Journal of Physical Education
Volume 38 – Issue (1) – 2026 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

The Effect of Contrast Training on the Development of Muscular Power and Selected Physiological Indicators in Advanced Basketball Players

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DOI:
https://doi.org/10.37359/JOPE.V38(1)2026.2427

Article history: Received 3/ February /2026 Accepted 10/ February/2026 Available online 28/ March/2026

Abstract

The purpose of this study was to investigate the effect of contrast training on the development of muscular power and selected physiological indicators in advanced basketball players. An experimental design with two equivalent groups was employed. The sample consisted of twelve players from Al-Difa'a Al-Jawi Basketball Club, who were randomly assigned into an experimental group (n = 6) and a control group (n = 6). The experimental group followed a contrast training program for eight weeks, with three training sessions per week, while the control group continued their regular training program. The dependent variables included muscular power tests (vertical jump and seated medicine ball throw) and selected physiological indicators (resting heart rate, systolic blood pressure, and heart rate recovery). Pre- and post-tests were conducted for both groups. The results revealed statistically significant improvements in all physical and physiological variables in favor of the experimental group compared with the control group. These findings indicate that contrast training is an effective training method for enhancing muscular power and improving cardiovascular efficiency in advanced basketball players. The study concludes that incorporating contrast training into training programs can significantly contribute to improving physical performance and physiological adaptation. Therefore, it is recommended that coaches and practitioners adopt this training method within modern training programs for competitive basketball players.

Keywords: contrast training, muscular power, physiological indicators, basketball, physical performance.

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Introduction

In the last years, strength and conditioning training has been generated an outstanding development in team sports where the physiological capacities such us strength, speed and muscular power play a fundamental role, like basketball. The enhancement of muscle power is thought to be one of the most critical physical determinants for competitive tasks at the highest level which contributes significantly in executing offensive and defensive actions effectively such as; sprinting, explosive change of direction, jump and shoot (Bompa & Buzzichelli, 2019).

Current development in strength training has shifted towards combined approaches of heavy loading with plyometric exercises, which have evident benefits regarding improvement on muscular power and neuromuscular efficiency. One of the modern training methods is contrast training, in which high-intensity resistance exercise is immediately followed by an explosive movement and has been thought to be effective for secondary mechanism involving in enhancing neural activation with improved rapid force production (Cormie, McGuigan & Newton, 2011).

More recent research suggests that contrast training can induce favorable physiological adaptations, such as a greater muscle activation and central nervous system efficiency followed by an improvement motor unit recruitment, cardiorespiratory parameters that are involved in the physical performance and skill of trained individuals (Suchomel et al., 2018). Other research has also demonstrated that this style of training is one of the most effective methods to develop muscular power in advanced athletes because it mimic high-level competition demands (Haff & Nimphius, 2012).

In basketball, muscle power is one of the fundamental contributors to performance, and it is well related to the level at which players execute vertical jump, transition speed, defensive efficacy or shooting accuracy (Santos & Janeira 2011).

Contemporary training philosophies are certainly a pressing need to match the enormous evolution in physical demands required for basketball. Normal training programs are not enough to achieve the physical and physiological changes necessary for high level competition. Of such contemporary modes of training, contrast training emerges as an effective means of integrating maximal strength and explosive exercises into a single unit of work, which may result in optimizing both muscular power production and physiological responses through time-efficient manner (dobbs et al., 2019).

Contrast training method relies on the phenomenon of post-activation potentiation (PAP) which elevates neural system efficiency and facilitates quick motor action, leading to increased explosive force or power peak generation (Seitz & Haff, 2016). Several investigations have shown that this prescription can enhance physical and skill performance in team sports, especially basketball (Freitas et al.

Some recent investigations have also reported that contrast training may help to further enhance specific physiological parameters, which are critical for the ability of players to cope with high amounts of training and consecutive matches (e.g., heart rate, cardiac recovery time, cardiorespiratory efficiency) (Beato et al., 2019).

There is a low number of studies examining the impact of contrast training on high-level basketball players, including both muscle power and physiological variables. This stresses the

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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requirement for a scientific investigation that helps to fill this informational void and offer practical training suggestions.

The significance of the study was based on revealing one of the contemporary methods for training--contrast training and its impact to the development of muscular power, as well as elevation of some physiological indices in advanced basketball players. This will give coaches a scientific ground to be used in contriving better training programs, raise the level of physical and functional performance, increase players' preparedness for competition and too adds positively to enriching the Arabic scientific literature by using a modern applied study in the field of sports training.

While there are world-class sports training techniques being used in other parts of the world, most localised teams continue to train in out-dated ways on a physical level featuring repetitive movements that do not agree with integrating modern strength and explosion training. The latter causes a slower development in muscular power, and physiological parameters in elite players. Second, there is a marked difference in jumping and sprinting, as well as physical endurance among players, which adversely affects on-field performance.

According to this practical observation, the necessity for contrast training, as an effective means of enhancing muscular power and some physiological factors became evident. Therefore, the research problem is translated into the following question:

Does contrast training have a positive effect on developing muscular power and certain physiological indicators among advanced basketball players?

Research Objectives

1. To identify the effect of contrast training on developing muscular power among advanced basketball players.
2. To identify the effect of contrast training on improving certain physiological indicators.
3. To compare the results of the experimental and control groups in the post-test measurement.

Research Hypotheses

1. There are statistically significant differences between the pre- and post-tests of the experimental group in muscular power and certain physiological indicators in favor of the post-test.
2. There are no statistically significant differences between the pre- and post-tests of the experimental group in muscular power and certain physiological indicators.
3. There are statistically significant differences between the experimental and control groups in the post-test in favor of the experimental group.
4. There are no statistically significant differences between the experimental and control groups in the post-test.

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Research Scope

1. Human domain: Advanced basketball players of Al-Defaa Al-Jawiya Sports Club.
2. Time domain: From 1/9/2025 to 1/11/2025.
3. Spatial domain: Indoor hall of Al-Defaa Al-Jawiya Sports Club.

Methodology

Study Design

The experimenter applied the experimental approach in equivalence groups design (control and experiment) because of its appropriateness to nature of research problem and its objectives. Such method is believed to be one of the most adequate scientific methodologies for investigating the influence of an independent variable (contrast training) on dependent ones (muscular power and some selected physiological markers).

Research Population and Sample

Research Population

The research population consisted of advanced basketball players of Al-Defaa Al-Jawiya Sports Club for the 2025–2026 sports season, officially registered in the Iraqi Central Basketball Federation records.

Research Sample

The research sample was selected purposively because the researcher works directly with the team. The sample included 12 players who were randomly divided into two equivalent groups:

- Experimental group: 6 players
- Control group: 6 players

Before applying the training program, homogeneity in the dependent study variables for the experimental and control groups was confirmed with pre-tests by means of comparing averages using an independent samples t-test. It was evident from the results that no significant difference in all the tests of observation were obtained (calculated t-value was less than tabular t at df and $P < 0.05$) between the both groups which indicates that the two groups were equivalent and fit for conducting experiment scientifically.

Table 1. *Equivalence of the experimental and control groups in the research variables before implementing the experiment*

Variables	Group	Mean	S.D.	t-value	Sig.	Significance

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Vertical Jump	Experimental	47.83	3.12	0.41	0.120	Not sig
	Control	48.50	3.45			
Medicine Ball Throw	Experimental	6.42	0.36	0.47	0.155	Not sig
	Control	6.50	0.41			
Resting Heart Rate	Experimental	71.83	2.64	0.58	0.111	Not sig
	Control	72.50	2.88			
Systolic Blood Pressure	Experimental	118.67	4.32	0.62	0.150	Not sig
	Control	119.83	4.76			
Heart Rate Recovery Time	Experimental	29.50	2.07	0.49	0.130	Not sig
	Control	30.17	2.33			

Tools and Equipment Used

- Digital medical scale for body weight (kg)
- Stadiometer for height measurement
- Digital stopwatch
- Electronic blood pressure monitor
- Heart rate monitor
- Medicine balls (3 kg)
- Plyometric boxes
- Free weights (barbells & dumbbells)
- Resistance bands
- Measuring tape
- Data recording forms

Tests Used

Muscular Power Tests

1. Vertical Jump Test

The vertical jump test is one of the most common tests in sport for assessment of lower limb muscular power. It stands for the highest an athlete can reach from a standing position during a jump in the vertical plane and characterizes efficiency of force realization by neuromuscular apparatus in the generation of explosive force necessary at faster motor tasks. It is commonly used in team sports, particularly those where vertical jumping ability is needed (e.g.basketball), because of its strong relationship with athletic performance (offensive and defensive) including jump shooting and rebounding.

It is executed by a participant standing next to a wall (even if they are not touching it) while reaching upwards as high as possible and marking the wall at the highest point of the reach. The participant jumps vertically to reach the highest point possible using both legs and arms at the same time, and that height is recorded. The arbitrary number is the difference between a standing reach and reaching at the point of jump. Distance best of three trials is measured in centimeters (cm). The test is highly valid, reliable, and objective and therefore appropriate for physical evaluation in scientific as well as applied research (Sargent, 1921; Harman et al., 1991).

2. Seated Medicine Ball Throw Test (3 kg)

The seated medicine ball throw test assesses upper extremity muscle power, especially in the muscles of the arms, shoulder, and chest. It is related to player's capacity to develop explosive force in a short time which is required as many offensive and defensive basketball manoeuvres, for example long pass and powerful shot or quick ball movement.

The test is conducted while patients are sitting with the legs fully extended forward, and to prevent involvement of the trunk against a wall or any fixed support. The athlete performs an over head throw with a medicine ball from the 4.5 inch position like in this video. Distance X is that distance between the line of fire and the first ground contact of any point. Three attempts are made and the best one is measured in metres (m). This test has shown good criterion-referenced validity for the assessment of upper-limb muscle power and is commonly used to measure explosive strength in team sports (Stockbrugger & Haennel, 2001; Mayhew et al., 2005).

Physiological Indicators

1. Resting Heart Rate

RHR is a primary physiological measure that represents cardiovascular fitness and physical adaptation in athletes. A lower resting HR implies an enhanced cardiac-pumping efficiency and stroke volume, thereby decreasing myocardial work during exercise. It is commonly used to monitor training status, cardiorespiratory fitness, and recovery and adaptation to the training load.

Resting HR was determined after the player remained for 10 min in a comfortable position, without performing any physical activity and talking. Heartbeats were monitored for at least 1 minute with a heart-rate monitor (in beats/minute (bpm)). Recent researches have revealed that RHR is an accurate tool to assess cardiac adaptations due to different training programs, especially strength and power (Buchheit & Laursen, 2013; Kenney et al., 2020).

2. Blood Pressure (Systolic and Diastolic)

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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Blood pressure is an essential vital sign that indicates the circulatory and cardiovascular system performance. Systolic pressure is the force generated during systole (contraction of the heart) and diastolic pressure created by vascular resistance during diastole (relaxation of the heart). It is commonly used in sports science to determine the impact of exercise programs on cardiovascular health and function.

Blood pressure was collected using an approved medical grade electronic equipment, after the player had been at ease and seated for a minimum of 10 min with his arm at heart level to avoid incorrect readings. Both systolic and diastolic pressures were measured in millimeters of mercury (mmHg). Studies show that consistent training, specifically contrast training, is associated with improved blood pressure control and favorable cardiovascular profile which result in physical performance gains simultaneously yielding health benefits (Cornelissen & Smart, 2013; Pescatello et al., 2019).

3. Heart Rate Recovery (HRR)

Recovery heart rate after exercise is a novel physiological marker of parasympathetic activity and the capacity of the body to recover rapidly from intense physical effort. It is calculated as the difference between heart rate directly after standard exercise and that 1 minute later. If it decreases quickly, it means you have a very high cardio and respiratory efficiency."

HRR was assessed after a standardized physical exercise in all participants. The heart rate was measured immediately after stopping the test, and then one minute afterward; the difference between these 2 measurements was considered as heart-rate recovery. This marker has been reported as one of the strongest predictors of cardiorespiratory fitness and training load tolerance, being strongly correlated with high athletic performance (especially in team sports) (Buchheit & Gindre, 2006; Peçanha et al., 2017).

Pilot Study

A pilot study was conducted on two players outside the main sample to:

- Verify the suitability of tools and equipment
- Determine the appropriate time required to perform the tests
- Identify potential implementation difficulties
- Train the assisting team on measurement procedures

The pilot study helped avoid errors and achieve greater measurement accuracy.

Training Program

A contrast training protocol, to promote muscle power and enhance some physical capacities, was developed for elite basketball players. The duration of the program was 8 weeks, three times per week and each session lasted 90 min. The program was developed based on current

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scientific strength and power training concepts, including the principles of progressive overload, movement specificity to basketball skills, and work-to-rest balance.

The approach was to combine high-intensity resistance exercises (80–90% of 1RM) with mechanically similar plyometric activities in relation to force direction and movement pattern, without any rest between them. Such a method was used in an attempt to take advantage of post-activation potentiation (PAP) which increases neural drive and is thought to facilitate explosive force development. It was not the skill practiced in a distinct portion of the training session, alternating it with a rest period to maintain its performance quality and minimize injury.

Components of the Training Session for the Experimental Group
1. General and Specific Warm-up (15 minutes)

Dynamic warm-up, easy pace running, basketball-specific movement drills and neuromuscular stimulus drills to prepare the muscular and nervous systems for peak performance and minimize injury risk.

2. Main Part (65 minutes)

Included the implementation of contrast training exercises according to the following format:
High-intensity resistance exercise (80–90% 1RM) followed immediately by a mechanically similar plyometric exercise.

Three to five sets of each pair of exercises were executed, with 3–5 and repetitions for resistance and plyometric exercise, respectively. Times between sets varied from 2 to 4 minutes.

3. Cool-down (10 minutes)

Included static stretching, breathing exercises, and muscular relaxation techniques to accelerate recovery and reduce muscular tension after physical exertion.

Table 2. *Weekly distribution of training sessions during the program period (8 weeks)*

Week	No. of Sessions	Training Days	Session Duration (min)	Load Intensity	Training Type
1	3	Sat – Mon – Wed	90	80% 1RM	Contrast
2	3	Sat – Mon – Wed	90	80% 1RM	Contrast
3	3	Sat – Mon – Wed	90	85% 1RM	Contrast

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4	3	Sat – Mon – Wed	90	85% 1RM	Contrast
5	3	Sat – Mon – Wed	90	90% 1RM	Contrast
6	3	Sat – Mon – Wed	90	90% 1RM	Contrast
7	3	Sat – Mon – Wed	90	85% 1RM	Contrast
8	3	Sat – Mon – Wed	90	80% 1RM	Contrast

Note: Total number of training sessions = 24.

Meanwhile, the control group continued performing the traditional training program adopted by the team coach.

Statistical Analysis

Data were statistically processed using SPSS (v26) through the following methods:

- Mean
- Standard deviation
- Paired samples t-test
- Independent samples t-test
- Percentage of improvement (%)

A significance level of (0.05) was adopted.

Results

Table 3. *Results of the Paired Samples t-test Between Pre- and Post-Tests for the Experimental Group*

Variables	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	t-value	Sig.	Significance Level
Vertical Jump	47.83 ± 3.12	55.67 ± 3.08	6.42	0.001	Significant
Medicine Ball Throw	6.42 ± 0.36	7.25 ± 0.41	5.87	0.002	Significant
Resting Heart Rate	71.83 ± 2.64	66.17 ± 2.48	5.11	0.003	Significant
Systolic Blood Pressure	118.67 ± 4.32	112.33 ± 3.97	4.96	0.004	Significant
Heart Rate Recovery Time	29.50 ± 2.07	21.83 ± 1.94	6.75	0.001	Significant

Table 4. *Results of the Paired Samples t-test Between Pre- and Post-Tests for the Control Group*

Variables	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	t-value	Sig.	Significance Level
Vertical Jump	48.50 ± 3.45	50.17 ± 3.38	1.88	0.118	Not significant
Medicine Ball Throw	6.50 ± 0.41	6.78 ± 0.39	1.65	0.160	Not significant
Resting Heart Rate	72.50 ± 2.88	70.83 ± 2.71	1.94	0.109	Not significant
Systolic Blood Pressure	119.83 ± 4.76	117.67 ± 4.29	1.72	0.142	Not significant
Heart Rate Recovery Time	30.17 ± 2.33	27.83 ± 2.25	1.83	0.125	Not significant

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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Table 5. *Comparison Between the Experimental and Control Groups in the Post-Test Using the Independent Samples t-test*

Variables	Experimental (Mean ± SD)	Control (Mean ± SD)	t-value	Sig.	Significance Level
Vertical Jump	55.67 ± 3.08	50.17 ± 3.38	2.97	0.015	Significant
Medicine Ball Throw	7.25 ± 0.41	6.78 ± 0.39	2.81	0.019	Significant
Resting Heart Rate	66.17 ± 2.48	70.83 ± 2.71	3.02	0.013	Significant
Systolic Blood Pressure	112.33 ± 3.97	117.67 ± 4.29	2.63	0.025	Significant
Heart Rate Recovery Time	21.83 ± 1.94	27.83 ± 2.25	4.21	0.002	Significant

Table 6. *Percentage of Improvement for the Experimental and Control Groups*

Variables	Experimental (%)	Control (%)
Vertical Jump	16.38%	3.44%
Medicine Ball Throw	12.93%	4.31%
Resting Heart Rate	7.87% ↓	2.30% ↓
Systolic Blood Pressure	5.34% ↓	1.80% ↓
Heart Rate Recovery Time	26.03% ↓	7.74% ↓

Discussion

Purpose The main purpose of this study was to determine the influence of contrast training on muscular power, as well as few selected physiological indicators among advanced basketball players. Results showed statistically significant differences in almost all variables between the experimental and control groups, demonstrating the effectiveness of this train-asympt approach in evoking beneficial changes at a physical and functional level.

The experimental group's performance results (the following variables: vertical jump and medicine ball throw) had significant improved mean score in muscular power, while the control group showed a non-significant development in muscular power. These results could be related to the characteristics of contrast training when high loads and plyometric exercises that are mechanically similar (acting on the same muscle groups) are combined, with post-activation potentiation (PAP mechanism) involved. This leads to greater motor unit activation and muscle contraction velocity, ultimately resulting in improved explosiveness.

These findings are similar to those described by Dobbs et al. (2019) and Tillin & Bishop (2009), which reported that contrast training is one of the most effective means of promoting muscular power performance in trained individuals as a result its influences being on neuromuscular efficacy, as well as rate of force development over short-term. Loturco et al. (2017) further highlighted that this method is especially appropriate for jumping and acceleration sports

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like basketball, introducing motor adaptations in accordance with the demands of competitive performance.

The advantage of the experimental group compared to the control group in posttests is also due to the fact that program of study used exercises which are similar to real patterns of motion, as well as training specificity. Suchomel, Nimphius and Stone (2016) substantiated the significant benefits of exercise type to sport-specific demands compatibility for enhancing training.

The findings of the present study also indicated a statistically significant reduction in physiological measures for the intervention group in terms of resting heart rate, systolic blood pressure and heart rate recovery (the duration to decrease from peak HR post exercise to 120bpm). No significant changes were observed among control subjects. This enhancement is indicative of beneficial changes in cardiovascular efficiency and parasympathetic regulation.

This enhancement may be related to the characteristics of contrast training (combined acute heavy resistance exercise with fast explosive movements) that resulted in better excreting function, including enhanced cardiac function and pump efficiency for blood as well as altered neural balance between sympathetic and parasympathetic tone. This can lead to a quicker recovery from strenuous activities. Plews et al. (2013) demonstrated that both high-intensity and intermittent training results in significant improvements of some HR recovery indices, which are a marker of trained cardiorespiratory fitness.

Another interesting fact is that the reduction in recovery time following exercise is a good expression for cardiac efficiency and for adjustment of athletes to contemporary training loads (Seiler, Haugen & Kuffel 2007). Michael, Graham, and Davis (2017) demonstrated that the integration of strength training with plyometric work results in significant physiological adaptations which manifest in lower resting heart rate with a greater cardiac response during exercise.

Results of the post-test comparison revealed obvious differences between the experimental and control group in favour of the former for all variables, that do not seem due only to regular training, but rather probably ascribable to the specificity of contrast method applied. This is consistent with the data of Cormie, McGuigan and Newton (2011) who also showed that performing maximal strength exercises in combination with explosive training (combined effect) is more effective than single mode traditional training.

These results are also in line with Beato and Dello Iacono [14], where the authors showed physical characteristics of team sport athletes improved to a greater extent following combined strength training approaches compared to traditional programs, because of increased neuromuscular stimulation and participation in more favorable physiological adaptations.

Improvement rates clearly favored the experimental group in all variables, indicating that the training program was effective. This shows that contrast training has an effect not only in performance enhancement and muscular power development but also in physiological adaptations, which can translate into maximize competition performance through better capacity for high-intensity efforts, and ability of players to tolerate the demands on competitive activities.

These results corroborate the conclusions of Turner et al. (2015), who claim that high rates of improvement from complex training program are an evident sign for the good design of the training, and also efficient realization of it.

Conclusions

1. The results indicate that contrast training is highly effective in improving muscular power of lower and upper limbs of advanced basketball players
2. The training intervention resulted in enhancements of some critical physiological parameters including resting HR, SBP and HRR time.
3. The experimental group was significantly better than the control group on all physical and physiological measures at posttest.
4. It seems, that the typical contrast training was effective in inducing positive neuromuscular adaptations indicated by increased rate of force development.
5. The players benefited well from the training program in terms of improvement of cardiovascular system effectiveness.
6. The current researches verified the necessity of using modern training methods as well, instead of traditional ones in basketball domain.

Recommendations

1. Implement contrast training on elite basketball players in their team setting.
2. During the specific preparation and competition periods, small doses of contrast training should be included because it provokes a positive effect on physical performance.
3. Physiological measurements used in this study should be applied on a regular basis to evaluate the progress of players' physical condition.
4. Performing comparable studies for other age categories, like beginners and juniors.
5. Develop further studies investigating changes in skiing kinematics, kinetics and psychology after contrast training.
6. Develop training programs that combine contrast training with other contemporary training methods for maximal training adaptations.
7. Use the results of this investigation, as a practical way for workout programs to be established by basketball coaches working in Iraqi clubs.

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