Journal of Life Sciences & Biomedicine, vol. 8(81), No 1, p. 52-57 (2026)

Functional parameters of the cardiorespiratory system in female athletes

Khatun Aslanova*, Mushgunaz Abbasova

Azerbaijan Sport Academy, 98 Fatali Khan Khoyski Ave., AZ1072, Baku, Azerbaijan

***For correspondence:** xatun.aslanova.2024@sport.edu.az*

Received: April 17, 2026; Reviewed: June 01, 2026; Accepted: June 10, 2026

Assessing the physiological characteristics of the cardiorespiratory system is essential for determining athletic conditioning and adaptation levels. Evaluating the functional capacities of the cardiorespiratory system in team sport athletes provides crucial data for training optimization. The primary objective of this study is to conduct a comparative analysis of the functional reserves of the cardiorespiratory system in female basketball and volleyball players using the Ruffier test. We enrolled a total of 20 female athletes (10 basketball players and 10 volleyball players) in the study. The methodology involved measuring heart rate indicators (P_1, P_2, and P_3) at rest, immediately following a standardized physical load, and during the recovery phase, followed by the calculation of the Ruffier Index (RI). Statistical analysis demonstrates distinct cardiovascular and respiratory recovery pathways between the two groups. The mean Ruffier Index (RI) value was 9.52±0.7 (fair level) for female basketball players and 8.2±0.8 (fair level) for female volleyball players. These findings indicate that regular training in team sports significantly shapes the specific functional capacity and adaptive reserves of the cardiorespiratory system during youth development.

Keywords: *Female basketball players, female volleyball players, Ruffier test, cardiorespiratory system, physical capacity, heart rate recovery*

INTRODUCTION

Maintaining human physical capabilities at an optimal level over the long term can be effectively achieved through systematic physical activity. Team sports remain highly popular among the youth. Regular training in any team sport places a significant workload on the musculoskeletal system and internal organs, stimulating their functional state and enhancing overall bodily vitality (Medvedev et al., 2022). Consistent athletic training acts as a direct physiological stimulus for the majority of cellular structures within the athlete`s tissues. Systematic physical workloads significantly optimize the vestibular apparatus and the physiological pathways responsible for maintaining static and dynamic body balance in sports disciplines (Zavalishina et al., 2021a).

Enhancing the functional efficiency of the entire cardiorespiratory system forms the cornerstone for developing high physical capacity, which is particularly relevant for athletic performance. For engagement in any sports discipline, the developmental levels of both the cardiovascular and respiratory systems hold critical importance. The presence of substantial functional reserves in these systems can be characterized by an increased myocardial mass, larger diameters of the trachea and bronchi, and well-developed respiratory musculature. Exercise physiologists show great interest in determining the developmental level of the cardiorespiratory system in representatives of various team sports who regularly participate in training sessions within their chosen disciplines (Mogilnikov, 2024; Zavalishina et al., 2021b).

Evaluating the cardiorespiratory system primarily serves to predict an athlete`s competitive efficiency rather than simply tracing health status. Both basketball and volleyball require high dynamics, high-intensity movement

https://doi.org/10.59849/2710-4915.2026.1.52
Available online 30 June 2026

patterns, and the co-activation of aerobic and anaerobic energy systems. Success in these sports depends not only on morphological parameters but also on how efficiently the cardiovascular system recovers following strenuous physical load. Depending on the specific differences in physical workload, each sport triggers distinct physiological adaptations within the organism.

Basketball operates predominantly in an aerobic-anaerobic energy supply regimen due to its movement structure, which involves high-intensity running, sudden decelerations, sprints, and continuous full-court transitions. This workload promotes an increase in myocardial endurance. Conversely, volleyball consists primarily of explosive jumps, blocking actions, and offensive spikes, which fundamentally rely on anaerobic energy mechanisms. These metabolic and tactical differences directly manifest themselves in the post-exercise heart rate recovery process (Mammadova, 2026).

The comparative characteristics of the cardiorespiratory system in female basketball and volleyball players are shaped by the nature of their competitive activities. While basketball demands superior aerobic endurance due to continuous running, volleyball is characterized by intermittent, explosive speed-strength efforts. Therefore, this study is to conduct a comparative evaluation of the functional state and adaptive reserves of the cardiorespiratory system in female basketball and volleyball players.

MATERIALS AND METHODS

We executed the Ruffier test as the primary investigative tool in this research. The Ruffier test is a fundamental, non-invasive method for evaluating myocardial endurance and the cardiovascular response to standardized physical exertion. This test allows for a comprehensive analysis of cardiac reactivity during exercise and the efficiency of subsequent recovery pathways. Applying this method serves to individualize athletic training methodologies and contributes to kinesiological theories within sports science (Ravi, 2020).

We executed the experimental methodology in the following chronological phases:

- Resting heart rate assessment (P_1): Prior to testing, the participants rested in a seated position for 5 minutes under quiet conditions to ensure baseline stabilization. Following this resting period, we measured and recorded the heart rate (pulse beats) for 15 seconds.
- Standardized physical load: The athletes performed 30 deep squats within a fixed timeframe of 45 seconds. To ensure rhythmic consistency and workload standardization across all participants, we used an auditory metronome.
- Immediate post-exercise heart rate assessment (P_2): Immediately upon completion of the physical load, we measured the heart rate during the first 15 seconds. This parameter reflects the acute reactivity of the cardiovascular and respiratory systems to physical stress.
- Recovery phase heart rate assessment (P_3): Following 1 minute of passive recovery in a seated position, we obtained the final 15-second heart rate measurement. This indicator determines the organism`s autonomic recovery (restitution) capacity.

The obtained numerical data were processed using the standard Ruffier Index formula:

$$\boldsymbol{RI = \frac{4 * (P1 + P2 + P3) - 200}{10}}$$

where:

- RI represents the Ruffier index (expressed in arbitrary units);
- P1 is the 15-second heart rate at rest;
- P2 is the 15-second heart rate immediately following the 30 squats;
- P3 is the 15-second heart rate measured at the 1-minute mark of the recovery phase.

We interpreted the calculated index scores according to the following established evaluation scale:

- 0.0-2.9: Excellent (high functional capacity);
- 3.0-6.0: Good (satisfactory);
- 6.1-10.0: Fair (moderate);
- 10.1-15.0: Weak (poor);
- >15.0: Very weak (unsatisfactory).

Statistical processing of the empirical data was performed using Microsoft Excel. We evaluated the statistical significance of differences

between the comparative groups using Student`s independent *t*-test, considering results significant at a threshold of $p<0.05$.

RESULTS AND DISCUSSION

The empirical findings reveal the distinct adaptation mechanisms of the cardiorespiratory system in female basketball and volleyball players in response to standardized physical exertion. The outcomes of the Ruffier test demonstrate clear variance between the two sports disciplines. Based on our statistical evaluation, trained female basketball players exhibit a different functional performance profile of the cardiovascular system compared to trained female volleyball players, with statistical significance established at $p<0.05$ (Table 1, Table 2, Fig.).

Our analysis shows that the mean Ruffier Index (RI) value for female basketball players was 9.52±0.7, placing the overall functional capacity and adaptation to physical workload within this cohort into the "Fair" category. The fact that certain athletes exhibited index scores exceeding 10.0 reflects a relatively prolonged post-exercise recovery process of their cardiorespiratory systems. These findings suggest that a greater programmatic emphasis should be placed on endurance conditioning within their training process.

The mean Ruffier Index (RI) for female volleyball players was established at 8.2, which presents a slightly more favorable adaptation profile compared to the basketball cohort. Specifically, the performance of Athlete 5 (RI=4.8) represents the highest functional capacity within the group. In contrast, we observed opposite trends in Athlete 7 and Athlete 8. The elevated index scores in these specific athletes indicate a suboptimal adaptation and an unsatisfactory cardiovascular recovery process in response to physical exertion (Raheel et al., 2022).

Table 1. Heart rate dynamics and Ruffier Index (RI) outcomes in female basketball players (n=10) during the Ruffier test.

Athlete	P_1 (15 sec)	P_2 (15 sec)	P_3 (15 sec)	Ruffier Index (RI)	Evaluation
N.N.	24	34	21	11.6	Weak
E.T.	21	35	24	12.0	Weak
E.V.	20	27	19	6.4	Fair
L.A.	22	32	20	9.6	Fair
F.M.	23	36	22	12.4	Weak
A.H.	19	29	18	6.4	Fair
N.Q.	21	31	21	9.2	Fair
S.S.	24	33	23	12.0	Weak
M.I.	20	28	19	6.8	Fair
D.R.	22	30	20	8.8	Fair
Mean *(M±m)*	21.6±0.5	31.5±0.9	20.7±0.6	9.52±0.7	Fair

Table 2. Heart rate dynamics and Ruffier Index (RI) outcomes in female volleyball players (n=10) during the Ruffier test.

Athlete	P_1 (15 sec)	P_2 (15 sec)	P_3 (15 sec)	Ruffier Index (RI)	Evaluation
H.M.	18	29	21	7.2	Fair
A.A.	20	30	19	7.6	Fair
M.A.	20	28	19	6.8	Fair
I.H.	21	27	20	7.2	Fair
S.Ə.	18	27	17	4.8	Good
V.K.	22	26	21	7.6	Fair
A.C.	28	28	27	13.2	Weak
N.A.	23	31	25	11.6	Weak
L.M.	19	28	20	6.8	Fair
S.R.	21	30	22	9.2	Fair
Mean *(M±m)*	21.0±0.9	28.4±0.5	21.1±0.9	8.2±0.8	Fair

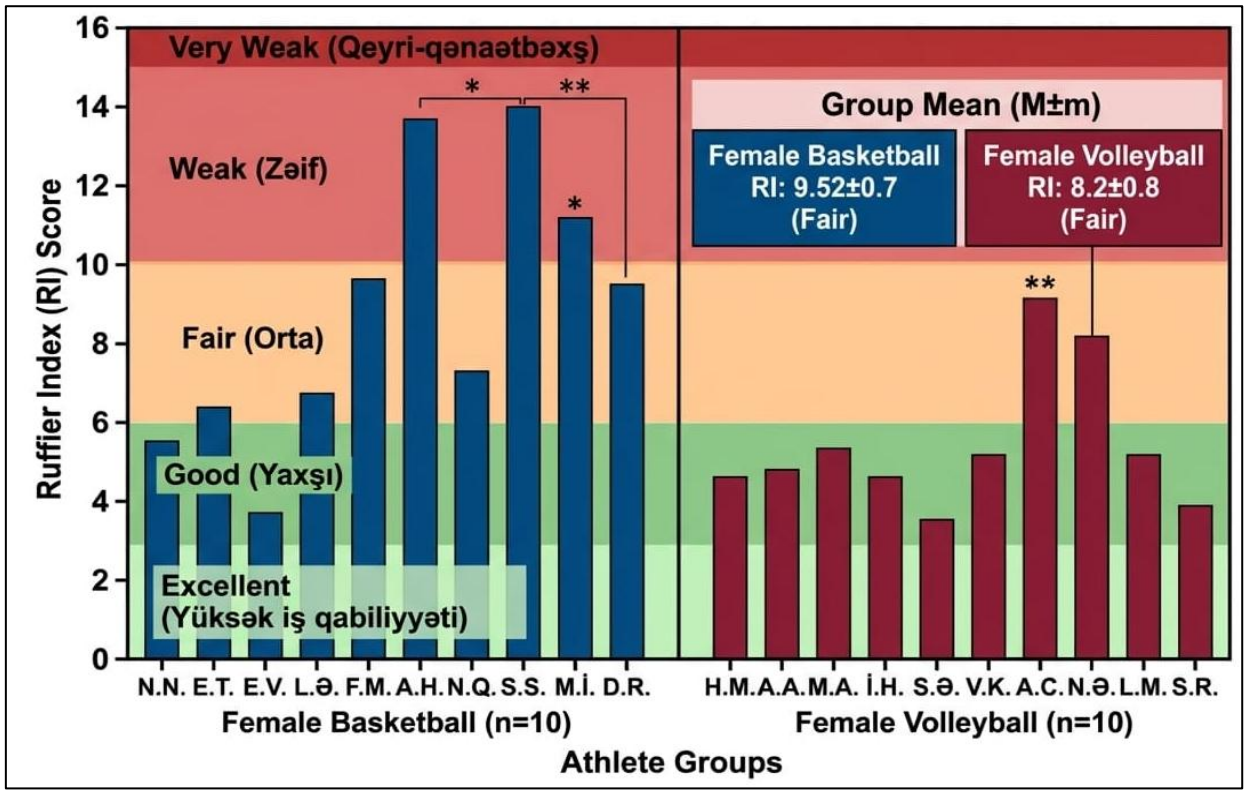

Fig. Comparative analysis of individual Ruffier Index (RI) scores and group averages between female basketball (n=10) and volleyball (n=10) athletes across functional evaluation categories.

To contextualize these findings within sports cardiology, the variation in cardiac autonomic regulation between these cohorts must be linked to the specific biomechanical and metabolic demands of each sport. Basketball involves prolonged, acyclic bouts of high-intensity running interspersed with rapid changes of direction, demanding a continuous contribution from both aerobic and anaerobic energy pathways (Silverthorn, 2016). This sustained volumetric load triggers significant eccentric myocardial remodeling over time, expanding stroke volume and improving systemic perfusion.

The higher mean RI (9.52±0.7) observed in our basketball cohort, alongside specific individuals exceeding the 10.0 threshold (such as Athlete 1, 2, 5, and 8), underscores a state of transient autonomic mismatch or incomplete vagal reactivation post-exercise. When physical workloads chronically mismatch an athlete`s current functional ceiling, cardiac output efficiency drops, leading to compensatory tachycardia during recovery (Mogilnikov et al., 2024; Sakellaropoulos, 2019).

Volleyball conditioning emphasizes interval-based explosive movements, such as vertical jumps, short sprints, and reactive blocking, relying heavily on the ATP-CP and anaerobic glycolytic systems (Smith& Brown, 2020). The superior mean RI (8.2±0.8) and the outstanding adaptation of Athlete 5 (RI=4.8) point toward an efficient parasympathetic reinstatement mechanism. In interval sports, the cardiovascular system is highly trained to lower the heart rate quickly during brief stoppages in play, such as between rallies or sets. This rapid parasympathetic reactivation-often referred to as efficient heart rate deceleration-characterizes superior athletic conditioning and localized muscular endurance (Scott et al., 2017).

The weak performance of volleyball Athlete 7 (RI=13.2) and Athlete 8 (RI=11.6) indicates localized cardiovascular strain. In individual cases where recovery kinetics are severely delayed, it

points toward peripheral fatigue or suboptimal stroke volume compensation, forcing the heart to maintain elevated rates to clear metabolic waste products (Sawka & Coyle, 1999). Our data clearly indicate that tracking these heart rate windows (P_1, P_2, and P_3) provides coaches with an invaluable, non-invasive direct window into early overtraining detection, enabling the vital transition from rigid group-level training sessions to precision-guided, individualized recovery mechanisms.

CONCLUSIONS

Based on our evaluation of cardiorespiratory adaptations to physical exertion and recovery dynamics in female basketball and volleyball players, we obtained the following conclusions:

1. Female volleyball players exhibit a high adaptive capacity of the cardiovascular system in response to physical workloads. The rapid return of post-exercise physiological parameters to baseline values indicates superior endurance and myocardial efficiency (economization of cardiac function). This confirms that systematic athletic training enhances the functional reserves of the myocardium, accelerating recovery pathways within optimal boundaries.
2. The "weak" functional index observed in some female basketball players suggests that their individual adaptation to the prescribed physical workload is suboptimal, meaning the intensity of their training loads may not fully align with their current functional capacities. Consequently, coaching staff should design individualized conditioning programs to balance workload and recovery.
3. Utilization of this cardiorespiratory assessment framework facilitates the prevention of overtraining and cumulative fatigue in female athletes. Furthermore, it enables the formulation of specialized, data-driven training regimens aimed at optimizing competitive performance during tournament periods.
4. In conclusion, different sports disciplines exert distinct physiological influences on the structural and functional development of the cardiorespiratory system in female athletes. While basketball conditioning predominantly stimulates respiratory reserve capacities and hypoxic tolerance, volleyball training promotes cardiovascular endurance and morphological stability.

FUNDING

This study did not receive any specific grant from the state, commercial, or non-commercial organizations.

CONFLICT OF INTEREST

The authors confirm the absence of a conflict of financial/non-financial interests related to the writing of the article.

AUTHOR CONTRIBUTIONS

Khatun Aslanova conceived the study, collected and analyzed the historical and demographic data, and prepared the original manuscript draft. She also contributed to the interpretation of historical sources, data verification, and manuscript revision. Mushgunaz Abbasova assisted in the methodological framework, literature review, and critical editing of the manuscript. She contributed to manuscript preparation, language editing, formatting, and final review. Authors read and approved the final version of the manuscript.

AI STATEMENT

The authors confirm that no artificial intelligence (AI) tool was used to generate the research data, historical interpretations, analyses, or conclusions presented in this manuscript. Any AI-assisted tools, if used, were limited to language editing and formatting support, and all content was reviewed and verified by the authors.

REFERENCES

Mammadova Sh., Ganiyeva M., Guliyeva M., (2026) Comparative analysis of functional and pathological changes in the cardiovascular and respiratory systems of athletes during heat stroke. *Journal of Medicine-24*, **3 (1):** 38-43; doi: 10.36719/3104-4700/4/38-43

Medvedev I.N., Karpov V.Yu., Makurina O.N., Eremin M.V., Dorontsev A.V., Sibgatulina F.R.,Ivanov D.A. (2022) Functional reaction of the cardiovascular system to irritation of vestibular receptors in students engaged in different types of martial arts. *IJBBE*, **16:** 96-104; doi: 10.46300/91011.2022.16.12

Mogilnikov Yu.V. (2024) Peculiarities of modern women`s volleyball. *Uchenye Zapiski Universiteta Imeni P.F. Lesgafta*, **5 (231):** 163-166 (in Russian).

Raheel Ch., Julia H.M., Afzal R. (2022) Physiology, Cardiovascular. Treasure Island (FL): StatPearls Publishing; URL: ncbi.nlm.nih.gov/books/NBK493197/

Ravi Sh.R. Khalid A.A., Kanagaraj R., Paul A.S., Venkata N.K., Irshad A., Jaya Sh.T., (2020) Cardiorespiratory fitness as a correlate of cardiovascular, anthropometric, and physical risk factors: Using the Ruffier test as a template. *Can. Respir. J.,* **2020:** 3407345; doi: 10.1155/2020/3407345.

Sakellaropoulos S., Zimmermann A.J., Bengel C., Wilhelm M. (2019) Cardiopulmonary exercise testing in sports cardiology. *Sport and Exercise Medicine Switzerland,* 12 p.; doi: 10.34045/SSEM/2019/3

Sawka M.N., Coyle E.F. (1999) Influence of body water and blood volume on thermoregulation and exercise performance in the heat. *Exercise and Sport Sciences Reviews*, **27:**167-218.

Scott M., Kenneth S.G, Glen M.D., (2017) Cardiac autonomic responses during exercise and post-exercise recovery using heart rate variability and systolic time intervals - a review. *Front. Physiol*., **8:** 301; doi: 10.3389/fphys.2017.00301

Silverthorn Deem U., Johnson Bruce R., Ober William C., Garrison Claire W., Andrew C. (2016) Human physiology: An integrated approach. 7th ed. San Francisco: Pearson, 838 p.

Zavalishina S.Yu., Karpov V.Yu., Bakulina E.D., Rysakova O.G. (2021a) The function of maintaining body balance in students involved in various sports. *Journal of Biochemical Technology*, **12(4):** 94–98.

Zavalishina S.Yu., Karpov V.Yu., Rysakova O.G., Rodionov I.A., Pryanikova N.G., Shulgin A.M. (2021b) Physiological reaction of the body of students to regular physical activity. *Journal of Biochemical Technology*, **12(2):** 44–47.

ORCIDS:
Khatun Aslanova: https://orcid.org/0009-0000-8804-8583
Mushgunaz Abbasova: https://orcid.org/0000-0002-5027-8970