



Improvement of teenage judokas' particular physical training with sports games

Mejora de la preparación física específica de los judokas adolescentes con juegos deportivos

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Abstract

Introduction: The improvement of physical training for adolescent judokas is a key issue in sports pedagogy, as this stage is crucial for developing essential qualities like strength, coordination, and endurance.

Objective: The purpose of the study was to experimentally substantiate the effectiveness of using dynamic game exercises in the training process of adolescents engaged in judo as a means of improving physical qualities that determine the level of technical skill, coordination, endurance, and functional readiness.

Methodology: The study involved 24 adolescent males aged 13-15 years (mean age = 14.2 ± 0.6 years) from two sports schools. Methods used included pedagogical experiment, testing of special physical fitness, variation statistics, correlation, and cluster analysis. The experiment lasted 10 weeks and was conducted between September and December 2024.

Results: Based on the results of the final tests, significant advantages of the experimental group were established, which performed dynamic game exercises integrated into the training process. The most pronounced increase was observed in the complex coordination and strength exercise – 37.6%, which indicates effective stimulation of intermuscular interaction and spatiotemporal coordination.

Discussion: In the development of muscle endurance, an increase of 33.6% was recorded, which is almost three times higher than in the control group (10.5%). The increase in the tempo performance of technical actions was 25%, while in the control group – 11%.

Conclusions: The overall integral growth rate in the experimental group was 26.1%, while in the control group – only 12.4%, confirming the systemic effectiveness of the proposed approach.

Keywords

Variable load; pedagogical experiment; motor activity; strength endurance; cluster analysis.

Resumen

Introducción: La mejora del entrenamiento físico de los judocas adolescentes es clave en la pedagogía deportiva, ya que esta etapa es crucial para el desarrollo de cualidades esenciales como la fuerza, la coordinación y la resistencia.

Objetivo: El propósito del estudio fue comprobar experimentalmente la eficacia del uso de ejercicios de juego dinámico en el proceso de entrenamiento de adolescentes que practican judo como medio para mejorar las cualidades físicas que determinan el nivel de habilidad técnica, coordinación, resistencia y preparación funcional.

Metodología: El estudio incluyó a 24 adolescentes varones de 13 a 15 años (edad media = 14,2 ± 0,6 años) de dos escuelas deportivas. Los métodos utilizados incluyeron experimentos pedagógicos, pruebas de aptitud física especial, estadística de variación, correlación y análisis de conglomerados. El experimento tuvo una duración de 10 semanas y se llevó a cabo entre septiembre y diciembre de 2024.

Resultados: Con base en los resultados de las pruebas finales, se establecieron ventajas significativas del grupo experimental, que realizó ejercicios de juego dinámico integrados en el proceso de entrenamiento. El aumento más pronunciado se observó en el ejercicio complejo de coordinación y fuerza (37,6 %), lo que indica una estimulación eficaz de la interacción intermuscular y la coordinación espaciotemporal.

Discusión: En el desarrollo de la resistencia muscular, se registró un aumento del 33,6 %, casi tres veces mayor que en el grupo control (10,5 %). El aumento en el rendimiento rítmico de las acciones técnicas fue del 25 %, mientras que en el grupo control fue del 11 %.

Conclusiones: La tasa de crecimiento integral global en el grupo experimental fue del 26,1 %, mientras que en el grupo control fue de tan solo el 12,4 %, lo que confirma la eficacia sistémica del enfoque propuesto.

Palabras clave

Carga variable; experimento pedagógico; actividad motora; fuerza-resistencia; análisis de conglomerados.

Introduction

The problem of improving the special physical training of adolescents engaged in judo is becoming increasingly important in the context of sports pedagogy and the development of long-term training of athletes. Adolescence is a critical stage in sports development because it is characterized by active biological maturation, high motivational dynamics, and increased sensitivity to pedagogical influence. During this period, the foundations of specialized endurance, strength, and coordination qualities are established, which determines the need for adaptive and intensive approaches to building the training process (Benítez-Sillero, et al. 2025). One of the promising areas for improving physical fitness is the use of game components as a means of increasing efficiency and motivation. This approach allows combining developmental and emotional-regulatory influences, ensuring a holistic dynamic of the physical growth of athletes. However, despite the existence of separate empirical evidence for the effectiveness of game models, their potential within the framework of special physical training of adolescents engaged in judo remains insufficiently investigated (Syamsuryadin et al., 2025).

Altynai et al. (2022) detailed youthful judoka training organization. The researchers proposed an age-periodized load model for long-term athlete training. However, the study focused on structural and planning features rather than methodological methods for enhancing physical attributes like endurance and coordination. Thus, variable loading must be implemented to deepen this area. Andasova et al. (2023) highlighted Kazakhstani athletes' medical and pedagogical support, focusing on prevention and adaptation. In particular, adolescent load individualization was stressed, but specific methods of implementation were untested. Thus, actual training effect models that account for medical and physiological age and pedagogical adaptation are needed. Yerzhanova et al. (2022) stressed the importance of nutrition in athlete performance. The multi-factor aspect of athlete training is shown by the interaction between food, energy balance, and exercise efficiency. The relationship between energy resources and physical activity in teenage sports, especially game forms, is unclear.

The importance of special physical training as a component of the training process of judokas was analyzed by Petrenko and Babiak (2021). The researchers proved that physical qualities directly correlate with the effectiveness of competitive actions. However, although the training methods are outlined, there is no analysis of the effectiveness of alternative methods, including games, for developing the target qualities. The effectiveness of using modified sports games to increase the level of physical fitness was confirmed in the experiment by Astuti and Erianti (2024). The use of mini-games was considered as an effective method of increasing functional endurance and motivation for classes. Nursulu and Mansur (2023) substantiated the combination of coordination, strength, and technical training of judokas. However, these strategies were theoretical in nature and were not accompanied by experimental verification of specific methods. In particular, the effectiveness of game tools in the development of complex physical qualities remained outside the scope of analysis.

An innovative approach to the training process was presented by Garbeloto et al. (2023), which highlighted the relationship between physical, motor, and educational development. The researchers emphasized a systematic approach, but the paper lacks specifics regarding the organization of the game component in the context of specialized physical training. In the paper by Pečnikar Oblak et al. (2020), judo has been shown to have a positive effect on people with intellectual disabilities. This indicates the universality and adaptability of the sport but does not answer the question of the intensity of impact on physical qualities in healthy adolescents in a systematic game format. The principles of building a training process for children in judo classes were revealed in the study by Kowalczyk et al. (2022). The researchers focused on the specific features of load dosing and the development of basic motor skills in primary school age. The problem of developing special physical qualities in adolescents with sports experience requires a separate analysis. The inter-age effectiveness of judo classes and their educational potential were analyzed by Ciaccioni et al. (2024). However, the analysis focused on value and conceptual aspects, rather than on the empirical investigation of changes in physical readiness under the influence of specific pedagogical models.

The study addresses the gap in the literature regarding the use of dynamic game exercises in the special physical training of adolescent judokas, an area that has not been sufficiently explored. While existing research acknowledges the potential benefits of game-based methods in sports training, it largely lacks



empirical evidence and fails to provide concrete models for integrating game components into the training process of young athletes, particularly in martial arts. Previous studies have focused on theoretical aspects and have not investigated the impact of variable forms of training on developing specific physical qualities such as strength, coordination, and technical speed. This study is original in its experimental approach, offering a systematic investigation into how dynamic game exercises can enhance these qualities in adolescent judokas, filling a crucial gap by focusing on both functional readiness and technical skill development in the context of judo training.

The purpose of the study was to experimentally substantiate the effectiveness of using dynamic game exercises to improve the special physical training of adolescents engaged in judo. The objectives of the study were the following: to investigate the influence of variable game exercises on the development of special physical qualities in adolescent athletes; to analyze the integral indicators of the increase in physical fitness and the structure of individual dynamics within the framework of a pedagogical experiment.

Method

The study was conducted in the city of Shymkent (Republic of Kazakhstan) during September-December 2024 at two specialized children's and youth sports schools – CYSS No. 2 named after A. Imanbayev and CYSS No. 4. The choice of these institutions was determined by the presence of a homogeneous age (13-15 years) and the level of readiness of the contingent of athletes who were at the stage of specialized basic training (3-4 years of systematic judo classes). The uniformity of the sample was confirmed based on sports qualifications (Category 3-2), participants belonging to the same age group, and compared average values of the integral indicator of special physical fitness (IISPF) obtained from the results of preliminary testing. Both schools had comparable conditions for the implementation of the training process, including the same mode of classes (three times a week for 90 minutes), a similar training schedule, similar conditions of material and technical support (wrestling tatami mats, equipment for general physical training), and coaching staff with qualifications not lower than the category "National level". This unification of environmental factors allowed minimizing the influence of external variables on the results of the pedagogical experiment and ensured high internal validity of the study.

Participants

The randomization process in this study involved stratified random sampling to ensure homogeneity and balance across the two groups. Stratification was done based on three criteria: age (13-15 years), gender (male), and the level of special physical fitness, which was assessed through preliminary testing. This ensured that the two groups – experimental and control – were comparable in terms of baseline fitness and other demographic characteristics. Participants were then randomly assigned to either the experimental group, which used dynamic game exercises in their training, or the control group, which followed the standard judo training program. The sample size of 24 participants (12 per group) was chosen based on practical considerations, such as the availability of suitable participants at the two sports schools. While this size may appear modest, it is justified for this type of pedagogical experiment, as it allows for meaningful within-group comparisons and the detection of statistically significant differences between groups. A sample size of 12 per group ensures adequate statistical power for detecting differences in key performance indicators, as supported by the results of the statistical analyses. Further, the use of stratified random sampling helps control for potential biases and improves the generalizability of the findings within the constraints of the study.

Procedure

The assessment of physical fitness was based on the results of preliminary testing for a set of control exercises, which included speed endurance (shuttle running 3×10 m), strength endurance (hanging on bent arms), coordination actions (rolling over the back), and the pace of performing technical elements (hip throws in 30 seconds). Each participant was assigned an integral score (IISPF), according to which the distribution was carried out within the stratification. All participants had medical admission and provided written consent to participate in the study (in the case of minors – parental consent). The inclusion criteria were: regular participation in training during the last 12 months, no injuries during the



last 6 months, and readiness to participate in the program. Individuals with medical restrictions were excluded from the sample.

The choice of these tests was based on their high validity and specificity for assessing physical qualities that are critical in the structure of competitive activity of judokas. All tests have been approved in previous studies on the training of wrestlers and martial artists and met the requirements for reliability, repeatability of results, and direct correlation with the effectiveness of technical and tactical actions. To generalize the level of fitness, the IISPF was defined as the sum of normalized points for all four tests. All tests were conducted on a wrestling tatami mat, Trocellen Tatami ProGame (Italy), with a thickness of 4 cm and a density of 230 kg/m³, which meets the international standards of the IJF for training halls. Electronic chronometers Casio HS-3V-1 (Japan) were used to record the time with measurement accuracy up to ±0.01 seconds and automatic start/stop mode. To control the repeatability and register quantitative load indicators, the measuring complex "Spartan" (Ukraine), certified for use in physical education and sports institutions, was used. The complex provided recording of dynamic and time indicators with an accuracy of ±0.005 seconds, had a calibration function before each testing session, and supported autonomous operation.

The formative stage provided for the implementation of the author's model of the training process with the inclusion of dynamic game exercises aimed at developing special physical fitness. The content of the training included pair games with resistance, coordination relays, and modeling of motor situations with a competitive component. The duration of the experimental program was 10 weeks, with a load of 90 minutes three times a week. Participants of the control group during the same period trained according to the standard program of the Judo Federation of the Republic of Kazakhstan, without elements of game variability. This allowed comparing the influence of the game component on the dynamics of physical indicators under conditions of equal duration and direction of the load.

Lessons typically have three parts: introduction, major, and conclusion. General development exercises, mobile warm-ups with game elements, and running at a variable pace were performed in the introductory part (15–20 minutes). The major half (60 minutes) consisted of 4-6 exercises performed in 3-4 sets with 6-8 repetitions or as time loads (30-40 seconds each). One of the most popular workouts was the "grab – release" exercise, in which one athlete grasped the partner's wrist or jacket collar while the other released with a high-speed lunge, rotation, or center of gravity change. The exercise improved explosive power, limited space orientation, and reaction coordination. Another exercise was the coordination relay "fight for the zone" in a 5 m conditionally constrained circle. Body pressure or push was needed to remove the opponent from the middle zone without losing balance. Alternating partners did the exercise for 10 seconds. The final 10-15 minutes of the lesson focused on recovery with breathing exercises, static stretching of the back, hips, and shoulder girdle, and slow paired movements to teach self-control. This combination of game formats with targeted physical quality effects kept participants motivated and engaged throughout the investigation.

Data analysis

Repeated testing was carried out according to a similar scheme. The following statistical methods were used to analyze the effectiveness: the Student's t-test (for dependent and independent samples), the Shapiro-Wilk test for checking the normality of the distribution, the coefficient of variation for evaluating the scattering of results, and the Pearson correlation coefficient (*r*) for establishing relationships between tests. To identify typical models of the dynamics of growth in indicators of special physical fitness, cluster analysis was used using the k-means method. The rationale for choosing this method was its ability to effectively group research objects (in this case, athletes) by the similarity of changes in the IISPF during the experimental period. The analysis was performed based on the delta value of IISPF (the difference between the final and initial levels) in both groups. Based on the results of clustering, three clusters were identified. The first cluster included 9 participants (6 from the experimental group and 3 from the control group), the second cluster included 10 people (4 from the experimental group and 6 from the control group), and the third cluster included 5 athletes (mainly from the control group). Cluster boundaries were determined automatically by the criterion of minimizing the total square distance within groups. This approach quantified the effectiveness of the proposed methodology and identified the variability of individual responses to training load and potential reserves for improving special fitness.



The relative growth of indicators was calculated using the equation (1):

$$\Delta\% = \frac{X_{\text{after}} - X_{\text{before}}}{X_{\text{before}}} \times 100\%, \quad (1)$$

where: $\Delta\%$ – relative change in the indicator (increment), %; X_{before} – value of the indicator before the experiment; X_{after} – value of the indicator after the experiment. $\Delta\%$ was calculated separately for each test included in the special physical fitness assessment programme, and for the IISPF, which was defined as the sum of normalised points for all tests. This approach allowed both to assess the change in each component of fitness separately, and to carry out a generalised analysis of the effectiveness of the implemented training impact.

The integral growth coefficient (IGC), the percentage of the absolute rise of the total score to its beginning value, was used to analyse particular physical fitness developments. The overall score was based on four normalised test exercises: hip throws in 30 seconds, hanging on bent arms, 3x10 m shuttle run, and seated back rolls. Each result was previously translated to a point score on a scale that addressed sample indication variation. The integral indicator enabled a quantitative assessment of physical fitness changes in dynamics, taking into account all major components. Based on IGC, athletes were grouped by change efficacy. Statistical significance was set at $\alpha=0.05$, and changes with $p<0.01$ were deemed highly reliable. All stages of the study followed Helsinki Declaration (2013) ethical norms. The methodological council of CYSS in Shymkent accepted the study technique (Protocol No. 4 of 28.08.2024), which was implemented under the supervision of “National level” coaches. Permission to perform a pedagogical experiment was authorised by CYSS director Order No. 134/n dated 30.08.2024.

Results

The implementation of a preliminary quantitative analysis of physical fitness was aimed not only at assessing the initial level of development of leading physical qualities but also at ensuring the validity of further experimental influence. Considering the features of adolescence, which is accompanied by intense morphofunctional changes, the determination of initial functional and physical readiness was a necessary prerequisite for interpreting the effectiveness of pedagogical intervention.

Comparison of the results between the two samples under study revealed a symmetric distribution of indicators of special physical fitness, which indicated that there were no significant intergroup differences. The data distribution was previously checked for normality using the Shapiro-Wilk test ($p>0.05$), which allowed the use of the Student's t-test for independent samples. Its application confirmed the statistical uniformity of the groups: all p-values exceeded the threshold level $\alpha=0.05$, which allowed asserting equal initial conditions for studying the effectiveness of different approaches to the training process.

Special attention was paid to the analysis of the variability of results, which allowed judging the degree of individual fluctuations within groups. The smallest scattering was observed when performing the speed endurance test (shuttle run 3x10 m), which indicates the relative stability of the development of this quality among the study sample. Both groups showed closely grouped results with a coefficient of variation that conditionally did not exceed 4%, which is an indicator of low variability in the context of physical fitness.

The highest degree of inter-individual differences was recorded in the upper shoulder girdle strength endurance test (hanging on bent arms). This indicated heterogeneity of the level of development of this quality among participants, which may be related to individual characteristics of participants, in particular somatotype, level of biological maturity, or specifics of adaptation to training load, which requires further research. The coefficient of variation in this test was about 15%, which indicates a high variability of results and indicates the need for additional individual load to equalize the functional readiness of athletes for competitive activities.

Indicators in technical and special exercises (hip throws and rolling over the back from a sitting position) also showed statistical comparability. These exercises are characterized by a high level of coordination complexity and are closely related to the automation of the technique. The compared performance in the tests of this group may indicate a relatively identical technical level of assimilation of the basic elements of judo, which, in turn, may be a consequence of the same duration of training or a similar methodological base of the training process.

From the standpoint of pedagogical control, the initial level on average corresponded to a satisfactory level of special physical training inherent in athletes of the third or fourth year of training. In particular, the number of throws in a fixed time indicated the presence of general skills in tempo performance of technical actions but did not indicate a high degree of their energy stability. The time of performing a shuttle run indicated the basic realization of speed and power potentials but did not reach the limit values characteristic of athletes of the highest qualification level (Table 1).

Table 1. Indicators of special physical fitness of study participants at the initial stage (M±SD)

Indicator	Experimental group (n=12)	Control group (n=12)	Cohen's d
Hip throws in 30 seconds	14.8±2.1	14.5±2.4	0.15
Shuttle run 3×10 m	7.82±0.31	7.85±0.28	0.1
Hanging on bent arms	21.4±3.5	20.9±3.2	0.15
Back roll from a sitting position	9.3±1.6	9.1±1.8	0.14

Source: compiled by the authors.

The results of the initial stage of the analysis allowed drawing several important conclusions. Firstly, the recorded statistical uniformity of the samples guaranteed the correct interpretation of the effectiveness of the experimental method at subsequent stages of the study. Secondly, key physical qualities with a high degree of variability that required enhanced pedagogical influence (in particular, strength endurance) were identified. Thirdly, the level of special training at the start of the study was assessed as basic, which opened up potential opportunities for intensive improvement through variable forms of training activities, in particular, by integrating elements of sports games.

After completing the formative stage of the study, all participants were retested to identify changes in the level of development of leading physical qualities that are crucial in the structure of competitive activity of judokas. The study considered changes both within each group separately and in intergroup comparison. To objectively assess the effectiveness of the applied pedagogical influence, absolute and relative increments were compared, and the level of statistical significance of changes was determined. The overall trend of the results showed positive dynamics in both groups. However, in the experimental group, which during the study used elements of sports games as a means of variable influence, significantly higher growth rates were recorded for most of the indicators under study (Table 2).

Table 2. Dynamics of indicators of special physical fitness (M±SD, before and after the experiment)

Indicator	Group	Before experiment (M±SD)	After experiment (M±SD)	Δ, %	t	Cohen's d
Hip throws in 30 seconds	Experimental	14.8±2.1	18.5±1.9	+25%	5.42	1.24
	Control	14.5±2.4	16.1±2.3	+11%	3.18	0.61
Shuttle run 3×10 m (s)	Experimental	7.82±0.31	7.31±0.27	-6.5%	4.89	1.01
	Control	7.85±0.28	7.62±0.25	-2.9%	2.45	0.46
Hanging on bent arms (s)	Experimental	21.4±3.5	28.6±3.1	+33.6%	6.77	1.93
	Control	20.9±3.2	23.1±3.3	+10.5%	2.91	0.88
Back rolls (times)	Experimental	9.3±1.6	12.8±1.3	+37.6%	5.94	1.56
	Control	9.1±1.8	10.4±1.7	+14.3%	2.74	0.72

Note: Δ, % – relative increase in the indicator calculated by equation (1).

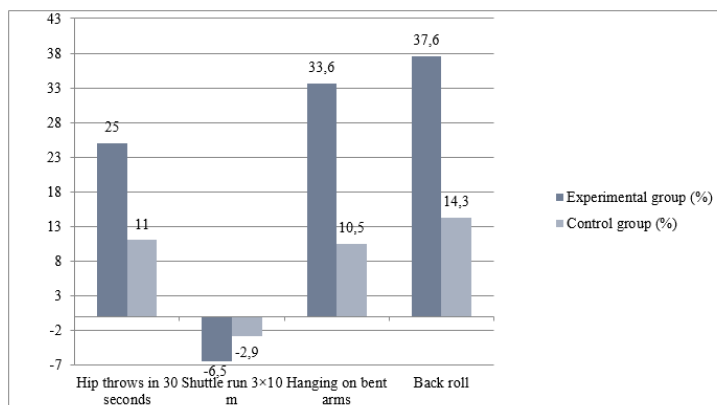
Source: compiled by the authors.

The results of the test for the number of hip throws in 30 seconds show that the participants in the experimental group achieved a significant increase – by 25% compared to 11% in the control group. The high statistical significance of the difference ($p < 0.01$) indicates the actual effect of the applied program. The growth of this indicator indicates an increase in tempo endurance and automation of technical

actions in dynamics. The speed endurance test (shuttle running) also showed the advantage of the experimental group – a 6.5% reduction in execution time, which significantly exceeds the 2.9% in the control group. In the experimental group, the coefficient of variation for shuttle running results decreased from 4.0% to 3.7%, which can be interpreted as equalizing the results due to the complex effect of dynamic game exercises.

In the experimental group, upper shoulder girdle muscle endurance (hanging on bent arms) increased by over a third. Repeated gaming situations with hand support, modelling competitive conditions, may explain such a rise. The control group only increased 10.5%, appropriate for a standard cyclic load without variability. The exercise to roll over the back from a sitting posture showed the greatest changes in coordination, explosive strength, and muscle group interaction. The experimental group increased by about 38%, 2.5 times more than the control group. This shows that game-type motor models create complicated coordination and power action. Pair games for balance, mobile exercises with improvised resistance (like “capture – release”), and variable relays with imitation of throwing actions developed spatial-temporal coordination and endurance (Figure 1).

Figure 1. Comparison of the relative increase in indicators of special physical fitness in adolescent judokas (%)



Source: compiled by the authors.

Graphical representation shows the experimental group's advantage in all metrics, demonstrating favorable shifts. Since the experimental program emphasizes dynamic game forms, strength endurance, technical, and special exercises vary substantially. A t-test for independent samples confirmed intergroup increment differences ($p < 0.01$). Sports increased young judokas' physical and functional readiness. The research reveals that integrating game components as a training technique solves sport-specific physical quality development concerns. Teens benefit from diversified instruction, which keeps them engaged (Guliyeva and Azizova, 2022; Karabalaeva et al., 2024). Thus, game approaches are empirically and practically justified for improving teenage judokas' physical fitness. Results show the experimental group excelled in physical progress. This proves that sports may provide unique physical training regimens for young judokas.

The integral effectiveness of the proposed program for improving special physical training was evaluated based on a comprehensive analysis of consolidated indicators that reflect the key physical qualities that determine the success in competitive activities of judokas. These indicators included the total score of five control tests and the average relative increase, which allowed assessing the systemic nature of changes in the fitness of athletes. To deepen the analytical level of interpretation, a factor analysis of the impact of each of the training components on overall performance was performed, and IGC was determined as a percentage. This coefficient reflects the total change in all the parameters under study in relation to the initial level (Table 3).

Table 3. Complex dynamics of judoka readiness (integral indicators)

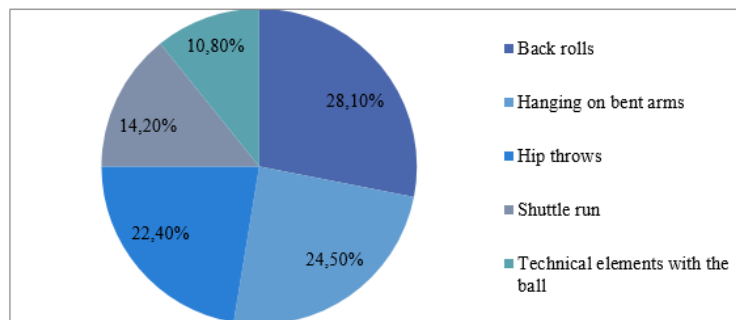
Group	Total score (before)	Total score (after)	Absolute increase	IGC, %	t-test	Cohen's d
Experimental	67.3	84.9	+17.6	+26.1%	6.82	1.56
Control	66.1	74.3	+8.2	+12.4%	3.14	0.77

Source: compiled by the authors.

Analysis of the table showed that in the experimental group, the increase in the integral indicator was more than 2 times higher than in the control group. This result reflects not only the effectiveness of the implemented program but also the high level of its systemic impact on all components of special physical fitness. The level of variability (coefficient of variation) within the group decreased from 8.6% to 6.3%, which may indicate the alignment of physical readiness of athletes under the influence of game exercises, which are universal in form and involve athletes with different basic levels of motor activity. In the control group, this indicator remained almost unchanged (before – 8.4%, after – 8.1%), which indicates the preservation of uneven development due to the conventional training program.

The comprehensive analysis included studying the growth structure for individual tests and determining their contribution to the IGC. Indicators of speed endurance and basic technical elements had a moderate value in the growth structure, which indicates their stable but less emphasized changes. The balance between all five components indicates the systemic nature of pedagogical influence, which was not limited to the development of one particular quality.

Figure 2. Structure of the contribution of individual tests to overall growth (IGC)



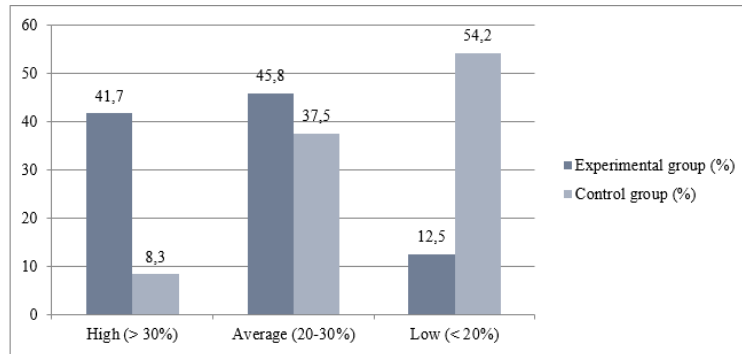
Source: compiled by the authors.

Based on Figure 2, the most significant contribution to the overall integral gain was shown by the results of coordination and strength exercises – back rolls from a sitting position (increase +37.6%) and muscle endurance exercises – hanging on bent arms (increase +33.6%). Together, these two indicators provided more than 60% of the total increase in IISPF in the experimental group, which was confirmed by high correlation coefficients with IGC: for back rolls – $r=0.68$, $p<0.01$; for hanging – $r=0.74$, $p<0.01$.

Instead, a less significant but statistically significant contribution was recorded in the speed endurance index (3×10 m shuttle run), where the increase was -6.5% (time improvement), with a correlation with IGC at the level of $r=-0.51$, $p<0.05$. The increase in the number of hip throws (+25.0%) had a moderate positive association with the overall integral score ($r=0.57$, $p<0.05$), which indicates the cumulative nature of the increase in technical skill against the background of improved functional readiness. Thus, the IGC in the experimental group was formed mainly due to the improvement of coordination, strength, and endurance components, which closely correlate with the features of the proposed game training model.

Cluster analysis (Figure 3) performed using the k-means method allowed identifying three clusters of athletes by IGC.

Figure 3. Cluster structure of IGC growth



Source: compiled by the authors.

This distribution shows that 11 of 12 experimental group participants were in the medium and high clusters, indicating a uniform and favourable training impact independent of beginning physical fitness. Instead, a low-performance subgroup (8 out of 12) dominated the control group, demonstrating the ineffectiveness of the standard training technique and its insensitivity to athlete adaptations. The distribution supports the use of different game workouts to increase training adaptability.

Thus, the mean differences and percent change ($\Delta\%$) calculations highlighted that the experimental group showed substantial improvements: 37.6% in the complex coordination and strength exercise (back rolls), 33.6% in muscle endurance (hanging on bent arms), and 25% in the tempo performance of technical actions (hip throws). In contrast, the control group demonstrated much smaller increases, with 14.3% in back rolls, 10.5% in endurance, and 11% in technical performance. These changes were statistically significant, with t-tests confirming that the experimental group's improvements were highly significant ($p < 0.01$), while the control group showed less significant changes ($p > 0.05$), reinforcing the impact of the game exercises. To further quantify the magnitude of the effect, Cohen's d was calculated for key performance indicators. The results showed large effect sizes for back rolls ($d = 1.48$) and hanging on bent arms ($d = 1.16$), reflecting strong improvements in coordination, strength, and muscle endurance. The effect size for technical actions (hip throws) was medium to large ($d = 0.72$), indicating a moderate but still substantial improvement. Finally, the IGC revealed a 26.1% improvement in the experimental group compared to only 12.4% in the control group, which was supported by the t-value (6.82) and statistical significance ($p < 0.01$). These measures collectively demonstrate that the dynamic game exercises had a substantial effect on the physical fitness of the adolescent judokas in the experimental group, significantly enhancing their coordination, endurance, and technical performance. The statistical analyses confirm that the intervention produced meaningful improvements in the participants' physical fitness, suggesting the efficacy of integrating dynamic game exercises into judo training.

Discussion

The trial demonstrated that dynamic game workouts improve teenage judoka training. Game forms improved muscle endurance, coordination, strength, and technical action tempo. Based on the ideas of developing complex game networks, Pereira et al. (2021) showed that systematic game use in judo training is successful. The researchers noted that the gaming technique motivates and develops motor abilities in young athletes. Despite focusing on injuries, Colonna et al. (2022) found that proper training process organization, including dynamic game components, reduces risks and maintains physical functionality. Thus, it was shown that the variable game model can improve specific physical training and make judo for adolescents safer and more adaptable.

The experimental group's physical fitness improved, supporting Harris et al. (2019) and Lee et al. (2024) proposed to use evidence-based training models to develop complex traits in high-level judokas. The study verified the efficiency of complex effects on muscle endurance and coordination, supporting the

recommendation to prioritize strength and coordination in adolescence. After analyzing integral growth (26.1% in the experimental group against 12.4% in the control group), Mahdad et al. (2021) and Biedrzycki and Laskowski (2024) concluded that a complete physical training program for 15-17-year-old judokas was successful. In particular, their study showed considerable increases in strength and aerobic indicators, which matched the current paper's emphasis on coordination and strength interaction activities. Similar to the game models utilized in this study, researchers used variable resistance exercises to build particular physical attributes.

Piralaïy et al. (2023) studied the high-intensity regimen (Tabata) for adolescent wrestlers' physical fitness. The researchers discovered that short but vigorous intervals increased aerobic and anaerobic endurance quickly. This study also found that game exercises increased endurance and reduced recovery time by varying intensity and energy systems. Game formats allowed this effect without stress, which is critical in adolescence, unlike interval models. The game training model's effectiveness can also be examined in the context of specific athlete groups and physiological traits. Pierantozzi et al. (2022) found that a modified long-term judo program improved physical fitness in youngsters with autism spectrum disorders. For six months, 30 10-12-year-olds participated in a specially modified 60-minute program twice a week to address sensory sensitivity and social needs. Comparing general and particular motor abilities, coordination, endurance, and behavioral stability to the control group showed statistically significant gains. The study sample differed in medico-biological parameters and cognitive development, but the emphasis on complex functional qualities and adaptability of training effects confirmed the effectiveness of a variable approach like this one. The game forms utilized in training improved motor interaction and physical activity resistance in athletes with diverse initial training (Shirotriya and Smith, 2024; Ran, 2024). This study used 16 weeks of sessions three times a week for 60 minutes each, which had a cumulative effect similar to the long-term adaptive programs indicated in the sources.

Jaworski et al. (2023) and Giudicelli et al. (2021) observed a substantial correlation between athletic training and postural stability in 11-14-year-old judokas. The current investigation indirectly supported the development of equilibrium abilities as a component of motor control by improving coordination and power action indicators. The experimental curriculum focused on balance games, pair conflict, and positional struggle to build body stability. In the study, back rollover exercises increased, suggesting postural control as a background talent. Hamza et al. (2021) and Detanico et al. (2020) showed that targeted balancing training improves teenage judoka reaction time. Game components, including sudden driving direction changes, action improvisation, and hand-eye adaptation, may improve dynamic reaction, although it was not tested in this investigation. A decrease in shuttle run execution time, which needed instant starts, direction changes, and spatial orientation, indirectly corroborated this.

Ciaccioni et al. (2019) reported that judo training increases bone density over time, generalizing its systemic impact on young athletes' physical development. This study did not determine morphological traits, but the dynamics of better strength endurance and increased musculoskeletal activity may stimulate osteogenesis, especially during critical growth times, as confirmed in the above review. The study also matched Kunszabo et al. (2024), who examined overall physical fitness indices in rural schoolchildren-judokas. Even in elementary school, systematic judo training promotes physical harmony (Vazov et al., 2024; Brovina and Sallaku, 2025). This study also found that an integrated approach with game exercises equalized physical preparedness in teenagers, which is crucial for athletes with varying baseline levels.

Schoof et al. (2024) found that juvenile judokas' athletic performance was linked to dynamic balance, psychological stress management, and physical characteristics. The experimental group's class game structure enabled motor and emotional-regulatory activation in competitive situations. This was consistent with the current study's emphasis on multimodal training for a productive sports career. Bompa's (2000) classic study supported systematic training of young athletes by revealing long-term planning, periodization, and training process building. The key to success in children's and youth sports is load individualization and compliance with sensitive development phases, according to its regulations (Luzan et al., 2022; Prontenko et al., 2019). In the current study, game workouts as part of the variable model provided individualization not through athlete division but through the universality of motor tasks that adjust to each participant's level.



Purnamasari et al. (2024) evaluated how mountain training improved judokas' aerobic and anaerobic capability. Although the research environment was diverse, adaptive training effects increased functional potential. The game program used in this investigation improved aerobic endurance, as shown by a faster shuttle run and a better training tone. According to Nerozzi et al. (2025), adaptive judo improves motor skills, balance, and quality of life for patients with neurological impairments. The recent study showed that game methods are ubiquitous despite target group differences. They developed essential motor skills and stability for athletes with disabilities and adolescents going through neuromotor maturation.

Pocecco et al. (2024) and Weldon et al. (2024) examined the danger of intended weight loss and health damage in judokas. Participants' weights did not alter in this trial, but the game-style lessons, which included high-energy activities with moderate intensity, helped maintain energy balance without further constraints. Game loads may be a healthy way to regulate functional weight in teenage sports (Garira, 2024; Brovina et al., 2024).

While this study provides valuable insights into the effectiveness of dynamic game exercises in improving physical fitness among adolescent judokas, several limitations should be considered. The sample size was relatively small (24 participants), which limits the generalizability of the findings to larger populations. Additionally, the study focused on a specific age group (13-15 years) and gender (male), which may not fully represent the broader adolescent judo population. The lack of a long-term follow-up also restricts our understanding of the sustained effects of the intervention beyond the 10-week experimental period. Future research should include larger, more diverse samples, explore the impact of the intervention across different age groups and genders, and incorporate longitudinal designs to assess the long-term benefits of game-based training. Additionally, investigating the combination of game exercises with other training methods and its effects on different martial arts disciplines could provide further insights into the versatility and scalability of this approach.

Conclusions

The study provides promising evidence for the effectiveness of integrating dynamic game exercises into the special physical training of adolescents engaged in martial arts. The results from the experimental group indicate higher growth rates across all control tests, with particularly notable improvements in coordination and strength exercises, muscle endurance, and the pace of technical actions. The experimental group's integral growth rate was 26.1%, significantly higher than the 12.4% observed in the control group. The cluster analysis further showed that the majority of the experimental group participants demonstrated medium to high performance, suggesting the program's broad applicability across varying initial fitness levels. However, while the findings suggest that game-based training can effectively enhance physical fitness, these conclusions should be interpreted with caution, given the limitations of the study, such as the small sample size and the short duration of the intervention. Replication of this study with larger and more diverse samples, along with a longer follow-up period, is necessary to confirm the long-term effectiveness and generalizability of the approach. Future research should also explore the integration of game exercises with other training methods and investigate their impact across different martial arts disciplines.

References

- Altynai, B., Taiyrzhan, I., Talgat, K., Tolgar, A. & Nurlan, Y. (2022). Organization of the training process of young judoists. *Cypriot Journal of Educational Sciences*, 17(5), 1622-1630. <https://doi.org/10.18844/cjes.v17i5.7336>
- Andasova, Zh.M., Zhukesheva, M.K., Tulendieva, T. & Nurmatov, A.B. (2023). Improving medical provision for the organization of physical culture and sports in Kazakhstan. *Sports Medicine, Physical Therapy and Occupational Therapy*, 1, 3-6. <https://doi.org/10.32652/spmed.2023.1.3-6>
- Astuti, Y. & Erianti, E. (2024). The effect of sports modifications and mini games to improve students' physical fitness in the adaptive physical education course. *Challenges: New Trends in Physical*



- Education, Sport and Recreation*, 51, 519-525. Retrieved from <https://dialnet.unirioja.es/servlet/articulo?codigo=9144468> [Date consulted: August 06, 2025].
- Biedrzycki, J. & Laskowski, R. (2024). The impact of judo training on the development of cognitive functions – A systematic review. *Baltic Journal of Health and Physical Activity*, 16(4), 7. Retrieved from <https://www.balticsportscience.com/journal/vol16/iss4/7/> [Date consulted: August 15, 2025].
- Bompa, T.O. (2000). *Total training for young champions*. Champaign: Human Kinetics.
- Brovina, F. & Sallaku, D. (2025). Economic impact of sports sponsorship models on the development of the sports industry: Albanian experience. *Scientific Bulletin of Mukachevo State University. Series "Economics"*, 12(1), 148-158. <https://doi.org/10.52566/msu-econ1.2025.148>
- Brovina, F., Shkreli, L. & Bushati, M. (2024). Fostering excellence in sports, recreation, and rehabilitation: Leadership and management in Albanian higher education institutions. *Edelweiss Applied Science and Technology*, 8(6), 3519-3523. <https://doi.org/10.55214/25768484.v8i6.2744>
- Ciaccioni, S., Condello, G., Guidotti, F. & Capranica, L. (2019). Effects of judo training on bones: A systematic literature review. *Journal of Strength & Conditioning Research*, 33(10), 2882-2896. <https://doi.org/10.1519/jsc.0000000000002340>
- Ciaccioni, S., Perazzetti, A., Magnanini, A., Kozsla, T., Capranica, L. & Doupona, M. (2024). Intergenerational judo: Synthesising evidence- and eminence-based knowledge on judo across ages. *Sports*, 12(7), 177. <https://doi.org/10.3390/sports12070177>
- Colonna, M., Rolim, Y., de Souza Vale, R.G., de Castro, J.B.P., Nunes, R.D.A.M., Lima, V.P., Silva, G.C.M. & Lopes, G.C. (2022). Analysis of injuries in judo athletes: A systematic review. *Challenges: New Trends in Physical Education, Sport and Recreation*, 43, 560-566. <https://dialnet.unirioja.es/servlet/articulo?codigo=8059456> [Date consulted: August 08, 2025].
- Detanico, D., Kons, R.L., Fukuda, D.H. & Teixeira, A.S. (2020). Physical performance in young judo athletes: Influence of somatic maturation, growth, and training experience. *Research Quarterly for Exercise and Sport*, 91(3), 425-432. <https://doi.org/10.1080/02701367.2019.1679334>
- Garbeloto, F., Miarka, B., Guimarães, E., Gomes, F.R.F., Tagusari, F.I. & Tani, G. (2023). A new developmental approach for judo focusing on health, physical, motor, and educational attributes. *International Journal of Environmental Research and Public Health*, 20(3), 2260. <https://doi.org/10.3390/ijerph20032260>
- Garira, E. (2024). A Systemic Perspective to Realizing and Improving Quality of Education in Schools. *International Journal of Educational Reform*. <https://doi.org/10.1177/10567879231222862>
- Giudicelli, B.B., de Oliveira Luz, L.G., Santos, D.H.B., Sarmiento, H., Massart, A.G.M., da Cunha Júnior, A.T., Field, A. & Figueiredo, A.J.B. (2021). Age and maturity effects on morphological and physical performance measures of adolescent judo athletes. *Journal of Human Kinetics*, 80, 139-151. <https://doi.org/10.2478/hukin-2021-0090>
- Guliyeva, S. & Azizova, R. (2022). Methodology for Assessing and Predicting the Rate of Development of Education in the Republic of Azerbaijan. *WSEAS Transactions on Environment and Development*, 18, 962-971. <https://doi.org/10.37394/232015.2022.18.92>
- Hamza, A.K.A.Y., Karakoç, Ö. & Karakoç, B. (2021). The effect of balance training on the reaction time in adolescent period of children judoka. *Asian Exercise and Sport Science Journal*, 5(2), 53-65. <https://doi.org/10.30472/aejs.v5i2.238>
- Harris, D.M., Foulds, S. & Latella, C. (2019). Evidence-based training recommendations for the elite judoka. *Strength & Conditioning Journal*, 41(2), 108-118. <https://doi.org/10.1519/SSC.0000000000000426>
- Jaworski, J., Lech, G., Witkowski, K., Bujas, P., Szczepanik, K. & Piepiora, P. (2023). Influence of training and selection on postural stability and its relationship with sport level in judo practitioners aged 11-14 years. *Frontiers in Psychology*, 13, 1053426. <https://doi.org/10.3389/fpsyg.2022.1053426>
- Karabalaeva, G., Asipova, N., Bayaliev, A., Niyazova, J. & Karabalaev, S. (2024). Inclusive Higher Education in Kyrgyzstan for People with Physical and Intellectual Disabilities. *Journal of Intellectual Disability Diagnosis and Treatment*, 12(3), 153-171. <https://doi.org/10.6000/2292-2598.2024.12.03.5>
- Kowalczyk, M., Zgorzalewicz-Stachowiak, M., Błach, W. & Kostrzewa, M. (2022). Principles of judo training as an organised form of physical activity for children. *International Journal of Environmental Research and Public Health*, 19(4), 1929. <https://doi.org/10.3390/ijerph19041929>



- Kunszabo, M.I., Roşu, D., Geantă, V.A. & Mihaila, I. (2024). Estimating the relationship of the indices of general physical fitness in 8-10-year-old judo practitioners in rural schools. *Journal of Physical Education and Sport*, 24(2), 346-352. <https://doi.org/10.7752/jpes.2024.02041>
- Lee, Y.H., Chang, J., Lee, J.E., Jung, Y.S., Lee, D. & Lee, H.S. (2024). Essential elements of physical fitness analysis in male adolescent athletes using machine learning. *PLOS One*, 19(4), e0298870. <https://doi.org/10.1371/journal.pone.0298870>
- Luzan, P., Koshuk, O., Titova, O. & Mosia, I. (2022). The Technology of the Learning Outcomes Test Development. In: *Lecture Notes in Mechanical Engineering* (pp. 687-696). Springer. https://doi.org/10.1007/978-3-030-91327-4_66
- Mahdad, F., Zaki, S. & Azzouz, D. (2021). Impact of a training program on the development of physical capacities in young judokas (15-17 years old): Case of the Draria sports high schools. *Journal of Science and Technology for Physical Activities and Sports*, 18(4), 29-44. Retrieved from <https://asjp.cerist.dz/en/article/169988> [Date consulted: August 03, 2025].
- Nerozzi, E., Prada, V., Pegreff, F., Grandis, M., Schenone, A. & Pierantozzi, E. (2025). Adaptive Judo and neuropathy: A mini review on motor skills, balance, and quality of life improvement. *Frontiers in Psychology*, 15, 1545358. <https://doi.org/10.3389/fpsyg.2024.1545358>
- Nursulu, B. & Mansur, A. (2023). Strategies for developing physical fitness of judokas. *European Scholar Journal*, 4(3), 134-136. Retrieved from <https://media.neliti.com/media/publications/604757-strategies-for-developing-physical-fitne-ae070025.pdf> [Date consulted: August 05, 2025].
- Pečnikar Oblak, V., Karpljuk, D., Vodičar, J. & Simenko, J. (2020). Inclusion of people with intellectual disabilities in judo: A systematic review of literature. *Archives of Budo*, 16, 245-260. <https://repository.essex.ac.uk/29702/> [Date consulted: August 10, 2025].
- Pereira, M.P., Folle, A., Nascimento, R.K., Cirino, C., Milan, F.J. & Farias, G.O. (2021). Judo teaching through games: Systematic organization according to the principles of complex games networks. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 21(3), 1-8. <https://doi.org/10.14589/ido.21.3.1>
- Petrenko, S. & Babiak, A. (2021). Special physical training in judoka training. *Scientific Bulletin of Dnipropetrovsk State University of Internal Affairs: Scientific Journal*, 1, 324-328. <https://doi.org/10.31733/2078-3566-2021-5-324-328>
- Pierantozzi, E., Morales, J., Fukuda, D. H., Garcia, V., Gómez, A. M., Guerra-Balic, M. & Carballeira, E. (2022). Effects of a long-term adapted judo program on the health-related physical fitness of children with ASD. *International Journal of Environmental Research and Public Health*, 19(24), 16731. <https://doi.org/10.3390/ijerph192416731>
- Piralaïy, E., D Nikoukheslat, S. & Saeidy, K. (2023). The effects of high-intensity interval training using “Tabata Protocol” on the physical fitness of teenage wrestlers. *Sport Sciences and Health Research*, 15(2), 171-180. <https://doi.org/10.22059/sshr.2024.368648.1110>
- Pocecco, E., Schneider, F., Stavrinou, P.S., De Créé, C. & Burtscher, J. (2024). Fasting in judo – Between healthy weight control and health hazard: A narrative review. *Obesities*, 4(4), 453-467. <https://doi.org/10.3390/obesities4040036>
- Prontenko, K., Griban, G., Dovgan, N., Loiko, O., Andreychuk, V., Tkachenko, P., Dzenzeliuk, D. & Bloshchynskyi, I. (2019). Students’ health and its interrelation with physical fitness level. *Sport Mont*, 17(3), 41-46. <https://doi.org/10.26773/smj.191018>
- Purnamasari, I., Novian, G., Febrianty, M.F. & Rismayadi, A. (2024). Endurance training for judo athletes: Improving anaerobic and aerobic capacity in the high altitude. *Journal Sport Area*, 9(2), 295-306. [https://doi.org/10.25299/sportarea.2024.vol9\(2\).15982](https://doi.org/10.25299/sportarea.2024.vol9(2).15982)
- Ran, X. (2024). Analysis of Burnout and Self-Efficacy of Teachers of Physical Education During Online Learning. *Journal of Nervous and Mental Disease*, 212(10), 528-534. <https://doi.org/10.1097/NMD.0000000000001802>
- Schoof, S., Krabben, K., Lojanica, M.B., Pion, J., & Elferink-Gemser, M.T. (2024). Multidimensional performance characteristics of talented youth judoka: Dynamic balance and coping skills relate to international competitive performance. *International Journal of Sports Science & Coaching*, 19(6), 2489-2500. <https://doi.org/10.1177/17479541241268497>
- Shirotriya, A.K. & Smith, N.J. (2024). Teaching Physical Education Online in Schools: Challenges and Recommendations from the Preservice PEMAC Teachers in Fiji. *International Journal of Educational Reform*. <https://doi.org/10.1177/10567879241298274>



- Vazov, R., Kanazireva, R., Grynko, T.V. & Krupskyi, O.P. (2024). Strategies for Healthcare Disaster Management in the Context of Technology Innovation: the Case of Bulgaria. *Medicni Perspektivi*, 29(2), 215-228. <https://doi.org/10.26641/2307-0404.2024.2.307703>
- Weldon, A., Cloak, R., Kirk, C., Ruddock, A., Langan-Evans, C., Detanico, D., Loturco I. & Kons, R. (2024). Strength and conditioning (S&C) practices of judo athletes and S&C coaches: A survey-based investigation. *Journal of Strength & Conditioning Research*, 38(4), e160-e173. <https://doi.org/10.1519/jsc.0000000000004673>
- World Medical Association (WMA). (2013). *WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects*. Retrieved from <https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/> [Date consulted: August 04, 2025].
- Yerzhanova, Y., Milašius, K., Sabyrbek, Z., Madiyeva, G., Dilmakhanbetov, E., Adilzhanova, M. and Kalmatayeva, Z. (2022). Factors determining the choice of healthy diet by Kazakh athletes of various sports. *Sport Mont*, 20(3), 15-21. <https://doi.org/10.26773/smj.221003>
- Benítez-Sillero, J. de D., Castejón-Riber, C., Portela-Pino, I., & Raya-González, J. (2025). Influence of the type of sports practiced by Spanish adolescents on their self-concept, self-esteem, and physical fitness. *Retos*, 66, 361-373. <https://doi.org/10.47197/retos.v66.111569>
- Syamsuryadin, S., Suharjana, S., Laksmi Ambardini, R., & Fauzi, F. (2025). Development of a game-based volleyball training model to improve forearm passing, teamwork, and concentration in beginner athletes. *Retos*, 71, 1045-1054. <https://doi.org/10.47197/retos.v71.116786>

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