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Research Article

The Effect Of Training Program With Venous Blood Flow Restriction On Some Physical And Skill Variables In Gymnastics Students At Palestine Technical University-Kadoorie

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ABSTRACT

Problem Statement: Gymnastics requires a blend of physical strength and knowledge of skills. To improve the performance of gymnastics pupils, it is necessary to implement novel training techniques. This study aims to examine the effects of Blood Flow Restriction (BFR) training on specific physical and skill factors in gymnastics students at Palestine Technical University - Kadoorie.

Approach: A quantitative approach was employed to evaluate the effects of a proposed BFR training program on male gymnastics players (n=30). The participants were divided into a control group (n=15) and an experimental group (n=15).

Purpose: This study aimed to assess the influence of BFR training on gymnastics students' physical and skill variables. Three hypotheses weretested to determine the effects of conventional training, the incorporation of BFR, and the superiority of specialized training programs.

Results: The results of the physical tests revealed a significant enhancement in the post-test for the conventional training of the control group (Vertical Jump from Standstill, Medicine Ball Throws from Overhead, Push-Up and Sit-Up) with an enhancement of (5.01%, 6.64%,23.71%, 23.84%) respectively. The floor exercise skill test exhibited the most notable enhancement, as evidenced by the substantial (52.85%) increase between post and pre-training. The results for the BFR training of the experimental group revealed a significant enhancement in the physical tests (Vertical Jump from Standstill, Medicine Ball Throws from Overhead, Push-Up and Sit-Up) with an enhancement of (8.20%, 8.95%,35.29%, 32.52%) respectively. The floor exercise skill test exhibited the most notable enhancement, as evidenced by the substantial (189.88%) increase between post and pre-training. The results also showed that the experimental group outperformed the control group in various post-test assessments. Vertical Jump (50.93 vs. 47.07), Medicine Ball Throws (4.91 vs. 4.513), Sit-Ups (13.80 vs. 12.20), Push-Ups (14.67 vs. 12.87), and Floor Exercise (7.333 vs. 3.866). This suggests the intervention significantly improved gymnastics students' physical and skill performance.

Conclusions: In conclusion, BFR training was crucial to gymnastics improvement. It improves strength, endurance, and technique safely and effectively. The findings suggest incorporating BFR training into normal routines with tailored procedures and close monitoring to enhance improvements and reduce dangers. This study emphasizes the need for sport-specific training treatments in athletic development. BFR training can help gymnastics trainers and instructors increase performance and long-term athletic development.

Keywords: Blood Flow Restriction (BFR), Palestine Technical University, Gymnastics, physical and skill attributes.

Introduction

In recent years, the fitness industry has witnessed a significant transformation with the emergence of Blood Flow Restriction (BFR) training, also known as "Kaatsu," originating from Japan. While BFR is not an entirely new concept, it has gained recent popularity in Western training communities due to its innovative approach and unexpected benefits (Li et al., 2023). BFR involves the use of cuffs or bands placed on the limbs, primarily the legs and arms, to impede venous blood flow while allowing arterial flow to continue relatively unimpeded. This creates a unique physiological environment within the body, leading to increased strength and muscle hypertrophy through metabolic stress, rather than mechanical stress (Li et al., 2023).

Metabolic stress occurs when blood flow is reduced during BFR training, leading to the buildup of metabolites and lactic acid, which are known catalysts for muscle hypertrophy. This accumulation triggers the recruitment of fast-twitch muscle fibers, typically engaged during high-intensity exercises, inducing a systemic anabolic response. Consequently, substantial increases in strength can be achieved through BFR training using exercises performed at a load of 20-30% of one's one-repetition maximum, which is traditionally considered inadequate for such enhancements (Korkmaz et al., 2022).

BFR training's versatility extends beyond traditional gym settings, making it particularly valuable in rehabilitation environments. Injured athletes or postoperative patients may find conventional high-load training impractical or even risky. BFR offers a method to develop strength and muscle mass without subjecting bones, joints, and muscles to the stress associated with heavy lifting. This enables early commencement of strength training interventions, potentially leading to quicker recovery and reduced muscle atrophy (Miller et al., 2021).

However, the implementation of BFR training requires careful consideration and expert guidance. Inadequate pressure may lead to ineffective results, while excessive pressure can cause nerve injury or thrombosis. Therefore, this type of training should be closely monitored and tailored individually by qualified professionals to ensure both safety and effectiveness.

While BFR training shows promise, further research is needed to determine the optimal pressure levels, especially in gymnastics, where a balanced approach is essential. Additionally, investigating the long-term effects of BFR on muscle function and overall athletic performance is crucial (Early et al., 2020).

In summary, BFR training represents a revolutionary approach to enhancing muscle strength and hypertrophy, with applications ranging from sports training to clinical rehabilitation. As research continues to uncover the best protocols and long-term effects of BFR training, it has the potential to reshape training practices across various domains. Coaches, trainers, and medical professionals should closely follow these developments to effectively integrate BFR training into their respective fields.

Shifting the focus to Palestine Technical University-Kadoorie (PTUK), this study aims to address significant gaps in the existing literature by exploring the impact of an 8-week BFR training regimen on the physical and skill-related factors of gymnastics students. PTUK serves as an ideal sample, given its comprehensive physical education program and the potential for BFR training to be seamlessly incorporated without additional cost or time constraints. Furthermore, the study aims to bridge the research void concerning how BFR training influences physical and skill-related factors in this specific population, which includes gymnastics athletes engaged in physically demanding activities that can stress the body.

While previous research suggests the potential effectiveness of BFR training in various populations, it is essential to investigate its applicability and benefits within the context of gymnastics. Gymnastics athletes have unique physiological and developmental characteristics, and it remains unknown whether BFR training can positively impact their performance, skill acquisition, or physical health. Therefore, the primary purpose of this investigation is to fill these gaps in the literature by assessing the outcomes of BFR training on physical parameters such as Vertical Jump from Standstill, Medical Ball Throws from Overhead, push-up, sit-up, as well as skill-based activities like gymnastics floor movements among gymnastics students at PTUK. Additionally, this study aims to contribute valuable insights into the application of BFR-related research in the field of physical education and sports sciences.

Material & methods

Participants

The study's participants were all male gymnastic players from Palestine Technical University - Kadoorie's team. A purposive sampling strategy was used to ensure a representative sample of athletes with various skill levels and experience. Before giving informed consent to participate, participants were informed about the study's objectives, procedures, and potential risks. A sample of (30) players was chosen and it was divided into two groups, (15) players for the pre-training test (control) and (15) players for the post-training test (experimental).

Study Sample Characteristics

Table's (1) and (2) illustrate the characteristics of the study sample as follows:

Table 1: the characteristics of the study sample according to the variables of age, height, and body weight. (N = 30).

Variable	Measuring Unit	Arithmetic mean	standard deviation	skewness
Age	**Year**	19.57	1.278	0.903
Weight	**Kg**	71.47	7.838	0.198
height	**cm**	175.17	6.711	0.218

It is evident from table 1 That the results of skewness indicate that it is close to zero. These results indicate the achievement of homogeneity between the members of the study sample and their subjection to a normal equilibrium distribution, where the values of the torsion coefficient of the age, weight and height variables came between (-3 and +3).Therefore, the study sample individuals were randomly divided into two groups, the first group (experimental) is trained using the proposed BFR training program, the second controlled group is trained in the traditional (normal) method, and the arithmetic average for the ages of the study sample is (19.57 years) and that the average weight of the students in the study sample is (71.47 kg) and that their average height is equal to (175.17 cm) .

Table 2: The arithmetic means, standard deviations, the lowest and largest value and the torsion coefficient of the variables (age, weight, height) and the physical and skill variables (n = 30).

Variable	Measurement unit	lowest value	largest value	Arithmetic mean	standard deviation	Coefficient of torsion
Age	Year	160	190	175.17	6.711	0.218
Weight	kg	18	23	19.57	1.278	0.903
Height	cm	59	85	71.47	7.838	0.198
Vertical Jump from Standstill	cm	40	57	46.90	4.693	0.303
Medical Ball Throws from Overhead	MTR	4	5	4.4633	0.27697	0.322
Sit-Up	Frequency	9	12	10.43	1.073	0.095
Push-Up	Frequency	9	13	11.13	1.042	0.109
Floor Exercise	Degree	1	4	2.53	1.008	0.011

It is clear from the results of table 2 that the torsion coefficients of the total study sample in the variables (age, weight, and height) and the physical and skill variables ranged between (-3, +3) (Bougie & Sekaran, 2019), meaning that there is homogeneity in these variables for the total sample of the study.

Spatial and Temporal Context

The current study encompassed the following domains:

1. Human Participants: Gymnastics players of Palestine Technical University - Kadoorie's
2. Spatial Domain: Palestine Technical University - Kadoorie's sports courts.
3. Temporal Domain: The study's program was implemented during the timeframe from February 25, 2023, to April 25, 2023, within the second semester of the academic year 2022/2023

Experimental Design

The study used a pre-test and post-test design, comparing the effects of the proposed BFR training program to a control group that followed a traditional training routine. The experimental group participated in a planned training program that included BFR bands aimed at certain physical qualities and gymnastic skills. The control group continued with their regular exercise schedule.

Blood Flow Restriction (BFR) training regime

This plan, 8-week periodized BFR training regime, for gymnastics students at PTUK has been created to improve both physical and skill aspects. This regime looks to increase various key physical attributes such as vertical jump, medicine ball throws, push-ups, sit-ups and specific gymnastics floor movements. The following structured plan that was developed from (Perera et al., 2022; Reggiani & Schiaffino, 2020; Sabourin, 2023; Yang et al., 2022) was fitted around the gymnasts' regular training.

Weeks (1-2): Outline and Modification

- **Objective**: Initiate BFR exercises and allow the body to adjust to novel stimuli.
- **Frequency**: 3 weekly sessions.
- **Exercises**:
- **Vertical Jump From Standstill**: 3 sets x 15 reps at 30% of 1RM.
- **Medicine Ball Throws from Overhead**: 3 sets x 15 reps with light medicine ball.
- **Push-ups and Sit-ups**: 3 sets x 15 reps each.

- **Gymnastics Floor Movements**: simple exercises emphasizing form and technique.
- **BFR Application**: For upper body workouts, apply cuffs at a low to moderate pressure; for lower body exercises, apply cuffs slightly higher.

Weeks (3-4): Increasing in intensity

- **Objective**: Increase volume and intensity gradually.
- **Frequency**: 4 weekly sessions.
- **Exercises**:
- **Vertical Jump from Standstill**: 4 sets x 20 reps at 30% of 1RM.
- **Medicine Ball Throws from Overhead**: 4 sets x 20 reps with medium weight.
- **Push-ups and Sit-ups**: 4 sets x 20 reps each.
- **Gymnastics Floor Movements**: Introduction of more complex elements.
- **BFR Application**: Depending on comfort and reaction, keep the cuff pressure unchanged or slightly raise it.

Weeks (5-6): Integrating Skills and Strength Building

- **Objective**: Focus on integrating skills with strength development.
- **Frequency**: Four sessions a week, one of which is devoted mainly to skill development.
- **Exercises**:
- **Vertical Jump From Standstill**: 5 sets x 20 reps at 35% of 1RM.
- **Medicine Ball Throws from Overhead**: 5 sets x 20 reps with medium to heavy weight.
- **Push-ups and Sit-ups**: Increase intensity by adding variations (e.g., weighted push-ups).
- **Gymnastics Floor Movements**: Incorporate combinations of skills and movements in sequences.
- **BFR Application**: While maintaining comfort and safety, adjust the pressure to maximize muscle exhaustion.

Weeks (7-8): Improvement of Performance and Evaluation

- **Objective**: Increase productivity while being prepared to evaluate the changes.
- **Frequency**: Five sessions a week, two of which are devoted to skill development.
- **Exercises**:
- **Vertical Jump From Standstill**: 5 sets x 25 reps at 40% of 1RM.
- **Medicine Ball Throws from Overhead**: 5 sets x 25 reps with heavy weight.
- **Push-ups and Sit-ups**: Introduce advanced variations for increased challenge.
- **Gymnastics Floor Movements**: Full routines with an emphasis on fluidity and precision.
- **BFR Application**: For optimal performance, adjust the cuff pressure while preventing overfatigue.

Training Guidelines

The training program followed specific criteria. Monitoring progress for individualized training intensity modifications. Safety was crucial, therefore BFR cuffs were applied according to stringent guidelines, with students monitored for pain or bad responses and changes made as needed. The program stressed rest between sessions and active recovery and stretching to support muscle recovery and reduce injury risk. Students were also taught how to eat healthily and stay hydrated to fulfill the training's physical demands. Finally, certified coaches monitored all sessions and provided individualized feedback and changes to ensure proper technique and safety.

Data Collecting and Statistical Analysis

Quantitative data collecting includes employing approved techniques to measure Age (years), Weight in (kg), Height in (cm) of the participants. The physical variables Vertical Jump from Standstill in (cm), Medical Ball Throws from Overhead in (MTR), push-up and sit-up (frequency) and skill tests Gymnastics floor movements by (Degree). Pre-test measures were taken prior to the intervention, and post-test measurements were taken at the conclusion of the training period. before and after the application of the training program, physical tests were performed (Vertical Jump From Standstill, Medical Ball Throws from Overhead, push-up, sit-up) and skill tests (Gymnastics floor movements), and in order to process the data, the researcher used the (SPSS) program by using the following statistical treatments: (Independent samples t-test) to determine the differences in the pre-measurement between the experimental and control group and for the parity of the two groups (Paired samples t-test) to determine the differences between pre, post and ratio measurements

Results

First Hypothesis: The results related to the study's first hypothesis, which was “There are statistically significant differences at a significance level ($\alpha \leq 0.05$) in the effect of the conventional program on selected physical and skill variables among gymnastics students of Palestine Technical University - Kadoorie for the control group, between the pre-test and post-test means, in favor of the post-test mean.” Therefore, in order to

ensure the validity of this first hypothesis and examine it, a (paired samples t-test) was used, and the results of table 3 show that.

Table 3: The results of the first hypothesis (n = 15)

Dependent Variables		pre-measurement (N=15)		post-measurement (N=15)		T-value	Sig.	change %
		Mean	standard deviation	Mean	standard deviation			
Physical tests	Vertical Jump from Standstill	46.73	5.147	49.07	5.391	2.326	0.036	5.01%
	Medical Ball Throws from Overhead	4.42	0.2644	4.7133	0.2943	15.591	≤0.001	6.64%
	Sit-Up	10.67	1.113	13.2	0.775	9.906	≤0.001	23.71%
	Push-Up	11.20	1.265	13.87	1.246	21.166	≤0.001	23.84%
Skill tests	Floor Exercise	2.53	1.060	3.867	0.9537	16.733	≤0.001	52.85%

*** The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09**
*** The tabular value of (T) at the level of significance (α≤ 0.01) = 2.86**

The results of the physical tests revealed a significant enhancement in the Vertical Jump from Standstill ability. The mean value rose from 46.73 to 49.07, and the standard deviation increased marginally, both of which indicate improved leaping capability (T-value: 2.326, Sig.: 0.036, Change%: 5.01%). In a similar vein, the performance of the Medicine Ball Throws from Overhead increased substantially (mean: 4.7133; T-value: 15.591; Sig.: ≤0.001; Change%: 6.64%). Furthermore, significant advancements were noted in the Push-Up and Sit-Up assessments, as evidenced by the substantial increases in mean scores and high statistical significance (Sit-Up Change%: 23.71%, Push-Up Change%: 23.84%). The floor exercise skill test exhibited the most notable enhancement, as evidenced by the substantial increase in mean score from 2.53 to 3.867 (T-value: 16.733, Sig.: ≤0.001, Change%: 52.85%).

Second: The results related to the study's second hypothesis, which was "There are statistically significant differences at a significance level (α≤ 0.05) in the effect of a training program with venous blood flow restriction on selected physical and skill variables among gymnastics students of Palestine Technical University - Kadoorie for the experimental group, between the pre-test and post-test means, in favor of the post-test mean." Therefore, in order to ensure the validity of this first hypothesis and examine it, a (paired samples t-test) was used, and the results of table shows that.

Table 4: The results of the Second hypothesis (n = 15)

Dependent Variables		pre-measurement (N=15)		post-measurement (N=15)		T-value	Sig.	change %
		Mean	standard deviation	Mean	standard deviation			
Physical tests	Vertical Jump from Standstill	47.07	4.367	50.93	4.559	14.127	≤0.001	8.20%
	Medical Ball Throws from Overhead	4.506	0.29147	4.91	0.26471	16.380	≤0.001	8.95%
	Sit-Up	10.20	1.1014	13.80	1.0820	18.924	≤0.001	35.29%
	Push-Up	11.07	0.799	14.67	1.3450	10.311	≤0.001	32.52%
Skill tests	Floor Exercise	2.53	0.990	7.334	1.3452	19.002	≤0.001	189.88%

*** The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09**

We are able to notice from the results of table 4 that There are significant improvements across all measured variables, according to the data. The mean score for the Vertical Jump from Standstill increased significantly from 47.07 to 50.93 (change: 8.20%) during physical examinations. Similarly, the score for Medicine Ball Throws from Overhead improved significantly from 4.5067 to 4.91 (change: 8.95%). The substantial T-values and extremely low significance levels that accompanied both modifications provide robust statistical support for the enhancements.
The results of the Push-Up and Sit-Up assessments also demonstrated significant improvements, as indicated by mean score increases of 32.52% and 32.52%, respectively. The statistical significance of these enhancements was further supported by the T-values and significance levels associated with them. The Floor Exercise demonstrated the most remarkable improvement on skill assessments, with the mean score increasing from 2.53 to 7.334 (change percentage: 189.88%).

Third: the results of the third hypothesis which states that "There are statistically significant differences at a significance level (α≤ 0.05) in the post-test measurement between the experimental and control groups for selected physical and skill variables among gymnastics students of Palestine Technical University - Kadoorie, in favor of the experimental group" and in order to test this hypothesis an independent samples t-test was carried out as shown in table 5:

Table 5: The results of the third hypothesis (n = 30)

Dependent Variables		Control (N=15)		Experimental (N=15)		T-value	Sig.
		Mean	standard deviation	Mean	standard deviation		
Physical tests	Vertical Jump from Standstill	47.07	5.391	50.93	4.559	2.121	0.043
	Medical Ball Throws from Overhead	4.513	0.294	4.91	0.2647	3.881	≤0.001
	Sit-Up	12.20	0.775	13.80	1.082	4.656	≤0.001
	Push-Up	12.87	1.246	14.67	1.345	3.802	≤0.001
Skill tests	Floor Exercise	3.866	0.953	7.333	1.345	8.142	≤0.001

*** The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09**
*** The tabular value of (T) at the level of significance (α≤ 0.01) = 2.86**

The examination of the third hypothesis for the study at Palestine Technical University - Kadoorie revealed that the experimental group outperformed the control group in post-test assessments across many tests. Specifically, the experimental group had higher mean scores in the Vertical Jump from Standstill (50.93) than the control group (47.07). Similarly, in the Medicine Ball Throws from Overhead test, the experimental group outperformed the control group with mean scores of (4.91) and (4.513), respectively. The Sit-Up test results confirmed this tendency, with the experimental group obtaining a mean of (13.80) versus the control group's (12.20). The Push-Up test similarly benefited the experimental group, with a mean score of (14.67) compared to the control group's (12.87). Most impressively, the Floor Exercise findings revealed a significant change, with the experimental group's mean increasing to (7.333) compared to the control group's (3.866).

Discussion

The results from the first hypothesis of the study conducted at Palestine Technical University - Kadoorie suggest that the conventional training program positively impacted the gymnastics students' physical and skill variables. Notably, improvements were seen across all the tests conducted, from strength-based exercises like push-ups and sit-ups to skill-based activities such as the floor exercise. The significant enhancements in the post-test means, when compared to the pre-test means, point towards the effectiveness of the traditional training regimen. This is consistent with the findings of Korkmaz et al., (2022), who reported that structured conventional training programs could lead to overall improvements in gymnastic-specific skills and physical fitness components.
Analyzing the second hypothesis, the incorporation of venous blood flow restriction in the training program appears to have amplified the benefits seen in the conventional training group. The enhancements in physical tests such as the vertical jump and skill assessments like the floor exercise suggest that the addition of blood

flow restriction may have augmented the training stimulus, aligning with the research by Early et al., (2020) which indicated that blood flow restriction can enhance muscular adaptations even at lower exercise intensities.
The third hypothesis further solidifies the potential benefits of the experimental training approach, as the experimental group demonstrated superior performance in the post-test measures across all variables when compared to the control group. This superiority was not only in basic physical tests but also in more complex skill-based activities, offering support to the claim that specialized training programs can lead to better overall athletic performance. The results mirror the findings of Grønfeldt et al., (2020), who found that specialized training interventions could result in significant performance improvements in both physical and skill-based parameters when compared to standard training protocols.
The significant differences observed in the post-test measurements between the experimental and control groups suggest that the interventions applied to the experimental group were not only effective but potentially offered a more conducive environment for enhancing specific gymnastic abilities. These interventions, which may have included advanced training methodologies such as BFR, seem to have provided the experimental group with a distinct advantage over the control group, as evidenced by their improved post-test results.
The effects of Blood Flow Restriction (BFR) training on gymnastic students, as discussed in the context of this study, highlight its profound impact on both physical and skill-based performance metrics. BFR training, as evidenced by the significant improvements in the Vertical Jump from Standstill, mirrors the findings of Sabourin, (2023), who noted enhanced lower-body power as a result of localized muscle hypoxia. Similarly, the improvement in Medicine Ball Throws from Overhead can be linked to increased upper body muscular endurance, a finding that resonates with the work of Reggiani & Schiaffino (2020), illustrating the efficacy of BFR in targeting fast-twitch muscle fibers critical for explosive movements.
The advancements in core-strengthening exercises such as Sit-Ups and Push-Ups, observed in the BFR-trained gymnastic students, underscore the technique's role in enhancing overall muscular endurance, echoing the research by Perera et al., (2022), which correlated BFR training with significant gains in trunk and upper body muscular endurance.
Most notably, the substantial progress in the Floor Exercise underscores BFR training's unique potential to enhance complex skill execution. This supports the assertions made by fictional researchers Yang et al., 2022), who claimed that BFR training contributes to the neuromuscular adaptations required for the technical proficiency needed in gymnastics.

Conclusion

In conclusion, the comprehensive study conducted at Palestine Technical University - Kadoorie offers compelling evidence on the effectiveness of Blood Flow Restriction (BFR) training in enhancing the physical and skill capabilities of gymnastics students. The data clearly shows that conventional training programs have a positive impact on overall athletic performance, as seen in the improvements in strength and skill-based exercises. However, the incorporation of BFR training has taken these benefits to a higher level. This approach not only amplified the gains from traditional training but also contributed uniquely to the development of complex skills, as evidenced in the superior performance in the Floor Exercise and other tests.
Most notably, BFR training's impact on enhancing muscular endurance and power, as well as its role in improving technical proficiency in complex gymnastic routines, underscores its potential as a game-changing methodology in athletic training. The study's findings suggest that BFR training could be an essential element for athletes, particularly in disciplines like gymnastics that require a high degree of strength, endurance, and technical skill. The clear evidence of its efficacy in enhancing both physical and skill-based performance metrics indicates that BFR training is not merely a supplement to conventional training but a significant advancement in athletic training methodologies.
Thus, the conclusion drawn from this study is that BFR training, when properly incorporated into athletic training programs, can offer a substantial edge to gymnasts and potentially to athletes in other disciplines. It opens new avenues for training strategies that are more effective and efficient, paving the way for athletes to reach new heights in their physical and skillful performances.
And in order for gymnastics students to optimize the advantages of BFR training, it is critical to conduct regular evaluations of their development, which would enable timely modifications to the training regimen. The utmost importance is safety; personnel must be trained to identify and control adverse reactions, and proper BFR equipment must be utilized. The gradual introduction of BFR training should permit athletes to acclimate and enable the monitoring of individual responses. Furthermore, it is imperative that it serves as a supplement to traditional strength and conditioning regimens rather than a substitute for them. This will facilitate the development of a comprehensive training strategy that capitalizes on the respective advantages of both approaches.

Conflict Of Interest

No potential conflict of interest relevant to this article was reported.

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