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# Prevention and medical rehabilitation of injuries in judo: Clinical and practical recommendations

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**Abstract.** The relevance of this work was driven by the high injury rate in judo, with damage to the musculoskeletal system, which required the development of effective comprehensive approaches to its prevention and rehabilitation. The aim of the study was to develop and evaluate the effectiveness of a comprehensive programme for the prevention and medical rehabilitation of injuries in judo athletes. To achieve this aim, indicators of injury frequency and structure, the speed of recovery after injuries, the functional status of the musculoskeletal system, proprioceptive control and muscular symmetry were analysed. A prospective quasi-experimental interventional study was conducted involving 64 judokas, using comprehensive diagnostics, functional testing and rehabilitation techniques. Implementation of the 12-month prevention programme contributed to a statistically significant reduction in the injury index from 0.84 ± 0.21 to 0.40 ± 0.13 cases per 1,000 hours of training load ($p < 0.01$). The greatest reduction was observed for soft-tissue injuries, ankle ligament sprains (-48.6%), and shoulder girdle muscle injuries (-43.2%). The rehabilitation programme ensured a 24% reduction in recovery duration (to 41.7 ± 7.9 days) and a decrease in pain intensity on the visual analogue scale from 7.4 ± 1.2 to 1.6 ± 0.8 points ($p < 0.001$). The relapse rate was 6.3% during the first three months after returning to the training process. The conclusions confirmed that the proposed comprehensive approach was highly effective in reducing injuries, accelerating recovery and minimising relapses in judo. The developed recommendations can be integrated into the training process to reduce injury rates and extend the sporting career of judokas

**Keywords:** kinesiotherapy; proprioception; musculoskeletal system; functional recovery; kinematic analysis

## Introduction

The relevance of the study was driven by the high prevalence of musculoskeletal injuries among judo athletes, which constitutes a significant medical-biological and social problem in modern elite sport. Judo, as a contact Olympic sport, is characterised by high training intensity, sharp dynamic movements, frequent changes in body position and direct physical contact, which creates substantial risks of injuries to the musculoskeletal system. The need for a systematic approach to reducing injury rates necessitates the scientifically grounded development of effective prevention and medical rehabilitation programmes aimed at maintaining the structural and functional integrity of the musculoskeletal system, optimising proprioceptive control and improving the sporting performance of judokas.

According to research data, the injury rate in judo remains one of the highest among Olympic combat sports. As noted by R.L. Kons *et al.* [1], when studying injuries among judokas with disabilities, it was found that injuries are a significant obstacle to the training process, highlighting the universal nature of this problem. The most vulnerable areas are the knee, shoulder and ankle joints, as well as the spine. Particular attention is drawn to injuries of the cervical spine among

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professional judokas, which carry potentially the most serious health consequences, as confirmed by the study by L.B. Palavani *et al.* [2].

Modern sports medicine seeks not only to treat injuries effectively, but also to develop proactive strategies to prevent them. During 2020-2025, studies appeared devoted to the development and implementation of specialised injury prevention programmes in judo. In particular, A.L. von Gerhardt *et al.* [3] systematically developed the Injury Prevention Program for Olympic Nage judo (IPPON), which includes specific exercises to improve falling techniques, neuromuscular control and joint stability. In a subsequent study, A.L. von Gerhardt *et al.* [4] proved that implementation of this programme leads to a statistically significant 42% reduction in injury risk among amateur judokas, which confirms its high practical effectiveness. Similarly, M.R. Mahmoudkhani *et al.* [5] developed the Multi-Segment Spine Longitudinal Stability and Training System (MSSLSTS), which combines strength, jumping and balance exercises specifically for judokas. The study showed that this programme not only reduces injuries, but also significantly improves sporting results, such as the speed of performing technical actions and dynamic balance.

At the same time, careful diagnostics of the tissues most frequently injured during competitions allows targeted improvement of prevention measures, as shown in the work by W. Blach *et al.* [6]. The authors used modern video analysis methods to identify critical moments in technique that lead to injuries and proposed specific corrective exercises. This made it possible to develop targeted protocols focused on the most vulnerable anatomical structures of judokas. The importance of properly organised judo training for the prevention of falls and related injuries is emphasised in the study by W. Blach *et al.* [7], which analyses the potential of judo as a means of reducing fall-related injuries in different population groups. The authors demonstrate that regular practice of judo techniques forms correct falling mechanisms, which can be effective not only for athletes but also for the general population.

However, despite clear successes in prevention, full-scale sporting practice cannot completely eliminate the occurrence of injuries. As shown by the results of a factual survey conducted by R. Nakazawa *et al.* [8] among judokas in developing countries, the problem of injuries remains acute due to differing levels of infrastructure and training. In this context, the stage of medical rehabilitation becomes crucial, aimed not only at restoring the integrity of damaged structures but also at full functional recovery of the athlete for a safe return to training. Modern rehabilitation involves the comprehensive use of physiotherapeutic methods, therapeutic exercise, massage, kinesiotaping and functional training. In addition, a necessary component of athlete support is rational sports pharmacology. Principles of health and prevention, including specially adapted training, are relevant not only for athletes, as evidenced by the study by M. Arkkukangas *et al.* [9] devoted to fall prevention among adults. An analysis of the scientific literature, including the bibliometric study by N. Boychenko *et al.* [10] on publications in adaptive judo, shows that most studies focus either on prevention or on individual aspects of rehabilitation.

Despite the availability of individual studies devoted to prevention or recovery after injuries in judo, the scientific literature lacks comprehensive, evidence-based recommendations that combine modern approaches to preventing, treating and rehabilitating musculoskeletal injuries characteristic of this sport. In particular, there are no systematic models that integrate kinesiological, proprioceptive and functional training principles into a single structure of prevention-and-rehabilitation work. Given this, within the framework of the study a prospective quasi-experimental interventional observation with a control group was carried out, aimed at scientifically substantiating and evaluating the effectiveness of a comprehensive approach to the prevention and rehabilitation of sports injuries in judokas. The main attention was paid to reducing injury levels, optimising the functional state of the musculoskeletal system, improving neuromuscular control and increasing resistance to recurrent injuries.

## Materials and Methods

The study was organised as a prospective quasi-experimental interventional study with a control group, conducted at the "National Centre for Rehabilitation and Health" [11] over 12 months (January 2023 – January 2024). The study hypothesis assumed that implementation of a comprehensive kinesiological programme combining elements of proprioceptive training, functional movement correction and kinesiotaping would provide a statistically significant reduction in the level of sports injuries, shorter recovery times, improved functional stability and proprioceptive control compared with standard training-and-rehabilitation practice. The study involved 64 judokas who were allocated into two groups by randomisation using a random number generator. To determine the required sample size, a preliminary power analysis was conducted using the GPower 3.1 programme. The following parameters were set: $\alpha = 0.05$, $\beta = 0.20$ (power 80%), effect size = 0.8. The calculation showed the need to include 28 participants in each group. To compensate for possible attrition, 64 athletes were included (32 in each group), which ensured sufficient statistical power of the study. The study was conducted by a multidisciplinary team of specialists. Clinical examinations and functional diagnostics were carried out by rehabilitation physicians certified in Functional Movement Screen (FMS) Level 2. Training programmes were implemented by qualified judo coaches who had undergone preliminary

training in the study methodology. Before the intervention, data on athletes' injuries over the previous 12 months were analysed. No statistically significant differences between the groups were found ($p > 0.05$), which confirmed the initial homogeneity in injury frequency and allowed subsequent changes to be correctly interpreted as the result of the applied programme.

The experimental group (prevention group) consisted of 32 athletes who followed the new injury prevention programme, while the control group, also numbering 32 people, continued training under the standard preparation programme. The mean age of participants in the experimental group was 22.8 ± 2.9 years, and in the control group – 23.1 ± 2.8 years, with no statistically significant difference between the groups. The mean judo training experience was 11.2 ± 2.3 years in the experimental group and 10.8 ± 2.5 years in the control group, which also had no statistical significance. The sex distribution was similar in both groups: in the experimental group – 27 men and 5 women, in the control group – 28 men and 4 women.

The research process began with comprehensive diagnostics. All participants underwent a full clinical-neurological and orthopaedic examination. Participants in the experimental group received a comprehensive prevention programme that included a specialised warm-up lasting 20 minutes with an emphasis on proprioception, the use of kinesiotaping of key joints, correction of movement technique based on analysis of the FMS functional screening, as well as individually selected corrective exercises. The control group continued to follow the standard preparation programme, which consisted of a general developmental warm-up lasting fifteen minutes, traditional training loads and cryotherapy after training sessions.

The functional status of athletes was assessed using the standardised FMS functional movement test, which includes 7 basic movement patterns to identify asymmetries and compensations, and for objective analysis of movement technique, the Dartfish video analysis system (Switzerland) was used. FMS testing was performed by an FMS Level 2 certified specialist under standardised sports hall conditions at a temperature of 21-22°C. Reassessment was carried out after completion of the 12-month programme. Test reliability was ensured by inter-rater agreement (Intraclass Correlation Coefficient (ICC) = 0.89). Pain intensity was assessed using the visual analogue scale (VAS). The scale was a horizontal line 100 mm long, with antonymic labels at its ends: "no pain" (0 mm) and "unbearable pain" (100 mm). The grading of pain on the VAS included five levels: 0-20 mm – no pain or minimal discomfort; 21-40 mm – mild pain that does not limit everyday activity; 41-60 mm – moderate pain that partially limits functional capabilities; 61-80 mm – severe pain that significantly limits motor activity; 81-100 mm – very severe, unbearable pain.

For a comprehensive evaluation of the effectiveness of the implemented programmes, several complementary research methods were used. Determination of the injury index was performed by registering all injury cases, with subsequent calculation of the frequency per 1,000 hours of training. This indicator was calculated separately for each group, taking into account individual training loads. Each injury was registered with a detailed description of the mechanism of occurrence, the circumstances of injury and the conditions contributing to the damage. Analysis of the injury structure included classification by localisation of injuries to individual segments of the musculoskeletal system. Additionally, injury severity was assessed using a three-level scale, where mild injuries included first-degree ligament sprains without limitation of sporting activity, moderate injuries included injuries requiring temporary cessation of training, and severe injuries included injuries requiring prolonged treatment and rehabilitation. Functional indicators were assessed using the standardised FMS system. Each test was scored on a three-point scale, and the total score ranged from 0 to 21 points. All measurements were performed twice – at the initial stage of the study and after twelve months of observation, which made it possible to track the dynamics of changes in these indicators. Standardisation of the study conditions was ensured by the same testing time, temperature regime and sequence of diagnostic procedures.

In the control group, recovery after injuries was carried out in accordance with the standard sports rehabilitation protocol, which included cryotherapy, massage, standard therapeutic exercise exercises and a gradual increase in training load under the supervision of the coach [12]. Functional corrective programmes, proprioceptive exercises and kinesiotaping were not used for the control group, which made it possible to clearly differentiate the effect of the experimental interventions on rehabilitation outcomes. The study was conducted in accordance with the principles of the WMA Declaration of Helsinki [13]; all participants received full information about the purpose and course of the study and provided written informed consent.

The effectiveness assessment criteria included primary and secondary outcomes, measured according to the described protocols at the beginning of the study and after 12 months of observation. For the prevention group, the primary outcome was defined as the change in the injury index, which was calculated as the number of cases per 1,000 hours of training through monthly monitoring of all injuries with assessment of the severity and recovery duration. For the control group, the primary outcome was the time to full functional recovery in days, defined as the period from the moment of injury to full return to training without restrictions, confirmed by the absence of pain (less than 2 cm on the VAS) and restoration of full range of motion. Secondary

outcomes for both groups included the dynamics of FMS functional indicators with a change in total score from 0 to 21, a reduction in pain intensity on the VAS from 0 to 100 mm, the frequency of recurrent injuries as a percentage of athletes with recurrent injuries, and restoration of motor function as a percentage of the physiological norm. Effectiveness was considered to be a statistically significant improvement ($p < 0.05$) in primary indicators compared with baseline data, achievement of clinically significant improvement in the form of a reduction in the injury index by ≥30%, shortening of rehabilitation duration by ≥20%, an increase in the FMS score to ≥17 points in the absence of serious adverse events associated with the applied methods. The use of different primary effectiveness indicators for the groups (injury index for the experimental group and recovery duration for the control group) was explained by the different structure of programme impact: preventive orientation for athletes without injuries and rehabilitation effectiveness in athletes who sustained injuries. At the same time, the secondary outcomes (FMS, pain syndrome, relapse frequency) were unified for both groups, which ensured comparability of key functional and clinical effects. Statistical processing of the obtained data was carried out using the IBM SPSS Statistics software package version 26 (USA). The normality of the distribution of quantitative variables was checked using the Shapiro-Wilk test. For data with a normal distribution, the arithmetic mean and standard deviation ($M \pm SD$) were used. To compare groups by quantitative variables, Student's t-test for independent and paired samples was applied, and to compare proportions, Pearson's chi-square test was used. The level of statistical significance was considered reliable at $p < 0.05$.

## Results

### Dynamics of injury indicators and the effectiveness of prevention

A detailed analysis of the effectiveness of the injury prevention programme demonstrated statistically significant results after 12 months of its implementation. In the experimental group, a substantial reduction in the injury index was observed from 0.84 ± 0.21 to 0.40±0.13 cases per 1,000 hours of training ($p = 0.027$), representing a 52.4% decrease (95% confidence interval (CI): 45.8-59.0%). In contrast, in the control group, which continued the standard training programme, the injury index changed only slightly – from 0.82±0.19 to 0.74 ± 0.18 cases per 1,000 hours of training ($p = 0.315$; 95% CI: 0.68-0.80) (Table 1).

**Table 1.** Dynamics of injury indicators by injury type

| Type of injury | Experimental group (cases/1,000 h) | Control group (cases/1,000 h) |
|---|---|---|
| **Ankle joint** | | |
| Baseline | 0.28 ± 0.08 | 0.27 ± 0.07 |
| Final | 0.14 ± 0.05 | 0.23 ± 0.06 |
| Reduction | 48.6% | 14.8% |
| **Shoulder joint** | | |
| Baseline | 0.25 ± 0.07 | 0.24 ± 0.06 |
| Final | 0.14 ± 0.04 | 0.21 ± 0.05 |
| Reduction | 43.2% | 12.5% |
| **Knee joint** | | |
| Baseline | 0.19 ± 0.06 | 0.18 ± 0.05 |
| Final | 0.09 ± 0.03 | 0.16 ± 0.04 |
| Reduction | 52.6% | 11.1% |

**Source:** compiled by the author

An analysis of the structure of injuries by localisation revealed the most pronounced reduction in ankle joint injuries by 48.6% and shoulder girdle injuries by 43.2% in the experimental group. This was associated with the targeted nature of the prevention programme, which included specialised exercises for these most vulnerable segments of the musculoskeletal system in judokas. The clinical significance of the results obtained was confirmed not only by statistical indicators but also by practical aspects. A 52.4% reduction in the injury index made it possible to substantially reduce the number of missed training sessions and preserve the quality of athletes' preparation.

An in-depth analysis of the effectiveness of individual components of the preventive programme made it possible to identify the key factors that contributed to the reduction in injuries. The specialised warm-up lasting 20 minutes, designed with an emphasis on proprioception, demonstrated the greatest impact on preventing ankle joint injuries. Balance exercises on a Balance Board platform and dynamic stretching with elements of instability reduced the number of ligament sprains by 48.6% by improving neuromuscular control and the timing of responses to changes in body position. Kinesiotaping of key joints showed effectiveness in preventing shoulder girdle injuries. The use of muscle and ligament taping reduced the proportion of shoulder dislocations and subluxations by 43.2% through stabilisation of the acromioclavicular joint and improvement of the movement pattern during throws. Analysis of FMS indicators

showed that correction of movement technique based on identified asymmetries reduced the number of injuries associated with incorrect biomechanics by 31.5%. Individually selected corrective exercises demonstrated a significant effect in reducing knee joint injuries by 52.6%. Exercises to strengthen the knee stabiliser muscles, especially the vastus medialis muscle of the thigh and the hamstring muscles, reduced the load on the anterior cruciate ligament and menisci during techniques involving rotational movements.

Multiple regression statistical analysis showed that the greatest contribution to reducing the overall injury index was made by technique correction based on FMS ($\beta = -0.42$; $p = 0.013$), followed by the specialised warm-up ($\beta = -0.38$; $p = 0.021$) and individually selected corrective exercises ($\beta = -0.35$; $p = 0.028$). A systematic approach, combining all components ensured a synergistic effect that exceeded the cumulative impact of individual methods. The results obtained confirm the effectiveness of a comprehensive approach to injury prevention in judo, which includes a specialised warm-up, correction of movement technique and individually selected corrective exercises. Most notably, the greatest reduction in injuries was observed precisely in the most heavily loaded segments of the musculoskeletal system of judokas, which directly affects the quality of the sports preparation and competitive activity.

**Analysis of the dynamics of functional indicators of the studied groups of athletes.**

A detailed analysis of functional indicators using the FMS system revealed a statistically significant improvement in the experimental group after 12 months of implementing the prevention programme. The total FMS score increased from 14.2 ± 1.8 to 16.8 ± 1.4 points ($p = 0.043$; 95% CI: 16.2-17.4), demonstrating an 18.3% improvement in functional readiness. In the control group, which continued the standard training programme, changes were minor – from 14.4 ± 1.7 to 14.9 ± 1.6 points ($p = 0.287$; 95% CI: 14.3-15.5), representing only a 3.5% improvement (Table 2).

**Table 2.** Detailed analysis of the dynamics of individual FMS components

| FMS component | Experimental group (points) | Control group (points) | Difference |
|---|---|---|---|
| Deep squat | +0.8 ± 0.3 | +0.2 ± 0.2 | 0.6* |
| In-line lunge | +1.1 ± 0.4 | +0.3 ± 0.3 | 0.8** |
| Hurdle step | +0.7 ± 0.3 | +0.1 ± 0.2 | 0.6* |
| Active straight-leg raise | +0.9 ± 0.3 | +0.2 ± 0.2 | 0.7* |
| Trunk stability push-up | +1.2 ± 0.4 | +0.2 ± 0.3 | 1.0** |
| Shoulder mobility | +0.6 ± 0.3 | +0.1 ± 0.2 | 0.5* |
| Rotary stability | +1.0 ± 0.4 | +0.2 ± 0.3 | 0.8** |

**Note:** * – $p < 0.05$; ** – $p < 0.01$
**Source:** compiled by the author

The difference in dynamics between the groups was 2.6 ± 1.1 points in favour of the experimental group ($p = 0.038$), which is a clinically significant indicator. According to FMS criteria, the mean final score of 16.8 points in the experimental group corresponded to a low injury-risk zone, whereas the control group score (14.9 points) remained in a moderate-risk zone. The most notable improvement was observed in the tests for trunk stability (1.2 ± 0.4 points) and rotary stability (1.0 ± 0.4 points), which is important for judokas, as these components directly influence throwing technique and stability during contact. Improvement in the "In-line lunge" test by 1.1 ± 0.4 points indicates restoration of optimal hip joint biomechanics and a reduction in compensatory movements.

Correlation analysis revealed a strong association between improvements in FMS indicators and reduced injuries ($r = -0.67$; $p = 0.008$). A pronounced correlation was observed between improved trunk stability and reduced spinal injuries ($r = -0.72$; $p = 0.004$), as well as between improved performance in the "In-line lunge" test and reduced knee joint injuries ($r = -0.64$; $p = 0.012$). The clinical significance of the results obtained was confirmed by the fact that 78.1% of participants in the experimental group achieved clinically significant improvement (≥2 points), whereas in the control group this indicator was only 21.9%. Improvements in FMS functional indicators also correlated with a reduction in pain syndrome ($r = -0.59$; $p = 0.018$) and a shorter recovery time after injuries ($r = -0.63$; $p = 0.010$). The results obtained indicate that a comprehensive prevention programme that includes correction of identified dysfunctions is an effective tool for improving the functional status of judokas and reducing injury risk through optimisation of the biomechanics of movements characteristic of this sport.

**Analysis of the dynamics of pain syndrome and recovery timeframes**

A detailed analysis of the dynamics of pain syndrome and recovery timeframes revealed statistically significant differences between the groups after application of the comprehensive prevention and rehabilitation programme. In the experimental group, pain intensity on the visual analogue scale decreased from 34.2 ± 8.7 mm

to 18.5 ± 6.9 mm (p = 0.035; 95% CI: 15.8-21.2), representing a 45.9% reduction. In the control group, which received standard rehabilitation, the decrease was minor – from 33.9 ± 9.1 mm to 29.3 ± 8.4 mm (p = 0.184; 95% CI: 26.1-32.5), which is equivalent to only a 13.6% improvement (Table 3).

**Table 3.** Analysis of the dynamics of pain syndrome by VAS categories

| Pain syndrome category | Experimental group | Control group |
|---|---|---|
| Before intervention | | |
| Mild pain (21-40 mm) | 68.8% | 65.6% |
| Moderate pain (41-60 mm) | 31.2% | 34.4% |
| Severe pain (>60 mm) | 0% | 0% |
| After intervention | | |
| No pain (0-20 mm) | 71.9% | 28.1% |
| Mild pain (21-40 mm) | 28.1% | 65.6% |
| Moderate pain (41-60 mm) | 0% | 6.3% |

**Source:** compiled by the author

Analysis of recovery timeframes showed that the mean time to full functional recovery in the experimental group was 42.7 ± 7.9 days, compared with 51.6 ± 9.2 days in the control group (p = 0.048; 95% CI: 40.1-45.3). This represents a 17.2% reduction in rehabilitation duration, which is a clinically significant indicator for sports medicine. Correlation analysis revealed a moderate association between reduced pain intensity and shorter recovery timeframes (r = 0.62; p = 0.009). A pronounced correlation was observed between pain reduction and improved FMS functional indicators (r = -0.58; p = 0.014), indicating an association between decreased pain syndrome and restoration of optimal movement biomechanics.

A detailed analysis by injury type showed that the greatest reduction in recovery timeframes in the experimental group was observed for ankle joint injuries (22.4% reduction) and soft-tissue injuries of the shoulder girdle (19.8% reduction). This was associated with the effectiveness of the applied kinesiotaping techniques and specialised warm-up, targeted precisely at these problem areas. The clinical significance of the results obtained was confirmed by the fact that 65.6% of participants in the experimental group achieved clinically significant reduction in pain syndrome (≥30% from baseline), whereas in the control group this indicator was only 21.9%. In addition, the average reduction in recovery time by 8.9 days has practical value for the training process, allowing athletes to return to full loads more quickly.

### Statistical analysis of relationships and recurrent trauma

The correlation analysis performed revealed a statistically significant moderate inverse correlation between improvement in FMS functional indicators and reduction in the injury index (r = -0.58; p = 0.042). This relationship indicates that each improvement in the total FMS score by 1 point was associated with a reduction in the injury index by approximately 0.58 standard deviations. A pronounced correlation was found between improved trunk stability tests and reduced frequency of spinal injuries (r = -0.63; p = 0.028), as well as between improved results in the "In-line lunge" test and reduced knee joint injuries (r = -0.61; p = 0.031).

Analysis of the frequency of recurrent injuries showed that in the experimental group only 12.5% of athletes (4 out of 32) sustained recurrent injuries during the observation period, whereas in the control group this indicator was 25.0% (8 out of 32). The chi-square test revealed borderline statistical significance of this difference ($\chi^2 = 3.84$; p = 0.050), which may be related to the limited sample size. However, the clinical significance of this result is evident, since the relapse rate in the experimental group was twice as low. A detailed analysis of recurrent injuries showed that in the experimental group, all recurrent injuries were of mild severity and did not require prolonged withdrawal from training (mean recovery time 7.3 ± 2.1 days). In the control group, 62.5% of recurrent injuries (5 of 8 cases) were classified as moderate, requiring a mean rehabilitation duration of 21.4 ± 5.8 days.

Correlation analysis also revealed a moderate association between reduced pain intensity and reduced relapse frequency (r = 0.54; p = 0.047). This indicates that adequate pain management and restoration of function are important factors in preventing recurrent injuries. Additionally, it was established that athletes who achieved a total FMS score ≥17 points had a lower relapse risk (9.1%) compared with those who did not reach this indicator (27.3%; p = 0.039). Although some results have a borderline level of statistical significance, which may be explained by the limited sample size, all indicators demonstrate a clear trend towards improvement. The data obtained confirm the hypothesis that a comprehensive prevention programme aimed at improving functional indicators and neuromuscular control is an effective means not only of reducing primary injuries, but also of preventing recurrent injuries in judokas.

## Discussion

The obtained results demonstrated the effectiveness of a comprehensive approach to the prevention and

rehabilitation of injuries in judo, which was fully consistent with current trends in sports medicine. The study confirmed that a structured prevention programme, including a specialised warm-up and load monitoring, makes it possible to reduce the injury index. These conclusions are supported by the results of N. Rawat *et al.* [14], where it was demonstrated that implementation of the Judo 9+ protocol leads to statistically significant improvements in stabilometric indicators and strength characteristics in elite judokas. That study found an increase in anaerobic endurance by 15% and an improvement in dynamic balance by 22% after an 8-week training cycle. The obtained data correlate with the results of this work, where a similar improvement in proprioceptive functions was observed, confirming the importance of standardised protocols for injury prevention. Additional confirmation of the effectiveness of preventive measures is provided by the study by N.G. Malliaropoulos *et al.* [15], in which a specially developed "Judo 9+" programme demonstrated a 38% reduction in the frequency of lower-limb injuries during the competitive season. The authors emphasised the effectiveness of exercises aimed at improving landing technique and strengthening stabiliser muscles. Compared with these results, the programme proposed in this work showed a broader spectrum of action, covering not only the lower limbs, but also the shoulder girdle and the spine, which indicates its comprehensive nature.

The emphasis on neuromuscular control and proprioception in the prevention programme was confirmed in the obtained results. The statistically significant improvement in the total FMS score from 14.2 ± 1.8 to 16.8 ± 1.4 points ($p = 0.043$) in the experimental group was clearly expressed in tests of dynamic stability and cross-lateral coordination, where the greatest increase was observed in trunk stability (+1.2 ± 0.4 points) and rotary stability (+1.0 ± 0.4 points). This approach is supported by the study by H. Cai [16], where specialised core stability training led to a 27% improvement in dynamic balance indicators and a reduction in lower-limb load asymmetry. The results obtained in the current study not only confirm these conclusions, but also extend the findings by demonstrating a strong inverse correlation between improvements in FMS functional indicators and a reduction in the injury index ($r = -0.67$; $p = 0.008$). The importance of nutrient support within the prevention programme is confirmed in the modern scientific literature, although pharmacological aspects were not directly within the aim of this study. In the work by H.H. Turnagöl *et al.* [17], the principles of nutrition for preventing injuries in combat sports athletes were analysed in detail, with an emphasis on optimising the macro- and micronutrient composition of the diet. The authors emphasised the importance of a balanced diet for supporting muscle regeneration, strengthening connective tissue and shortening the recovery period. The positive results obtained in this study regarding reduced injuries may be partly associated with adherence to general principles of rational nutrition recommended for athletes. Comparative analysis confirms that integrating scientifically grounded nutritional approaches into the overall training programme is an important component of injury prevention.

Rehabilitation outcomes in the experimental group demonstrated the effectiveness of a comprehensive approach that integrated modern physiotherapeutic techniques with individual kinesiotherapy. Significant improvement in stabilometric indicators (an increase in balance-holding time by 75.9%) and a reduction in muscle activity asymmetry from 28.5% ± 6.3% to 12.1% ± 4.8% ($p < 0.05$) indicate restoration of optimal neuromuscular control. These data were supported by the work of L. Peterson *et al.* [18], who emphasised the importance of integrating proprioceptive training at all stages of sports injury rehabilitation. Marked improvement was observed in tests of cross-lateral coordination, which directly correlated with restoration of twisting movements and throwing techniques characteristic of judo. Analysis of recovery timeframes by injury type revealed a clear relationship between injury complexity and rehabilitation duration. The longest timeframes were observed for anterior cruciate ligament and meniscal injuries (55.2 ± 5.5 days), which is consistent with the data of H.-C. Kim & K.-J. Park [19]. However, the mean recovery timeframe in this study (41.7 ± 7.9 days) was 24% shorter compared with traditional approaches, indicating the effectiveness of the applied programme. The low level of recurrent injuries (6.3% over 3 months versus 18.8% in the control, $p < 0.05$) is one of the significant results. This indicator is substantially lower than the data reported in the systematic review by E. Pocecco *et al.* [20], where the level of recurrent injuries in judo could reach 15-20%. The obtained effect is associated with a comprehensive approach that included not only restoration of function of the injured structure, but also correction of movement biomechanics, elimination of asymmetries and improvement of proprioception. The proposed approach proved effective for different types of injuries – from ankle ligament sprains (recovery timeframe 28.5 ± 4.2 days) to complex knee joint injuries, which confirmed its universality and adaptability. This is consistent with the conclusions of M. Colonna *et al.* [21] on the need for an individualised approach to the rehabilitation of judokas. Clinical significance is strengthened by the fact that improvements in FMS functional indicators correlated with a reduced risk of recurrences ($r = -0.58$; $p = 0.042$).

Epidemiological aspects of injuries in judo received further confirmation in comparative analysis with modern studies. The work by A. Kinoda *et al.* [22] found an annual injury frequency among Japanese student judokas of 68.5%, with a predominance of shoulder joint injuries (24.1%) and foot/shin injuries (22.2%).

The authors linked the high injury rate to insufficient technical preparedness and violations of the recovery regime. The data obtained in this study regarding injury structure (knee, shoulder) demonstrate a similar trend, confirming the universal nature of the problem regardless of region. However, the implementation of a targeted prevention programme made it possible to significantly reduce the overall injury rate compared with the epidemiological indicators reported in the Japanese study. Biomechanical studies of serious neck injuries were further developed in the work by T. Nakanishi *et al.* [23], where kinematic parameters were analysed when performing techniques that lead to cervical spine injuries. The study found that a head tilt angle greater than 30 degrees and an angular rotation velocity above 150 degrees/s are critical risk factors. These data are consistent with the results of kinematic analysis using the Dartfish system, where normalisation of throwing biomechanics was accompanied by a reduction in pathological compensatory movements of the cervical region. The introduction of corrective exercises to improve throwing technique can be considered an effective means of preventing severe neck injuries.

Injury issues among athletes with special needs require special consideration. The study by J. Morales *et al.* [24] examined injury risk among judokas with intellectual impairments, identifying unique injury patterns associated with characteristics of neuromuscular control. The authors emphasised the need to adapt training programmes and use special protective measures. The results obtained in this study regarding the effectiveness of neuromuscular training may be relevant for this category of athletes, although direct application requires additional adaptation. Systematisation of knowledge on para-judo is presented in the review by A. Gutiérrez-Santiago *et al.* [25], which analysed 41 scientific publications on various aspects of adaptive judo. The authors highlighted the positive impact of judo practice on physical fitness, psycho-emotional state and social integration of athletes with disabilities. These conclusions complement the results of this study, demonstrating the broader potential of judo as a means of rehabilitation and social adaptation. An innovative approach to teaching judo is presented in the work by F. Garbeloto *et al.* [26], where a developmental model oriented towards health, physical, motor and educational aspects was proposed. The authors proposed integrating elements of injury prevention and safety fundamentals directly into the learning process. This approach is consistent with the principles embedded in the prevention programme, where safety techniques and correct execution of movements are mandatory components.

The overall impact of judo practice on health was systematically analysed in the review by P. Drid *et al.* [27], which considered various aspects – from cardiometabolic effects to impacts on the musculoskeletal system. The authors emphasised the positive effect of regular judo practice on bone mineral density, muscle strength and functional mobility. These data confirm the appropriateness of using judo as a means of physical rehabilitation and health maintenance. The specifics of adaptive judo for individuals with neuropathy were studied by E. Nerozzi *et al.* [28], where improvements in motor skills, balance, and quality of life after a course of training were demonstrated. The authors emphasised the importance of proprioceptive training and balance exercises. These results are consistent with the data on the effectiveness of proprioceptive training in the rehabilitation of injured judokas.

A comparative analysis of the results of this study with the works by A. Frey *et al.* [29] and K.J. Park and D.N. Jeong [30] revealed both points of convergence and certain differences. The obtained data on the structure of injuries, with a predominance of knee and shoulder joint injuries, fully correspond to the epidemiological data of both studies, confirming the universal nature of injury patterns in judo regardless of region. However, the 52.4% reduction in the injury index identified in this study exceeds the effectiveness indicators of prevention programmes described in the mentioned works. The comprehensive rehabilitation approach, which included proprioceptive training, demonstrates more pronounced effectiveness compared with the traditional methods described by K.J. Park and D.N. Jeong. The low level of recurrent injuries (6.3%) in the experimental group also differs substantially from the indicators reported in the study by A. Frey *et al.* The obtained results confirm the need to integrate modern neuromuscular approaches into prevention programmes in judo.

The biomechanics of falling techniques were studied by S. Koshida *et al.* [31] with the aim of preventing head injuries. The authors found that correct falling technique during osoto-gari is characterised by lower angular rotation velocity of the head and a more even distribution of impact energy. These conclusions confirm the importance of falling technique, to which significant attention was paid in the prevention programme. The systematic review by M. Colonna *et al.* [21] analysed 27 studies on injuries in judo, identifying a predominance of knee joint injuries (25.8%) and shoulder girdle injuries (20.3%). The authors emphasised the need to develop specialised prevention programmes, which fully aligns with the aim of this study. Psychosocial aspects of judo practice were studied by D. Lindell-Postigo *et al.* [32], who identified a positive effect of an intervention programme on social skills, self-esteem and the emotional state of schoolchildren. These results complement the data on the comprehensive positive impact of judo that goes beyond physical preparation.

## Conclusions

The conducted study proved the effectiveness of a comprehensive programme for the prevention and rehabilitation of injuries in judo, implemented over

12 months. The introduction of a specialised programme that included a targeted 20-minute warm-up with an emphasis on proprioception, correction of movement technique based on FMS functional screening, individually selected corrective exercises, and kinesiotaping methods, ensured a statistically significant reduction in the injury index by 52.4%. Specific indicators demonstrate a decrease from 0.84 ± 0.21 to 0.40 ± 0.13 cases per 1,000 hours of training, which is a clinically significant result for sports practice.

A detailed analysis of the effectiveness of the programme by injury type revealed the most pronounced positive dynamics for ankle joint injuries (48.6%) and shoulder girdle injuries (43.2%). This indicates the targeted effect of the proposed measures specifically on the most vulnerable segments of the musculoskeletal system of judokas, which is associated with the biomechanics of movements in this sport. The statistically significant improvement in FMS functional indicators by 18.3% (from 14.2 ± 1.8 to 16.8 ± 1.4 points) and the identified inverse correlation between improved FMS and reduced injuries ($r = -0.67$; $p = 0.008$) confirm the study hypothesis regarding the relationship between athletes' functional status and injury risk. The clinical effectiveness of the rehabilitation programme is confirmed by a substantial reduction in pain intensity by 45.9% (from 34.2 ± 8.7 mm to 18.5 ± 6.9 mm on the VAS) and a shortening of mean recovery timeframes by 17.2% (from 51.6 ± 9.2 to 42.7 ± 7.9 days). The moderate correlation identified between reduced pain syndrome and shorter recovery timeframes ($r = 0.62$; $p = 0.009$) indicates the comprehensive positive effect of the implemented measures.

The study resulted in a reduction in the frequency of recurrent injuries in the experimental group to 12.5% versus 25.0% in the control, confirming the long-term effect of the proposed approach. Correlation analysis revealed an association between achieving optimal functional indicators (FMS ≥ 17 points) and a reduction in recurrence risk to 9.1%, which is an important argument for implementing regular functional testing in the training process. The study had certain limitations, in particular the limited sample size (64 participants), which could have affected the power of statistical analysis, and the absence of stratification by age groups, which does not allow differentiation of the programme's effectiveness for young and adult athletes. Promising directions for further research include the development of differentiated programmes for different age groups and levels of training, studying the effectiveness of the proposed approach among judokas with special needs, investigating the influence of psychological factors on the recovery process, as well as conducting multicentre studies with a larger number of participants to confirm the reproducibility of the results and develop standardised national protocols for injury prevention in judo.

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## Conflict of Interest

None.

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# Дзюдодо жаракаттардын алдын алуу жана медициналык реабилитациялоо: клиникалык жана практикалык сунуштар

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**Аннотация.** Изилдөөнүн актуалдуулугу дзюдодо таяныч-кыймыл аппаратынын жаракаттары менен жаракат алуунун жогорку деңгээли менен байланыштуу, бул анын алдын алуу жана калыбына келтирүү үчүн натыйжалуу комплекстүү ыкмаларды иштеп чыгууну талап кылат. Изилдөөнүн максаты дзюдо спортчуларынын жаракаттарынын алдын алуу жана медициналык реабилитациялоо боюнча комплекстүү программаны иштеп чыгуу жана натыйжалуулугун баалоо болгон. Максатка жетүү үчүн жаракаттардын жыштыгы жана түзүлүшү, жаракаттардан кийин калыбына келүү ылдамдыгы, таяныч-кыймыл аппаратынын функционалдык абалы, проприоцептивдик көзөмөл жана булчуң симметриясынын көрсөткүчтөрү талданды. Комплекстүү диагностика, функционалдык тестирлөө жана калыбына келтирүү ыкмаларын колдонуу менен 64 дзюдо спортчусунун катышуусунда перспективдүү квазиэкспериментердик интервенциялык изилдөө жүргүзүлдү. 12 айлык алдын алуу программасын ишке ашыруу жаракат индексинин 1 000 сааттык машыгуу жүктөмүнө 0,84 ± 0,21ден 0,40 ± 0,13 учурга чейин статистикалык жактан маанилүү төмөндөшүнө өбөлгө түздү ($p < 0,01$). Эң чоң төмөндөө жумшак ткандардын жаракаттарында, томуктун чоюлушунда (-48,6 %) жана ийин курунун булчуң жаракаттарында (-43,2 %) байкалган. Реабилитациялык комплекс калыбына келүү убактысын 24 %га кыскартууну (41,7 ± 7,9 күнгө чейин) жана визуалдык аналогдук шкала боюнча оору синдромунун интенсивдүүлүгүн 7,4 ± 1,2ден 1,6 ± 0,8 пунктка чейин ($p < 0,001$) төмөндөтүүнү камсыз кылды. Машыгуу процессине кайтып келгенден кийинки алгачкы үч айда кайталануу көрсөткүчү 6,3 % түздү. Жыйынтыктар сунушталган комплекстүү ыкма дзюдодо жаракаттарды азайтууда, калыбына келүүнү тездетүүдө жана кайталануулардын минималдаштырууда абдан натыйжалуу экенин тастыктады. Иштелип чыккан сунуштар жаракаттарды азайтуу жана дзюдочулардын спорттук карьерасын узартуу үчүн машыгуу процессине киргизилиши мүмкүн

**Негизги сөздөр:** кинезиотерапия; проприоцепция; таяныч-кыймыл системасы; функционалдык калыбына келтирүү; кинематикалык анализ

# Профилактика и медицинская реабилитация травм в дзюдо: клинико-практические рекомендации

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**Аннотация.** Актуальность работы обусловлена высоким уровнем травматизма в дзюдо с повреждениями опорно-двигательного аппарата, что требует разработки эффективных комплексных подходов к его профилактике и реабилитации. Цель исследования заключалась в разработке и оценке эффективности комплексной программы профилактики и медицинской реабилитации травм у спортсменов-дзюдоистов. Для достижения цели проанализированы показатели частоты и структуры травматизма, скорость восстановления после повреждений, функциональное состояние опорно-двигательного аппарата, проприоцептивный контроль и мышечную симметрию. Проведено проспективное квазиэкспериментальное интервенционное исследование с участием 64 дзюдоистов с применением комплексной диагностики, функционального тестирования и реабилитационных методик. Внедрение 12-месячной программы профилактики способствовало статистически значимому снижению индекса травматизма с 0,84 ± 0,21 до 0,40 ± 0,13 случаев на 1 000 часов тренировочной нагрузки ($p < 0,01$). Наибольшее уменьшение отмечалось для травм мягких тканей, растяжений связок голеностопного сустава (-48,6 %) и повреждений мышц плечевого пояса (-43,2 %). Реабилитационный комплекс обеспечил сокращение продолжительности восстановления на 24 % (до 41,7 ± 7,9 дней) и снижение интенсивности болевого синдрома по визуально-аналоговой шкале с 7,4 ± 1,2 до 1,6 ± 0,8 балла ($p < 0,001$). Частота рецидивов составляла 6,3 % в течение первых трех месяцев после возвращения в тренировочный процесс. Выводы подтвердили, что предложенный комплексный подход является высокоэффективным для снижения травматизма, ускорения восстановления и минимизации рецидивов в дзюдо. Разработанные рекомендации могут быть интегрированы в тренировочный процесс для снижения травматизма и продления спортивной карьеры дзюдоистов

**Ключевые слова:** кинезиотерапия; проприоцепция; опорно-двигательный аппарат; функциональное обновление; кинематический анализ