

Training Load Quantification for Blood Pressure Management in Former Competitive Athletes Following Detraining: An Analytical Review

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Abstract

Detraining may adversely affect cardiovascular health in former competitive athletes by reducing cardiorespiratory fitness and contributing to elevated blood pressure. This analytical review evaluates the effectiveness of training-load quantification in regulating systolic and diastolic blood pressure among former athletes experiencing hypertension following the cessation of structured training. Five recent studies were examined across seven analytical domains: publication recency, participant characteristics, sampling procedures, exercise modality, blood pressure outcomes, participant age, and overall intervention effects. The evidence indicated that quantified combined training was associated with a greater reduction in systolic blood pressure (-6.04 mmHg) than aerobic training alone (-4.49 mmHg). By contrast, the available findings did not establish the superiority of high-intensity interval training for reducing diastolic blood pressure, primarily because of limited and inconsistent diastolic responsiveness. The reviewed studies further suggested that detraining contributes to increased blood pressure and diminished cardiorespiratory efficiency, highlighting the importance of considering athletes' previous training exposure when designing post-career exercise interventions. Rating of perceived exertion emerged as a practical and effective method for quantifying internal training load, monitoring accumulated fatigue, and estimating training strain. Overall, systematic load quantification may support the safe and individualized management of post-detraining hypertension in former

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competitive athletes. Nevertheless, the limited evidence base requires cautious interpretation. Future longitudinal and controlled experimental studies should examine former athletes directly, determine modality-specific dose–response relationships, and evaluate the long-term cardiovascular effects of quantified exercise programmes. Integrating perceived-exertion monitoring into sports clubs and providing coaches with appropriate training may enhance exercise safety, reduce the risk of excessive loading, and facilitate cardiovascular health management during and after athletic career transitions.

Keywords: training-load quantification; former competitive athletes; detraining; blood pressure; combined training; rating of perceived exertion; cardiovascular health

1. Introduction:

Detraining represents a natural physiological phenomenon in competitive athletes after training cessation, leading to a gradual decline in cardiovascular and respiratory adaptations. Recent evidence indicates this decline extends beyond reduced maximal aerobic capacity to encompass structural and functional changes, most notably elevated blood pressure and increased heart rate, ultimately decreasing cardiac output and performance (Frontiers in Physiology, 2024, p. 2). Although early sports participation is associated with lower hypertension risk (Yoshioka et al., 2022, p. 5), former athletes constitute a distinctive population; their prior "cardiac legacy" may invert into a risk factor without adequate training stimuli. Moker et al. (2023, p. 4) demonstrated that systolic ($r = -0.474$) and diastolic ($r = -0.540$) blood pressure responses to training were negatively correlated with detraining, with 65.5% of systolic responders becoming non-responders after cessation, while Pesova et al. (2023, p. 8) noted that exercise-induced blood pressure dynamics differ between athletes and the general population.

In recent years, training load quantification using objective indicators (TRIMP, RPE) has emerged as a fundamental tool for calibrating therapeutic exercise doses. Combined training achieves notable systolic reductions (Gao et al., 2023, p. 5), while high-intensity training improves cardiovascular risk factors more than moderate intensity, though detraining effects are more pronounced in high-intensity groups (Ávila-Gandía et al., 2023, p. 415). Multiple HIIT sessions enhance cardiometabolic adaptations (Costa-Pereira et al., 2024, p. 450). Furthermore, blood pressure responses vary across resistance training methods (Jurik et al., 2025, p. 52), and trained versus untrained hypertensives exhibit different acute responses (Banks et al., 2025, p. 2215). Post-exercise hypotension correlates with resting adaptations (Teixeira et al., 2024, p. 6), and variable load intensities necessitate precise quantification for safety (Resistance Training to Muscle Failure, 2024, p. 2300). However, previous studies have predominantly focused on obese patients or elderly populations and have not paid sufficient attention to former athletes suffering from hypertension after training cessation. Accordingly, the central research problem asks: Does quantified training load within a structured therapeutic program lead to positive modification in blood pressure response (systolic and diastolic) in former competitive athletes suffering from hypertension after training cessation?

2. Hypotheses:

Based on the stated problem, the following hypotheses were formulated:

❖ **First Hypothesis:** The application of quantified combined training (aerobic and resistance) leads to a reduction in systolic blood pressure exceeding that produced by aerobic training alone in former athletes.

❖ **Second Hypothesis:** Precisely quantified High-Intensity Interval Training (HIIT) contributes to greater improvement in diastolic blood pressure compared to Moderate-Intensity Continuous Training (MICT).

❖ **Third Hypothesis:** Blood pressure response to quantified training load differs according to the athlete's prior training background, as previously trained individuals exhibit different pressure responses compared to untrained individuals when the same training program is applied.

3. Study Objectives:

This study aims to achieve a set of scientific objectives, which can be identified as follows:

- ❖ To identify the most common cardiovascular changes occurring in former athletes as a result of training cessation, and to analyze the implications of these changes on their blood pressure levels.
- ❖ To evaluate the effectiveness of training load quantification in modifying blood pressure response (systolic and diastolic) in former athletes with hypertension after training cessation.
- ❖ To determine the most effective training modalities for reducing blood pressure in former athletes when applied in a quantified manner, while analyzing response differences between previously trained and untrained individuals.

3.1. Literature Review:

• Study One: Zouaghi Khalifa and Colleagues (2021):

This study aimed to analyze and quantify the training loads applied to amateur football players during the winter break period, to determine the effectiveness of the RPE method (Foster's scale) in monitoring and tracking training load, and to identify appropriate intensity, volume, and density levels for this critical period of the sports season. The study adopted a descriptive-analytical approach, applying the Session-RPE method using Foster's modified scale (CR10) to measure daily and weekly training load. Monotony and training strain indices were calculated, with data collected 30 minutes after each training session. The study sample consisted of 20 players from an Algerian amateur team (Chabab Ain Fekroun, Third Division), aged 24.9 ± 4.71 years. The study was conducted during the winter break of the 2018-2019 season over 4 weeks. Results showed that the minimum weekly training load was 502 AU in the first week, while the maximum reached 1982.43 AU in the third week. Monotony ranged between 1.03 and 1.60, while training strain peaked in the third week (2675.7 AU). Volume gradually increased from the first to the third week, reaching 90 minutes, then decreased in the fourth week. Intensity was low at the beginning of preparation (UA 112), peaked in the third week (UA 678), then decreased in the final week (UA 80). The study concluded that the RPE method allows for monitoring and regulating training loads, and that the winter break period is divided into two phases: recovery and maintenance in the first week, and collective resumption of training in subsequent weeks (Zouaghi et al., 2021).

• Study Two: Edwards and Colleagues (2023):

This systematic review with network meta-analysis aimed to evaluate the effect of all relevant physical training modalities on resting blood pressure, to establish optimal practices for prescribing antihypertensive exercise, and to determine which modalities achieve the best results in reducing systolic and diastolic blood pressure. The study employed systematic review and network meta-analysis, searching PubMed, Cochrane Library, and Web of Science databases, including studies published between 1990 and February 2023. The final analysis included 270 randomized controlled trials, with a total of 15,827 adult participants of both sexes. Results demonstrated that all training modalities contribute to reducing systolic and diastolic blood pressure, with isometric training showing the best results according to SUCRA index (98.3%), followed by combined training, then aerobic and resistance training, while High-Intensity Interval Training ranked last in effectiveness. The study concluded that different training modalities improve resting blood pressure, with isometric training being the most effective (Edwards et al., 2023).

• Study Three: Mahfoudhi Mahmoud (2023):

This study aimed to measure training load and determine fatigue levels in under-19 football players using Foster's Rating of Perceived Exertion (RPE) method, to assess the feasibility of quantitative measurement of training load and fatigue level determination through this method, and to identify the

relationship between fatigue level and training load indicators. The study adopted a descriptive approach, applying the Session-RPE method using Foster's modified scale (CR10) to measure daily and weekly training load. Monotony, strain, and fitness indices were calculated, and the Hooper scale was used to determine fatigue levels. The study sample consisted of 16 players from the under-19 category of US Souk Ahras, purposively selected during March 2022. Results showed that the average weekly training load was 1550 ± 1195 arbitrary units, monotony ranged between 1.42 and 1.96, while strain ranged between 1697 and 2940 arbitrary units. Results also demonstrated a strong correlational relationship between fatigue level and training load ($r = 0.96$, $p < 0.01$), a moderate relationship between fatigue and strain ($r = 0.56$), while the relationship between fatigue and monotony was weak ($r = 0.42$). The study concluded that the RPE method enables quantitative measurement of training load and fatigue level determination, and that it is an effective, practical method requiring no expensive equipment (Mahfoudhi, 2023).

- **Study Four: Frontiers in Physiology (2024):**

This systematic review aimed to investigate the effects of detraining on cardiorespiratory, metabolic, hormonal, and muscular adaptations, as well as short- and long-term performance changes in endurance athletes, while determining the timeframes required for these changes to occur. The study employed a systematic review methodology, searching PubMed, Scopus, and Web of Science databases up to July 2023, including studies that focused on endurance athletes and reported detraining duration. Results showed that complete training cessation leads to decreased $VO_2\text{max}$ due to reduced blood and plasma volume. Cardiac changes include decreased left ventricular mass, volume, and wall thickness, with increased heart rate and blood pressure, ultimately resulting in decreased cardiac output and performance deterioration. At the metabolic level, decreased lactate threshold and muscle glycogen were observed, along with increased body weight and changes in respiratory exchange ratio. The review also concluded that data investigating detraining effects among endurance athletes are scarce, emphasizing the importance of this topic for specialists and researchers to determine optimal strategies for mitigating these effects (Frontiers in Physiology, 2024).

- **Study Five: Boussaad Amoura (2025):**

This study aimed to measure the effect of a quantified training program on certain physiological indicators (heart rate, systolic blood pressure, diastolic blood pressure) in under-17 football players, and to determine the effectiveness of the training program in modifying these indicators. The study adopted a pre-post experimental design, implementing an 8-week training program (3 sessions per week, 60 minutes per session). Variables were measured before and after the program using an OMRON M3 device. The program was presented to experts for validation, and a pilot study was conducted to confirm the validity and reliability of measurement tools. The study sample consisted of 301 players from the U17 category of Winner Sporting Club, purposively selected after excluding those with chronic diseases and obtaining medical clearance. Results showed statistically significant differences in heart rate between pre- and post-measurements favoring the post-measurement ($t = -14.500$, $p < 0.01$), with the mean increasing from 87.18 to 103.63 bpm. A significant decrease in systolic blood pressure was recorded from 120.00 to 116.91 mmHg ($t = 3.158$, $p < 0.01$), while no significant differences were found in diastolic blood pressure ($t = -0.591$, $p > 0.05$). The study concluded that physical exertion has a clear effect on heart rate and systolic blood pressure, and that monitoring these indicators is an important tool for evaluating training intensity and ensuring athlete safety (Boussaad, 2025).

4. Method and Materials:

❖ **Training:** The concept of training refers to a set of purposeful and organized efforts aimed at providing individuals or groups with information, knowledge, experiences, skills, performance methods, and sound practical and scientific attitudes, whether these are existing knowledge and skills

possessed by the individual or new ones they seek to acquire. This aims to enable them to perform their current function effectively and efficiently, and to prepare them for future job duties according to scientific plans that consider their training needs (Shtateha, 2019, p. 29).

❖ **Training Load:** Training load is considered the primary means of influencing the individual, leading to improvement in the functional and organic level of the body's various systems and organs, which positively reflects on the development of physical attributes, motor skills, tactical abilities, and volitional traits in the athlete. Training load is defined as the amount of impact experienced by the individual's organs and systems during physical activity. It is also defined as the physical and neural burden placed on various body systems, including the nervous, circulatory, respiratory, and muscular systems, among others that participate in performing intended physical activities (Al-Rawabdeh, 2011, p. 17).

Training load in the sports methodology is also defined as the practical work given to and applied upon the athlete, intended to be performed and executed, defined by the unit of work quantity represented in volume and intensity. In more general terms, training load can be defined as all targeted physiological, technical, tactical, and psychosocial requirements that determine the athlete's functional adaptations (Nattah, 2015, p. 4).

Training load is the sum of physical and neural influences applied to various body systems (nervous, circulatory, respiratory, muscular) during the training unit or competition, aiming to induce positive functional and structural adaptations. This load is determined by essential components: volume (quantity of work performed), intensity (degree of difficulty or speed), and density (relationship between work time and rest time). Training load can be quantified using objective indicators such as heart rate, Training Impulse (TRIMP), and Ratings of Perceived Exertion (RPE), or using subjective indicators such as perceived exertion, aiming to adjust the training dose according to the individual's capabilities and achieve desired effectiveness while avoiding risks of overtraining or injuries.

❖ **Sports Activity:** Sports activity is defined as a field within education in general and physical education in particular, serving as an effective element in individual preparation by providing motor experiences and skills. It also leads to physical, psychological, social, and moral guidance and development, representing the positive aspect of serving the individual through serving the community (Belkheir, 2021, p. 3). Additionally, sports activity represents behavior performed by the individual during their interaction with their environment, constituting a conscious act directed toward achieving a specific goal or reaching realistic model changes according to specific educational outcomes (Belkheir, 2021, p. 3).

It can also be defined as one of the fundamental educational fields contributing to comprehensive individual preparation by providing physical, psychological, and social capabilities enabling adaptation to oneself and society. It also contributes to personality formation in all mental, psychological, and social aspects, serving as an effective means of achieving general educational goals through developing the individual's strengths and capabilities, enabling contribution to self-development according to the principle of community, thereby achieving individual and societal well-being (Latrach, 2019, p. 3).

Sports activity is purposeful, planned human behavior practiced in an educational, recreational, or therapeutic context, based on using physical capabilities and motor skills according to specific rules and objectives, aiming to achieve comprehensive individual development in physical, psychological, social, and cognitive aspects. Sports activity serves as an effective tool in preparing individuals for life by providing capabilities enabling adaptation to oneself and society, developing positive values and attitudes, and enhancing physical and psychological health. This activity varies in form and content according to the target population (youth, elderly, athletes, patients) and according to its purpose (competitive, recreational, therapeutic, educational).

❖ **Blood Pressure:** Blood pressure is defined as the force generated by blood pushing against artery walls as it circulates through the cardiovascular system to supply body tissues and organs. Blood

pressure is expressed by two numbers: the first represents systolic pressure (the larger number), and the second represents diastolic pressure (the smaller number), measured in millimeters of mercury (mmHg). Blood pressure remains within a narrow range under normal conditions, fluctuating according to various factors such as time of day (night and day) and body position (standing or lying down). However, it rises during physical activity or exposure to emotional stress and psychological pressure, returning to normal levels once these influences subside and relaxation occurs. Blood pressure is considered elevated when its average remains above the normal range of 130-139 mmHg at rest and under psychological stability (Dekhiya, 2020, p. 754).

5. Participants:

The study population consists of all published scientific studies and references addressing the topic of training load quantification and its relationship to blood pressure in athletes, particularly those addressing former competitive athletes or similar populations.

The study sample consisted of five primary studies purposively selected based on their availability, recency, relevance to the research topic, and diversity of methodologies and tools.

5.1. Materials:

This study relied on content analysis of previous studies and systematic reviews, with the researcher identifying seven main axes:

- Number of recent studies since 2022.
- Sample type.
- Sample selection method.
- Type of physical activity performed.
- Blood pressure levels.
- Age and body mass index.
- Study results.

Table 01: Systematic Review to Determine the Effect of Different Training Modalities on Blood Pressure in Adults:

Reference	Physical Activity	Blood Pressure (mmHg)	Age	Results
Edwards et al., (2023)	Aerobic, Resistance, Combined, HIIT, Isometric	Stage 1 and stage 2 hypertension	Adults	SBP reduction: -4.49 mmHg (aerobic), -4.55 mmHg (resistance), -6.04 mmHg (combined), -4.08 mmHg (HIIT), -8.24 mmHg (isometric). Isometric training superior (SUCRA: 98.3%)

This systematic review with network meta-analysis (270 RCTs, 15,827 adults) ranked training modalities for lowering resting blood pressure. Isometric training was most effective (SUCRA: 98.3%), followed by combined, aerobic, resistance, and finally HIIT. Combined training reduced systolic blood pressure by -6.04 mmHg, outperforming aerobic training alone (-4.49 mmHg). However, the findings are generalized across adults and lack specificity for former athletes, highlighting the need for targeted research on this population (Edwards et al., 2023).

Table 02: Field Study to Determine the Effect of Training Load Quantification on Measuring Fatigue Levels in Football Players:

Reference	Physical Activity	Blood Pressure (mmHg)	Age	Results
Mahfoudhi Mahmoud, (2023)	RPE Method (Foster) for measuring training Load	Training load, fatigue level, monotony, strain, fitness	Under 19	Mean weekly load 1550 ± 1195 AU, strong correlation between fatigue and load ($r = 0.96$), moderate correlation between fatigue and strain ($r = 0.56$)

This field study on under-19 football players ($n=16$) evaluated the RPE method for quantifying training load and fatigue. A strong correlation existed between fatigue and training load ($r = 0.96$), and a moderate correlation with strain ($r = 0.56$). While the RPE method proved practical and cost-effective, the small sample size and short one-month duration limit generalizability, recommending larger-scale, longer-term investigations (Mahfoudhi, 2023).

Table 03: Systematic Review to Determine the Effect of Detraining on Cardiorespiratory Adaptations in Endurance Athletes:

Reference	Physical Activity	Blood Pressure (mmHg)	Age	Results
Frontiers in Physiology, (2024)	Detraining	Left ventricular mass, heart rate, VO_2 max, blood pressure	Endurance athletes	Decreased VO_2 max, decreased left ventricular mass, increased heart rate and blood pressure, decreased cardiac output

This systematic review examined detraining effects in endurance athletes. Complete cessation led to decreased VO_2 max, reduced left ventricular mass, increased heart rate and blood pressure, and ultimately decreased cardiac output and performance. The review underscores that detraining reverses cardiovascular adaptations; however, it lacked precise details on the number of studies and specific timeframes for each physiological change, calling for more focused research (Frontiers in Physiology, 2024).

Table 04: Analysis and Quantification of Training Load During the Winter Break Period in Football Players:

Reference	Physical Activity	Blood Pressure (mmHg)	Age	Results

Zouaghi Khalifa et al., (2021)	RPE Method (Foster) for quantifying training load	Weekly training load, monotony, strain, volume	Amateurs (Third Division)	Minimum load 502 AU, maximum 1982.43 AU, volume increased to 90 minutes in week 3, peak intensity UA 678 in week 3
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This descriptive-analytical study quantified training load in amateur football players (n=20) during a 4-week winter break using the RPE method. Weekly load ranged from 502 AU to 1982.43 AU, with volume and intensity peaking in the third week (90 minutes; UA 678). The RPE method effectively distributed loads during critical periods, yet the short study duration and focus on amateur teams restrict broader application to elite or former athlete populations (Zouaghi et al., 2021).

Table 05: Experimental Study on the Effect of Physical Exertion on Blood Pressure in Football Players:

Reference	Physical Activity	Blood Pressure (mmHg)	Age	Results
Boussaad Amoura, (2025)	Quantified training program (8 weeks, 3 sessions/ week)	Systolic and diastolic blood pressure, heart rate	Under 17	Heart rate increased from 87.18 to 103.63 bpm ($p < 0.01$), SBP decreased from 120.00 to 116.91 mmHg ($p < 0.01$), no significant DBP change ($p > 0.05$)

This experimental pre-post study (n=301, U17 football players) applied an 8-week quantified program. Heart rate significantly increased, systolic blood pressure significantly decreased (120.00 to 116.91 mmHg), but diastolic blood pressure showed no significant change. Despite the large sample and validated tools, limitations include the short 8-week intervention, absence of long-term follow-up, and exclusive focus on U17 players, omitting former athletes (Boussaad, 2025).

6. Discussion of Results of Hypotheses:

The discussion reveals a general consensus across the five analyzed studies that training load quantification effectively improves cardiovascular indicators, yet its efficacy is highly dependent on the selected training modality and the population's specific characteristics. Regarding the first hypothesis—that combined training yields superior systolic blood pressure (SBP) reduction compared to aerobic training alone—the evidence is robust. The meta-analysis by Edwards et al. (2023) confirmed this by showing a greater SBP drop for combined training (-6.04 mmHg) versus aerobic training (-4.49 mmHg), a finding further supported by Boussaad's (2025) experimental work. However, the review by Frontiers in Physiology (2024) qualifies this by demonstrating that such benefits are reversible; detraining inevitably returns SBP to elevated levels, meaning continuity of combined training is mandatory for sustained results. Concerning the second hypothesis, which proposed that HIIT surpasses MICT in improving diastolic blood pressure (DBP), the findings do not provide substantial backing. The Edwards et al. (2023) review indicated that HIIT's effect on

DBP was marginal compared to isometric or combined training. Likewise, Boussaad (2025) observed no statistically significant DBP changes post-intervention. This suggests that DBP is inherently less responsive to standard training stimuli than SBP, or that the intervention durations were too brief to affect it, thus leaving this hypothesis unconfirmed.

Regarding the third hypothesis—that blood pressure responses vary according to prior athletic background—the data offer credible support. The *Frontiers in Physiology* (2024) review highlighted that detraining reverses cardiorespiratory adaptations, leading to marked BP increases in former endurance athletes. This aligns with Moker et al. (2023), who found that 65.5% of SBP responders to training became non-responders after cessation, underscoring the critical role of prior conditioning. Additionally, Mahfoudhi (2023) demonstrated that using the RPE method enables tailored intensity adjustments, which is essential for accommodating individual training histories. Nevertheless, the authors acknowledge that this hypothesis still warrants direct experimental comparisons between former athletes and non-athletes to be definitively validated.

7. Conclusion:

The study confirms that training load quantification is an effective tool for regulating training intensity and monitoring blood pressure in former athletes after detraining. The findings robustly support the first hypothesis, as combined training (aerobic and resistance) produced superior systolic blood pressure reductions compared to aerobic training alone. The third hypothesis is also validated, as detraining elevates blood pressure and diminishes cardiorespiratory efficiency, emphasizing the critical role of prior training background in designing interventions. However, the second hypothesis regarding HIIT's superiority for diastolic pressure was unsupported, as diastolic pressure showed limited responsiveness across all studies.

Field studies further establish the RPE method as a practical, cost-effective means for quantifying daily/weekly loads and monitoring fatigue, revealing a strong load-fatigue relationship essential for preventing overtraining—especially for athletes returning after cessation.

Declarations

Ethics Approval: Not applicable; this study analyzed previously published research.

Informed Consent: Not applicable.

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Data Availability: All data were obtained from the published studies cited in the article.

Author Contributions: All authors contributed to the study design, analysis, manuscript preparation, and final approval.

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