Effects of land- and water-based high-intensity interval training using elastic bands on physical condition and motivation in female volleyball athletes

Efectos del entrenamiento interválico de alta intensidad en tierra y en agua con bandas elásticas sobre la condición física y la motivación en jugadoras de voleibol

Authors

Ruman [1]
Heny Setyawati [2]
Nasuka [3]
Siti Baitul Mukarromah [4]

[1-4] Universitas Negeri Semarang, (Indonesia)

Corresponding author:
Heny Setyawati
henysetyawati@mail.unnes.ac.id

Received: 19-12-25
Accepted: 12-03-26

How to cite in APA

Ruman, R., Setyawati, H., Nasuka, N., & Mukarromah, S. B. (2026). Effects of land- and water-based high-intensity interval training using elastic bands on physical condition and motivation in female volleyball athletes. *Retos, 79*, 140-150. https://doi.org/10.47197/retos.v79.118399

Abstract

Introduction: This study aims to analyze the effects of High-Intensity Interval Training (HIIT) using elastic bands, performed on land and in water, on the physical condition and motivation of female volleyball athletes. Volleyball demands high levels of explosive strength, agility, endurance, and psychological readiness to maintain optimal performance during training and matches.
Objective: To examine the effects of land-based and water-based High-Intensity Interval Training (HIIT) using elastic bands on the physical condition and motivation of female volleyball athletes.
Methods: A quasi-experimental pre-test–post-test design with a control group was implemented, involving 110 athletes from the Jaya Surya Volleyball Club in Pangandaran, Indonesia. Participants were divided into three groups: land-based HIIT, water-based HIIT, and a control group that continued standard training. The intervention lasted four weeks, with sessions conducted three to four times per week at an intensity of 80–90% HRmax. Physical fitness tests included endurance, strength, flexibility, agility, balance, speed, and power, while motivation was assessed using a validated Likert-scale questionnaire.
Results: The results showed significant improvements ($p < 0.05$) in both experimental groups, with the water-based HIIT group achieving the greatest improvements in endurance (+19.3%), flexibility (+4.3%), and motivation (+12.2%).
Discussion: These findings suggest that an aquatic environment enhances the effectiveness of exercise by optimizing physiological adaptations and intrinsic motivation. Furthermore, both training models positively influenced the athletes' motivation levels, with participants reporting higher levels of enjoyment and engagement during training sessions.
Conclusion: These findings suggest that integrating land-based and water-based HIIT using elastic bands can be an effective and innovative training strategy to improve physical performance and motivation among female volleyball athletes. This study provides practical implications for coaches and sports instructors in designing varied and efficient conditioning programs for volleyball athletes.

Keywords

Hight intensity interval training; elastic bands; aquatic training; physical condition; motivation; volleyball; female athletes.

Resumen

Introducción: El presente estudio tiene como objetivo analizar los efectos del entrenamiento por intervalos de alta intensidad (HIIT) con bandas elásticas, realizado en tierra y en el agua, sobre la condición física y la motivación de las jugadoras de voleibol. El voleibol exige altos niveles de fuerza explosiva, agilidad, resistencia y preparación psicológica para mantener un rendimiento óptimo durante los entrenamientos y los partidos.
Objetivo: Examinar los efectos del entrenamiento por intervalos de alta intensidad (HIIT) en tierra y en el agua con bandas elásticas sobre la condición física y la motivación de las jugadoras de voleibol.
Métodos: Se implementó un diseño cuasi-experimental de pre-prueba y post-prueba con un grupo de control, en el que participaron 110 jugadoras del Club de Voleibol Jaya Surya de Pangandaran, Indonesia. Las participantes se dividieron en tres grupos: HIIT en tierra, HIIT en el agua y un grupo de control que continuó con el entrenamiento estándar. La intervención duró cuatro semanas, con sesiones realizadas de tres a cuatro veces por semana a una intensidad del 80-90 % de la FCmáx. Las pruebas de aptitud física incluyeron resistencia, fuerza, flexibilidad, agilidad, equilibrio, velocidad y potencia, mientras que la motivación se evaluó mediante un cuestionario validado con escala de Likert.
Resultados: Los resultados mostraron mejoras significativas ($p < 0,05$) en ambos grupos experimentales, y el grupo de HIIT en el agua logró las mayores mejoras en resistencia (+19,3 %), flexibilidad (+4,3 %) y motivación (+12,2 %).
Discusión: Estos resultados indican que el entorno acuático mejora la eficacia del entrenamiento al optimizar la adaptación fisiológica y la motivación intrínseca. Además, ambos modelos de entrenamiento influyen positivamente en el nivel de motivación de las atletas, ya que las participantes manifestaron mayores niveles de disfrute y compromiso durante las sesiones de entrenamiento.
Conclusión: Estos hallazgos indican que la integración del HIIT en tierra y en el agua utilizando cuerdas elásticas puede constituir una estrategia de entrenamiento eficaz e innovadora para mejorar el rendimiento físico y la motivación entre las jugadoras de voleibol. Este estudio ofrece implicaciones prácticas para los entrenadores e instructores deportivos a la hora de diseñar programas de acondicionamiento variados y eficientes para las jugadoras de voleibol.

Palabras clave

Entrenamiento interválico de alta intensidad; bandas elásticas; entrenamiento acuático; condición física; motivación; voleibol; atletas femeninas.

Introduction

Physical conditioning and motivation are two fundamental determinants of athletic performance and long-term development in volleyball, (Hammami et al., 2022). A well-structured physical training program enhances physiological capacity, (Id et al., 2024) while motivation sustains effort, commitment, and persistence toward achieving performance goals. Among various physical conditioning strategies, High-Intensity Interval Training (HIIT) has gained increasing recognition as a time-efficient and evidence-based method for improving endurance, speed, and muscular strength across athletic populations, (Wang et al., 2026).

In recent years, elastic bands have been incorporated into HIIT programs to introduce variable resistance and stimulate neuromuscular adaptation. Compared with traditional free-weight training, elastic band–based HIIT is portable, (Stankovic et al., 2023) cost-effective, and adaptable to different training environments Previous findings indicate that elastic resistance training enhances explosive power, balance, (Al-rahmad et al., 2026) and coordination without substantially increasing body mass, suggesting predominant neural rather than hypertrophic adaptation, (Saúl & Vadivieso, 2026). For this reason, elastic band exercises have been widely recommended for volleyball athletes, whose performance depends heavily on speed, power, and motor control, (Spiering et al., 2023).

The main characteristics of HIIT, (Babiloni-lopez et al., 2022) in volleyball are: a) power, b) speed, c) accuracy of hits, d) precise timing of hits, and e) precise angles of hits in volleyball, (Stankovi, 2025). In this regard, training methods, training duration, and various training models are categorized as HIIT, including heart rate duration, power output, effort level, (Setyawati & Pramono, 2025) and playing strategies in volleyball, (Id et al., 2024).

The PICOS framework is used in evidence-based practice research, which means formulating research questions systematically, (Chen et al., 2026). In the context of volleyball learning, PICOS is certainly very helpful in designing learning research, HIIT methods, training methods, or types of student learning outcome evaluations, (Han et al., 2026). PICOS consists of P (population), I (intervention), C (component), O (outcomes), and S (study design), (Trybulski et al., 2026).

Meanwhile, water-based exercise offers unique physiological and psychological benefits, (Zhao et al., 2026). The buoyancy of water reduces impact stress on joints, while its hydrostatic pressure and multidirectional resistance increase muscular activation and energy expenditure, (Wang et al., 2026). These biomechanical conditions make aquatic training suitable not only for rehabilitation but also for enhancing endurance, flexibility, and psychological well-being, (Mao et al., 2026). Recent studies have also reported that aquatic exercise improves both mood and motivation through a more enjoyable training experience, (Medicine, 2026). From the perspective of Self-Determination Theory (Deci & Ryan), such environments fulfill athletes' needs for competence, autonomy, and social connection, which together foster intrinsic motivation and sustained engagement, (Yuan et al., 2026).file://C:\Users\mm\Documents\4. Kump Jurnal Internasional - Nasional\00. A-Journal Internasional Terindex Sqopuss, Schimago JR\00. Journal Retoss Spanyol_Prof. Juanz\04. Journal King Ruman_Cilacap\File revisi per-04 Feb 2026\(Barbosa Cano & Gomez-Baya, 2025).

Despite substantial evidence supporting both HIIT and aquatic exercise, few studies have directly compared the effects of HIIT using elastic bands performed on land versus in water, particularly among young female volleyball athletes, (Zhu, 2026). Most prior investigations have examined these modalities independently or within other sports such as swimming, handball, and consequently, (Spiering et al., 2023) limited data exist on how different training environments influence the physical and motivational responses of volleyball players to high-intensity interval training, (Plúas, 2025).

This study aims to analyze the impact of High Intensity Interval Training (HIIT) using elastic bands conducted on land and in water on the physical condition and motivation of female volleyball athletes, (Sabea et al., 2025) so that the expected results can improve the power, volley technique, flexibility, agility, and motivation of female volleyball players, (Saúl & Vadivieso, 2026).

This study addresses that gap by examining the effects of HIIT using elastic bands performed on land and in water on the physical condition and motivation of female volleyball athletes in Pangandaran, Indonesia. By employing a quasi-experimental design, this research aims to determine which training environment produces greater improvements in both physiological and motivational outcomes. It was hypothesized that HIIT performed in water would yield significantly higher improvements in endurance, flexibility, and athlete motivation compared with HIIT performed on land. The findings are expected to contribute to evidence-based practice and provide practical insights for coaches seeking efficient and motivating conditioning programs for developing athletes.

Method

This study employed a quasi-experimental design with a pre-test–post-test control group approach. The design was selected to observe changes in physical and motivational variables before and after the intervention, and to identify differences between training methods, (Jatmiko et al., 2025). Three groups were involved: the first experimental group performed High-Intensity Interval Training (HIIT) with elastic bands on land; (Hamilton & Finley, 2020) the second experimental group performed the same protocol in water; and a control group continued their regular volleyball practice without additional training. This design minimized external factors that could influence the outcomes and allowed for reliable comparison across treatments, (Smith & Hasan, 2020).

Participants

The study participants consisted of 110 female volleyball players from the Jaya Surya Volleyball Club in Pangandaran, Indonesia. Since the total population was less than 120 athletes, total sampling was used so that all members could fully participate as research subjects. The average characteristics of the athletes were height 180 ± 4.5 cm, weight 65 ± 3.8 kg, and age 19 ± 1.2 years. The normality test showed that all data were normally distributed ($p > 0.05$), ensuring the homogeneity of the sample before intervention. All participants were given an explanation of the research objectives, procedures, and ethical considerations. Participation was voluntary, and written consent was obtained prior to data collection. Ethical approval was granted by the Research Ethics Committee of Semarang State University, and all participants were deemed eligible for the study.

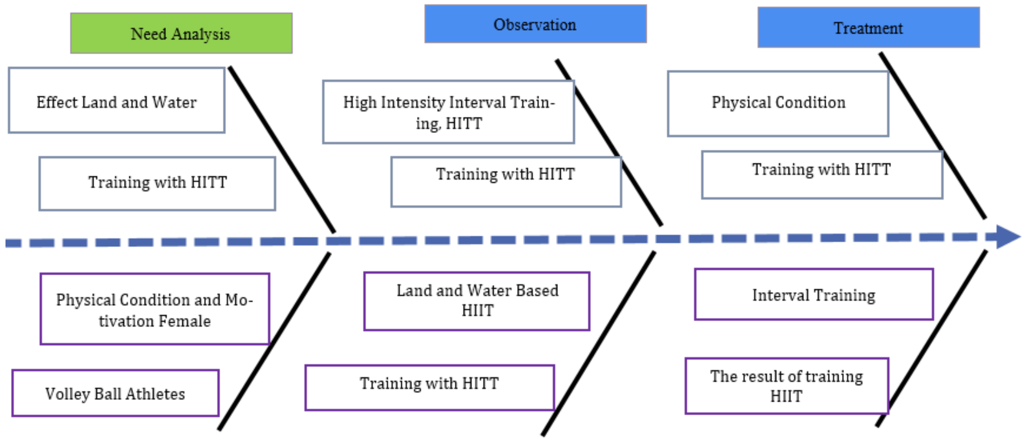
Procedure

The experimental procedure consisted of three stages: pre-test, training intervention, and post-test. The pre-test assessed baseline physical condition and motivation. The intervention phase lasted four weeks, with three to four sessions per week, each lasting 30–60 minutes. Training intensity is maintained between 80%–90% of maximum heart rate (HRmax) using heart rate monitoring. The post-test is conducted immediately after the last session to measure performance changes in all variables. Both experimental groups follow an identical training structure, differing only in the training environment, while the control group follows standard volleyball sessions without HIIT guidelines. Group allocation is done as a control group (comparison) and an experimental group (treatment). The club name is Pangandaran Volley Ball.

Data analysis

All quantitative data were analyzed using statistical tests and presented descriptively and inferentially. The Kolmogorov–Smirnov test confirmed the normality of the data ($p > 0.05$). Paired t-tests were applied to identify significant differences between pre-tests and post-tests in each group, while independent t-tests were used to compare post-test differences between groups. The entire series of tests used t-tests and ANOVA tests. In addition, multiple linear regression analysis was also performed to determine the contribution of HIIT to changes in motivation. The analysis showed that HIIT was responsible for 61.2% of the variance in motivation ($R^2 = 0.612$), with the water-based program showing a higher regression coefficient ($\beta = 0.688$) than the land-based program ($\beta = 0.412$). The entire series used t-tests, ANOVA tests, and post hoc tests. Statistical significance was set at $p < 0.05$ for all analyses.

Figure 1. Flow Diagram



Training Protocol

The HIIT protocol consists of three stages: warm-up, high-intensity exercise, and cool-down, with a training duration of three times a week. The warm-up lasts for three minutes, followed by six cycles of high-intensity activity. Each cycle consists of two minutes of maximum effort at 80%–90% HRmax, followed by one minute of active recovery at 50%–60% HRmax. The session ends with a three-minute cool-down. The workout uses elastic bands to provide progressive resistance targeting upper and lower muscle groups. Movements include squats, lunges, vertical jumps, push-ups, sit-ups, and shuttle runs, all adapted for land and water conditions. The intensity of the training is adjusted to the participants' abilities, including the training volume of three times a week, training density and complexity, and the appropriate training mode. For the aquatic group, training is conducted in waist- to chest-deep water to maintain sufficient resistance and buoyancy, thereby reducing the impact on the joints while maintaining muscle load.

Measurement Instruments

Two categories of instruments were used: test-based measures for physical performance and non-test measures for motivation. Physical condition was assessed using standardized field tests covering eight key components of fitness, (Elwy et al., 2020). All measurements followed established protocols, and each test was performed three times, with the best result used for analysis, (Smith & Hasan, 2020).

Table 1. Physical condition tests and measured components

No.	Test name	Component measured	Instrument / measurement method
1	Multistage Fitness Test (Bleep Test)	Endurance	MFT audio, cones, 20 m track
2	Push-Up Test	Upper body strength	Stopwatch
3	Sit-Up Test	Abdominal strength	Stopwatch
4	60-Meter Sprint	Speed	Stopwatch
5	Sit and Reach Test	Flexibility	Sit-and-reach bench with ruler
6	Stork Stand Test	Balance	Stopwatch
7	Shuttle Run (4×5 m)	Agility	Stopwatch
8	Vertical Jump Test	Explosive power	Vertical jump scale board

Note: All tests followed standardized field procedures. The highest score from three trials was recorded as the final result. Sources:

Motivation was measured using a Likert-scale questionnaire adapted from Suharsimi Arikunto (2010). The instrument evaluated three dimensions of motivation: intrinsic (internal drive, enjoyment, personal achievement), extrinsic (external rewards, recognition, competition), and social (cooperation, teamwork, sense of belonging). The questionnaire was administered to all groups before and after the four-week intervention.

Results

Participant Characteristics A total of 110 female volleyball athletes from the Jaya Surya Volleyball Club in Pangandaran, Indonesia, participated in the study. All participants completed the training protocol and post-test evaluations. The mean age of participants was 19.0 ± 1.2 years, the mean height was 180.0 ± 4.5 cm, and the mean body weight was 65.0 ± 3.8 kg. All participants were high school students with similar educational backgrounds and training experience (3–5 years in organized volleyball). The homogeneity test using one-way ANOVA showed no significant differences among the three groups ($p > 0.05$) for all demographic and anthropometric variables. This confirms that the groups were statistically equivalent before the intervention, ensuring that subsequent differences could be attributed to the HIIT programs.

Table 2. Baseline characteristics of participants (N = 110)

Variable	Land-based HIIT (n=36)	Water-based HIIT (n=36)	Control (n=38)	p-value
Age (years)	19.1 ± 1.3	18.9 ± 1.1	19.0 ± 1.2	0.721
Height (cm)	179.8 ± 4.3	180.1 ± 4.5	180.2 ± 4.7	0.866
Weight (kg)	65.1 ± 3.6	65.3 ± 3.9	64.8 ± 4.0	0.793
Training experience (years)	4.1 ± 0.8	4.0 ± 0.7	4.2 ± 0.9	0.675
Education level	High school	High school	High school	—

Note: Values are presented as mean ± standard deviation (SD). The p-value was obtained from one-way ANOVA for testing group homogeneity. No significant differences were observed ($p > 0.05$).

Based on the results shown in the table above, it can be seen that: Age (years) for land-based HIIT (n=36) was 19.1 ± 1.3, water-based HIIT 18.9 ± 1.1, control 19.0 ± 1.2, and p-value 0.721. Then, Height (cm) for land-based HIIT (n=36) was 179.8 ± 4.3, water-based HIIT 180.1 ± 4.5, control 180.2 ± 4.7, and p-value 0.866. Then, weight (kg) for land-based HIIT (n=36) was 65.1 ± 3.6, water-based HIIT 65.3 ± 3.9, control 64.8 ± 4.0, and p-value 0.793. Then, training experience (years), land-based HIIT (n=36) was 41.08 ± 0.0, water-based HIIT was 4.0 ± 0.7, control was 4.2 ± 0.9, and p-value was 0.675. Education level, high school.

The results confirm that all participant groups were comparable in age, physical profile, and training experience prior to the experimental treatment, fulfilling the assumption of homogeneity.

Main Outcomes of HIIT Interventions

Following four weeks of training, both experimental groups demonstrated notable improvements in nearly all components of physical fitness and athlete motivation. Table 3 shows the mean scores of pre-test and post-test data, as well as the percentage of improvement for each test variable. The water-based HIIT group exhibited the highest relative gains, particularly in endurance, flexibility, and motivation indicators.

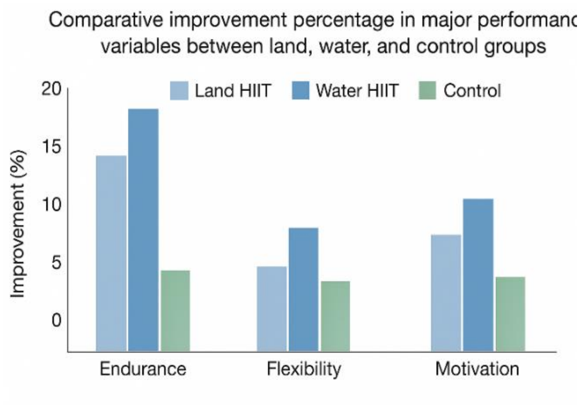
Table 3. Pre- and post-test results and improvement percentage for physical and motivational variables

Variable	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Improvement (%)	t-value	p-value
Endurance (Bleep Test)	Land HIIT	61.08 ± 4.67	71.12 ± 2.12	16.4%	3.81	0.000
	Water HIIT	62.01 ± 2.12	74.03 ± 1.87	19.3%	4.12	0.000
	Control	61.02 ± 4.67	61.11 ± 3.92	0.1%	0.12	0.903
Push-Up Strength	Land HIIT	61.03 ± 4.31	63.02 ± 4.87	3.3%	2.46	0.018
	Water HIIT	63.02 ± 4.12	66.08 ± 3.91	4.8%	2.78	0.010
	Control	62.02 ± 4.11	62.00 ± 3.97	0.0%	0.07	0.945
Flexibility (Sit & Reach)	Land HIIT	71.02 ± 0.09	73.01 ± 0.10	2.8%	2.92	0.006
	Water HIIT	72.01 ± 0.10	75.13 ± 0.09	4.3%	3.84	0.000
	Control	63.01 ± 0.09	63.02 ± 0.08	0.0%	0.21	0.835
Motivation (total score)	Land HIIT	80.25 ± 4.33	88.90 ± 3.92	10.8%	3.75	0.001
	Water HIIT	81.02 ± 3.87	90.93 ± 3.41	12.2%	4.12	0.000
	Control	80.11 ± 4.22	80.25 ± 4.11	0.2%	0.15	0.881

Note: Values represent mean ± standard deviation (SD). Improvement (%) = [(Post − Pre) / Pre] × 100. Paired-sample t-tests were used to assess within-group differences; $p < 0.05$ was considered statistically significant.

Both land and water HIIT groups demonstrated significant gains ($p < 0.05$) across all physical and motivational domains, while the control group showed no significant improvement. The largest improvement was observed in endurance (+19.3%) and motivation (+12.2%) in the water-based HIIT group, confirming that aquatic training conditions provided additional performance benefits.

Figure 2. Comparative improvement percentage in major performance variables between land, water, and control groups



The figure above shows the percentage change in key fitness indicators (endurance, flexibility, motivation) after four weeks of HIIT training. The water-based HIIT group showed greater improvement in all three aspects, with the largest differences in endurance (19.3%) and motivation (12.2%), compared to the land-based HIIT group and the control group.

Statistical analysis proved that both HIIT methods significantly improved the physical performance and motivation of volleyball athletes ($p < 0.05$). However, the water-based HIIT group consistently outperformed the land-based HIIT group in all variables, especially endurance, flexibility, and motivation. Multiple regression models also showed that HIIT explained 61.2% of the variance in motivation (R^2 = 0.612), with water-based HIIT contributing more strongly (β = 0.688) than land-based training (β = 0.412). The final results indicate that training patterns in an aquatic environment can not only improve physiological parameters but also strengthen psychological engagement, suggesting that water-based HIIT offers an optimal combination of physical stimulus and motivational reinforcement for young female volleyball athletes.

Discussion

The results of this study revealed that High-Intensity Interval Training (HIIT) using elastic bands, performed both on land and in water, significantly improved the physical condition and motivation of female volleyball athletes. However, the magnitude of improvement was greater in the water-based HIIT group, particularly in endurance, flexibility, and motivation. These findings emphasize that the training environment plays a decisive role in shaping both physiological adaptations and psychological responses to high-intensity exercise.

Overall, the research findings related to endurance, flexibility, and motivation show that statistical analysis proves that both HIIT methods significantly improve the physical performance and motivation of volleyball athletes ($p < 0.05$). However, the water-based HIIT group consistently outperformed the land-based HIIT group in all variables, especially endurance, flexibility, and motivation. The multiple regression model also showed that HIIT explained 61.2% of the variance in motivation (R^2 = 0.612), with water-based HIIT contributing more strongly (β = 0.688) than land-based training (β = 0.412). The final results indicate that training patterns in an aquatic environment can not only improve physiological parameters but also strengthen psychological engagement, suggesting that water-based HIIT offers an optimal combination of physical stimulus and motivational reinforcement for young female volleyball athletes.

The superior results in the aquatic HIIT group can be explained by several biomechanical and physiological mechanisms. Water provides multidirectional resistance that increases muscle activation while reducing joint stress through buoyancy. This dual effect enables athletes to perform at higher cardiovascular intensity with lower perceived fatigue, allowing greater training volume and recovery efficiency reported that aquatic resistance training enhances both aerobic and anaerobic capacity due to hydrostatic pressure and turbulence, which intensify cardiovascular load and oxygen uptake. Similarly, confirmed that hydro-based HIIT elicits comparable or greater improvements in endurance and muscular performance than equivalent land-based protocols.

The improvement in flexibility observed in the water-based group aligns with findings by , who emphasized that the multidirectional flow of water facilitates joint mobility and dynamic stretching. In the current study, participants in the aquatic group achieved a 4.3% increase in flexibility compared with 2.8% in the land-based group. This difference may be attributed to enhanced neuromuscular coordination and proprioceptive feedback, both of which are stimulated by fluid dynamic resistance during underwater movement.

Motivation outcomes further highlight the psychological advantages of the aquatic setting. Training in water fosters enjoyment, reduces perceived exertion, and encourages social interaction — factors known to strengthen intrinsic motivation. According to *Self-Determination Theory* (Deci & Ryan), environments that satisfy athletes' needs for competence, autonomy, and relatedness promote higher intrinsic motivation and long-term engagement. The buoyant, low-impact nature of water allows athletes to focus more on skill execution and less on discomfort, leading to positive affective responses and sustained participation. These results are consistent with C:\Users\mm\Documents\4. Kump Jurnal Internasional - Nasional\00. A-Journal Internasional Terindex Sqopuss, Schimago JR\00. Journal Retoss Spanyol_Prof. Juanz\04. Journal King Ruman_Cilacap\File revisi per-04 Feb 2026\(Yang et al., 2024), who found that enjoyable and novel training contexts enhance athlete motivation and adherence. Similarly, demonstrated that motivation acts as a mediating factor linking training intensity to performance outcomes, reinforcing the interactive relationship between psychological and physiological adaptation, (Hafidz, 2025).

From a physiological standpoint, the higher endurance gain in the aquatic HIIT group (+19.3%) compared with the land-based group (+16.4%) reflects amplified cardiovascular adaptations. HIIT protocols are known to stimulate both central mechanisms (cardiac output, stroke volume) and peripheral mechanisms (capillary density, mitochondrial function). In aquatic environments, hydrostatic pressure increases venous return and cardiac preload, producing greater cardiac efficiency. Confirmed that aquatic interval training improves recovery kinetics and aerobic performance more effectively than similar land-based routines. This evidence supports the present finding that aquatic HIIT elicits more pronounced endurance adaptations.

The significant improvements in upper and abdominal strength across both experimental groups validate the effectiveness of elastic resistance within HIIT frameworks, (López-serrano, 2025). Elastic bands provide progressive tension throughout the range of motion, enhancing stabilizer muscle activation and improving intramuscular coordination further noted that resistance-band HIIT reduces muscle imbalance and enhances lower-limb power, crucial for explosive volleyball actions such as spiking and blocking. These findings confirm that elastic resistance training is a viable, low-risk alternative to free-weight methods, particularly in sports requiring rapid power generation and agility, (Muharram, 2025).

The regression analysis strengthens this interpretation by demonstrating that the aquatic HIIT group showed a higher regression coefficient ($\beta = 0.688$) than the land-based group ($\beta = 0.412$), indicating that environmental engagement amplifies the physiological benefits of training. This aligns with the biopsychosocial model of sports performance, which posits that physical, psychological, and social dimensions interact dynamically to shape athletic outcomes.

Overall, the current study contributes new evidence by integrating both physiological and motivational dimensions within one experimental framework. Whereas previous research often examined physical or psychological outcomes separately, the present findings demonstrate how environmental context and training design jointly determine adaptation efficiency. This holistic perspective underscores the importance of considering environmental enrichment — such as the aquatic medium — as a tool to optimize performance, motivation, and well-being among competitive athletes.

Practical Implications

The results have important implications for coaches, sports scientists, and athletic trainers developing integrated conditioning programs for volleyball players. Implementing HIIT with elastic bands in water provides a time-efficient and safe strategy that simultaneously enhances endurance, flexibility, and motivation. The reduced mechanical load and buoyant resistance make this method particularly valuable during in-season training and rehabilitation, helping maintain conditioning while minimizing fatigue and injury risk. Coaches can also use aquatic HIIT to increase athlete engagement and enjoyment, which are crucial for sustaining long-term development.

For sports organizations and training academies, incorporating aquatic HIIT into regular conditioning cycles can improve both physical and psychological resilience. This interdisciplinary approach aligns with contemporary sports science emphasizing balanced development between physiological performance and mental well-being. Therefore, water-based HIIT should be considered a scientifically supported, enjoyable, and effective complement to traditional land-based training for volleyball and similar high-impact sports.

Limitations and Future Research

Several limitations should be acknowledged. First, the study focused solely on female volleyball athletes from a single club in Pangandaran, Indonesia, which may limit generalizability across other populations or competition levels. Second, the intervention duration was relatively short (four weeks), so long-term retention of the observed improvements remains uncertain. Third, although valid field tests were employed, the absence of advanced physiological assessments—such as heart rate variability, lactate concentration, or electromyography—limits the depth of mechanistic interpretation. Lastly, motivational outcomes were derived from self-reported questionnaires, which could be influenced by response bias.

Future studies should expand the scope by including male athletes, mixed-gender teams, and participants from diverse sports requiring high power and endurance. Longer interventions could reveal the sustainability of performance and motivational adaptations. Moreover, the integration of biomechanical and physiological monitoring tools—such as motion sensors, wearable trackers, and metabolic analyzers—would yield richer data on training loads and recovery dynamics. Research exploring variations in water depth, temperature, and resistance intensity could identify optimal aquatic HIIT parameters. Finally, longitudinal studies assessing competition performance and injury incidence after aquatic HIIT would further validate its long-term practical utility.

High-Intensity Interval Training (HIIT) exercises using elastic bands increase the leg muscle power of female volleyball athletes by the intervention lasted four weeks, with sessions conducted three to four times per week at an intensity of 80–90% HRmax. Physical condition tests included endurance, strength, flexibility, agility, balance, speed, and power, while motivation was assessed through a validated Likert-scale questionnaire. The results showed significant improvements ($p < 0.05$) in both experimental groups, with the water-based HIIT group achieving the highest gains in endurance (+19.3%), flexibility (+4.3%), and motivation (+12.2%). These findings indicate that the aquatic environment enhances training effectiveness by optimizing physiological adaptation and intrinsic motivation. Therefore, water-based HIIT with elastic resistance represents an efficient and psychologically engaging conditioning method for volleyball athletes.

This study concludes that High-Intensity Interval Training (HIIT) using elastic bands is an effective strategy for improving both the physical performance and motivation of volleyball athletes. However, the findings clearly indicate that performing HIIT in an aquatic environment produces superior results compared with land-based training. The multidirectional resistance of water optimizes cardiovascular and neuromuscular adaptation while reducing mechanical stress on the joints. Simultaneously, the buoyant and stimulating aquatic setting enhances intrinsic and extrinsic motivation by increasing enjoyment, reducing perceived exertion, and fostering social interaction. The study showed that water-based HIIT resulted in greater improvements in endurance (+19.3%), flexibility (+4.3%), and motivation (+12.2%) than land-based HIIT. These results confirm that environmental factors play a critical role in the efficiency of training adaptations. The superior performance of the aquatic group aligns with physiological evidence that hydrodynamic resistance enhances oxygen utilization and muscular coordination, and with psychological theory—particularly Self-Determination Theory—which explains that supportive environments strengthen motivation and engagement.

Collectively, these findings provide robust empirical support for incorporating aquatic HIIT with elastic resistance into volleyball conditioning programs. This approach not only improves physical capabilities but also nurtures sustained motivation, which is essential for long-term athletic development. Coaches and practitioners are encouraged to integrate alternating cycles of land and water-based HIIT to achieve an optimal balance between performance enhancement, recovery, and athlete well-being.

Conclusions

High-Intensity Interval Training (HIIT) exercises using elastic bands increase the leg muscle power of female volleyball athletes by the intervention lasted four weeks, with sessions conducted three to four times per week at an intensity of 80–90% HRmax. Physical condition tests included endurance, strength, flexibility, agility, balance, speed, and power, while motivation was assessed through a validated Likert-scale questionnaire. The results showed significant improvements ($p < 0.05$) in both experimental groups, with the water-based HIIT group achieving the highest gains in endurance (+19.3%), flexibility (+4.3%), and motivation (+12.2%). These findings indicate that the aquatic environment enhances training effectiveness by optimizing physiological adaptation and intrinsic motivation. Therefore, water-based HIIT with elastic resistance represents an efficient and psychologically engaging conditioning method for volleyball athletes.

This study concludes that High-Intensity Interval Training (HIIT) using elastic bands is an effective strategy for improving both the physical performance and motivation of volleyball athletes. However, the findings clearly indicate that performing HIIT in an aquatic environment produces superior results compared with land-based training. The multidirectional resistance of water optimizes cardiovascular and neuromuscular adaptation while reducing mechanical stress on the joints. Simultaneously, the buoyant and stimulating aquatic setting enhances intrinsic and extrinsic motivation by increasing enjoyment, reducing perceived exertion, and fostering social interaction. The study showed that water-based HIIT resulted in greater improvements in endurance (+19.3%), flexibility (+4.3%), and motivation (+12.2%) than land-based HIIT. These results confirm that environmental factors play a critical role in the efficiency of training adaptations. The superior performance of the aquatic group aligns with physiological evidence that hydrodynamic resistance enhances oxygen utilization and muscular coordination, and with psychological theory—particularly Self-Determination Theory—which explains that supportive environments strengthen motivation and engagement.

Collectively, these findings provide robust empirical support for incorporating aquatic HIIT with elastic resistance into volleyball conditioning programs. This approach not only improves physical capabilities but also nurtures sustained motivation, which is essential for long-term athletic development. Coaches and practitioners are encouraged to integrate alternating cycles of land and water-based HIIT to achieve an optimal balance between performance enhancement, recovery, and athlete well-being.

Acknowledgements

My research was supported by the Center for Education Finance Services (PUSLAPDIK) and the Education Fund Management Agency (LPDP). I would like to take this opportunity to thank the Rector of Universitas Negeri Semarang, Indonesia, LPDP, BPI, and BPPT of the Republic of Indonesia, the partner high schools in Pangandaran, West Java, Indonesia, the rest of the research team, and the publisher of Retos, Spanish.

Financing

My research was supported by the Center for Financing and Assessment of Higher Education (PPAPT),

Ministry of Higher Education, Science, and Technology (Kemdiktisaintek) and the Education Fund Management Agency (LPDP) Republic of Indonesian.

References

Al-rahmad, A. H., Sofyan, H., Usman, S., Kuala, U. S., Kemenkes, P., & Kuala, U. S. (2026). Effectiveness of Obesicare application use in promoting healthy eating behaviours : a quasy-experimental study in Aceh , Indonesia. 2026, 598–614.

Babiloni-lopez, C., Gene-morales, J., Saez-berlanga, A., Ramirez-campillo, R., Moreno-murcia, J. A., & Colado, J. C. (2022). The Use of Elastic Bands in Velocity-Based Training Allows Greater Acute External Training Stimulus and Lower Perceived Effort Compared to Weight Plates.

Chen, Y., Zhang, X., Han, B., Mo, T., Gou, Q., Zhang, Q., & Guo, C. (2026). Acute Effects of Floss Band at Different Pressures on Multidimensional Ankle Stability in Patients with Chronic Ankle Instability : A Randomized Controlled. September 2025, 1–15.

Elwy, A. R., Wasan, A. D., Gillman, A. G., Johnston, K. L., Dodds, N., McFarland, C., & Greco, C. M. (2020). Using formative evaluation methods to improve clinical implementation efforts: Description and an example. Psychiatry Research, 283(April 2019), 112532. https://doi.org/10.1016/j.psychres.2019.112532

Hafidz, A. (2025). El efecto de una bebida de bicarbonato de sodio en la recuperación de la fatiga anaeróbica y del ácido láctico después del ejercicio extenuante The Effect of a Sodium Bicarbonate Drink on the Recovery of Anaerobic Fatigue and Lactic Acid After Exhausting . 2025, 841–849.

Hamilton, A. B., & Finley, E. P. (2020). Reprint of: Qualitative methods in implementation research: An introduction. Psychiatry Research, 283(April 2019), 112629. https://doi.org/10.1016/j.psychres.2019.112629

Hammami, R., Gene-Morales, J., Abed, F., Selmi, M. A., Moran, J., Colado, J. C., & Rebai, H. H. (2022). An eight-weeks resistance training programme with elastic band increases some performance-related parameters in pubertal male volleyball players. Biology of Sport, 39(1), 219–226. https://doi.org/10.5114/BIOLSPORT.2021.101601

Han, X., Chen, J., Xu, W., Trybulski, R., & Clemente, F. M. (2026). Comparing The Effects of Small-Sided Handball Games and High-Intensity Interval Training on The Physical Health and Fitness of Untrained Individuals : A 16-Week Randomized Controlled Study. February, 16–33.

Id, Y. L., Abdullah, B. Bin, Bin, H., & Saad, A. (2024). Effects of high-intensity interval training on strength , speed , and endurance performance among racket sports players : A systematic review. 1–19. https://doi.org/10.1371/journal.pone.0295362

Jatmiko, T., Sidik, R. M., Kusnanik, N. W., Utami, T. S., Labib, M., Ar, S., & Aji, W. R. (2025). How to cite in APA Keywords Resumen Palabras clave As one of the popular team sports , volleyball has been played in almost all countries in the world (Car- Method Study Design This study is a quasi-experimental study with a comparative study design . Th. 2025, 192–200.

López-serrano, C. (2025). Time-out impact on performance and scoring dynamics in boys ' youth volleyball Impacto del tiempo muerto en el rendimiento y la dinámica de puntuación en el voleibol juvenil masculino Authors How to cite in APA Keywords Resumen Palabras clave. 2025, 1086–1097.

Mao, Y., Chen, Z., Marcos-frutos, D., Li, Z., & Huang, S. (2026). Evaluating Velocity-Based Approaches for Predicting One-Repetition Maximum in The Snatch. February, 130–137.

Medicine, P. S. (2026). Vibration Rolling , Non-Vibration Rolling , and Static Stretching for Delayed- Onset Muscle Soreness on Physiological Changes and Recovery of Athletic Performance in Runners. February, 149–158.

Muharram, N. A. (2025). Desarrollo de una pulsera de detección de frecuencia cardíaca basada en IoT para el entrenamiento de resistencia en voleibol Authors Development of IoT-based pulse rate detection bracelet for volleyball endurance training Abstract How to cite in APA Keywo. 2025, 931–940.

Plúas, C. W. (2025). Análisis de datos longitudinales en estudios sobre salud pública y hábitos deportivos Autores Resumen Cómo citar en APA Palabras clave Keywords Introducción. 2025, 1343–1351.

Sabea, N. M., Abdalkarem, A. A., Raad, S., Albayati, Y., Shlaka, I., & Alshaher, A. (2025). How to cite in APA Keywords Resumen Palabras clave Research problem Research objective Research hypotheses. 2025, 1360–1367.

Saúl, G., & Vadivieso, E. (2026). Eficiencia metabólica y demanda cardiovascular : análisis comparativo entre Yoga y HIIT en varones de mediana edad Autores Resumen Cómo citar en APA Palabras clave Keywords Introducción. 2026, 412–423.

Setyawati, H., & Pramono, H. (2025). Development of a web-based athletic sports learning model in sports talent schools Desarrollo de un modelo de aprendizaje deportivo basado en la web en escuelas de talentos deportivos Authors How to cite in APA Keywords Resumen Palabras clave. 2025, 1018–1031.

Smith, J. D., & Hasan, M. (2020). Quantitative approaches for the evaluation of implementation research studies. Psychiatry Research, 283(August 2019), 112521. https://doi.org/10.1016/j.psychres.2019.112521

Spiering, B. A., Clark, B. C., Schoenfeld, B. J., Foulis, S. A., & Pasiakos, S. M. (2023). Maximizing Strength: The Stimuli and Mediators of Strength Gains and Their Application to Training and Rehabilitation. Journal of Strength and Conditioning Research, 37(4), 919–929. https://doi.org/10.1519/JSC.0000000000004390

Stankovi, D. (2025). Effects of Elastic Band Training on Physical Performance in Team Sports : A Systematic Review and Meta-Analysis. 1–14.

Stankovic, M., Djordjevic, D., Trajkovic, N., & Milanovic, Z. (2023). Effects of High - Intensity Interval Training (HIIT) on Physical Performance in Female Team Sports : A Systematic Review. Sports Medicine - Open. https://doi.org/10.1186/s40798-023-00623-2

Trybulski, R., Olaniszyn, G., Matuszczyk, F., Gałęziok, K., & Vovkanych, A. (2026). Eccentric Training for Tendinopathies in Athletes : A Scoping Review and Evidence Gap Map. September 2025, 34–57.

Wang, Y., Luo, Z., Zhou, Z., & Zhang, X. (2026). Physical Activity Modifies the Association between C-Reactive Protein - Triglyceride - Glucose Index (CTI) and Dyslipidemia : Evidence from a 10-Year Chinese Cohort. February, 112–129.

Yuan, J., Zeng, Q., Wang, A., Zhang, Y., & Li, J. (2026). Machine Learning Applications in Non-Contact Lower Limb Sports Injury Prediction : A Systematic Review. September 2025, 172–194.

Zhao, Z., Liu, Y., & Xu, K. (2026). Optimizing Agility Training in Team Sport Players — The Role of Perception- Action Coupling : A Systematic Review with Multi-Level Meta-Analysis. February, 84–111.

Zhu, D. (2026). Scoring and Possession Small-Sided Games Elicit *Distinct 48-Hour Muscle Damage and Neuromuscular Responses in Basketball Athletes*. February, 221–234.

Authors and translators' details:

Ruman	ruman89@students.unnes.ac.id	Author
Heny Setyawati	henysetyawati@mail.unnes.ac.id	Corresponding/ Author
Nasuka	nasuka@mail.unnes.ac.id	Author
Siti Baitul Mukarromah	sitibaitul@mail.unnes.ac.id	Translator