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Dynamics of functional state recovery indicators in athletes during training camps

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Abstract

Background and Study Aim Training camps are a stage in the annual training cycle of wrestlers. They are characterized by a high concentration of training loads and increased functional stress on the organism. Under such conditions, the effectiveness of recovery processes becomes a factor determining athletes' adaptive capacity, functional readiness, and training performance. The purpose of this study was to examine the dynamics of physiological, functional, and subjective recovery indicators in wrestlers during different stages of a training camp within the framework of medical and pedagogical monitoring.

Material and Methods The study involved 24 male wrestlers of competitive level who participated in a centralized training camp. This was a single-group repeated-measures study with four measurement time points: baseline (3 days before the camp), initial (days 1–3), main (days 10–12), and final (days 19–21). The evaluated indicators included resting heart rate, heart rate variability parameters [root mean square of successive differences (RMSSD), primary outcome], the Ruffier index, and subjective indicators of functional state (well-being, activity, and mood). Heart rate variability was recorded under standardized resting conditions. Statistical analysis included descriptive statistics and repeated-measures ANOVA with effect sizes (partial η^2) and 95% confidence intervals for within-subject changes.

Results The results showed a trend toward improvement in recovery-related indicators during the training camp. RMSSD increased from 50.8 ± 6.1 ms at baseline to 55.3 ± 6.9 ms at the final stage (mean change 4.5 ms; 95% CI [2.1, 6.9]; $p = 0.01$; Cohen's dz = 0.7). A gradual decrease in resting heart rate (from 64.1 ± 2.9 to 61.8 ± 2.6 bpm; mean change −2.3 bpm; 95% CI [−3.5, −1.1]; $p < 0.01$) and Ruffier index values was observed. These changes indicate improved cardiovascular efficiency and functional readiness. Subjective indicators of functional state also showed positive dynamics. Their progression was not strictly parallel, which indicates individual differences in the perception of training load and recovery. Despite overall favorable trends, individual analysis revealed that a subset of athletes (29.2%) exhibited less pronounced or unstable recovery dynamics.

Conclusions The findings indicate that recovery processes during training camps are characterized by stage-dependent dynamics and inter-individual variability. The observed changes suggest improved parasympathetic modulation and cardiovascular efficiency. However, due to the single-group design, causal inferences are limited. The combined use of objective physiological indicators and subjective assessment tools provides a basis for evaluating recovery in the context of medical and pedagogical monitoring.

Keywords: functional state, recovery dynamics, training camps, heart rate variability, wrestlers; medical and pedagogical control

Glossary

Training camp — a centralized and time-limited stage of sports preparation. It is characterized by a high concentration of training loads and regulated recovery processes.

Functional state — an integrative characteristic that reflects the level of physiological readiness and adaptive capacity of an athlete.

Heart rate variability (HRV) — a non-invasive indicator of autonomic nervous system regulation. It is based on variations in time intervals between heartbeats.

Root mean square of successive differences (RMSSD) — a time-domain HRV parameter that reflects parasympathetic activity and recovery status.

Pedagogical control — a system for monitoring and managing the training process based on objective and subjective indicators of athletes' condition.

Introduction

The organization of training loads and recovery processes is a component of the preparation

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system in modern sport. Training camps are used as a concentrated stage of preparation during which athletes are exposed to increased training volume and intensity within a limited period. Such conditions create physiological and functional demands on the organism and require regulation of recovery processes. Monitoring the functional state of athletes during these periods allows tracking adaptation to training loads and changes in functional readiness.

The contemporary system of athletic training in combat sports is characterized by high training intensity, a substantial volume of specialized and competitive activities, and pronounced stress-related effects on the functional systems of athletes. In this context, the restoration of functional state is associated with performance capacity, adaptive potential, and competitive outcomes in wrestlers [1, 2]. Training camps represent a concentrated stage of the annual training cycle aimed at developing athletes' specific work capacity. The high density of training stimuli during these periods is accompanied by functional strain and may increase the risk of chronic fatigue, overtraining, and functional disturbances, particularly in highly qualified athletes [2, 3].

Wrestling involves combined manifestations of fatigue associated with high-intensity anaerobic work, strength efforts, emotional stress, and the need for rapid recovery between bouts. During training camps these factors intensify, which leads to changes in cardiovascular parameters, autonomic balance, and metabolic and neuromuscular functions [4, 5]. Such conditions require medical and pedagogical monitoring based on dynamic evaluation of athletes' functional state.

Heart rate and heart rate variability indicators are widely used for assessing functional state and recovery processes in athletes. These indicators reflect autonomic regulation and allow identification of adaptive shifts associated with training loads [6, 7, 8]. Their interpretation requires a dynamic approach and consideration of individual responses during the training camp period [9, 10]. Studies in Kazakhstani scientific literature consider restoration of functional state within the framework of medical and pedagogical monitoring systems. Static assessment of individual physiological indicators does not allow adequate evaluation of athletes' functional state without analyzing their dynamics at different stages of sports preparation under intensified training conditions [11, 12, 13].

In contemporary sports theory and practice, restoration of athletes' functional state is considered a component of training process management and medical–pedagogical monitoring. Recovery processes are viewed as a continuous part of adaptation that supports the stability of functional systems under training loads; insufficient or delayed recovery may disrupt adaptive mechanisms and reduce training effectiveness [1]. International studies indicate that monitoring recovery helps prevent overtraining syndrome and chronic fatigue. Early signs of functional overstrain may remain undetected when isolated assessments are used, which supports the need for systematic monitoring of athletes' functional state [9].

Training camps represent a form of training organization characterized by a high concentration of training stimuli and limited opportunities for spontaneous recovery. During these periods, a mismatch between training loads and recovery capacities may occur, particularly in highly qualified athletes [2]. Inadequate recovery under such conditions may reduce work capacity and lead to unfavorable adaptive responses [3, 14, 15].

Heart rate and heart rate variability (HRV) indicators are widely used for assessing functional state and recovery processes. HRV reflects autonomic regulation and allows identification of adaptive shifts associated with training stimuli [6]. The RMSSD index reflects parasympathetic activity and is used for monitoring recovery under training camp conditions; its decrease is associated with increased training stress, whereas its increase indicates recovery processes [7, 8, 16, 17]. Ultra-short HRV recordings have also been proposed for rapid monitoring of athletes' functional state during training camps [7, 16, 17]. These approaches are also considered applicable in combat sports, where monitoring of functional state is required under conditions of high training loads and mixed physical demands [18].

Contemporary monitoring approaches emphasize comprehensive assessment of recovery that combines physiological, functional, and subjective indicators. Integrating objective data with subjective recovery and well-being scales improves interpretation of adaptive responses and detection of insufficient recovery [19]. Such monitoring supports adjustment of training content, volume, and intensity according to athletes' functional state and increases the diagnostic value of monitoring under training camp conditions [8, 15].

Wrestling is characterized by high-intensity motor activity, a substantial share of anaerobic work, and psycho-emotional stress. Wrestlers demonstrate metabolic, autonomic, and neuromuscular manifestations of fatigue [4]. Intensive training cycles are associated with changes in hormonal status, markers of muscle damage, and autonomic regulation, while adaptive responses depend on the structure of training loads and the conditions of their implementation [5, 18, 19, 20].

Analysis of research findings has shown that monitoring the restoration of athletes' functional state is considered an element of training process management and medical–pedagogical monitoring. Researchers emphasize that indicators of heart rate and heart rate variability, including RMSSD, allow the identification of adaptive responses associated with training loads and recovery processes during periods of intensified preparation. Authors also note that effective monitoring requires dynamic assessment of physiological and subjective indicators throughout the training cycle, particularly under conditions of concentrated training loads such as training camps. At the same time, interpretation of recovery indicators during different stages of training camps remains a complex task due to variability in athletes' responses and the interaction of physiological and training-related factors.

Additionally, scientific evidence indicates that restoration of functional state is associated with the effectiveness of the training process during training camps. Existing studies often focus on individual indicators or examine other sports and stages of the annual training cycle. As a result, the dynamics of recovery indicators during different stages of training camps and the variability of athletes' responses are not always considered in an integrated manner. In the context of physical culture and sport pedagogy, recovery indicators are used not only as physiological characteristics but also as elements of pedagogical diagnostics that support regulation of training loads and feedback within the training process. These circumstances indicate the relevance of further examination of the dynamics of recovery indicators during the training camp period within the framework of systematic monitoring of athletes' functional state.

To examine the dynamics of physiological, functional, and subjective recovery indicators in wrestlers during different stages of a training camp within the framework of medical and pedagogical monitoring. It was assumed that recovery indicators of functional state in wrestlers during a training camp would demonstrate stage-dependent and individual variability associated with adaptation to training loads and recovery processes. It was also assumed that dynamic monitoring of physiological, functional, and subjective indicators would allow identification of changes in athletes' functional state at different stages of the training camp.

Materials and Methods

Participants

The study involved male wrestlers (n = 24) specializing in Greco-Roman and freestyle wrestling, aged 18–24 years. The athletes' qualification levels corresponded to Candidate for Master of Sport (advanced-level athletes) and Master of Sport (highly qualified athletes) of the Republic of Kazakhstan. All participants had at least six years of systematic training experience. They had no acute or exacerbated chronic diseases and were cleared for training loads based on the results of comprehensive medical examinations. The athletes had a body mass of 70.3 ± 8.5 kg, a height of 174.2 ± 6.8 cm, and training experience of 7.8 ± 1.9 years. Participation in the study was voluntary and conducted in accordance with ethical standards for scientific research in sport.

Exclusion criteria were injury during the camp, use of medications affecting autonomic function (e.g., beta-blockers), and failure to complete all four measurements. A post hoc power analysis (G*Power 3.1) indicated that with 24 participants and a moderate effect size (f = 0.25) for the repeated-measures factor, the study had 80% power to detect a significant time effect at $\alpha = 0.05$.

Research Design

This was a prospective single-group repeated-measures study. Due to the absence of a comparator group, the analysis was limited to within-subject temporal associations and does not allow causal conclusions. The study was conducted during scheduled training camps involving athletes specializing in wrestling in the preparatory period of the annual training cycle. The duration of the training camp was 21 days, which corresponds to methodological recommendations for organizing the training process in combat sports. The study was conducted using a repeated-measures framework.

Four assessment stages were identified:

- baseline stage — 3 days prior to the start of the training camp;
- initial stage — days 1–3 of the training camp;
- main stage — days 10–12;
- final stage — days 19–21 of the training camp.

All assessments were conducted at the same time of day, in the morning hours prior to the start of training sessions and under conditions of relative rest. This approach minimized the influence of circadian variations in functional indicators.

A comprehensive assessment of wrestlers' functional state recovery was performed using physiological, functional, and subjective methods. Heart rate variability measurements were recorded in a standardized body position.

The 21-day training camp consisted of two training sessions per day (morning and afternoon), six days per week. Each session lasted 90–120 minutes. The training content included technical–tactical drills (60% of total time), strength and conditioning exercises (30%), and recovery activities (10%). Intensity was monitored using heart rate (Polar H10) and session rating of perceived exertion (sRPE, CR-10 scale). The mean weekly training volume was approximately 18 hours, with an average intensity of 75–85% of individual maximal heart rate during the main sessions.

The primary outcome was RMSSD (root mean square of successive differences), a time-domain heart rate variability index reflecting parasympathetic activity. Secondary outcomes included resting heart rate (HRrest), SDNN (standard deviation of NN intervals), the Ruffier index, and subjective ratings of well-being, activity, and mood.

Heart rate variability (HRV) recording. All measurements were performed in the morning (07:00–08:00) after an overnight fast. Athletes were in a supine position following 10 minutes of quiet rest. A 5-minute RR interval recording was obtained using a Polar H10 chest strap (Polar Electro, Finland) with a sampling rate of 1000 Hz. Data were transferred to Kubios HRV Standard software (version 3.5) for analysis. Artifact correction was performed using the automatic filter (medium level) and was manually verified. The within-subject coefficient of variation for RMSSD in our laboratory is <5% (based on test–retest reliability in 10 athletes). This value is consistent with reliability estimates for short-term HRV recordings reported in previous studies [16].

Ruffier test. Athletes performed 30 squats in 45 seconds. Heart rate was measured at rest (P0), immediately after exercise (P1), and after one minute of recovery (P2). The Ruffier index was calculated as (P0 + P1 + P2 − 200) / 10.

Subjective assessments. Athletes completed a modified version of the Well-Being, Activity, and Mood questionnaire (Russian adaptation of the SAN scale) before HRV measurements during the training camp stages (initial, main, and final). Each item was rated on a 5-point Likert scale (1 = very low, 5 = very high).

Statistical Analysis

Statistical analyses were performed using SPSS Statistics 26.0 (IBM, USA). Data are presented as mean ± standard deviation (M ± SD). Normality of distribution was tested using the Shapiro–Wilk test. All variables met the normality assumption ($p > 0.05$), except for subjective scores, which were analyzed using non-parametric tests.

A one-way repeated-measures ANOVA was conducted with Time (baseline, initial, main, final) as the within-subject factor. Mauchly's test of sphericity was applied, and if the assumption was violated, the Greenhouse–Geisser correction was used. Effect sizes are reported as partial eta-squared (η^2) with 90% confidence intervals.

For the primary outcome (RMSSD) and other continuous variables, pairwise comparisons between the baseline and final stages were performed using paired t-tests. Mean differences, 95% confidence intervals (CI), and Cohen's dz effect size were calculated. For subjective indicators (ordinal data), the Friedman test was used, followed by Wilcoxon signed-rank tests with Bonferroni correction for post hoc comparisons.

There were no missing data; all 24 participants completed all four assessments. Statistical significance was set at $\alpha = 0.05$ (two-tailed). No adjustment for multiple comparisons was applied to the primary contrast because it was prespecified a priori (baseline vs. final RMSSD). Analyses of secondary outcomes and additional pairwise comparisons were considered exploratory and interpreted accordingly.

Results

All 24 participants completed measurements at all four time points (baseline, initial, main, and final), and no data were missing. Descriptive characteristics of physiological and functional indicators across the training camp stages are presented in Table 1.

As shown in Table 1, repeated-measures ANOVA revealed significant time effects for all cardiovascular indicators. Resting heart rate increased during the initial stage compared with baseline ($p < 0.001$) and then gradually decreased during the subsequent stages, reaching values below baseline by the final stage ($p < 0.01$). Heart rate variability indicators also showed significant

Table 1. Dynamics of physiological and functional indicators during the training camp (M ± SD) with repeated-measures ANOVA and effect sizes.

Indicator	Baseline	Initial	Main	Final	Time effect (RM-ANOVA)	Baseline–Final change
Resting HR, bpm	64.1 ± 2.9	68.5 ± 3.2	66.4 ± 3.1	61.8 ± 2.6	$F(2.1,48.3)=12.4$, $p<0.001$, $\eta^2=0.35$	Δ = −2.3 bpm; 95% CI [−3.5, −1.1]; Cohen's dz = 0.8
RMSSD, ms	50.8 ± 6.1	42.1 ± 6.4	45.0 ± 7.2	55.3 ± 6.9	$F(2.3,52.9)=8.9$, $p<0.001$, $\eta^2=0.28$	Δ = +4.5 ms; 95% CI [2.1, 6.9]; Cohen's dz = 0.7
SDNN, ms	88.6 ± 8.4	78.4 ± 9.2	81.2 ± 9.0	93.7 ± 9.5	$F(2.2,50.6)=7.6$, $p=0.001$, $\eta^2=0.25$	Δ = +5.1 ms; 95% CI [2.3, 7.9]; Cohen's dz = 0.6
Ruffier index, a.u.	7.4 ± 1.0	9.8 ± 1.1	8.7 ± 1.0	6.9 ± 0.9	$F(2.4,55.2)=9.8$, $p<0.001$, $\eta^2=0.30$	Δ = −0.5; 95% CI [−1.0, 0.0]; Cohen's dz = 0.4

Notes: Data are presented as mean ± SD. The time effect was assessed using one-way repeated-measures ANOVA. The Greenhouse–Geisser correction was applied when the sphericity assumption was violated. The effect size for ANOVA is reported as partial η^2. The baseline–final change is presented as the mean difference (Δ) with a 95% confidence interval and Cohen's dz. For the Ruffier index, the baseline–final comparison did not reach statistical significance.

temporal changes. RMSSD decreased during the initial stage ($p < 0.001$), partially recovered during the main stage, and exceeded baseline values by the final stage ($p = 0.01$). SDNN demonstrated a similar pattern of change. The Ruffier index increased during the initial stage compared with baseline ($p < 0.001$), decreased during the main stage, and returned to baseline levels by the final stage.

Subjective well-being, activity, and mood scores decreased during the initial stage compared with baseline (all $p < 0.01$). In the main stage, these indicators improved for the group, although individual variability remained. By the final stage, subjective scores increased further and variability decreased (Table 2).

As shown in Table 2, individual analysis revealed that 7 athletes (29.2%) did not demonstrate an increase in RMSSD from the initial to the main stage, and their values remained below baseline during this period. These athletes also reported lower subjective well-being scores in the main stage compared with the rest of the group ($p = 0.008$). Comparative analysis indicated inter-individual variability in recovery responses. Athletes with higher baseline RMSSD values showed greater recovery by the final stage compared with athletes with lower baseline RMSSD ($p = 0.02$). In addition, athletes with delayed HRV recovery demonstrated higher resting heart rate at the final stage than the rest of the group ($p = 0.01$). Table 2 presents the dynamics of subjective recovery indicators assessed during the training camp.

Resting heart rate showed a significant decreasing trend from the initial to the final stage ($F(2.1, 48.3) = 12.4$, $p < 0.001$, $\eta^2 = 0.35$; Figure 1). Individual trajectories varied, as indicated by the standard deviation bars.

RMSSD dynamics (Figure 2) showed a significant quadratic trend ($F(1, 23) = 14.2$, $p < 0.001$, $\eta^2 = 0.38$), with an initial decrease followed by an increase above baseline. The 95% confidence intervals for mean RMSSD at each time point are shown in Figure 2.

The Ruffier index (Figure 3) showed a significant overall time effect ($F(2.4, 55.2) = 9.8$, $p < 0.001$, $\eta^2 = 0.30$). Pairwise comparisons confirmed significant differences between the initial and final stages ($p < 0.001$). However, the baseline–final comparison did not reach statistical significance ($p = 0.06$).

Subjective indicators (Figure 4) showed significant changes over time (Friedman $\chi^2 > 12$, $p < 0.01$ for all measures). Post hoc comparisons

Table 2. Dynamics of subjective indicators of functional state during the training camp.

Indicator	Initial stage	Main stage	Final stage	χ^2 (df=2)	p-value
Well-being	3 [3–4]	4 [3–4]	4 [4–5]	14.2	<0.001
Activity	3 [3–4]	4 [3–4]	4 [4–5]	12.8	0.002
Mood	3 [3–4]	4 [4–4]	5 [4–5]	16.5	<0.001

Note: Data are presented as median [IQR]. Changes over time were assessed using the Friedman test. χ^2 is the Friedman test statistic; df = 2; n = 24.

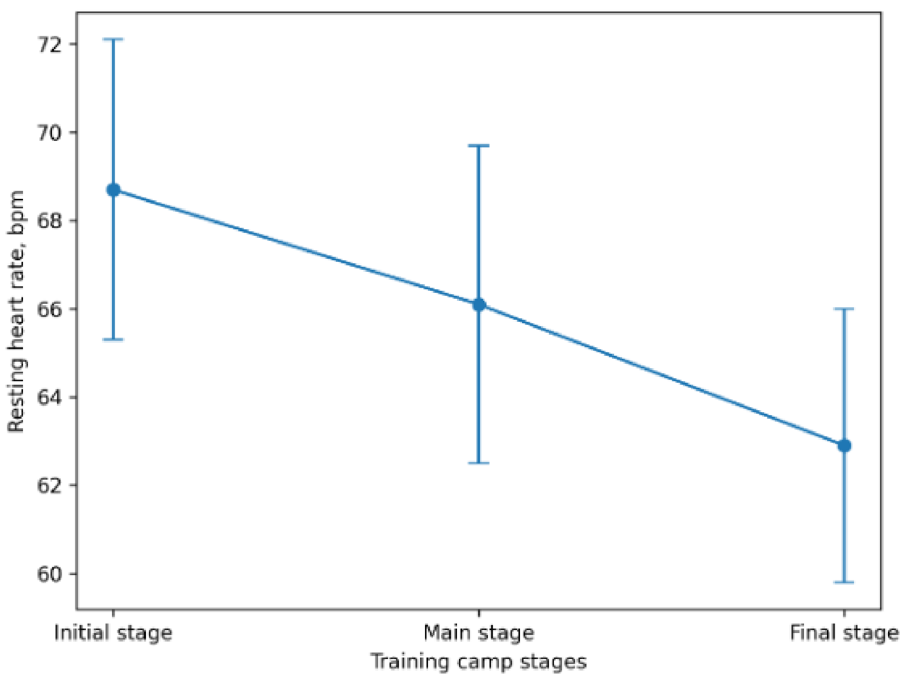

Figure 1. Dynamics of resting heart rate during the training camp (mean ± SD).

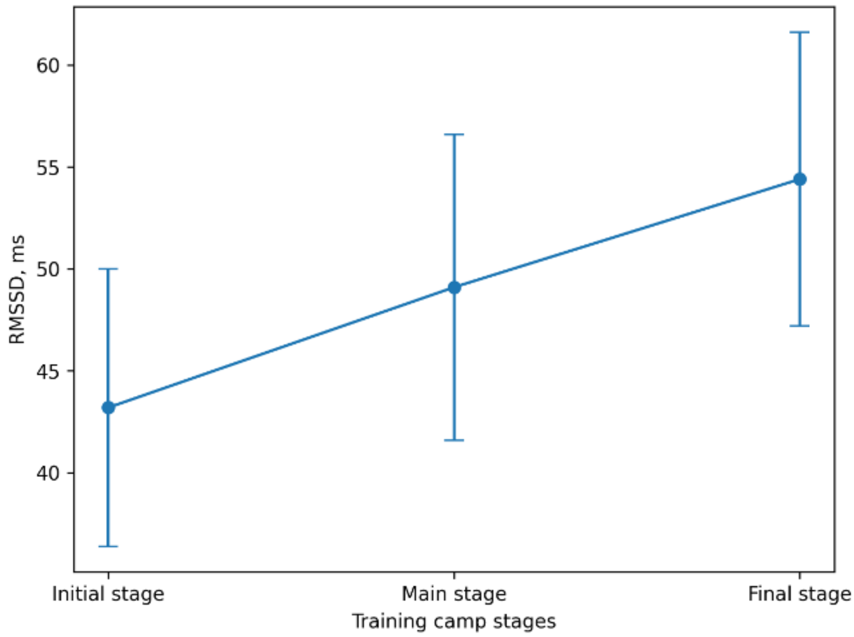

Figure 2. Dynamics of RMSSD during the training camp (mean ± SD).

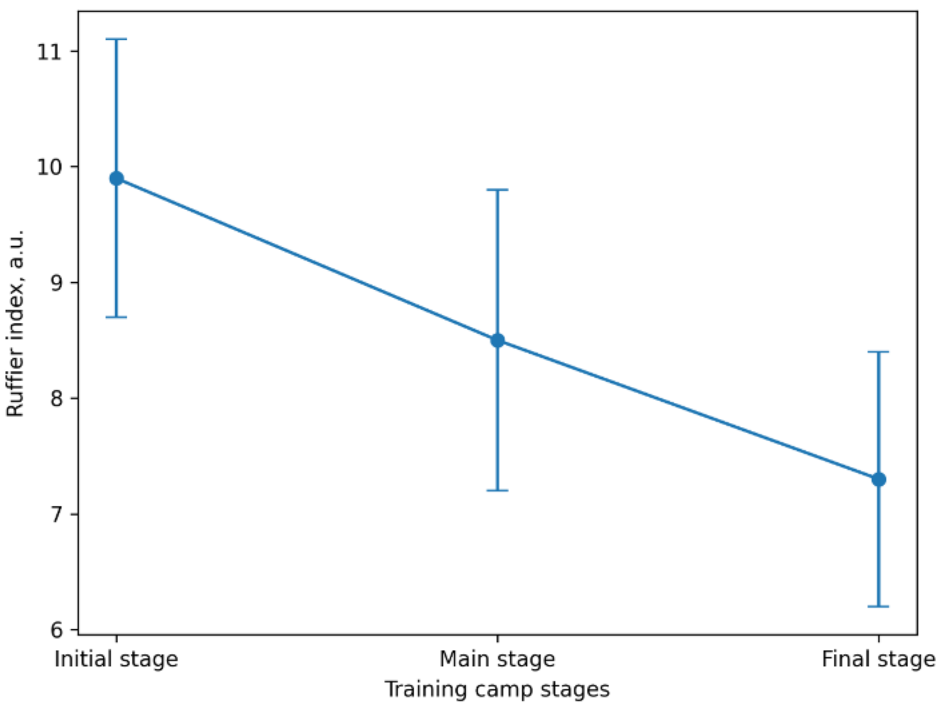

Figure 3. Dynamics of the Ruffier index during the training camp (mean ± SD).

indicated that final scores were higher than initial scores for all three measures ($p < 0.01$).

Subjective indicators (Figure 4) showed significant changes over time (Friedman $\chi^2 > 12$, $p < 0.01$ for all measures). Post hoc comparisons indicated that final scores were higher than initial scores for all three measures ($p < 0.01$).

Individual analysis revealed that 7 athletes (29.2%) exhibited atypical responses: their RMSSD did not exceed baseline values by the final stage (48.2 ± 4.1 ms vs. baseline 50.5 ± 5.2 ms, $p = 0.28$), and their resting heart rate remained higher than in the rest of the group (64.5 ± 2.8 vs. 60.8 ± 2.1 bpm, $p = 0.01$).

Discussion

The purpose of this study was to examine the dynamics of physiological, functional, and subjective recovery indicators in wrestlers during different stages of a training camp within the framework of medical and pedagogical monitoring. The findings show that training camps represent a period of pronounced functional strain that requires systematic monitoring of recovery processes. The

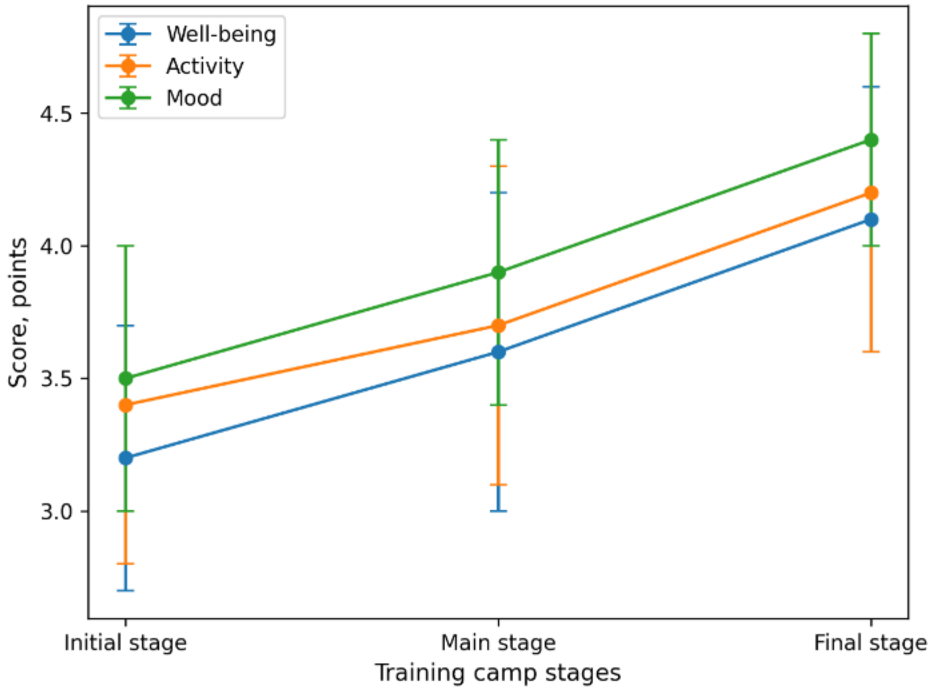

Figure 4. Dynamics of subjective functional state indicators during the training camp (mean ± SD).

observed decrease in resting heart rate and the increase in heart rate variability indices in the majority of wrestlers suggest the development of adaptive shifts consistent with improved cardiovascular efficiency and parasympathetic regulation. These results are consistent with contemporary concepts of the physiological mechanisms underlying athlete recovery [6, 7, 8].

An increase in the RMSSD index during training camps is regarded by several authors as an indicator of an adequate balance between training load and recovery interventions [6, 14]. Studies conducted under training camp conditions have shown that positive RMSSD dynamics are associated with increased adaptive reserve and a reduced risk of accumulated fatigue [8, 13]. The results of the present study are generally consistent with the findings of Chen Y.-S. et al. and Coelho A. B. et al., who confirmed the diagnostic value of heart rate variability indicators for monitoring recovery under conditions of centralized training [7, 8].

At the same time, the individual differences identified in the dynamics of recovery indicators in 29.2% of wrestlers indicate that the positive group trend is not universal. Similar evidence has been reported in studies highlighting pronounced individual variability in autonomic regulation responses to training loads, particularly in sports characterized by high intensity and psycho-emotional stress [5, 16]. In wrestling, such variability may be associated with differences in training experience, functional readiness, bout style, as well as individual sensitivity to training loads and recovery interventions.

From a pedagogical perspective, the identified individual differences in recovery dynamics support the transition from standardized approaches to more individualized regulation of training loads. The use of dynamic recovery data enables coaches to adjust training tasks and maintain a balance between training load and recovery.

From the standpoint of medical–pedagogical monitoring, the present findings confirm the limitations of static assessments of athletes' functional state. Single-point measurements of heart rate or HRV do not allow detection of latent signs of inadequate recovery, whereas dynamic monitoring during the training camp provides a more objective assessment of adaptive processes and enables timely adjustment of training loads [9, 10].

The results of the study are consistent with the research hypothesis and demonstrate the feasibility of using dynamic monitoring of functional state recovery indicators under training camp conditions. They emphasize the necessity of individualizing medical–pedagogical monitoring in wrestling, while acknowledging that causal interpretations require controlled designs.

Limitations of the study

Several limitations of the present study should be acknowledged. First, the single-group design without a control group precludes causal attribution of the observed changes to the training camp itself. Second, the sample size (n = 24) was not based on an a priori power calculation, which may affect the generalizability of the findings. Third, the absence of biochemical markers of fatigue and the limited range of subjective recovery indicators restrict deeper mechanistic insights. Future studies should include a control group and objective markers of stress and recovery and should employ controlled designs to confirm causality and explore underlying mechanisms. These limitations do not diminish the significance of the obtained results; they define directions for future research aimed at expanding the set of diagnostic criteria and conducting a more in-depth analysis of individual recovery trajectories in wrestlers.

Conclusions

1. Over the course of the training camp, the majority of athletes showed a progressive increase in RMSSD (mean change +4.5 ms; 95% CI [2.1, 6.9]) and a decrease in resting heart rate (mean change −2.3 bpm; 95% CI [−3.5, −1.1]), suggesting improved parasympathetic modulation and cardiovascular efficiency.
2. However, 29.2% of athletes exhibited less pronounced or unstable recovery dynamics, indicating inter-individual variability in adaptive responses.
3. Dynamic monitoring of physiological (HRV, heart rate), functional (Ruffier index), and subjective indicators provided a comprehensive picture of recovery processes and allowed early identification of athletes with potential incomplete recovery.

These findings support the inclusion of repeated-measures monitoring in medical–pedagogical practice to individualize training load management. Due to the absence of a control group, the observed changes cannot be causally attributed to the training camp itself and represent temporal associations.

The practical significance of the study lies in the proposed set of indicators that can be integrated into routine monitoring of wrestlers during training camps to enhance the quality of training process management and help prevent chronic fatigue and overtraining.

Conflict of Interest

The authors declare no conflict of interest.

Use of artificial intelligence tools

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve language clarity and academic style. The authors reviewed and edited the content and take full responsibility for the final version of the manuscript.

References

1. Platonov VN. *System of athletes' preparation in Olympic sport: General theory and its practical applications*. Kyiv: Olympic Literature; 2015.
2. Halson SL. Monitoring Training Load to Understand Fatigue in Athletes. *Sports Medicine*, 2014;44(S2):139–147. https://doi.org/10.1007/s40279-014-0253-z
3. Badea D. The Recovery of the Effort Capacity during Training Camps. In: *5th International Congress of Physical Education, Sports and Kinetotherapy,* 2016. P. 128–135. https://doi.org/10.15405/epsbs.2016.06.18
4. Franchini E, Brito CJ, Artioli GG. Weight loss in combat sports: physiological, psychological and performance effects. *Journal of the International Society of Sports Nutrition*, 2012;9(1): 52. https://doi.org/10.1186/1550-2783-9-52
5. Karaman ME, Arslan C, Kinaci AE. The Effect of Single Bout of Competitive Training on Muscle Damage and Liver Enzymes in University Student Wrestling and Taekwondo Athletes. *Journal of Pharmaceutical Research International*, 2021; 26–30. https://doi.org/10.9734/jpri/2021/v33i1731304
6. Buchheit M. Monitoring training status with HR measures: do all roads lead to Rome? *Frontiers in Physiology*, 2014;5. https://doi.org/10.3389/fphys.2014.00073
7. Chen YS, Clemente FM, Bezerra P, Lu YX. Ultra-Short-Term and Short-Term Heart Rate Variability Recording during Training Camps and an International Tournament in U-20 National Futsal Players. *International Journal of Environmental Research and Public Health*, 2020;17(3): 775. https://doi.org/10.3390/ijerph17030775
8. Coelho A, Nakamura F, Morgado M, Holmes C, Di Baldassarre A, Esco M, et al. Heart Rate Variability and Stress Recovery Responses during a Training Camp in Elite Young Canoe Sprint Athletes. *Sports*, 2019;7(5): 126. https://doi.org/10.3390/sports7050126
9. Meeusen R, Duclos M, Foster C, Fry A, Gleeson M, Nieman D, et al. Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport Science (ECSS) and the American College of Sports Medicine (ACSM). *European Journal of Sport Science*, 2013;13(1): 1–24. https://doi.org/10.1080/17461391.2012.730061
10. Sylta Ø, Tønnessen E, Seiler S. From Heart-Rate Data to Training Quantification: A Comparison of 3 Methods of Training-Intensity Analysis. *International Journal of Sports Physiology and Performance*, 2014;9(1): 100–107. https://doi.org/10.1123/ijspp.2013-0298
11. Kulanbaev AB, Mustafin AS, Sagyndykov AK. Funktsional'noe sostoyanie sportsmenov v sisteme vrachebno-pedagogicheskogo kontrolya [Functional state of athletes in the system of medical and pedagogical control]. *Theory and Methodology of Physical Culture,* 2018;3:45-52. (In Russian).
12. Sagyndykov AK. *Mediko-biologicheskie osnovy uprleniya trenirovochnym protsessom sportsmenov* [Medical and biological foundations of managing the training process of athletes]. Almaty; 2020. (In Russian).

13. Nurgaliev AT, Zhumabekov NK. Variabel'nost' serdechnogo ritma kak pokazatel' vosstanovleniya sportsmenov [Heart rate variability as an indicator of athletes' recovery]. *Bulletin of the Academy of Sports and Tourism,* 2022;3:45-52. (In Russian).
14. Clemente FM, Silva AF, Sarmento H, Ramirez-Campillo R, Chiu YW, Lu YX, et al. Psychobiological Changes during National Futsal Team Training Camps and Their Relationship with Training Load. *International Journal of Environmental Research and Public Health*, 2020;17(6): 1843. https://doi.org/10.3390/ijerph17061843
15. Chen YS, Pagaduan JC, Bezerra P, Crowley-McHattan ZJ, Kuo CD, Clemente FM. Agreement of Ultra-Short-Term Heart Rate Variability Recordings During Overseas Training Camps in Under-20 National Futsal Players. *Frontiers in Psychology*, 2021;12: 621399. https://doi.org/10.3389/fpsyg.2021.621399
16. Plews DJ, Laursen PB, Stanley J, Kilding AE, Buchheit M. Training Adaptation and Heart Rate Variability in Elite Endurance Athletes: Opening the Door to Effective Monitoring. *Sports Medicine*, 2013;43(9): 773–781. https://doi.org/10.1007/s40279-013-0071-8
17. Kellmann M, Bertollo M, Bosquet L, Brink M, Coutts AJ, Duffield R, et al. Recovery and Performance in Sport: Consensus Statement. *International Journal of Sports Physiology and Performance*, 2018;13(2): 240–245. https://doi.org/10.1123/ijspp.2017-0759
18. Chernozub A, Korobeynikov G, Mytskan B, Korobeinikova L, Cynarski WJ. Modelling Mixed Martial Arts Power Training Needs Depending on the Predominance of the Strike or Wrestling Fighting Style. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 2018;(18): 28–36. https://doi.org/10.14589/ido.18.3.5
19. Bahenský P, Grosicki GJ. Superior Adaptations in Adolescent Runners Using Heart Rate Variability (HRV)-Guided Training at Altitude. *Biosensors*, 2021;11(3): 77. https://doi.org/10.3390/bios11030077
20. Nagovitsyn RS, Volkov PB, Miroshnichenko AA, Tutolmin AA, Senator SYu. The influence of special graduated weight load in Greco-Roman wrestling on the growth of students' sports results. *Physical Education of Students*, 2017;21(6): 294. https://doi.org/10.15561/20755279.2017.0606

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