ФІЗИЧНА КУЛЬТУРА І СПОРТ

PHYSICAL FITNESS OUTCOMES RESPONSES TO CIRCUIT RESISTANCE TRAINING – A RANDOMIZED CONTROLLED TRIAL

РЕЗУЛЬТАТИ ФІЗИЧНОЇ ПІДГОТОВКИ У ВІДПОВІДЬ НА КРУГОВЕ ТРЕНУВАННЯ З ОПОРОМ – РАНДОМІЗОВАНЕ КОНТРОЛЬОВАНЕ ДОСЛІДЖЕННЯ

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Abstracts

Purpose. This research study was conducted to identify the effect of circuit resistance training on selected physical fitness outcomes among women volleyball players.

Materials and methods. 24 players were considered as a sample for this study. The participants were randomly assigned into two groups namely experimental group (n=12) and the control group (n=12). The training program was given to the experimental group for 8 weeks and 3 day per weeks, 60–65 minutes per session. The Control group did not participate in the training designed for this study but they engage in regular volleyball training program. The variables of the study were measured twice, once before the training and then after the training. The results of a statistical analysis comparing the experimental group and the control group on four variables.

Results. Paired sample t-test was showed significant difference on physical fitness among the experimental group. The statistical analysis revealed that after eight weeks of CRT there have significant increase in chosen variable such as muscular strength ($t = 14.182$, $df = 11$, $p = .000$), upper body strength ($t = 6.588$, $df = 11$, $p = .000$), explosive power ($t = 10.776$, $df = 11$, $p = .000$), and core stability ($t = 5.089$, $df = 11$, $p = .000$) in the experimental group when compared to control group.

Conclusions. The study's findings concluded that 8 weeks of circuit resistance training significantly improved in physical fitness outcomes, like muscular strength, upper body strength, explosive strength, and core stability in volleyball players, when compared to the control group.

Key words: circuit resistance training, core stability, explosive strength, muscular strength, upper body strength.

Мета. Це дослідження було проведено з метою визначення впливу тренувань з опором на окремі показники фізичної підготовки у жінок-волейболісток.

Матеріали та методи. У дослідженні взяли участь 24 гравчині. Учасниці були випадковим чином розподілені на дві групи: експериментальну (n=12) та контрольну (n=12). Експериментальна група проходила тренувальний курс протягом 8 тижнів, 3 дні на тиждень, по 60–65 хвилин на сеанс. Контрольна група не брала участі в тренуваннях, розроблених для цього дослідження, але займалася за звичайною програмою тренувань з волейболу. Змінні дослідження вимірювалися двічі: до тренувань і після них. Результати статистичного аналізу порівнюють експериментальну групу та контрольну групу за чотирма змінними.

Результати. Парний t-критерій показав значну різницю у фізичній підготовці серед експериментальної групи. Статистичний аналіз виявив, що після восьми тижнів CRT відбулося значне збільшення обраних змінних, таких як м'язова сила (t = 14,182, df = 11, p = 0,000), сила верхньої частини тіла (t = 6,588, df = 11, p = 0,000), вибухова сила (t = 10,776, df = 11, p = 0,000) та стабільність тулуба (t = 5,089, df = 11, p = 0,000) в експериментальній групі порівняно з контрольною групою.

Висновки. Результати дослідження показали, що 8 тижнів циклічного силового тренування значно поліпшили фізичну форму, таку як м'язова сила, сила верхньої частини тіла, вибухова сила та стабільність тулуба у волейболістів, порівняно з контрольною групою.

Ключові слова: циклічне силове тренування, стабільність тулуба, вибухова сила, м'язова сила, сила верхньої частини тіла.

Introduction. Volleyball is a team sport with high-intensive activity that requires players to execute movements like jumping, blocking, shuffling, or changing directions, diving and smashing [7]. Vertical jump ability, repeated blocking, smashing and agility are important actions that determine key performance in volleyball [18; 21]. For women volleyball players, gaining physical fitness is important for improve performance, avoid injury, and maintaining general athletic health [8; 20]. To achieve these abilities, strength and conditioning are fundamental role, specifically those aimed at enhancing strength, agility, power, speed, and aerobic capacity [25].

In recent years, strength and conditioning have become highly important in all training regimens, especially in sports specific training. One of the corner stone of strength and conditioning is Resistance training. Resistance training consists of heavy-load and power focused strategies, is extensively used to enhance muscular strength, endurance and explosive power in team sports [5; 24].

Of these, Circuit resistance training (CRT) is a time-efficient training method that includes resistance exercises carried out in sequence with minimal rest [16]. And also, CRT is a method to enhance muscular strength and cardiovascular fitness simultaneously [15]. While previous studies on CRT have shown its positive effect on physical fitness variables [9; 13], most of the studies are held on obese people, general humans, and some athletes, but limited studies have focused on CRT effects among women volleyball players. Considering the physical demands of volleyball, it is essential to investigate how CRT response to physical fitness variables such as muscular strength, upper body strength, explosive power and core stability in this demographic.

This study focused on evaluating the effect of circuit resistance training on selected physical fitness outcomes among women volleyball players. By filling this research gap, the study expected to provide valuable guidance for coaches, trainers, and sports professionals in creating more effective training program suited and efficient for women volleyball players.

Material and Methods

Participants

This study was an experimental research design for 8 weeks training, to see the effect of circuit resistance training on selected physical fitness among women volleyball players in SRM Institute of Science and Technology, Chennai. The sample size was calculated with the following parameters using G*Power software: Effect size, d =0.90 (Ideal / Medium effect), α error probability=0.1, Power (1-β error probability) =0.80. The estimated sample size was 24(Approx.) for each group with a non-centrality parameter of 2.204, a critical region of 1.321 and degrees of freedom being 22. For an anticipated dropout rate of 10%, n=1 for each group was added, and the required sample size was 13 for each group. And the total sample size was 26 (Approx.). For this study, all 24 players were considered as a sample. Among 24 students, 12 of the participants were experimental groups (n=12) while the other 12 participants were considered as the control group (n=12) of the study with simple random sampling technique. The age of the participants who selected for the study was ranged from 19–24. The participants who free from injury were selected for the study. For this study informed consent was collected from all the participants.

Procedure. In the beginning of the study, 26 participants were assessed for eligibility. Out of these, 2 participants were excluded due to injuries and disqualified based on the inclusion criteria. The remaining 24 participants were randomly assigned to two equal groups. 12 participants were experimental group and received CRT as a training intervention. 12 other participants were in the control group and did not receive any specific training. In the follow up phase, the experimental group actively participated throughout the training period, no participants were discontinued in either experimental or control group. At last, all the participants for initial analysis were included in the final analysis, with no dropouts. The variables of the study were measured twice, once before the training and then after the training. The detailed procedure of the study is presented in Figure 1.

Fitness Measurements

Physical fitness measurements such as muscular strength, upper body strength, explosive power, and core stability were employed for pre and post intervention assessment. Muscular strength was tested using sit ups test (number of sit ups in one minute), upper body strength was measured by push ups (total number of push ups performed), explosive power assessed by overhead medicine ball throw test (distance covered in meters), and core stability measure by plank hold test (time in seconds). These standardized tests were selected as metrics of physical fitness that are both reliable and comparable. Detail of the test presented in the below mentioned table 1.

Intervention Procedures. All the players in the experimental group were familiarized with exercise and equipment. The circuit resistance training was designed for 8 weeks of duration, 3 sessions in a week. In every session there had three circuits to complete for the participants, with 12 exercises (stations) in a circuit and 8–10 repetitions in every exercise (station). 50–55% of one repetition maximum (1-RM) was

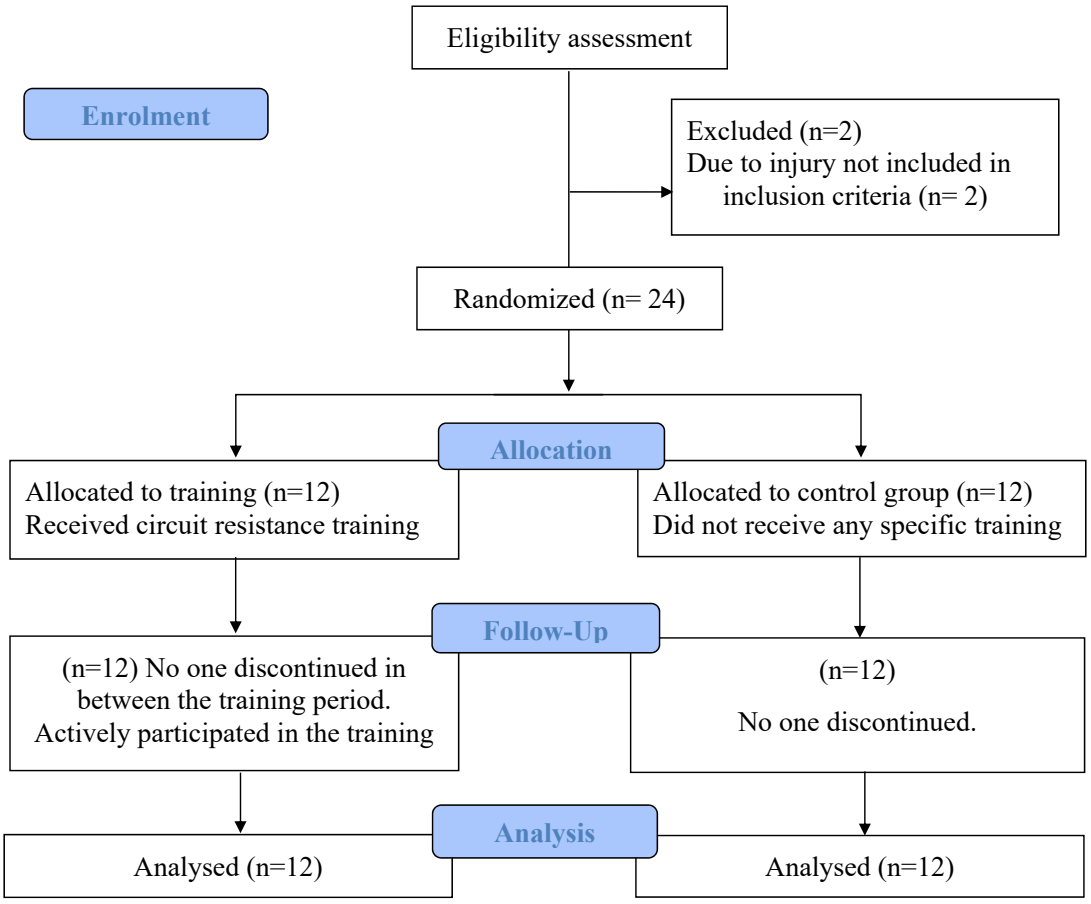

Fig. 1. Representing procedure of the study

Table 1

Selected tests for data collection

Variables	Tests	Unit of measurements
Muscular strength	Sit ups	Numbers in 1 minute
Upper body strength	Push ups	Maximum numbers
Explosive power	Overhead medicine ball throw	Distance covered in meter
Core stability	Plank test	Time in seconds

considered as the intensity of first two weeks in the training program. The next two weeks (3–4 week) of training onwards the intensity was increased step by step; in the 3rd and 4th weeks of training the intensity was 55–65% of 1RM; in the 5th and 6th week the intensity at 65–75% of 1RM; at last the training program ends at 75–85% of 1-RM. The rest period between stations and circuits were 30–60 seconds and 2–3 minutes, respectively. The circuit, were focused on all the major muscle groups in the body. In the session, participants had 15-minutes of warming-up and 10-minutes of cooling down. Every training session lasted between 60–65 minutes. Detailed circuit resistance training program presented in the below mentioned table 2. The Control group did not participate in specific training designed for this study but they engage in regular volleyball training program, it includes skill training, drills and game play. No structured resistance or strength training was followed by control group.

Analysis. The Shapiro-Wilk normality test was used to analyse the distribution of numerical values. Once normality test was confirmed, the intervention effects were examined by paired sample t-tests to determine within group effect such as muscular strength, upper body strength, explosive strength, and core stability of women volleyball players. 0.05 level was set for significance level and statistical analysis using SPSS statistics 22 version.

Results. The table 3 presents the results of a statistical analysis comparing the experimental group and the control group on four variables: muscular strength, upper body strength, explosive power, and core stability. Each variable has measurements taken before (pre-test) and after (post-test) an intervention or experiment. Here's a breakdown of what the data represents and what the statistical results indicate:

Muscular Strength

The EG's mean score increased from 46.50 at pre-test to 51.83 at post-test. The paired t-test ($t = 14.182$, $df = 11$, $p = .000$) indicates a highly significant improvement. This suggests that the intervention had a robust effect on enhancing overall muscular strength. In contrast, the CG's scores changed very little from 52.67 to 52.92 and the difference was not statistically significant ($t = .761$, $df = 11$, $p = .463$). This stability implies that any improvement in the EG

Table 2

Training program for the experimental group

Weeks	Warm up	Exercises	Set	Reps	Rest	Intensity	Warm down
1–2 week	Dynamic stretching (15 minutes)	Dumbbell Chest press, barbell incline bench press, leg extension, leg flexion, seated cable row, military press, barbell biceps curl, seated triceps press, leg press, dumbbell flyes, sit-up and barbell squat	3	8–10	30–60 se-conds	50–55% of 1RM	Static stretching (10 minutes)
3–4 week	Dynamic stretching (15 minutes)		3	8–10	30–60 se-conds	55–65% of 1RM	Static stretching (10 minutes)
5–6 week	Dynamic stretching (15 minutes)		3	8–10	30–60 se-conds	65–75% of 1RM	Static stretching (10 minutes)
7–8 week	Dynamic stretching (15 minutes)		3	8–10	30–60 se-conds	75–85% of 1RM	Static stretching (10 minutes)

Table 3

Pre and post-test score of selected variables of experimental group and control group

Variables	Test	Experimental Group				Control Group			
		Mean	SD	t	Sig. (2-Tailed)	Mean	SD	T	Sig. (2-Tailed)
Muscular strength	Pre test	46.50	7.24	14.182	0.000	52.67	10.50	0.761	0.463
	Post test	51.83	7.10			52.92	10.68		
Upper body strength	Pre test	36.67	8.80	6.588	0.000	41.42	8.27	1.593	0.139
	Post test	39.75	8.87			41.92	7.99		
Explosive power	Pre test	2.36	0.40	10.776	0.000	2.3075	0.35	1.615	0.135
	Post test	2.66	0.35			2.3233	0.35		
Core stability	Pre test	2.01	0.69	5.089	0.000	2.2775	0.72	1.307	0.218
	Post test	2.39	0.60			2.2867	0.72		

P (0.000) highly significant difference; SD-Standard deviation.

is likely attributable to the intervention rather than a natural progression or external factors.

Upper Body Strength

The EG improved significantly, with the mean score rising from 36.67 to 39.75 (t = 6.588, df = 11, p = .000). This significant increase suggests that the intervention effectively boosted upper body strength. The CG showed a slight, non-significant increase from 41.42 to 41.92 (t = 1.593, df = 11, p = .139), further reinforcing that the observed gains in the EG are a result of the intervention.

Explosive Power

The EG's explosive power improved from a mean of 2.3658 to 2.6683, with a highly significant t-test result (t = 10.776, df = 11, p = .000). This finding indicates that the intervention positively influenced the participants' ability to generate force rapidly. The CG did not show a meaningful change (2.3075 pre-test vs. 2.3233 post-test, t = 1.615, df = 11, p = .135), suggesting that explosive power improvements were specific to the intervention.

Core Stability

The EG demonstrated a significant increase in core stability, with the mean score rising from 2.0183 to 2.3908 (t = 5.089, df = 11, p = .000). This indicates that the intervention effectively enhanced the participants' ability to maintain stability in their core muscles. The CG's scores remained virtually unchanged (2.2775 to 2.2867, t = 1.307, df = 11, p = .218), underscoring the efficacy of the intervention for the EG.

The statistical analysis revealed that after eight weeks of CRT there have significant increase in chosen variable such as muscular strength (t = 14.182, df = 11, p = .000), upper body strength (t = 6.588, df = 11, p = .000), explosive power (t = 10.776, df = 11, p = .000), and core stability (t = 5.089, df = 11, p = .000) in the experimental group when compared to control group.

Discussion on findings. This study's major focus was to identify the effect of circuit resistance training on selected physical fitness outcomes among women volleyball players. The major findings of the study were that after the eight week of circuit resistance training, experimental group showed significant improvements in all four variables, suggesting the intervention was effective. The control group showed no significant changes, indicating that any observed improvements were likely due to the intervention rather than chance. Similarly, the study results were consistent with previous studies.

The study's findings revealed that the training has showed significant improvement in muscular strength of the experimental group. This finding is supported by some of previous studies and shown a positive impact [3; 4; 9; 12; 17; 19; 22; 23]. Moreover, our study results align with the study of D.W. Mola, & G.T. Bayısa, results compared to the control group and the baseline data following a 12-week practice period, it was determined that the experimental groups' treatment had significantly improved the muscular strengths [13]. Similar to participants of our research, their study investigated on young adults underwent moderate-intensity circuit training, highlighting the constancy of CRT effects across similar population. Further,

K. Lee, & K.O. An reported that 12 week of high intensity circuit resistance exercises improves the physical strength and supporting the CRT effect for enhancing muscular fitness [10]. These findings strengthen CRT as an efficient method for enhancing physical fitness in diverse demographic, including athletes.

The results of the study indicated that the experimental group had significant improvement in the Upper body strength. This finding also consistent with previous studies and shown the improvements in upper body strength [1; 6; 11; 15]. A. Buch et. al. confirmed that CRT was safe and viable mode of resistance training which can increase upper body strength, which mirrors the improvements observed in the study [2]. Their study corresponds to our findings, particularly when considering the upper body performance, which is essential for move like blocking and spiking in volleyball. Additionally, a study by Francisco Antonio Muñoz-Martínez et al. observed that after resistance circuit-based training there have greater significant effects on maximal strength in the upper limbs, reinforcing our findings related to upper body strength improvements. The study validates strength improvements observed on experimental group in our study and reaffirm that CRT is a useful modality for building upper body strength in athletes [14].

The findings of the study also indicate that the training intervention has showed significant improvement in the explosive strength and core stability. In the case of explosive strength, a previous literature [4], study result shown that 12 week resistance type circuit training significantly improves explosive strength. This study closely aligns with our study observations, CRT as an efficient and practical modality for improving strength related performance in athletic populations. Similarly, these results supported our study findings that circuit resistance training enhances physical fitness outcomes among women volleyball players. Although, the study achieved the positive effects, it has some limitation that should be acknowledged. The sample size of the study was small, to ensure generalizability expand sample size and different athletic population. Blinded allocation was not employed in the study, which may not create participant willingness to follow the treatment and understand what they are performing. In this study, long term follow assessment was not included to determine whether the improvements observed in the physical fitness variables were maintained after the intervention period. The long-term follow-up not allowed for timely assessment of training effect and there have a chance to participant's withdrawal. According to the result, it is not clear whether the observed benefits were maintained over time or if the changes reduced once training stopped. This limitation restricts ability to assess long-term effect of CRT on physical fitness outcomes. Future study should add in long term follow-up assessment to determine how long the training effects and understand long-term benefits of training.

The present study can benefit directly players, coaches, sports physiotherapists, and sports scientists. CRT can be used in different purposes and ways, such as general conditioning, sports specific training, rehabilitation, and injury prevention. This study confirms that circuit resistance training can improve physical fitness of volleyball players. In this study, the investigator used 50–80 percentage intensity in the training intervention for improving physical fitness. For better results, players and coaches can increase the intensity of the intervention. If the intervention is set at low intensity, the training can be used for rehabilitation, injury prevention, and progressive return to the previous performance. CRT can be used as method for recovery and regeneration. Future studies should examine how CRT effect in different sporting event and general populations, and also find out the combination effect with different training.

Conclusions. The study's findings concluded that 8 weeks of circuit resistance training significantly improved the physical fitness outcomes, like muscular strength, upper body strength, explosive strength, and core stability in volleyball players, when compared to the control group. Therefore, this study suggests that CRT can be beneficial for improving physical fitness

and CRT can be incorporated into other sporting events' training regimens to enhance physical performance.

Conflicts of Interest. The author reports that no possible conflicts of interest exist in the issue of publication of this manuscript.

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