Q_1; Q_3 — interquartile range.

Table 4. Dynamics of WOMAC scale scores in patients with osteoarthritis and post-COVID syndrome before and after complex rehabilitation, M±SD (n=72)

WOMAC subscales	Control Group (I, n=36)			Intervention Group (II, n=36)				
	before TRC	after TRC	p1	before TRC	after TRC	p1	Post-treatment Mean Difference (95% CI)	p2
Pain, *points*	9.3±1.6	6.6±1.2	<0.001	9.4±1.6	2.1±0.9	<0.001	**4.50 (4.00; 5.00)**	<0.001
Stiffness, *points*	4.3±1.2	2.6±0.8	<0.001	4.4±1.2	2.0±0.8	<0.001	**0.60 (0.22; 0.98)**	0.002
Physical Function, *points*	32.7±3.2	24.4±3.1	<0.001	33.8±3.4	13.2±2.8	<0.001	**11.20 (9.81; 12.59)**	<0.001
Total points, *points*	46.6±7.1	33.2±6.8	<0.001	47.6±7.2	17.3±4.1	<0.001	**15.90 (13.26; 18.54)**	<0.001

Notes:
1. p_1 — statistical significance of differences within a group (calculated using the paired Student's t-test);
2. p_2 — statistical significance of differences between the experimental and control groups after treatment (calculated using the independent samples Student's t-test);
3. 95% CI — 95% confidence interval for the post-treatment mean difference between the groups;
4. All values are presented as M ± SD, where M is the mean and SD is the standard deviation;
5. TRC — therapeutic rehabilitation complex;
6. WOMAC — Western Ontario and McMaster Universities Osteoarthritis Index.

a profound improvement in the clinical status of the patients. Post-treatment evaluations revealed median Lequesne index scores of 2.0 [2.0; 2.75] for gonarthrosis and 2.0 [2.0; 3.0] for coxarthrosis. These outcomes demonstrated a statistically significant superior improvement compared to the control group ($p<0.001$). Such a marked therapeutic effect successfully shifted the patients in the intervention group from the category of severe functional impairments to the zone of minimal clinical manifestations (Table 3).

Dynamics of WOMAC index. A detailed assessment of daily mobility and the differentiation of pain intensity relative to physical activity were carried out using the WOMAC index. Baseline evaluation of joint stiffness and pain characteristics across both observation groups before the complex rehabilitation intervention revealed moderately pronounced mechanical pain during ambulation and moderate morning stiffness. Furthermore, limitations in functional capacity, such as prolonged walking and performing household chores, were exacerbated by manifestations of chronic fatigue secondary to post-COVID syndrome. Consequently, patients experienced regular moderate discomfort, forcing them to adapt their lifestyles and avoid excessive physical loads (Table 3). Following the complex rehabilitation program, a regression of the pain syndrome, a reduction in morning stiffness, and an overall improvement in functional activity were observed in both groups. However, the post-treatment questionnaire indicators were significantly superior in the intervention group of patients who received combined kinesiotherapy as part of their complex treatment. Specifically, a substantial improvement—manifested as a nearly 4.5-fold decrease in scores—was noted within the pain syndrome category, alongside a 2.6-fold improvement in the functional activity domain. These patients reported an increased walking distance on flat surfaces, as well as an enhanced functional status during complex daily movements, including descending and ascending stairs, sitting, and performing essential household chores. Conversely, patients in the first (control) group retained notable difficulties in daily activities and continued to exhibit moderate manifestations of the pain syndrome, with post-treatment parameters improving only 1.3-fold and 1.4-fold, respectively. Analyzing the total scores on the WOMAC scale confirmed that while clinical symptoms improved in both cohorts, the intervention group achieved a significantly lower mean score of 17.3 points compared to 33.3 points in the control group, demonstrating a statistically significant therapeutic advantage ($p<0.001$) (Table 4).

Dynamics of Quality of Life According to the EuroQol-5D-5L Questionnaire. The EuroQol-5D-5L questionnaire was employed to evaluate the patients' quality of life regarding both OA symptoms and to quantitatively measure the impact of key post-COVID syndrome manifestations — including cognitive impairment, fatigue, and psychological distress — on their overall functional status. Baseline evaluation revealed an almost identical profile of diminished quality of life across both cohorts ($p>0.05$). The most pronounced impairments were identified within the «mobility» and «pain/discomfort» dimensions in both observation groups, each yielding a median score of 3.0 points. These findings directly correlate with the clinical manifestations of OA and the moderate functional restrictions secondary to post-COVID syndrome (Table 4). Analysis of the post-treatment outcomes demonstrated an improved quality of life profile in both groups. However, the intervention group, which received combined kinesiotherapy as a core element of their complex rehabilitation, exhibited a highly significant regression of impairments across all five dimensions of the scale ($p1<0.001$). Upon completion of the rehabilitation course (at the 1-month follow-up), the median response for patients in the main intervention shifted to 1.0 points with an interquartile range of [1.0; 1.0] in two specific domains («pain/discomfort» and «anxiety/depression»), indicating a complete absence of complaints or functional limitations in these areas. Conversely, conventional physical therapy failed to produce meaningful adjustments in the patients' self-care capacity and ability to perform daily activities. In both of these dimensions, post-treatment changes within the control group were statistically insignificant ($p1>0.05$), with the median scores remaining stagnant at 2.0 points. Ultimate intergroup analysis confirmed the definitive statistical superiority of the differentiated kinesiotherapy protocol over the conventional regimen for every evaluated EuroQol-5D-5L criterion ($p2 < 0.001$) (Table 5).

Dynamics of Post-COVID-19 Functional Status (PCFS) Scale. At baseline, all observed patients exhibited mild functional limitations corresponding to Grade 2 on the Post-COVID-19 Functional Status (PCFS) scale. This state was clinically characterized by a constellation of post-COVID symptoms that imposed certain restrictions on daily life, such as a reduced pace of work or the delegation of certain household duties, though patients remained fully capable of independent self-care. The primary manifestations contributing to this Grade 2 functional impairment included diminished general well-being (manifested as systemic weakness and reduced exercise tolerance), circadian rhythm disruptions (specifically somnolence), myalgia, muscular weakness, and emotional-volitional distress (depressed mood and emotional instability). Notably, patients with severe functional impairments matching Grades 3 or 4 on the PCFS scale were excluded from the study cohort. Post-treatment evaluation of functional limitations via the PCFS scale revealed a substantial improvement in the functional capacity of patients across both cohorts following the complex rehabilitation program. However, a transition to negligible functional limitations (PCFS Grade 1: the patient can perform all usual duties and activities, despite potential residual pain, anxiety, or depression) was observed in 24 (66.7%) patients in the control group, compared to only 6 (16.7%) patients in the intervention group. Conversely, a complete absence of functional limitations (PCFS Grade 0: the patient experiences no restrictions in daily living and is entirely free of pain, anxiety, or depression symptoms) was achieved by 12 (33.3%) patients in the control group and the vast majority of patients in the main group—30 (83.3%) individuals. This therapeutic advantage in favor of the differentiated kinesiotherapy protocol was highly statistically significant ($p<0.001$) (Table 6).

Furthermore, a comprehensive analysis of the dynamics between the WOMAC and PCFS scales

Table 5. Dynamics of EuroQol-5D-5L quality of life scores in patients with osteoarthritis and post-COVID syndrome before and after complex rehabilitation, Me [Q_1; Q_3] (n=72)

EQ-5D-5L dimensions	Control Group (I, n=36)			Experimental Group (II, n=36)			
	before TRC	after TRC	p1	before TRC	after TRC	p1	p2
Mobility, points	3.0[1.0;3.0]	2.0[1.0;3.0]	<0.05	3.0[2.0;3.0]	1.0[1.0;2.0]	<0.001	<0.001
Self-care, points	2.0[1.0;3.0]	2.0[1.0;3.0]	>0.05	2.0[1.0;3.0]	1.0[1.0;2.0]	<0.001	<0.001
Normal daily activities, points	2.0[1.5;2.0]	2.0[1.0;3.0]	>0.05	2.0[2.0;3.0]	1.0[1.0;2.0]	<0.001	<0.001
Pain/discomfort, points	3.0[2.0;3.0]	2.0[1.0;2.0]	<0.05	3.0[1.0;3.0]	1.0[1.0;1.0]	<0.001	<0.001
Anxiety/depression, points	2.0[1.0;3.0]	1.0[1.0;2.0]	<0.05	2.0[1.0;3.0]	1.0[1.0;1.0]	<0.001	<0.001

Notes:

1. p1— statistical significance of differences within a group (calculated using the non-parametric Wilcoxon signed-rank test);

2. p2 —statistical significance of differences between the main and control groups after treatment (calculated using the non-parametric Mann–Whitney U test);

3. Data are presented as Me [Q_1; Q_3] — where Me — median, Q_1; Q_3 — interquartile range.

Table 6. Distribution of patients with osteoarthritis and post-COVID syndrome by PCFS grades before and after complex rehabilitation, n (%) (n=72)

Functional Status (PCFS Scale)	Control Group (I, n=36)		Intervention Group (II, n=36)		
	before TRC	after TRC	before TRC	after TRC	p
Grade 0 (No symptoms)	—	12 (33.3)	—	30 (83.3)	<0.001
Grade 1 (Negligible symptoms)	—	24 (66.7)	—	6 (16.7)	<0.001
Grade 2 (Slight functional limitations)	36(100.0)	—	36 (100.0)	—	>0.05

Notes.
p — statistical significance of differences between groups after rehabilitation was calculated using Pearson's χ^2 test;
TRC — therapeutic rehabilitation complex;
PCFS — post-COVID-19 Functional Status;
n is the number of patients, and % is the percentage for categorical variables

demonstrated a clear positive synergistic effect: a substantial reduction in the WOMAC score—specifically within the «pain» and «physical function» domains—strongly correlated with a progressive improvement in the PCFS grade. This correlation indicates that restoring large-joint mobility directly mitigates the degree of everyday maladaptation triggered by post-COVID syndrome. Consequently, kinesiotherapy plays a distinct dual role in the complex rehabilitation of patients presenting with concomitant osteoarthritis and post-COVID syndrome. On the one hand, the targeted local impact on the affected joints enhances movement biomechanics, directly reducing WOMAC scores. On the other hand, the aerobic, carefully dosed nature of these physical exercises improves pulmonary ventilation and vascular endothelial function, which directly alleviates systemic post-COVID maladaptation as measured by the PCFS scale. Ultimately, this comprehensive improvement in underlying physiological markers translates directly into superior quality of life outcomes across all EuroQol-5D-5L dimensions.

Discussion

The findings of this study strongly align with the consensus in current medical literature, confirming that kinesiotherapy serves as a foundational modality of complex rehabilitation for both OA and post-COVID syndrome. Tailored kinesiotherapy techniques are fundamentally designed to restore respiratory and cardiovascular capacities, mitigate chronic fatigue, enhance muscle tone, improve arthrokinematics, stabilize the patient's psycho-emotional status, and facilitate a successful return to daily activities [10, 12, 13, 18]. These observations are consistent with a systematic review by Sánchez-García et al. (2023), which demonstrated that structured, dosed physical activity strategies within post-COVID rehabilitation protocols exert a profound positive impact across multiple dimensions of patient health, spanning from physical capacity to mental well-being [18]. Furthermore, for individuals navigating the long-term sequelae of COVID-19, a meta-analysis by Cheng et al. (2024) strongly recommends multimodal exercise regimens. These frameworks, which combine supervised aerobic training with resistance exercises, specialized pulmonary therapeutics, and mind-body practices such as Tai Chi, have demonstrated definitive efficacy in alleviating core manifestations of post-COVID syndrome, including systemic fatigue, myalgia, and diminished physical endurance [19].

Similarly, in OA management, kinesiotherapy remains an integral component of comprehensive restorative treatment. It exerts a profound positive effect on joint function by modulating critical molecular pathways, including the degradation of the extracellular matrix, chondrocyte apoptosis, inflammatory response, autophagy, and necrotic RNA alterations [10, 20].

Given the established synergistic effect of chronic low-grade inflammation in both OA (Chen et al., 2023) and post-COVID syndrome (Krasnoselsky et al., 2023), structured physical activity emerges as a pathogenetically justified therapeutic intervention for this specific patient cohort [4, 21]. This approach is largely mediated by the activity-induced release of anti-inflammatory myokines. Research by Mińko et al. (2024) and Laurens et al. (2020) confirms that targeted physical exertion, through the physiological signaling of myokines — biochemical signaling molecules synthesized and secreted during skeletal muscle contraction — significantly suppress both localized intra-articular and systemic inflammation [22, 23]. Specifically, during exercise, skeletal muscles act as an endocrine organ, secreting myokines that serve as a pivotal pathogenetic link. These molecules underpin the therapeutic benefits of physical training on general health, compensating for sarcopenic deficits and correcting systemic functional disorders [22-24]. Furthermore, myokines exhibit potent anti-inflammatory and immunomodulatory effects, facilitate the strengthening of periarticular musculature, and exert a protective impact on the vascular endothelium and pulmonary tissues [22, 23].

Accordingly, combined differentiated kinesiotherapy serves as a potent pathogenetic intervention for patients presenting with OA and

post-COVID syndrome. This approach leverages the regulated activation of contractile skeletal muscles, thereby potentiating the systemic release of myokines. Concurrently, kinesiotherapy enhances tissue oxygenation, which mitigates the manifestations of post-viral maladaptation and optimizes the functional capacity of the periarticular neuromuscular apparatus. Nevertheless, prescribing physical activity for this complex patient population demands strict individualization and careful differentiation, precisely tailored to the specific symptoms and degree of functional limitation. As demonstrated by Griffin (2024), carefully structured, individualized exercise regimens are essential to prevent the loss of skeletal muscle mass in individuals navigating post-COVID complications [25]. Given that systemic fatigue constitutes the hallmark feature of post-COVID syndrome, while joint pain remains the primary clinical manifestation of OA, therapeutic exercises must strategically balance low-intensity articular loading with gradual, submaximal aerobic progression to minimize the risk of post-exertional symptom exacerbation.

The variants of combined kinesiotherapy implemented in this study successfully address these therapeutic requirements. By utilizing an inclined plane to effectively unload the spine and affected large joints, and by alternating between active dynamic and static muscular contraction modes, this specialized protocol reduces the initial intensity of the intervention, thereby safely preventing the development of post-exertional malaise.

In the rehabilitation of patients presenting with OA and post-COVID syndrome, kinesiotherapy plays a pivotal dual role. Locally, the targeted intervention enhances joint biomechanics and movement kinematics. Systemically, the aerobic, carefully dosed nature of the exercises improves pulmonary ventilation and vascular endothelial function, thereby directly mitigating post-viral maladaptation. Ultimately, this comprehensive enhancement of underlying physiological markers successfully translates into superior overall quality of life outcomes. The results of this study clearly demonstrate that implementing a personalized protocol of differentiated combined kinesiotherapy significantly reduces the intensity of the arthritic pain syndrome while simultaneously alleviating the multifaceted manifestations of post-COVID maladaptation in this complex patient cohort.

Limitations. Nevertheless, certain limitations of the present study must be acknowledged, such as the relatively small patient sample size and the short-term observation period, which necessitate further evaluation of these rehabilitation outcomes in the long term. Due to the inherent nature of physical rehabilitation interventions, a double-blind design was also not feasible, as both the patients and the physical therapists were aware of the treatment allocation. However, this potential risk of bias was significantly mitigated by employing blinded independent assessors to perform all clinical evaluations. Additionally, due to the large number of outcomes analyzed across multiple subscales, no correction for multiple comparisons (such as Bonferroni or Holm-Bonferroni) was applied, which may increase the risk of Type I error; thus, these findings should be interpreted as exploratory. Consequently, prospects for further research should focus on extending this study to a larger observation group and conducting a rigorous, evidence-based comparative analysis against alternative physical therapy modalities.

Conclusions

The implementation of combined kinesiotherapy within the complex rehabilitation of patients with osteoarthritis who had suffered from COVID-19 demonstrated a pronounced therapeutic advantage across all evaluated parameters ($p_2<0.001$). Specifically, a highly significant 4.5-fold reduction in pain intensity was achieved according to the WOMAC index, alongside a nearly threefold restoration of joint physical function. Furthermore, a substantial regression of algofunctional impairments was recorded via the Lequesne index, shifting patients to the zone of minimal clinical manifestations with a post-treatment median score of 2.0 points ($p_1<0.001$).

The tailored course of combined kinesiotherapy facilitates a comprehensive restoration of daily functioning and quality of life in patients with osteoarthritis and concomitant post-COVID syndrome. Unlike the control group, patients in the main cohort achieved a state reflecting a complete absence of complaints or limitations (median score of 1.0 points) across all five dimensions of the EuroQol-5D-5L questionnaire. This improvement included the complete resolution of anxiety and depressive states, alongside the comprehensive recovery of self-care capacity and the ability to perform usual activities of daily living ($p_2<0.001$).

The utilization of a personalized, differentiated protocol of combined kinesiotherapy as a core element of complex rehabilitation for patients with large-joint osteoarthritis who have suffered from COVID-19 significantly enhances overall rehabilitation efficacy and substantially improves their long-term quality of life.

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Author Contributions
Olena Voloshyna: Conceptualization, Methodology; **Iryna Balashova:** Software, Data curation, Writing - Original draft preparation, Investigation; **Ihor Lysyi:** Visualization, Investigation; **Olga Dykova:** Software, Validation; **Larysa Kovalchuk:** Writing - Reviewing and Editing. All authors have read and agreed with the published version of the manuscript.

Conflict of Interest
The authors declare no conflict of interest regarding the publication of this article.

Ethical Approval
The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Odessa National Medical University (Protocol No. 6 dated 09.06.2026).

Informed Consent Statement
Informed consent was obtained from all subjects involved in the study.

AI Declaration
The authors declare that no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

Data Availability
The data presented in this study are available on request from the corresponding author due to privacy and ethical restrictions.

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