The effect of high intensity interval training vs moderate intensity continuous training on motor ability components in college women athletes

El efecto del entrenamiento en intervalos de alta intensidad frente al entrenamiento continuo de intensidad moderada sobre los componentes de la capacidad motora en atletas universitarias

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Abstract

Introduction: Balance, fine motor skills, and gross motor skills are the three components of motor ability that are necessary for independent living, completing daily tasks, and engaging in active engagement with the outside world. They are essential for physical health, mobility, and coordination. By encouraging self-care, exploration, and participation in sports and physical activities, they also influence social and cognitive development as well as emotional well-being.
Objective: This study investigated the effect of high intensity interval training vs moderate intensity continuous training on arm strength and flexibility in college women athletes.
Methodology: Forty-five (N=45) women athletes, with an Age: 18.58±0.29, Height: 165.18±0.75 and Weight: 62.38±1.13 were randomly assigned to one of three groups: the High-Intensity Interval Training Group (HIITG), the Moderate-Intensity Continuous Training Group (MICTG) and Control Group (CG). The training period was limited to three days per week for twelve weeks. Among the motor ability components arm strength and flexibility were selected as dependent variables. Arm strength was measured through push-ups test and flexibility was assessed via sit & reach test.
Results: HIIT and MICT workouts are useful and effective for athletes. However, further comprehensive comparative analyses are needed to make personalized recommendations for individuals in women athletes to determine which training method is the most optimal choice for their goals.
Conclusions: In summary, HIIT and MICT workouts are useful and effective for athletes. However, further comprehensive comparative analyses are needed to make personalized recommendations for individuals in women athletes to determine which training method is the most optimal choice for their goals.

Keywords

Arm strength; athletes; flexibility; high-intensity interval training; moderate-intensity continuous training; motor ability.

Resumen

Introducción: El equilibrio, la motricidad fina y la motricidad gruesa son los tres componentes de la capacidad motora necesarios para la vida independiente, la realización de las tareas cotidianas y la interacción activa con el mundo exterior. Son esenciales para la salud física, la movilidad y la coordinación. Al fomentar el autocuidado, la exploración y la participación en deportes y actividades físicas, también influyen en el desarrollo social y cognitivo, así como en el bienestar emocional.
Objetivo: Este estudio investigó el efecto del entrenamiento en intervalos de alta intensidad frente al entrenamiento continuo de intensidad moderada sobre la fuerza y la flexibilidad del brazo en atletas universitarias.
Metodología: Cuarenta y cinco (N=45) mujeres atletas, con una edad de 18.58±0.29, una estatura de 165.18 ± 0.75 y un peso de 62.38 ± 1.13, fueron asignadas aleatoriamente a uno de tres grupos: el Grupo de Entrenamiento Interválico de Alta Intensidad (GIIT), el Grupo de Entrenamiento Continuo de Intensidad Moderada (GICM) y el Grupo Control (GC). El período de entrenamiento se limitó a tres días por semana durante doce semanas. Entre los componentes de la capacidad motora, la fuerza y la flexibilidad del brazo se seleccionaron como variables dependientes. La fuerza del brazo se midió mediante la prueba de flexiones y la flexibilidad se evaluó mediante la prueba de sentarse y alcanzar.
Conclusiones: En resumen, los entrenamientos HIIT y MICT son útiles y efectivos para las atletas. Sin embargo, se requieren análisis comparativos más exhaustivos para elaborar recomendaciones personalizadas para las atletas femeninas y determinar qué método de entrenamiento es el más óptimo para sus objetivos.

Palabras clave

Fuerza del brazo; atletas; flexibilidad; entrenamiento en intervalos de alta intensidad; entrenmiento continuo de intensidad moderada; capacidad motora.

Introduction

Regular exercise produces several physiological changes that improve exercise capacity and health, regardless of age, gender, or the existence of a chronic illness. High-intensity interval training (HIIT), a well-liked and time-efficient method of intense exercise that enhances physical fitness by raising muscle power and maximum oxygen uptake (VO2max), has emerged as a solution to the widespread lack of physical activity caused by time constraints (Kumar et al., 2024). Both clinical and healthy populations benefit from the numerous physiological changes brought about by HIIT, which consists of brief bursts of intense activity at or near peak effort interspersed with rest or low-intensity exercise (Bidhuri et al., 2025).

High intensity interval training, or HIIT, is a form of exercise that has gained popularity due to its low time commitment and potential for major effects on exercise capacity. High-intensity interval training (HIIT) is thought to be an effective training technique for improving athletes' metabolic and cardiovascular systems (Stankovic et al., 2023). More people are realizing the advantages of high-intensity interval training (HIIT) for enhancing strength, power, neuromuscular function, and overall athletic performance (Hung et al., 2025; Amin Isanejad et al.,2023).

High-intensity interval training (HIIT) is a structured approach to exercise that alternates low-intensity recovery periods with brief bursts of high-intensity effort (typically 20 seconds to several minutes at 80–95% of maximal heart rate) (Bidhuri et al., 2025). There is growing recognition of HIIT's potential to enhance neuromuscular performance in strength and power-based sports. When properly structured, HIIT can promote strength development even though it is primarily linked to aerobic and anaerobic conditioning. Because its effects on maximal strength, rate of RFD, and hypertrophy differ from those of traditional resistance training, it is crucial to carefully weigh its advantages, disadvantages, and integration strategies (Hung et al., 2025).

High-intensity interval training and moderate-intensity continuous training methods are frequently suggested to enhance motor fitness components. Continuous or long, slow distance training is defined as prolonged periods of steady-paced exercise at a moderate or high aerobic intensity, usually 60 to 80% VO2max. Regular exercise may increase capillary density, oxidative enzyme activity, plasma volume, and VO2max in untrained individuals (Mazoochi et al., 2013).

The body is impacted by HIIT, especially the autonomic nervous system, blood pressure, hormones, blood glucose, and lactate levels. HIIT can result in physiological thickening of the heart's left ventricular myocardium in the cardiovascular system, which increases the heart's strength and capacity to pump blood with each contraction and lowers the heart beats per minute (Coates et al., 2023). Physical fitness, which measures the capacity of the heart, lungs, and blood vessels to supply oxygen to working muscles and tissues as well as the capacity of those muscles and tissues to use that oxygen, was assessed in this study using the Harvard Step Test (stair climbing). Determining a person's physical strength and ability to complete a task is one of the goals of the Harvard Step Test, a fitness test. Additionally, it is useful for assessing physical fitness levels based on heart rate frequency (Tschakert and Hofmann, 2013).

An established training technique that has seen a sharp rise in research interest, especially since the year 2000, is high-intensity interval training (HIIT) (Ekkekakis et al., 2023). Numerous studies have demonstrated that high-intensity interval training (HIIT) is a time-efficient training approach that produces skeletal muscle, metabolic, and cardiorespiratory adaptations that enhance sports performance (for review, see Midgley et al., 2006; Dolci et al., 2020). However, the majority of HIIT reviews note that little research has looked at the physiological and performance responses of competitive or highly trained athletes, in contrast to the amount of research that describes the physiological adaptations to endurance exercise training in sedentary and recreationally trained individuals (Billat, 2001; Laursen and Jenkins, 2002; Meyer et al., 2004).

Moderate-intensity continuous training (MICT) improves cardiovascular endurance and aerobic fitness while also helping to manage conditions like obesity and hypertension by increasing maximal oxygen uptake, glucose metabolism, and insulin sensitivity. While MICT may be better for some outcomes, like improving cholesterol profiles and overall body fat percentage, it can be less time-efficient than high-intensity interval training (HIIT), which often produces comparable or better results in other areas, like

reducing central adipose tissue (Adrian Ram et al., 2020). While proprioceptive training, or ProprT exercises, may be especially helpful for boosting cognitive abilities in public education, MICT may be the most effective way to increase students' aerobic capacity (Lsszlo Balogh et al., 2025; Douglas et al., 2021). Regarding their effects on cardiovascular and metabolic factors, as well as body fat mass and percentage, both interventions demonstrated comparable improvements in obese adults and sedentary adolescents (Martins et al., 2016; Sanca-Valeriano et al., 2023; Sun et al., 2024).

Notwithstanding its encouraging advantages, there are still unanswered questions in the literature about the precise effects of HIIT on functional fitness in older adults, especially in areas like strength, mobility, flexibility, and aerobic endurance that are directly linked to autonomy in day-to-day living (Niyazi et al., 2024). It is commonly accepted that one of the most important factors influencing independence and quality of life in older adults is functional fitness (Distefano et al., 2018). Mobility, balance, and general physical performance can all be negatively impacted by its progressive decline (Liu et al., 2019). Maintaining health and functional independence is largely dependent on muscle strength. In older adults, it is closely linked to improved physical performance, disability prevention, and a lower risk of morbidity and death(De Lima et al., 2018). Because of its ease of use, dependability, and high predictive value for unfavorable health outcomes in aging populations, handgrip strength has become one of the most popular indicators among the different assessment tools (Dodds et al., 2014).

Method

In this cohort study, a quantitative quasi-experimental design was carried out with the objective of an investigated the effect of high intensity interval training vs moderate intensity continuous training on arm strength and flexibility in college women athletes. Particularly as people age, arm strength and flexibility are essential for carrying out daily tasks, avoiding injuries, and preserving bone and muscle health. While flexibility guarantees a full range of motion, allowing for sports, bending, and reaching, strength permits lifting and carrying. When combined, they enhance balance, posture, and coordination, which lowers the chance of falls and promotes a longer, healthier life. These variables were measured before (pre-test) and after (post-test) the complete training cycle. Table 1 below shows the participants' demographics.

Table 1. Participant demographics

Demographics Characteristic	HIITG	MICTG	CG	Overall Average
Number of Participants	15	15	15	15
Average Age (Years)	18.50	18.61	18.64	18.58
Average Height (Cm)	165.20	165.13	165.2	165.18
Average Weight (Kg)	62.35	62.38	62.41	62.38

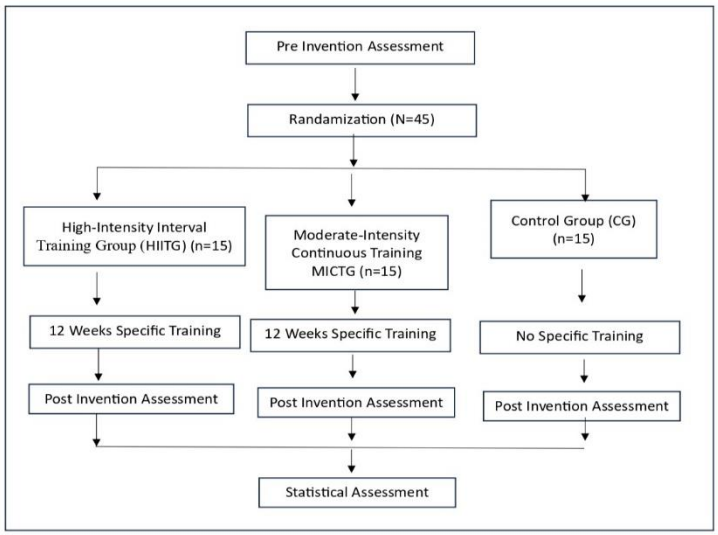
This study's main goal was to ascertain which exercise HITT or MICT is better at increasing arm strength and flexibility when compared to a control group. To assess the effects of both training techniques, the study employed a quasi-experimental design with a 12-week intervention period with a pre-test and post-test control group model. Training type, classified as either MICT or HITT was the independent variable. The push-up test was used to measure arm strength and flexibility was assessed via sit & reach test. The analysis's covariates were the pre-test results.

Participants

Forty-five (N=45) women participants were recruited for the study. The age, standing and body height of the subjects was ranged between Age: 18.58 ± 0.29, Height: 165.18±0.75 meters and Weight: 62.38±1.13 kilograms respectively. The researchers used random sampling as the sampling technique. All participants were healthy athletes with no prior history of any health issues. They regularly engaged in physical activities but had not participated in structured specific training. To make sure the participants fulfilled the inclusion and exclusion criteria, the researchers performed an initial screening using questionnaires, enrollment forms, and preliminary interviews. For validation and verification, they also asked for supporting documentation, including medical records, exercise records, and parental consent.

Three groups of 15 participants each were randomly assigned: the High-Intensity Interval Training Group (HIITG), the Moderate-Intensity Continuous Training Group (MICTG) and the Control Group (CG). All participants maintained a 93% attendance rate throughout the research implementation; none were turned away from the training. Each of the 45 participants came from the same geographical area and gave their all to the research activities.

Figure 1. Flow diagram of study group randomisation



Procedure

Arm Strength

With your arms outstretched, stand beneath the bar and grasp it with an overhand grip that is just a little bit wider than shoulder-width. Pull yourself up by pulling your elbows down and toward your body until your chin clears the bar, using your back muscles and shoulder blades to pull yourself up. Lower your body gradually back to the initial hanging position to control the descent.

Flexibility

The Sit and Reach test involve taking off your shoes and sitting on the floor with your knees straight and your legs outstretched. Align the soles of your feet with the beginning line on the measuring surface and place them against the sit-and-reach box. Reach forward slowly with both hands stacked, keeping your legs straight, and slide them as far along the measuring scale as you can without bouncing or bending your knees. For at least two seconds, hold the point that is the furthest away. The distance traveled, measured to the closest 0.5 cm, is your score.

Training Program

The high-intensity interval training and moderate-intensity continuous training intervention were thoughtfully created to systematically improve motor ability performance through a planned, progressive exercise regimen. A thorough summary of the 12-week training regimen is given in Tables 2 and 3, which also includes information on the particular exercises, their progression, level of difficulty, and the physiological adaptations that are being sought.

Table 2. Detailed high intensity interval training protocol

Week	Specific Exercise	Repetition	Sets	Recovery
1-4	Jumping Jack	8	2	10 Seconds Between Each Exercise and 180 Seconds Between Set
	Push-Up With Shoulder Touch	8	2	
	Power Plank Walk	8	2	
	Flutter Kick	8	2	

	12 M Shuttle Run	2 Bouts	2	
	Sit-Up	8	2	
5-8	Jumping Jack	10	3	10 Seconds Between Each Exercise and 180 Seconds Between Set
	Push-Up With Shoulder Touch	10	3	
	Power Plank Walk	10	3	
	Flutter Kick	10	3	
	12 M Shuttle Run	3 Bouts	3	
	Sit-Up	10	3	
9-12	Jumping Jack	12	4	10 Seconds Between Each Exercise and 180 Seconds Between Set
	Push-Up With Shoulder Touch	12	4	
	Power Plank Walk	12	4	
	Flutter Kick	12	4	
	12 M Shuttle Run	3 Bouts	4	
	Sit-Up	12	4	
	12 M Shuttle Run	2 Bouts	4	
	Sit-Up	8	4	

Table 3. Exercise intervention for moderate-intensity continuous training

Activity	Time	Week	Intensity (%HRR)	Duration and intensity of rests
Warm up	6 Minutes		20-30% HRR	
Exercises	48 Minutes	1-4	50% HRR x 4 Sets	40 sec. rest-work at 50% HRR
		5-8	60% HRR x 4 Sets	40 sec. rest-work at 50% HRR
		9-12	70% HRR x 4 Sets	40 sec. rest-work at 50% HRR
Cooling down	6 Minutes		20-30% HRR	
Total	60 Minutes			

Note: HRR - heart rate reserve

Data analysis

To compare post-test scores while analyzing for differences in pre-test scores, statistical analysis was done using Analysis of Covariance (ANCOVA). Scheffe's post-hoc test was used to calculate the post-hoc paired mean difference, and the significant level was set at a 0.05 confidence level ($p<0.05$). The statistical package for social science (SPSS) for Windows was used to compile and analyze the data.

Results

Arm strength

Table 4 shows that the pre-test means and standard deviation values of arm strength for HIIT, MICT and CG are 5.13±0.88, 5.00±0.73 and 5.27±1.29, these no significant differences ($F=0.25$, $p=0.779$) in the intimal phase. This indicated that everyone began with comparable arm strength levels. The post-test means and standard deviation values of arm strength for HIIT, MICT and CG are 7.53±0.88, 6.53±1.02 and 5.33±1.49, these analysis of the study indicated that there was a significant difference ($F=12.57$, $p<0.000$) between HIIT, MICT and CG. The adjusted posttest means values of arm strength for HIIT, MICT and CG are 7.53, 6.67 and 5.20 respectively. The analysis of covariance (ANOVA) revealed a significant difference among the groups ($F = 52.34$, $p<0.000$), strongly supporting the effectiveness of both HIIT and MICT in enhancing arm strength. Pair wise comparisons of Scheffe's Post Hoc test results are presented in table 5.

Table 4. Showing the analysis of co-variance on the parameter of arm strength (Measures in counts)

Test	HIITG	MICTG	CG	Source of Variance	Sum of Squares	df	Mean Squares	F-ratio	P value
Pre-Test Mean & SD	5.13±0.88	5.00±0.73	5.27±1.29	Between groups	0.53	2	0.27	0.25	0.779
				Within groups	44.67	42	1.06		
Post-Test Mean & SD	7.53±0.88	6.53±1.02	5.33±1.49	Between groups	36.40	2	18.20	12.57*	0.000
				Within groups	60.80	42	1.45		
Adjusted Post-Test Mean	7.53	6.67	5.20	Between sets	41.53	2	20.77	52.34*	0.000
				Within sets	16.27	41	0.40		

HIITG- High-Intensity Interval Training Group, MICTG- Moderate-Intensity Continuous Training Group, CG- Control group, df- degree of freedom, SD- Standard Deviation, *Significant at 0.05 level of confidence, Table value for df (2, 42) at 0.05 level = 3.22, Table value for df(2, 41) at 0.05 level = 3.23

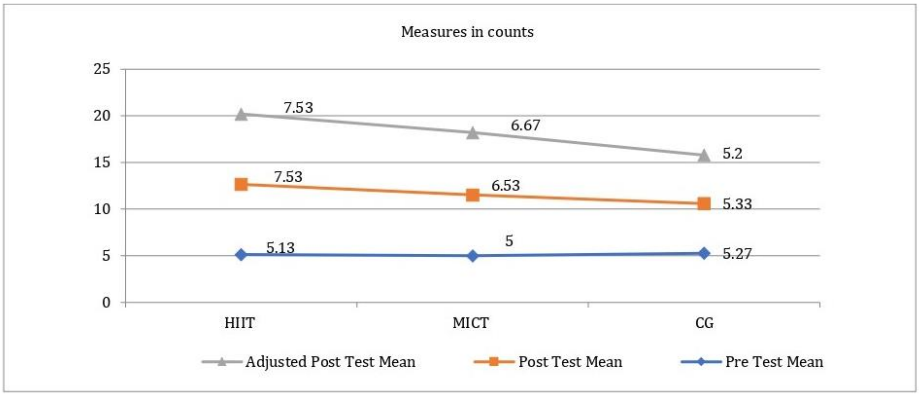
Table 5 shows that the mean difference values of HIIT and MICT, HIIT and CG, MICT and CG are 0.87, 2.33 and 1.47 respectively, which are greater than the confidence interval value of 0.58 on arm strength at 0.05 level of confidence. The results of the study showed that there was a significant difference between HIIT and MICT, HIIT and CG, MICT and CG. The above data also reveal that HIIT is better than MICT and CG.

Table 5. Scheffe's test for the difference between paired means on arm strength (Measures in counts)

HIIT	MICT	CG	Mean Difference	Confident Interval Value
7.53	6.67	---	0.87*	0.58
7.53	---	5.20	2.33*	
---	6.67	5.20	1.47*	

*Significant at 0.05 level of confidence.

Figure 2. Arm stenght on high-intensity interval training. Moderate-intensity continuous training, and control group athletes.



Flexibility

Table 6 shows that the pre-test means and standard deviation values of flexibility for HIIT, MICT and CG are 17.93±0.68, 17.87±0.72 and 18.20±0.83, these no significant differences (F=0.78, p=0.0464) in the intimal phase. This indicated that everyone began with comparable flexibility levels. The post-test means and standard deviation values of flexibility for HIIT, MICT and CG are 2.53±1.20, 20.33±1.19 and 18.33±1.40, these analysis of the study indicated that there was a significant difference (F=59.87, p<0.000) between HIIT, MICT and CG. The adjusted posttest means values of flexibility for HIIT, MICT and CG are 23.58, 20.42 and 18.20 respectively. The analysis of covariance (ANOVA) revealed a significant difference among the groups (F = 72.98, p < 0.000), strongly supporting the effectiveness of both HIIT and MICT in enhancing flexibility. Pair wise comparisons of Scheffe's Post Hoc test results are presented in table 7.

Table 6. Showing the analysis of co-variance on the parameter of flexibility (Measures in centimeters)

Test	HIITG	MICTG	CG	Source of Variance	Sum of Squares	df	Mean Squares	F-ratio	P value
Pre-Test Mean & SD	17.93±0.68	17.87±0.72	18.20±0.83	Between groups	0.93	2	0.47	0.78	0.464
				Within groups	25.07	42	0.60		
Post-Test Mean & SD	23.53±1.20	20.33±1.19	18.33±1.40	Between groups	206.40	2	103.20	59.87*	0.000
				Within groups	72.40	42	1.72		
Adjusted Post-Test Mean	23.58	20.42	18.20	Between sets	215.74	2	107.87	72.98*	0.000
				Within sets	60.60	41	1.48		

HIITG- High-Intensity Interval Training Group, MICTG- Moderate-Intensity Continuous Training Group, CG- Control group, df- degree of freedom, SD- Standard Deviation, *Significant at 0.05 level of confidence, Table value for df (2, 42) at 0.05 level = 3.22, Table value for df(2, 41) at 0.05 level = 3.23

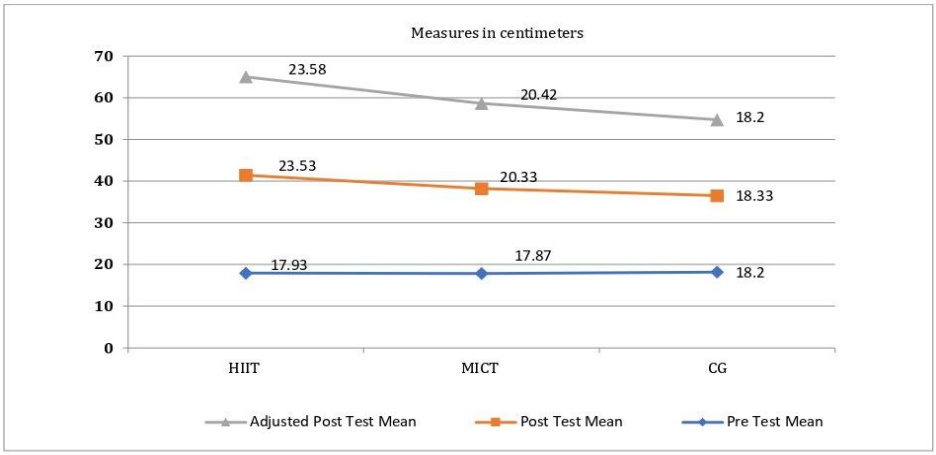
Table 7 shows that the mean difference values of HIIT and MICT, HIIT and CG, MICT and CG are 3.15, 5.38 and 2.23 respectively, which are greater than the confidence interval value of 1.13 on flexibility at 0.05 level of confidence. The results of the study showed that there was a significant difference between HIIT and MICT, HIIT and CG, MICT and CG. The above data also reveal that HIIT is better than MICT and CG.

Table 7. Scheffe's test for the difference between paired means on flexibility (Measures in centimeters)

HIIT	MICT	CG	Mean Difference	Confident Interval Value
23.58	20.42	---	3.15*	1.13
23.58	---	18.20	5.38*	
---	20.42	18.20	2.23*	

*Significant at 0.05 level of confidence.

Figure 3. Flexibility on high-intensity interval training, moderate-intensity continuous training, and control group atheltes.



Discussion

This study compares the effects of continuous, moderate-intensity training versus high-intensity interval training on arm strength in female collegiate athletes. The primary conclusions were that arm strength and flexibility were considerably increased by both HIIT and MICT programs. But when compared to MICT, HIIT produced larger gains in arm strength and flexibility. A flexible and successful technique for improving neuromuscular function, strength, power, and endurance is High-Intensity Interval Training (HIIT). Its benefits for power-based and intermittent sports are highlighted by its capacity to maximize motor unit recruitment, muscle fiber composition, and neuromuscular efficiency.

Careful planning, periodization, and customized programming are necessary to optimize the advantages of HIIT while reducing any potential interference effects with conventional resistance training. Comprehensive gains in explosive force production, fatigue resistance, and general athletic performance can be achieved by carefully combining HIIT with strength, hypertrophy, and plyometric training (Hung et al., 2025).

Abarzua et al. (2019) concluded from their review of the literature on teenagers that HIIT improves muscle strength and cardiovascular fitness, suggesting that its efficacy is not limited by age or initial fitness level. Since a direct correlation between physical fitness and cardiovascular risk in adulthood has been noted, it is crucial in this field of study to highlight the idea of health-related physical fitness, which includes strength, muscular endurance, flexibility, cardiorespiratory or aerobic capacity, and body composition (Ortega et al., 2005, Ruiz et al., 2009). HIIT appears superior to MICT in enhancing VO2 peak and, consequently, cardiopulmonary function in cancer survivors. Nonetheless, both training modalities yield comparable outcomes in body composition and physical function(Chenggen et al., 2025).

The evidence that is currently available indicates that HIIT and MICT can significantly increase the arm strength and flexibility of female athletes. In addition to increasing general physical fitness, high intensity interval training specifically improves arm strength and flexibility. According to these results, adding HIIT and MICT to general fitness programs that aim to improve health outcomes for people who want to perform better in sports is a good idea. Moreover, the results obtained in our study confirmed that the improvements obtained by MICT were similar to those obtained by HIIT in a group of women athletes, this was supported by Alleva et al., (2023) and Amin et al., (2023).

According to the study's findings, chosen dependent components such as arm strength and flexibility have considerably increased in all experimental groups, including high-intensity interval training and moderate-intensity continuous training. Additionally, the study's findings indicated that the control group had not significantly improved. Furthermore, it has been discovered that HIIT has a greater impact on arm strength and flexibility than MICT and CG.

Conclusions

Based on our observations, MICT may be the most useful training method for developing arm strength and flexibility. On the other hand, any type of training is beneficial, as each type improves arm strength and flexibility, which can affect athletes' performance. All two types of training were effective in increasing arm strength and flexibility. If the goal is to improve students' arm strength and flexibility, the most effective method is HIIT. However, c.

In summary, HIIT and MICT workouts are useful and effective for athletes. However, further comprehensive comparative analyses are needed to make personalized recommendations for individuals in women athletes to determine which training method is the most optimal choice for their goals.

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Conflicts of Interest

All authors clearly stated that they have no conflicts of interest.

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