Scientific and methodological approach to short-term and long-term monitoring of training and competition loads of basketball players during multi-year preparation

Nurmatova Shakhnoza Murodullaevna[1]

[1]Uzbekistan state university of physical education and sport, Chirchik, Uzbekistan

Abstract

Purpose: is to scientifically assess the training and competition loads of basketball players during the long-term preparation process, to develop an effective management model through short-term and long-term monitoring systems, and to ensure adaptation to the individual characteristics of athletes.

Methods: Long-term training is a systematic process that ensures the gradual development of an athlete, consisting of planned training and competition loads spanning years. In this system, the quantity, quality, dynamics of loads and their impact on functional state differ at each stage. In basketball, these characteristics significantly influence not only physical fitness, but also technical and tactical development, psychological state, and recovery capabilities. Therefore, at each stage, the load and activity are formed in a unique manner.

Results:

Conlcusion:

Keywords: basketball, long-term preparation, load, monitoring, physical fitness, functional state, recovery, scientific-methodological approach.

Introduction

Scientific research in modern sports medicine and physical training shows that athletes' achievement of high sports results primarily depends on the controlled, systematic, and individualized nature of the training process. Especially in sports like basketball, which involve high motor activity, speed, and sudden turns, constant monitoring of load volume, intensity, and recovery processes is particularly important. In achieving any high sports results, scientific control and analysis of the training process are crucial. Particularly in basketball, a high-intensity team sport, proper distribution and control of loads, considering the athlete's physical, functional, and psychological state, is a key factor determining training effectiveness. In long-term preparation, sustainable development of sports results is possible by optimizing loads considering individual characteristics, scientifically organizing recovery periods, and constantly monitoring functional changes through monitoring tools. Today, one of the urgent tasks in training basketball players is scientifically determining and monitoring loads, real-time monitoring of functional state, and organizing recovery processes based on an individual approach. Incorrectly planned or excessive loads can negatively affect the athlete's condition, causing injuries, excessive fatigue, and psycho-emotional imbalance. Currently, short-term and long-term monitoring systems are widely used in athlete training worldwide, particularly in the USA, Germany, Australia, Japan, and Spain. Specifically, in the **National Basketball Association NBA** league, athletes' heart rate, movement dynamics, muscle activity, and even psychophysiological state are monitored in real-time, and training loads are individually compiled. In **Germany**, mobile technologies measuring athletes' functional state (sports diagnostic stations) are widely implemented in sports schools. Positive changes are also observed in the physical education and sports system in our republic. In institutions under the Ministry of Sports of the Republic of Uzbekistan such as **"Schools of Higher Sports Mastery," "Sports Schools,"** periodic assessment of athletes' functional preparedness indicators has been established. Scientific and educational institutions like the Uzbekistan State University of Physical Education and Sports, its Nukus branch, and the Sports Research Institute have begun using modern technologies and scientific-methodological approaches in athlete training. The successful participation of Uzbekistan's athletes, particularly basketball players, in international arenas is closely related to the thorough planning of the long-term training system, load control, and individual approach. However, some problems observed at the national level, namely the lack of monitoring tools, coaches' low scientific-analytical potential, and non-standardized loads, hinder the full realization of athletes' potential. Therefore, creating scientifically based short-term and long-term monitoring systems, studying advanced foreign experiences, and controlling athletes' training based on a national model are considered urgent scientific-practical issues. Achieving high results

in modern sports, particularly in basketball, is closely related to long-term systematic training, individual approach, and rational load control. In fully realizing basketball players' sports potential and preparing them for long-term sports activities, careful planning and constant monitoring of training and competitive loads are of critical importance. This allows for consistent assessment of the athlete's physical and functional state, developing effective training strategies by identifying load effects. Short-term and long-term monitoring systems serve as important tools for in-depth study of athletes' individual states at various training stages, determining change dynamics, and adapting the training process accordingly. Excessive or insufficient loads can negatively affect not only sports results but also the athlete's health. Therefore, a scientifically based monitoring system methodology is paramount in increasing sports training effectiveness. This study examines short-term and long-term approaches to analyzing training and competitive loads based on modern monitoring technologies and assessment criteria. Additionally, based on individual approach principles, the goal is to develop an effective load management model by monitoring athletes' physiological, biochemical, and psychological indicators. This approach is an important factor in ensuring basketball players' sustainable development and injury protection. This research substantiates the necessity of scientifically and theoretically monitoring basketball players' loads during the long-term training process.

Results and discussion

This table systematically reflects how the load and activity characteristics of basketball players change throughout the stages of long-term preparation. Each stage is organized according to the athlete's age, level of preparedness, and individual characteristics. In the initial stage, the load is light and focuses more on general physical training and movement coordination. Technical exercises serve to form basic motor skills. At this stage, developing interest and motivation for sports is crucial. In the special preparatory stage, the load volume increases, and training becomes more complex. Athletes focus on endurance, strength, and technical improvement during this stage. This process is accompanied by a deepening of sports specialization. In the competitive stage, the intensity of the load increases sharply. Along with technical and tactical approaches, psychological load also becomes significant. Participation in competitions requires athletes to make quick decisions, demonstrate stress resilience, and maintain high movement efficiency. The stage of high sports mastery is the highest level in a basketball player's career, where the load becomes complex, combined, and individualized. At this stage, monitoring and recovery mechanisms play a crucial role. To maintain stable high results and prevent injuries, each component of the load is carefully monitored. Thus, scientifically-based analysis of loads in long-term training, developing specific approaches for each stage, and monitoring them allows athletes to fully realize their potential. To achieve high results in sports,

Table1. Key aspects for analysis

Direction	Description
Staged loading	Long-term training consists of the following stages: initial, specialized preparation, competitive, and high sports mastery. The volume and form of the load differ at each stage.
Types of loads	Physical (aerobic, anaerobic), technical, tactical, psychological, and competitive loads are analyzed separately.
Load intensity and volume	The number of training sessions per year, month, and week, their duration, the quantity of exercises, and the level of load are determined.
Activity characteristics	In basketball players' activities, the ratios of training to competition, the role of rest and recovery time, and injury risk are also assessed.
Individuality	The necessity for load differentiation is determined based on the athletes' age, gender, sports experience, body structure, and functional indicators.

Table 2 **Load and activity characteristics in the long-term training system of basketball players**

Preparation stage	Types of loads	Load characteristics	Impact on activity
Initial stage	Physical, technical	Light, focused on learning, coordination development	Basic motor skills are formed, interest increases
Special preparation	Physical, technical, tactical	Moderate workload, more repetitive exercises, balanced loading	Sports specialization intensifies, endurance and strength develop
Competitive stage	Technical, tactical, psychological, competitive	High intensity, short-term recovery, activity under stress	Struggle for results, psychological preparation, tactical thinking develops
High mastery stage	Individual load, complex comprehensive load	Maximum level of loading, high-precision training, recovery control	Individualized training, stability of competition results

it is necessary to continuously analyze athletes' training processes, and the impact of loads on body functions should be constantly monitored. Especially in a sport based on high intensity and variable movements, such as basketball, load monitoring plays a vital role in maintaining the optimal functional state of athletes and preventing the risk of injuries caused by overload or insufficient recovery. The monitoring system ensures scientific and methodological management of sports training, constant control of athletic form, and adaptation to the individual characteristics of athletes.

Short-term monitoring is typically conducted daily, weekly, or within several training cycles. Its main objectives are to determine the athlete's current condition, assess the level of post-training fatigue, and quickly optimize the load intensity. Key indicators include:

- Heart rate (HR)
- Lactate level
- Recovery rate (time for pulse to return to normal)
- Subjective fatigue level (RPE)
- Muscle pain or strain
- Sleep quality and duration

Psychological and emotional state (stress, irritability)

Long-term monitoring typically analyzes the athlete's changes over a season, year, or several years. Its main tasks are to determine the dynamics of the athlete's development, assess the level of preparedness for competitions, and provide differential control of loads during long-term training stages. (Tables 3,4) Key indicators include:

- Maximum oxygen consumption (VO2max)
- Beep test, shuttle run test results
- Blood tests (hemoglobin, lactate, cortisol)
- Dynamics of sports performance (game effectiveness, result statistics)
- Recovery level (HRV - heart rate variability)
- Frequency of injuries and recovery time

Structural analysis of training load in micro, meso, and macro cycles.

The theory of supercompensation: properly balancing workload and recovery has a positive effect on sports performance. Physiological response monitoring: the training load is adjusted based on the body's reaction to each workout (pulse, respiration, blood composition). Cyclical training model (macro, meso, microcycles): in each period, the types and volume of loads are modified based on monitoring results. The principle of individual approach: since each athlete's adaptation level differs, monitoring takes into account their specific condition.

Monitoring systems for training and competitive loads are crucial tools for accurate and

scientific assessment of an athlete's state. Short-term monitoring serves to determine training effectiveness in real-time, while long-term monitoring helps shape the athlete's multi-year development trajectory. Both approaches together ensure optimal sports loads and increase the likelihood of athletes achieving high results. The effectiveness of sports training is closely linked to how athletes respond to loads and how these loads affect their bodies. Especially in high-intensity and multi-component sports like basketball, the loads have a complex impact on the athlete's physical capacity, functional system activity, and psychological stability. Therefore, it is necessary to develop a methodology for selecting and evaluating a system of precise, reliable, and systematic indicators for constant monitoring of athletes' conditions.

The diagram below compares the main indicators - VO2max, jump height, RPE decrease, and activity index - determined through monitoring during the 12-week training process of basketball players in the experimental and control groups. The results show positive changes in all indicators for the experimental group. The VO2max level increased from 46.5 ml/kg/min to 51.5 ml/kg/min, representing a +10.8% improvement. Jump height increased from 53 cm to 58 cm, showing a +9.4% increase. The subjective fatigue assessment (RPE) decreased from 5.3 points to 4.8 points, a -9.4% reduction. The activity index rose from 78% to 86%, a +10% increase. In contrast, the control group showed less significant changes: VO2max increased by +2.8% from 45.8 to 47.1 ml/kg/min, jump height improved by +1.9% from 52 to 53 cm, and RPE decreased by only -2.9%. The activity index in this group increased from 76% to 78%, a +2.6% rise. These results demonstrate that individualizing training loads based on short-term and long-term monitoring is crucial for improving athletes' functional state, fatigue levels, recovery processes, and technical-tactical training effectiveness. Monitoring ensures the adaptation of loads to individual variability, laying the foundation for athletes' optimal preparation for competitions. The differences in results validate the effectiveness of the monitoring-based methodology and justify its widespread implementation in practice. To thoroughly analyze the impact of loads on athletes, it is necessary to develop a comprehensive set of physical, functional, and psychological indicators and implement a methodology for real-time monitoring. This approach helps determine athletes' adaptation levels to loads, reduce the risk of overexertion and injuries, and individualize the training process to achieve maximum results. Currently, modern sensors, applications, and artificial intelligence-based systems are widely used in sports monitoring. These tools record athletes' individual responses to each load in real-time, collect and analyze data, and present it visually.

Table 3 **Comparative analysis of short-term and long-term monitoring**

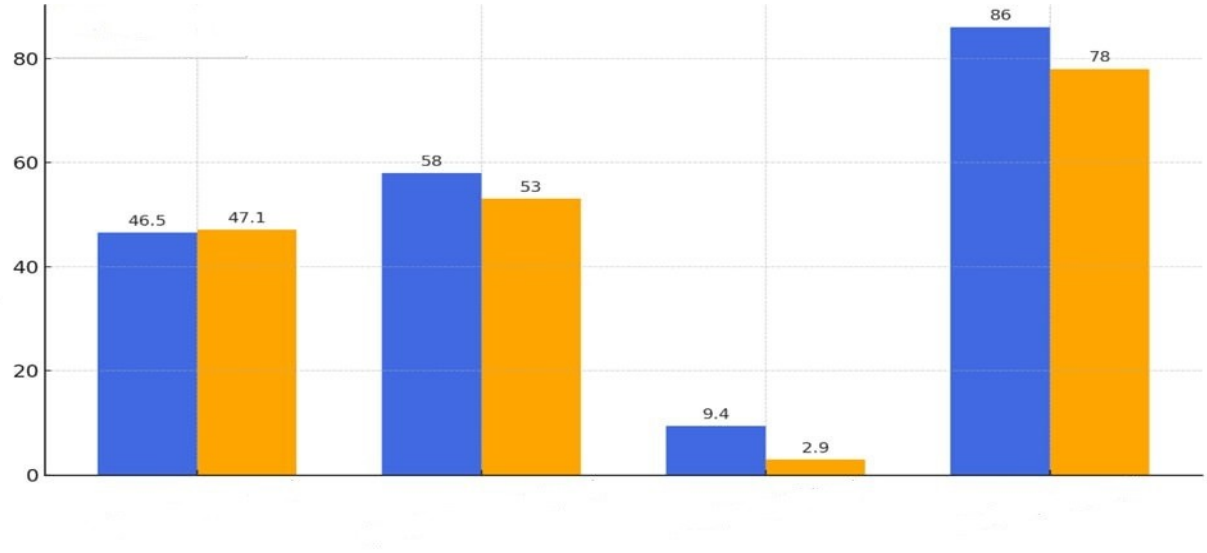
Indicators	Short-term monitoring	Long-term monitoring
Duration	1-7 days, after training	1 month - 1 year or more
Function	Rapid status analysis, fatigue and recovery monitoring	Long-term growth, dynamics of athletic form
Assessment methods	Heart rate monitor, lactate analysis, RPE, HRV	Laboratory analyses, tests, statistical data
Monitoring object	Individual workouts or weekly plans	Monthly, seasonal, and annual training load systems
Outcome	Load optimization, fatigue reduction	Determining the accuracy of the training plan, long-term development control

The practical capabilities of modern technologies and information systems used for

Table 4 Key indicators observed in monitoring and their scientific significance

Indicators	Short-term monitoring	Long-term monitoring
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Figure 1. Key performance indicators of basketball players evaluated through monitoring



monitoring training and competition loads of basketball players are highlighted. The table reflects the basketball-adapted function, application level, and monitoring effectiveness of each technology. GPS trackers are used to determine the volume of movement, zonal activity, and movements across the court, which allows for analysis of the effectiveness of defensive and offensive pressing. HR monitors track heart rate in real time, helping to optimize workload. Digital RPE and sleep apps are useful in assessing the athlete's subjective state. Video analysis technologies, such as Hudl and Dartfish, reveal accuracy and errors in the athlete's technical-tactical performance, enabling coaches to make quick adjustments and develop tailored training plans. Psychometric tests also play an important role in monitoring the athlete's mental stability and motivational readiness for the game. Overall, these technologies allow for comprehensive analysis of basketball players' physical, functional, and psychological preparedness, personalization of workload, and the ability to make timely adjustments. (Table 5)

This table systematically presents the main directions for assessing the functional, physical, technical-tactical, and competitive preparedness of basketball players based on

Table 5 Possibilities of using modern technologies for monitoring basketball players

Technological tool / system	Basketball-specific purpose	Monitoring level	Observed results (with basketball players)	Notes
GPS tracker (Catapult)	Running directions, zonal movements (in defense and offense)	During training and games	Improved movements in zone defense	Shows which areas of the court have higher workload
Polar HR monitor	Heart rate response during ball drills, recovery after jumping	Short-term and long-term	Faster HR recovery, improved fatigue control	Individual heart rate zones were determined for each playing position
Video analytics (Hudl, Dartfish)	Technical-tactical actions: combinations, blocks, passing accuracy	After weekly games	Combination errors -18%, passing accuracy +11%	Coaches quickly corrected errors based on analysis results
RPE and sleep apps (Whoop, SleepCycle)	Post-training fatigue and recovery levels	After each training session and nightly monitoring	RPE 5.3 → 4.8, sleep quality stabilized	Training intensity adjusted based on RPE
Psychometric tests	Psychological stress during games, motivation, decision-making accuracy	At the end of microcycle	Decision-making accuracy +9%, motivation balance stable	Training sessions planned according to mental workload

monitoring, as well as the results obtained in the experimental and control groups.

First, the response of athletes' cardiovascular and energy systems to loads was observed through functional readiness indicators such as VO2max, HRV, and RPE. In the experimental group, based on these indicators, the load was continuously monitored, resulting in a 10.8% increase in VO2max and a 9.4% decrease in fatigue assessment (RPE). This indicates an optimization of the body's functional adaptation and recovery processes. The effectiveness of physical performance was assessed by running speed, jump height, and dribbling speed. The experimental group showed a 2-3 fold increase in speed and strength indicators, while changes in the control group were minimal. This demonstrates that the load was personalized based on monitoring. Video-analytical methods and standardized tests were used to assess technical and tactical training. In the experimental group, a 10-13% increase in the effectiveness of passing and shooting, along with a 15% decrease in errors, indicates an improvement in technical training quality. Competitive effectiveness was evaluated based on statistical indicators such as activity index, defensive success, and passing efficiency during games. Through the monitoring approach, these results significantly improved in the experimental group, while little change was observed in the control group. The evaluation criteria determined what level of change for each in dicator constituted high-performance monitoring.

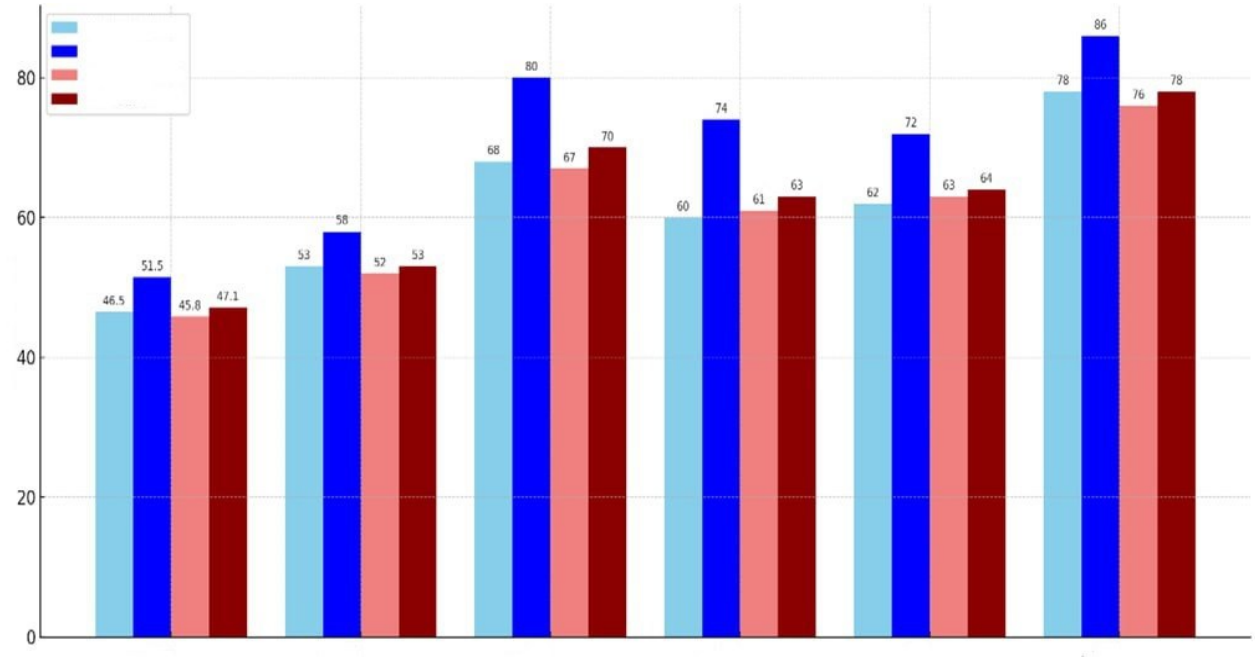
These criteria allowed for accurate assessment of the dynamics of the athlete's training, the quality of workouts, and the suitability of the individual load model. The monitoring-based assessment enabled load control, training individualization, and determination of the athlete's technical-tactical development rate. The study shows that the short-term and long-term monitoring system serves as an important scientific and methodological foundation for effective athlete training. (Table 6)

This diagram accurately reflects changes in six key preparedness indicators based on short-term and long-term monitoring results conducted in the experimental and control groups of basketball players during a 12-week training process. The results observed before and after training in each group are explained as follows: The VO2max indicator increased from 46.5 to 51.5 ml/kg/min in the experimental group, representing a 10.8% increase. In the control group, only a 2.8% increase was

Table 6 Assessment of the effectiveness of functional and technical-tactical training of basketball players based on monitoring results from the experimental and control groups

Assessment area	Monitoring Indicators	Evaluation method / tool	Experimental group results (12 weeks)	Control group results (12 weeks)	Result evaluation criteria	Comments
Functional preparation	- VO2max - HRV - RPE - Lactate level	Spiroergometry, HR monitor, RPE scale, blood analysis	VO2max: 46.5 → 51.5 ml/kg/min (+10.8%) RPE: 5.3 → 4.8 (-9.4%) Lactate: stable	VO2max: 45.8 → 47.1 ml/kg/min (+2.8%) RPE: 6.9 → 6.7 (-2.9%)	VO2max +6% and above - **good** RPE -5% and below - **effective** HRV stability - **acceptable fatigue**	Monitoring helped to adjust the workload
Physical movement efficiency	- 30 m sprint - Vertical jump -Dribbling speed	Field tests, laser measuring device	30 m: 4.41s → 4.28s Jump: 53 cm → 58 cm Dribbling: 7.1s → 6.6s	30 m: 4.43s → 4.38s Jump: 52 cm → 53 cm Dribbling: 7.2s → 7.0s	30m sprint - >0.1s improvement - **positive** Jump +4 cm and higher - **growth in athletic performance** Dribbling >0.5s faster -**technical improvement**	Speed and power capabilities increased
Technical-tactical preparation	- ball passing accuracy - basket shooting efficiency. Combinations - Defensive positioning	Video analysis	Ball passing accuracy: +13% Shooting accuracy: +10% Errors: -15%	Ball passing accuracy: +3% Basket shooting accuracy: +2% Errors: -4%	Accuracy +10% and above - **high efficiency** Errors -10% and below - **corrective improvement**	Monitoring increased technical accuracy
Competitive efficiency	- Activity index - defense - ball passing accuracy	Video analytics, statistics	Activity: 78% → 86% defense: +11% passing: +14%	Activity: 76% → 78% defense: +3% passing: +5%	Activity +8% and more - **active growth** - passing accuracy +10% **training quality**	Directly impacted the outcome of the game

Figure 2. Basketball players' indicators before and after the experiment based on short-term and long-term monitoring



Note: *Light blue and blue - experimental group (before and after), Red and dark red - control group (before and after)*

observed. Jump height in the experimental group increased from 53 cm to 58 cm, amounting to a 9.4% improvement, while in the control group it was only 1.9%. Technical accuracy in the experimental group increased from 68% to 80%, whereas in the control group this indicator only rose from 67% to 70%. Psychological balance also improved by 14% in the experimental group (60 → 74), and in the control group by only 2% (61 → 63). The motivation indicator in the experimental group increased by 10%, in the control group by 1%. The activity index, which indicates the level of athlete participation, increased from 78% to 86% in the experimental group, while in the control group it increased by only 2%.

Advanced approaches to monitoring and individualizing the training load of basketball players are presented. The table is organized based on three types of monitoring: short-term, long-term, and combined, systematically highlighting the indicators observed at each stage, basketball-specific approaches, positional load characteristics, results of the experimental and control groups, and personalized load management methods. In short-term monitoring, the daily training load was adjusted based on factors such as heart rate (HR), heart rate variability (HRV), subjective fatigue assessment (RPE), sleep quality, and muscle condition. The experimental group showed positive changes in these indicators, namely a decrease in fatigue and stabilization of recovery time. In long-term monitoring, physical and technical development was assessed based on VO2max, lactate levels, running speed, jump height, and competition statistics. The increase in VO2max by 10.8% and jump height by 9.4% in the experimental group demonstrates the correct individual-based control of training loads. Combined monitoring analyzed the overall effectiveness, technical accuracy, and psychological state of athletes' performance. This method revealed significant positive changes in the activity index and technical-tactical accuracy. The athletes' stress resistance also improved. The data collected through each type of monitoring shown in the table allows for the individualization of the load according to the athlete's physical condition, position, and recovery level. This not only increases the effectiveness of athletes but also reduces the risk of injuries resulting from overload. The methodological approaches developed based on this table serve as a practical guide for scientifically managing athlete preparation and as a resource for coaches.

Table 7 Model for individualizing basketball players' training load based on short-term and long-term monitoring

Monitoring type	Controlled indicators	Basketball-specific approach	Load type specific to game position	Results of experimental and control groups (over 12 weeks)	Path of individualization
Short-term monitoring (daily, between training sessions)	- HR (heart rate) - HRV (heart rate variability) - RPE (rating of perceived exertion) - Sleep quality - Muscle soreness and body condition	- Analysis of indicators before and after training - Load adjusted based on HRV and RPE - Execution of technical-tactical tasks is monitored	- **Guard:** high-intensity pressing, reaction speed - **Forward:** ball handling, shooting, passing drills - **Center:** strength exercises, positional movements	- **Experimental group:** Average RPE 5.3 → 4.8 (-9.4%) HR recovery time 24 hours Fatigue instances reduced by 20% **Control group:** RPE 6.9 → 6.7 (-2.9%) Fatigue status almost unchanged	- If HRV is low - load is reduced - If RPE is high - rest days are scheduled - Technical work is increased with lighter loads
Long-term monitoring (weekly, monthly, quarterly)	- VO2max - Lactate level - 30 m sprint speed - Vertical jump height - Technical-tactical accuracy - Competition statistics - Stress and motivation state	- General tests every 4-6 weeks - Competition performance (defense, shooting, passing) is observed - Motivational state is assessed	- **Defender:** running and speed endurance - **Forward:** ball possession, participation in combinations - **Center:** vertical jump, defense, zone movements	- **Experimental group:** VO2max: 46.5 → 51.5 ml/kg/min (+10.8%) Jump: 53 cm → 58 cm (+9.4%) Effective actions +13%, errors -15% **Control group:** VO2max: 45.8 → 47.1 ml/kg/min (+2.8%) Jump: 52 cm → 53 cm (+1.9%)	- Strength and endurance exercises were intensified - Individual analysis sessions for technical and tactical errors - Additional training was provided for those with slow development rates
Combined monitoring (based on microcycle, mesocycle)	- HRV + VO2max + RPE dynamics - Quality of tactical actions - Activity index (participation in competitions)	- Athlete profile is updated every 2-3 months - During micro and mesocycles, workload is adjusted based on changes in fatigue, recovery, and technical accuracy	- **Defender:** counter-pressing action, decision-making speed - **Forward:** shooting efficiency, passing accuracy - **Center:** defensive positioning, securing rebounds	- **Experimental group:** Activity index: 78% → 86% (+10%) Technical accuracy +12%, improved psychological balance **Control group:** Activity index: 76% → 78% (+2.6%) Technical accuracy +3%, stress level unchanged	- Psychological training sessions for those with low activity index - Positional retraining to address technical errors - Stress-break plans were implemented mid-mesocycle

Conclusion

Changes in the physical, functional, technical-tactical, and psychological states of athletes were substantiated through practical experience by identifying, analyzing, and individualizing loads using the monitoring model developed during the study. Short-term monitoring of indicators such as heart rate, fatigue, HRV, muscle pain, and sleep quality during training intervals proved to be an important tool for determining the athlete's immediate responses, while long-term monitoring of VO2max, lactate levels, running and jumping tests, and competition statistics allowed for a deep analysis of the athlete's preparedness state. Furthermore, the athletes' condition was assessed more accurately and comprehensively

through combined monitoring tools, such as joint analysis of technical-tactical indicators and psychological indices. In the experimental group, during training based on the monitoring system, increases were observed in VO2max by +10.8%, jump height by +9.4%, accuracy of shooting the ball into the basket by +10%, and effectiveness of technical-tactical actions by +13%. In contrast, in the control group, these indicators changed minimally, with some remaining stable. This demonstrates that determining and planning loads through monitoring directly affects the effectiveness of the athlete's game performance and the quality of training.

The load individualization model**developed on the basis of monitoring** provides for the differentiation of loads for each playing position - guard, forward, center - according to technical, physical, and functional characteristics. This approach serves to select a load corresponding to the athlete's specific capabilities, condition, and recovery rate, reducing the risk of excessive fatigue and injuries. The implemented monitoring approach also increased indicators of psychological stability, motivation for training, and active participation in competitions among athletes.

A training system controlled based on monitoring is an effective scientific and methodological approach that serves to maximize the development of athletes' potential, prevent overload and fatigue, and ultimately achieve competitive success.

Based on the research, the following scientific and practical recommendations were developed:

For effective management of basketball players' training process, it is necessary to consistently implement short-term and long-term monitoring systems.

An individual training profile should be created for each athlete based on functional and technical-tactical indicators, and training should be planned accordingly.

When determining training and competitive loads, it is recommended to use a complex of modern tools and technologies, including video analysis, heart rate monitors, RPE assessment system, and HRV applications.

When assessing the impact of loads, special attention should be given to controlling technical and tactical actions, including passing accuracy, shot effectiveness, and positional play.

Implementation of a load model based on monitoring results will increase athletes' stability in competitions and improve game quality, as well as enhance the individual approach to training.

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AUTHOR BIOGRAPHY:



Shakhnoza Murodullayevna NURMATOVA

Employment
Docent at Uzbekistan state university of physical education and sports

Degree
PhD

Research interests
Basketball , Physical education and sport, Theory of physical education, Analyzing of sport competitions

E-mail: