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METHODOLOGY OF IMPROVING TECHNICAL PREPAREDNESS OF HANDBALL PLAYERS IN THE ANNUAL TRAINING CYCLE: AN EXPERIMENTAL APPROACH

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ABOUT ARTICLE

Key words: handball, technical preparedness, goalkeeper training, annual training cycle, pedagogical experiment, physical fitness, functional monitoring, specialised exercise complex, periodisation, youth sports.

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Abstract: This study examines the development and implementation of a methodology for improving the technical preparedness of 15–17-year-old handball players during the annual training cycle. A pedagogical experiment was conducted over the 2023–2024 academic year involving control (n=10) and experimental (n=10) groups drawn from the educational-training stage of a sports school. Baseline anthropometric and physical fitness indicators showed no statistically significant intergroup differences (p>0.05), confirming the validity of the experimental design. Functional states of athletes were monitored using the "First Beat" technology, providing real-time heart-rate and energy expenditure data. A three-block specialised exercise complex was developed for goalkeeper technical training, covering ball-catching, lateral diving, footwork, penalty-shot repulsion, and decision-making under time pressure. In addition, an annual periodisation plan encompassing preparatory, competitive, and transition periods was constructed and applied. The experimental group demonstrated statistically significant improvements across all technical performance indicators compared to the control group by the conclusion of the study cycle. The findings confirm that structured, periodised technical training integrated with functional monitoring yields superior outcomes in youth handball goalkeeper development.

Introduction. Handball is one of the most physically and technically demanding team sports, requiring athletes to demonstrate high levels of speed, agility, coordination, strength, and game intelligence simultaneously [1]. The goalkeeper, in particular, occupies a pivotal role: a technically proficient goalkeeper can neutralise even the most sophisticated attacking combinations and directly influence the final score of a match [2]. Despite this acknowledged importance, the scientific literature on structured methodological approaches to goalkeeper and field-player technical development within the framework of an annual training cycle remains limited, especially in the context of post-Soviet sporting systems [3].

The contemporary practice of youth handball coaching frequently relies on narrow repetition of a small set of throwing and defensive techniques, offering insufficient variation and inadequate preparation for the dynamic demands of competitive play [4]. Research has shown that young players who undergo periodised, scientifically monitored training programmes develop technical skills at a significantly faster rate than those trained through conventional methods alone [5]. Furthermore, biomechanical analyses have demonstrated that correct technique not only improves performance but also substantially reduces injury risk — a factor of paramount importance in adolescent athletes whose musculoskeletal systems are still developing [6].

The present study was designed to address this gap by developing, implementing, and evaluating a comprehensive methodology for improving technical preparedness in youth handball players. The methodology integrates physical conditioning, specialised technical drills, functional monitoring, and a structured annual periodisation plan. The objective was to quantify the effects of this methodology on athletes' anthropometric profiles, physical fitness test results, and technically specific performance indicators across a full academic year.

The research was guided by three primary questions: (1) Do control and experimental groups exhibit equivalent baseline anthropometric and physical fitness characteristics at the outset of the study? (2) What are the functional load characteristics of training sessions as measured by heart-rate monitoring technology? (3) Does the application of the developed methodology produce statistically significant improvements in technical preparedness relative to a conventional training approach?

Materials and methods. Study Design and Participants

A pedagogical experiment was conducted at a sports school from September 2023 to August 2024. Twenty male handball players aged 15–16 years (educational-training stage, Year 2) were randomly assigned to a control group (n=10) and an experimental group (n=10). Both groups trained under the same coaching staff and facility conditions. The experimental group received the newly developed technical training methodology, while the control group continued with the standard training curriculum. Initial and final test sessions were conducted at the beginning and end of the academic year respectively. Intermediate monitoring was performed at four checkpoints throughout the year.

Ethical approval was obtained from the institutional review board of the university. Written informed consent was provided by athletes and their guardians. Participant anonymisation was maintained throughout data collection and reporting by replacing full names with initial-and-family-name codes (e.g., K-ov S.).

Anthropometric and Physical Fitness Assessment

Baseline anthropometric measurements included standing height (cm), body mass (kg), leg length (cm), and arm length (cm). Physical fitness was evaluated using six standardised handball-specific tests: (1) 40 m ball throw from goal to goal (m); (2) counter-attack pass accuracy (successful completions out of 10 attempts); (3) complex exercise time trial (seconds); (4) 30 m ball dribble (seconds); (5) standing throw distance with a 500 g ball using the dominant hand (m); and (6) 100 m shuttle run (seconds). All tests were administered under standardised conditions by the same assessor at each measurement point.

Functional State Monitoring

Functional state monitoring was conducted using the "First Beat" wearable heart-rate monitoring system during a representative baseline training session. Recorded parameters included: resting heart rate (HR_rest), average heart rate (HR_avg), maximum heart rate (HR_max), total training impulse (TRIMP score), total energy expenditure (kcal), and aerobic and anaerobic load scores. These data allowed for the individualisation of training prescriptions and the identification of athletes with insufficient or excessive load profiles.

Statistical Analysis

Descriptive statistics were computed for all variables, including mean (M), standard deviation (σ), and coefficient of variation (V%). The homogeneity of groups at baseline was verified using the independent-samples t-test, with a significance threshold of $p<0.05$. Pre-to-post changes within each group were assessed using the paired t-test. Between-group differences at post-test were evaluated using independent-samples t-tests. Statistical analyses were performed using SPSS v.26.0.

Results and discussion. 3.1 Baseline Anthropometric Characteristics

Table 1 presents the individual and group anthropometric data for the control group at the start of the study.

Table 1. Baseline anthropometric characteristics of control group athletes (n=10)

No	Athlete	Height (cm)	Weight (kg)	Leg length (cm)	Arm length (cm)
1	S-ev A.	185	75	41	30
2	G-ov X.	176	81	38	28.50
3	K-ov E.	170	68	41	26.50
4	K-ev K.	159	64	37.50	26.50
5	B-ov M.	154	50	35.50	25.50
6	A-ov Sh.	170	61	39.50	29.50
7	M-ov K.	155	54	33.50	26
8	B-ev R.	168	78	38.50	28.50
9	M-ev G.	146	50	34.50	24
10	T-ov K.	143	52	33.50	24
M±σ		169.64 ± 6.32	63.30 ± 14.05	37.25 ± 2.96	26.90 ± 2.34
V (%)		3.72	22.19	7.94	8.69

The control group exhibited a mean height of 169.64 ± 6.32 cm, mean body mass of 63.30 ± 14.05 kg, mean leg length of 37.25 ± 2.96 cm, and mean arm length of 26.90 ± 2.34 cm. The relatively high coefficient of variation for body mass (22.19%) reflects the morphological heterogeneity typical of adolescent athlete cohorts, where individual developmental trajectories vary considerably.

Table 2. Baseline anthropometric characteristics of experimental group athletes (n=10)

No	Athlete	Height (cm)	Weight (kg)	Leg length (cm)	Arm length (cm)
1	K-ov S.	178	75	40.50	29.50
2	Sh-ov Sh.	143	55	34	25
3	X-ev J.	175	61	42	28.50

4	A-ov Sh.	161	79	33.60	24.70
5	T-ov B.	147	67	34.10	25.80
6	Ba-ev R.	172	65	35.60	27.10
7	K-ov R.	153	52	39.10	29.30
8	A-ov Sh.	164	63	38.70	26.50
9	P-ov A.	181	51	36.70	30.10
10	J-ev E.	144	76	35.20	28.30
M±σ		170.80 ± 7.64	64.40 ± 11.65	36.95 ± 4.53	27.48 ± 3.39
V (%)		4.47	18.09	12.25	12.33

The experimental group demonstrated a mean height of 170.80 ± 7.64 cm, body mass of 64.40 ± 11.65 kg, leg length of 36.95 ± 4.53 cm, and arm length of 27.48 ± 3.39 cm. Although the experimental group was marginally taller and heavier on average, the differences are negligible at the group level.

Table 3 provides the direct comparison of baseline anthropometric indicators between groups.

Table 3. Comparative baseline anthropometric characteristics of both groups (n=20)

No	Indicator	Experimental group x±σ	V (%)	Control group m±σ	V (%)	p
1	Height (cm)	170.80 ± 7.64	4.47	169.64 ± 6.32	3.72	>0.05
2	Weight (kg)	64.40 ± 11.65	18.09	63.30 ± 14.05	22.19	>0.05
3	Leg length (cm)	36.95 ± 4.53	12.25	37.25 ± 2.96	7.94	>0.05
4	Arm length (cm)	27.48 ± 3.39	12.33	26.90 ± 2.34	8.69	>0.05

Statistical analysis confirmed that no significant intergroup differences existed for any anthropometric variable ($p>0.05$ for all comparisons). These findings establish that the two groups were morphologically homogeneous at the outset of the experiment, satisfying a fundamental prerequisite for valid pedagogical experimental design. The equivalence of groups at baseline indicates that any post-intervention differences between groups can be attributed to the differential training methodologies rather than pre-existing physical characteristics.

3.2 Baseline Physical Fitness Characteristics

Table 4. Comparative baseline physical fitness characteristics of both groups (n=20)

No	Test	Exp. group M±σ	V (%)	Con. group M±σ	V (%)	p
1	40 m ball throw (m)	34.40 ± 5.18	15.05	34.60 ± 5.05	14.59	>0.05
2	Counter-attack pass (out of 10)	5.30 ± 0.94	17.73	5.23 ± 0.97	18.54	>0.05
3	Complex exercises (sec)	14.77 ± 2.15	14.55	14.93 ± 1.52	10.17	>0.05
4	30 m dribble (sec)	5.76 ± 0.86	14.93	5.87 ± 0.98	16.67	>0.05
5	Standing throw distance (m)	19.70 ± 2.62	13.33	19.90 ± 2.56	12.86	>0.05
6	100 m shuttle run (sec)	25.67 ± 4.25	16.55	24.58 ± 3.75	15.25	>0.05

No statistically significant between-group differences were found for any of the six physical fitness tests at baseline ($p>0.05$). The experimental group recorded a mean 40 m ball throw of 34.40 ± 5.18 m compared to 34.60 ± 5.05 m for the control group; counter-attack pass accuracy averaged 5.30 ± 0.94 versus 5.23 ± 0.97 completions; complex exercise time was 14.77 ± 2.15 vs. 14.93 ± 1.52 seconds; the 30 m dribble averaged 5.76 ± 0.86 vs. 5.87 ± 0.98 seconds; standing throw distance was 19.70 ± 2.62 vs. 19.90 ± 2.56 m; and 100 m shuttle run time was 25.67 ± 4.25 vs. 24.58 ± 3.75 seconds.

These results corroborate the anthropometric findings in confirming that the groups were well-matched for physical preparedness at the start of the study. The baseline coefficients of variation for most tests ranged between 12 and 19%, which is considered acceptable for youth athletic cohorts and reflects the natural heterogeneity of adolescent physical development [7].

3.3 Functional State Monitoring via First Beat Technology

A representative training session was monitored using the First Beat wearable system to establish individual functional load profiles for experimental group athletes. Table 5 summarises the key functional parameters recorded for six monitored athletes.

Table 5. Functional load characteristics of monitored athletes during the baseline training session

Athlete	Duration	TRIMP (pts)	Kcal	HR min	HR avg	HR max	Aerobic / Anaerobic load

A. Toshpulatov (15 y)	1h 50m	29	530	61	105	175	1.3 / 0.7
H. Zuhriddínov (16 y)	1h 11m	44	406	69	124	189	2.2 / 1.5
I. Amirxon (16 y)	1h 07m	48	290	60	124	192	2.4 / 2.5
A. Niyazov (17 y)	1h 02m	50	250	82	131	201	2.5 / 3.3
B. Toshtemírov (14 y)	1h 11m	58	239	69	120	198	2.2 / 3.2
M. Mirsaidov (15 y)	55m	58	333	74	127	192	2.3 / 2.3

The monitored session commenced at 10:30 and included a 3-minute stretching warm-up, 7-minute joint mobility exercises, 800 m easy jogging, and 10–12 minutes of upper-body developmental work. The main section consisted of three 12-minute blocks of handball technical and physical exercises including goal-to-goal 40 m throws, counter-attack passes, standing throws, 30 m dribbling, and 100 m shuttle runs, with 90-second rest periods between exercises. The session concluded with 400 m maximal-effort sprinting (best time 55 sec; slowest 1:07) and a 5-minute cool-down stretch.

The TRIMP scores ranged from 29 (Toshpulatov, 15 years) to 58 (Mirsaidov and Toshtemírov), reflecting substantial individual variation in training load uptake. Athletes with lower TRIMP values and lower average heart rates (e.g., Toshpulatov: HR_avg = 105 bpm, TRIMP = 29) were identified as candidates for increased training intensity. Conversely, Toshtemírov (14 years) displayed a maximum HR of 198 bpm and an anaerobic load score of 3.2, suggesting a need for more careful load management and recovery monitoring.

The aerobic-to-anaerobic load balance varied markedly across athletes. Niyazov demonstrated the highest anaerobic load (3.3 pts) at a TRIMP of 50, indicating a strong capacity for high-intensity effort, while Toshpulatov's aerobic and anaerobic scores of 1.3 and 0.7 respectively pointed to predominantly low-intensity physiological engagement. These findings highlight the importance of individual load monitoring in youth training and provide empirical justification for the individualised elements incorporated into the developed methodology.

3.4 Developed Training Methodology and Annual Periodisation Plan

The core contribution of this study is the development and implementation of a structured annual technical training methodology for handball players, with particular emphasis on goalkeeper preparation. The methodology was organised according to three macro-periods: the preparatory period, the competitive period, and the transition period.

During the preparatory period, emphasis was placed on developing and consolidating technical skills. Training sessions followed a structure of: (a) general warm-up including light physical exercises (10–15 min); (b) technical element repetition and complex exercise execution (20–30 min); and (c) game simulation drills (20–25 min). Goalkeeper-specific focus in this period centred on ball-catching under varying directional demands, lateral diving with correct fall mechanics, footwork precision, and goalkeeper-defender coordination patterns.

During the competitive period, the primary goal was to increase the speed and precision of technical actions under match-realistic conditions. Training content prioritised rapid decision-making exercises, execution of tactical combinations under time pressure, and application of technical skills within full-sided and small-sided game formats. Stress-simulation drills including timed shot-stopping sequences were introduced to develop psychological resilience alongside technical competence.

The transition period focused on organism recovery and maintenance of core technical skills. Low-intensity sessions (20–30 min, 3 times per week) included easy reaction drills and light technical repetition. Video analysis sessions (1–2 hours, team and individual) were incorporated to review technical performance from the completed competition season and to set developmental goals for the subsequent annual cycle.

Table 6. Annual periodisation training plan for handball goalkeepers

Period	Training type	Exercises	Duration	Notes
	Physical conditioning	Reaction/speed drills; waiting & decision-making	30-40 min	Warm-up phase
Preparation	Basic technical drills	Catching, lateral diving, footwork refinement	45-60 min	4-5 times/week
	Defence movements	1-on-1 shot blocking; low-shot technique	30-40 min	Injury prevention focus
	Tactical prep	Goalkeeper–defender coordination	30 min	Blocked-shot positioning
	Game simulation	Counter-attacks, corner shots, 7-m penalty saves	45-60 min	5-6 times/week
Competition	Stress-state exercises	Time-constrained shot-stopping decisions	20-30 min	Psychological readiness

Transition	Individual work	Remediation of each goalkeeper's weak zones	30-40 min	With individual coach
	Recovery training	Light reaction & movement maintenance exercises	20-30 min	3 times/week
	Skill consolidation	Low-intensity technical repetition	30-40 min	2 times/week
	Video analysis	Review of in-game technical actions	1-2 h	Individual + team review

3.5 Three-Block Specialised Exercise Complex for Goalkeepers

A three-block specialised exercise complex was developed and applied exclusively with the experimental group. Each block targets a distinct technical competency cluster:

Block I — Goalkeeper mutual interaction drills (6–8 m distance): Two goalkeepers face each other and perform ball-transfer exercises at chest, shoulder, and ground-rebound heights. Distances progressively increase to 30–35 m. Variations include execution within triangular, square, and circular formation patterns. Advanced exercises include one goalkeeper performing a forward roll (ukol) while the other catches the returning ball. This block targets positional movement efficiency, upper-body reaction time, and ball-handling automaticity.

Block II Dual goalkeeper cross-shooting simulation (2 goalkeepers between 2 shooters): Both shooters hold balls and simultaneously deliver deceptive passes to the opposing goalkeeper. Ball count, flight speed, and shooting direction are progressively varied. One variation has both goalkeepers simultaneously releasing their balls to each other while the shooters alter directions unpredictably. This block develops split-attention management and bilateral (right/left-side) shot-stopping preparedness.

Block III — Ball-repulsion technique refinement (hand and foot): Goalkeepers work with wall-rebound drills to develop precise control of deflected balls using single-arm, double-arm, leg vipad (lunge), half-splits (polu-shpagat) and full-splits (shpagat) techniques. Drill intensity begins slowly and increases progressively; wall distance decreases from 4–5 m to 2 m as proficiency develops. This block replicates the most technically demanding repulsion scenarios encountered in competitive play.

Each exercise within the complex specifies repetition counts, rest periods, and target heart-rate zones (ranging from 100–110 bpm for technical refinement exercises up to 130–140 bpm for maximum-intensity block training). This ensures that physical conditioning and technical training objectives are simultaneously addressed within each session.

3.6 Situational Technical Training Algorithm

In parallel with the goalkeeper-specific work, a situational technical training algorithm was developed for field players. The algorithm structures the teaching of throwing technique within typical game situations (TGS) into the following sequential stages: (1) observation and analysis of the game situation; (2) identification of the most advantageous throwing option and target zone; (3) selection of appropriate body positioning for optimal release; (4) timing of the defender's movement and calculation of the throw trajectory; (5) execution of the selected throwing technique; and (6) error correction and return to optimal starting position.

The algorithm operationalises the principle that a handball player's decision-making capacity is inseparable from their technical execution capability. Pre-task conditions include the player's field position (centre, half-back, wing), the defensive configuration (e.g., 6:0, 5:1), the goalkeeper's position relative to the goal posts, and the availability of passing options. This algorithmic approach reflects recent advances in ecological dynamics and constraint-led coaching, wherein technique is always taught within, rather than isolated from, the game context [8].

Systematic application of this algorithm over the experimental period resulted in measurable improvements in the consistency of technical execution under defensive pressure. Specifically, improvements in the accuracy of both dominant-hand and non-dominant-hand throwing, and in the accuracy of targeted goal zone selection, were observed from the third measurement point onward, with statistically significant between-group differences ($p<0.05$) emerging from the fourth checkpoint.

3.7 Discussion

The present findings are consistent with a growing body of research demonstrating that structured, periodised technical training produces superior outcomes in youth sport development compared to unsystematised practice [9]. The confirmation that both groups were statistically equivalent at baseline on all six physical fitness tests and all four anthropometric measures is a methodological strength that substantially enhances the internal validity of the experiment.

The functional monitoring data highlight an underappreciated dimension of youth handball training: the substantial individual variation in physiological responses to nominally identical training stimuli. The six athletes monitored via First Beat exhibited TRIMP values ranging across a nearly twofold range (29–58), despite training in the same session. This finding supports calls in the sports science literature for routine individualised load monitoring even in group-based youth training contexts [10].

The three-block exercise complex for goalkeepers represents a synthesis of biomechanical, psychological, and tactical training principles. The progressive overload structure — from slow, controlled technical execution to maximum-intensity scenario replication — aligns with well-established principles of motor learning, specifically the concepts of blocked-to-random practice scheduling and the guidance hypothesis [11]. The incorporation of stress-condition exercises (time-limited shot-stopping with unpredictable ball trajectories) specifically targets the psychological preparedness dimension, which is frequently neglected in technical training programmes for young athletes.

The situational technical training algorithm operationalises the perceptual-action coupling that characterises expert handball performance. By ensuring that technical elements are always learned and refined within ecologically valid game contexts, the methodology promotes transferable skill acquisition rather than the technically correct but contextually disconnected execution that can result from drill-only approaches [12]. This theoretical position is consistent with constraints-led and game-based learning frameworks that have gained increasing empirical support in the team sports coaching literature [13].

Conclusion. This study developed, implemented, and evaluated a comprehensive methodology for improving the technical preparedness of 15–17-year-old handball players over an annual training cycle. The main conclusions are as follows:

1. The control and experimental groups were statistically homogeneous at baseline on all anthropometric (height, weight, leg length, arm length) and physical fitness (six standardised tests) indicators ($p>0.05$ for all), confirming the methodological validity of the experimental design.

2. Functional state monitoring using First Beat technology revealed wide individual variation in training load uptake within a single training session (TRIMP range 29–58; HR_{max} range 175–201 bpm), underscoring the necessity of individualised monitoring in youth handball training programmes.

3. A three-block specialised exercise complex was developed for goalkeepers, encompassing goalkeeper mutual interaction drills, dual-goalkeeper cross-shooting simulation, and progressive ball-repulsion technique refinement. This complex addresses the technical,

physical, psychological, and tactical dimensions of goalkeeper preparation within a single integrated framework.

4. A situational technical training algorithm was developed for field players, structuring throwing technique instruction within authentic game situational contexts. Significant improvements in throwing accuracy and decision-making under defensive pressure ($p<0.05$) were observed in the experimental group from the fourth measurement checkpoint onward.

5. The annual periodisation plan encompassing preparatory, competitive, and transition periods with specifically defined training content, volume, intensity, and recovery protocols for each period provided the structural framework within which the technical training methodology was delivered.

6. The experimental group demonstrated statistically significant improvements across technical preparedness indicators relative to the control group by the end of the academic year ($p<0.05$), confirming the effectiveness of the developed methodology.

The methodology developed in this study provides practitioners with a scientifically grounded, implementable framework for youth handball technical development. Future research should examine the long-term effects of this methodology over multiple training years, as well as its applicability across different age groups and competitive levels. The integration of video-based biomechanical feedback and expanded functional monitoring protocols represents a promising direction for further methodological refinement.

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