

## Comparative Analysis of Adaptations Progress in VO<sub>2</sub>max, Leg Power, and Agility among Male and Female Sports Science Students

### Análisis Comparativo del Progreso de las Adaptaciones en VO<sub>2</sub>max, Potencia de Piernas y Agilidad entre Estudiantes Masculinos y Femeninos de Ciencias del Deporte

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**Abstract.** The strength and conditioning program has emerged as a widely adopted, structured exercise intervention aimed at enhancing muscle strength, endurance, speed, power, flexibility, and physical function, all while mitigating the risk of injuries. Several studies, however, have assessed strength and conditioning interventions in general for sports science students at the university. Objectives: Therefore, this study aims to explore the differential effects of a strength and conditioning program incorporating a combination of Continuous Run (CR) and Circuit Training (CT) methods on VO<sub>2</sub>max, leg power, and agility applied to male and female sports science students. Material and Methods: Utilizing a quasi-experimental design with a one-group pretest-posttest setup spanning from July to October 2022, the study consisted of 8 microcycles (8 weeks) comprising 24 sessions, where each microcycle included 2 active rest days (recovery run). A total of 63 students with bachelor's degrees in sports science who have recently enrolled as freshmen in the Faculty of Sports Science (n = 39 men; n = 24 women; aged = 18-20 years; mass (kg) men and women = 60 ± 7 and 51 ± 6, Height (cm) men and women = 172 ± 4 and 158 ± 3, and not trained athletes) were selected through purposive sampling and provided informed consent in the present study. Pre- and post-measurements were conducted using the Multi-Stage Fitness Test (MSFT), standing broad jump test, and the Illinois agility run test. Descriptive and inferential data analyses (differential pre and post-test using the Wilcoxon test) were performed using SPSS 25 software. Results: Our findings reveal significant improvements in VO<sub>2</sub>max and leg power following the implementation of a strength and conditioning program that combines circuit training with continuous running for males (from 35.76±5.94 to 41.99±5.35 and 2.175±0.23 to 2.30±0.25, respectively; P<0.05). Meanwhile, for females, (25.97 ± 2.78 to 31.10 ± 3.09; 1.66±0.24 to 1.72±0.17; P<0.05). However, the study does not identify a significant improvement in agility for both male and female participants (17.90±0.95 to 17.69±0.87; P>0.05 and 20.13 ± 1.17 to 19.89 ± 1.19; P>0.05). Conclusions: This investigation provides valuable insights into the effectiveness of an integrated strength and conditioning program using a combination of Continuous Run (CR) and Circuit Training (CT) methods on VO<sub>2</sub>max and Leg power, for both males and females. Although there were no significant improvements in agility for either males or females, there was an increase in overall averages. The results offer implications for optimizing physical performance and refining training protocols. Therefore, the combination of Continuous Run (CR), circuit training (CT), and Circuit Resistance Training (CRT) has proven to be a practical strategy for enhancing VO<sub>2</sub>max and leg power. This is particularly relevant for coaches seeking to diversify exercise variations that can be applied to sports science students in the future

**Keywords:** *Strength and Conditioning, Circuit Training, Continuous Run, VO<sub>2</sub>max, Leg Power, Agility, Sports Science Students*

**Resumen.** El programa de fuerza y acondicionamiento ha surgido como una intervención de ejercicio estructurada ampliamente adoptada con el objetivo de mejorar la fuerza muscular, resistencia, velocidad, potencia, flexibilidad y función física, al tiempo que mitiga el riesgo de lesiones. Sin embargo, varios estudios han evaluado las intervenciones de fuerza y acondicionamiento en general para estudiantes de ciencias del deporte en la universidad. Objetivos: Por lo tanto, esta investigación tiene como objetivo explorar un programa de fuerza y acondicionamiento que abarque una combinación de Carrera Continua (CR) y Entrenamiento en Circuito (CT) sobre VO<sub>2</sub>max, potencia de piernas y agilidad en estudiantes de ciencias del deporte. Material y Métodos: Utilizando un diseño cuasixperimental con una configuración de preprueba y postprueba de un solo grupo que abarcó de julio a octubre de 2022, el estudio constó de 8 microciclos (8 semanas) que comprendían 24 sesiones, donde cada microciclo incluía 2 días de descanso activo (carrera de recuperación). Se seleccionaron 63 estudiantes con títulos de licenciatura en ciencias del deporte que se han inscrito recientemente como estudiantes de primer año en la Facultad de Ciencias del Deporte (n = 39 hombres; n = 24 mujeres; edad = 18-20 años; y no atletas entrenados) mediante un muestreo intencional y proporcionaron su consentimiento informado en el presente estudio. Se realizaron mediciones previas y posteriores utilizando la Prueba de Aptitud Física Multietapa (MSFT), la prueba de salto de longitud en posición de pie y la prueba de agilidad de carrera de Illinois. Se llevaron a cabo análisis de datos descriptivos e inferenciales (diferenciales pre y postprueba utilizando la prueba de Wilcoxon) mediante el software SPSS 25. Resultados: Nuestros hallazgos revelan mejoras significativas en VO<sub>2</sub>max y potencia de piernas después de la implementación de un programa de fuerza y acondicionamiento que combina el entrenamiento en circuito con la carrera continua en hombres (de 35.76±5.94 a 41.99±5.35 y de 2.175±0.23 a 2.30±0.25, respectivamente; P<0.05). Mientras tanto, para las mujeres (de 25.97 ± 2.78 a 31.10 ± 3.09; 1.66±0.24 a 1.72±0.17; P<0.05). Sin embargo, el estudio no identifica una mejora significativa en la agilidad tanto para los participantes masculinos como femeninos (de 17.90±0.95 a 17.69±0.87; P>0.05 y de 20.13 ± 1.17 a 19.89 ± 1.19; P>0.05). Conclusiones: Esta investigación proporciona ideas valiosas sobre la efectividad de un programa integrado de fuerza y acondicionamiento que utiliza métodos combinados de Continuous Run (CR) y Circuit Training (CT) en VO<sub>2</sub>max y la potencia de piernas. Aunque no hubo un aumento significativo en la agilidad, sí se observó una mejora en el promedio general. Los resultados ofrecen implicaciones para optimizar el rendimiento físico y perfeccionar los protocolos de entrenamiento. Por lo tanto, la combinación de CR (carrera convencional en pista y en la naturaleza) y CT (CT convencional y Circuit Resistance Training (CRT)) ha demostrado ser una estrategia práctica para mejorar el VO<sub>2</sub>max y la potencia de piernas. Esto es de gran interés para los entrenadores que buscan diversificar las variaciones de ejercicio aplicables a los estudiantes de ciencias del deporte en el futuro.

**Palabras clave:** Fuerza y Acondicionamiento, Entrenamiento en Circuito, Carrera Continua, VO<sub>2</sub>max, Potencia de Piernas, Agilidad, Estudiantes de Ciencias del Deporte.

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## Introduction

Strength and conditioning is described as a systematic and purposeful activity involving bodily movements that are planned, structured, and repetitive, with the aim of maintaining or improving physical fitness, overall health, and well-being. Essentially, the strength and conditioning includes a diverse range of exercises encompassing cardiovascular, strength, speed, flexibility, and endurance components, tailored to individual needs, decrease injury risk, and goals (Balyi et al., 2013; Bompa & Buzzichelli, 2015; González et al., 2022; Ilham & Dimiyati, 2021; Mario et al., 2022; Sukarmin et al., 2021; Sulistiyowati et al., 2022; Zouhal et al., 2010). The development of physical fitness components such as endurance, strength, speed, and flexibility plays a crucial role as determinants of fitness performance and chosen sports skills (Bahtra et al., 2020; Balyi et al., 2013; Bompa & Buzzichelli, 2015; Chaeroni et al., 2022; Donie et al., 2022). As a foundational step to shift the training focus to a specific sports discipline, every individual should address overall physical fitness matters through a comprehensive strength and conditioning program, and this applies to sports science students as well (Jadhav, 2020; Serviente et al., 2019; Silverman & Mercier, 2015). Not only athletes and coaches, but sports science students also have the need for optimal physical condition as they will encounter various sports practices and significant and complex stress during the course of their studies (Lopes Dos Santos et al., 2020). Thus, sports science students must maintain a high-quality physical condition because the demands of university life for sports science students necessitate strong aerobic abilities complemented by effective anaerobic capabilities (Çiçek, 2018).

The difference in the level of physical fitness will impact individuals' ability to engage in activities (Granero-Jiménez et al., 2022; A. Nugroho et al., 2021; Pratama et al., 2024; Rifki et al., 2023). In physiological terms, physical fitness is divided into two categories: fitness related to health and fitness related to sports skills (Farley, Stein, et al., 2020). Physical fitness related to health occurs when physical activities are performed without significant fatigue (Fynmore, 1985). Elements of health-related physical fitness include cardiovascular endurance, muscle strength, muscle endurance, flexibility, and body composition (Blair et al., 2001; Nova, Risma; Syahrial, Bakhtiar; Umar; Ilham; Fiky Zarya; Japhet, 2024; Park et al., 2021). On the other hand, elements of physical fitness related to sports skills include speed, power, balance, agility, coordination, and reaction speed (Corbin, 2000; Farley, Barrett, et al., 2020). Physical fitness is crucial for sports science students to support the quality of their human resources to complete their studies (Çiçek, 2018). Among the physical fitness elements most needed by sports science students are cardiovascular endurance, leg power, and agility (Yendrizal et al., 2023). This is because sports science students will be involved in the next semester with practical courses in sports skills, which involve high volume and intensity. Cardiovascular

endurance, as indicated by VO<sub>2</sub>max, is crucial to enhance for all sports science students so they can engage in high-volume physical activities for extended periods without significant fatigue. The maximum oxygen consumption (VO<sub>2</sub>max) plays a crucial role in the performance of endurance exercises as it establishes the highest boundary for aerobic metabolism (Dimiyati, Ilham, et al., 2023; Joyner, 2017). According to (Hoff et al., 2002) and (Montero et al., 2015) The high VO<sub>2</sub>max values depends on maximal oxygen uptake, having good cardiovascular endurance will influence the activities undertaken by students, such as their initiative and activeness in learning both theoretical and practical sports skills during practical classes. Considering the importance of cardiovascular endurance for sports science students, cardiovascular fitness needs to be enhanced. An effective way to improve cardiovascular endurance is through regular physical exercise (Bahtra et al., 2020). Exercises that stress the heart and lungs are criteria used to enhance cardiovascular endurance (Grigaliūnienė et al., 2013). One of the notable outcomes of exercise is the improvement in VO<sub>2</sub>max value, particularly with CR (Milanović et al., 2015). Continuous Run (CR) is one of the strategic and easily performed training methods to enhance VO<sub>2</sub>max values. Meanwhile, CR protect against cardiovascular disease and cancer, the two major causes of death in most developed countries (Lee et al., 2017). Continuous Running (CR) exercises can help prevent these diseases. Continuous running enhances your respiratory capacity, promoting improved ventilation and heightened metabolic efficiency. Participating in consistent running exercises improves the efficiency of the heart and lungs, leading to enhanced functionality and increased oxygen circulation within the bloodstream (Dhuha et al., 2020; Sridadi et al., 2021).

Another component of physical fitness that supports sports science students is leg muscle power because various activities in academic training demand high leg muscle power, such as basketball, volleyball, athletics, soccer, tennis, and so on. The power that can be enhanced by each individual depends on force and velocity (Chelly et al., 2010). Therefore, it is crucial to enhance power by focusing on strength and speed during the application of training loads on muscles. Based on previous research, power can be significantly increased after 8 weeks of heavy resistance training. Loads ranging from sub-maximal 60-90% of maximal dynamic strength, with repetitions of 8-12, are utilized to increase muscle mass and train power (Pratama et al., 2024; Tesch & Larsson, 1982). Thus, physiological adaptations to resistance training depend on muscle contractions, duration, and intensity utilized during exercise. In addition, a crucial physical fitness component required for sports science students is agility. Agility refers to an individual's ability to move the entire body in rapidly changing directions as quickly as possible. Agility is a subset of the parent component of physical fitness, namely speed, which encompasses acceleration, quickness, maximal velocity, speed endurance, and agility. Based on previous research, training

to improve agility can be conducted using circuit training, plyometrics, shuttle runs with coaches, variations of ladder drills, for instance, with specific designs, but performed with high intensity (Agostini et al., 2017; Irandoust & Jami, 2022; Labib Siena Ar Rasyid et al., 2023; Sidik & Rosdiana, 2023). Nevertheless, speed, including agility, is a challenging component of physical fitness to enhance (Trecroci et al., 2022).

Based on field observations, the cardiovascular endurance, leg power, and agility abilities of sports science students at Universitas Negeri Padang are still suboptimal. This is indicated by direct observations conducted by researchers in July 2023 at the athletic field of Universitas Negeri Padang, where measurements were taken using the Multi-Stage Fitness Test, standing broad jump, and Illinois agility test, resulting in low test scores. This is attributed to the lack of effective training programs and their misalignment with training objectives. The strength and conditioning training conducted by lecturers so far has not been well-programmed, thus failing to target the specific goals of each physical fitness component to be trained. However, this course is crucial for enhancing the most dominant physical fitness components (cardiovascular endurance, leg power, and agility) to prepare students for subsequent semesters.

To date, Circuit Training is one of the frequently utilized training methods to enhance physical fitness performance, including strength, speed, endurance, flexibility, strength endurance, power, and so forth (Berhimpong et al., 2023; Makadada et al., 2024). Circuit training effectively reduces the time spent on training while enabling adequate training volume (Mola & Bayisa, 2020). This method, designed to enhance aerobic conditioning, muscular endurance, and induce neuromuscular and strength adaptations, is characterized by the completion of single or multiple sets of diverse exercises consecutively, with minimal rest between exercises (Ramos-Campo et al., 2021). The intensity of the exercises varies, encompassing low (<60% of one maximum repetition (1-RM)), moderate (60–80% 1-RM), or high loads (>80% 1-RM) (Ramos-Campo et al., 2021). Repetition ranges can be high (12–15), low (<12), or based on a specific time duration (e.g., 30 s), all while maintaining a brief rest period between exercises, for example in 30 s (Ramos-Campo et al., 2021). From a procedural standpoint, circuit training is a physical training method in which an athlete moves sequentially from one designated training station to another in the most efficient manner. In circuit training program planning, exercises are selected according to individual needs (J Bovas & C. S Pradeep, 2020; Jadhav, 2020; Pranoto et al., 2023). In general, sports science students should initially undergo general conditioning before gradually progressing to specific training for the sports skills they are interested in. When finished with one circuit, the first exercise of the following circuit should be started. Circuit training is a form of body conditioning that involves resistance training and high-intensity aerobics. Besides, the results of circuit training will simultaneously increase muscle strength, endurance, cardiovascular fitness, and flexibility (Gopinathan, 2019; Sonchan et al., 2017;

Yuliandra et al., 2020).

In recent years, circuit training has attracted researchers' attention to improving physical fitness. Circuit training is famous as a strategy during exercise due to the distinct quality of physical fitness (Gopinathan, 2019). Circuit training can help you increase your strength and endurance by increasing the exercise repetitions at each station or by performing the required shorter exercise frequency (J Bovas & C. S Pradeep, 2020; Jadhav, 2020).

Furthermore, Circuit Training significantly enhances VO<sub>2</sub>max values when provided with adequate training (Sonchan et al., 2017). Circuit training (CT) has been shown to be effective in enhancing aerobic capacity, anaerobic capacity, improving body composition, increasing flexibility, and elevating muscle endurance (Firmansyah et al., 2024; Ramos-Campo et al., 2021). It is asserted that combining CT with aerobic exercise and weight training has been shown to improve physical fitness (Alcaraz et al., 2008; Sonchan et al., 2017).

The research previously reported has not specifically focused on the structure of circuit training programs that refer to the detailed training of muscles, including agonists and antagonists, as well as movement harmonization exercises. Moreover, after certain sessions, CT is followed by loaded circuit training (CRT). Meanwhile, aerobic exercises are performed on two different surfaces: athletic tracks and sand surfaces. Subsequently, all exercises are gradually implemented according to the training periodization stages, including general preparation, general-specific preparation, and specific preparation.

In the conventional approach to improving the physical fitness of sports science students, it is typically done through a strength and conditioning program in dedicated lectures led by instructors through a specific course. Various approaches to enhancing the physical fitness of sports science students have been explored (Yendrizal et al., 2023). However, structured and strategic approaches, such as incorporating a combination of continuous run and circuit training, remain limited. The circuit training (CT) in this study encompasses both conventional CT and circuit resistance training (CRT), involving specific loads, volumes, intensities, and recovery periods. In this research, continuous run includes conventional CR using the athletic track, CR on sand, and CR in a natural environment.

Therefore, we hypothesize that the dose (volume, intensity, and recovery) we designed in the form of an 8-week periodization with specific provisions. The exercises designed in this study are structured exercises and periodization. Therefore, based on the importance of the discussion above, this study aims to see the effect of circuit training combined with continuous running in testing for a statistically significant increase in the sports science student in terms of VO<sub>2</sub>max, leg power, and agility. Sports science students must have good physical and mental fitness and performance for exercise to be effective and productive. If so, the CR and CT will be a good means and intervention to improve the quality of physical fitness.

## Research Methods

### Study Design

This quasi-experimental research used a one-group pretest-posttest designed to test the effect of strength and conditioning program, performed CR and CT (Montgomery, 2013). The research subjects were selected using purposive sampling technique. This experimental study utilized two separate groups, one for males and one for females. Because quasi-experiments cannot control participants' activities outside the physical training program, the researchers were unable to specifically monitor participants' activities.

Meanwhile, the strength and conditioning program involving CR and CT commenced one day after the pretest and continued for 8 weeks. The training program was structured in three stages: 1) general preparation, encompassing physical training with a high volume and low intensity, aimed at general conditioning, anatomical adaptation, and injury prevention; 2) general-specific preparation, involving a transition from general (low-intensity) to specific preparation, incorporating higher-intensity exercises while reducing the training volume; 3) specific preparation, entailing a program with high intensity and low training volume. The final stage, posttest, was conducted on a different day after the completion of all intervention training sessions.

### Participant

Participants consisted of sixty-three sports science students with bachelor's degrees in sports science who recently joined as freshmen in the Faculty of Sports Science, Universitas Negeri Padang (n = 39 men and n = 24 women), selected through purposive sampling. The inclusion criteria were: 1) being a new sports science student in 2022 taking physical conditioning courses; 2) aged 18-20 years. The exclusion criteria for this study were: 1) not being an athlete/trained athlete; 2) students majoring in fields other than sports science; 3) having a history of degenerative diseases; and 4) having a history of moderate-to-severe sports injuries. All procedures were approved by the Ethics Committee of Universitas Negeri Padang. All participants were provided with information regarding the nature, purpose, procedures, and associated risks, and they provided written informed consent.

### Intervention Procedure

The first stage of this research involved obtaining research permits. All necessary equipment and infrastructure were administratively prepared. After completing all research administration, the pretest was conducted to gather data on VO<sub>2</sub>max, leg power, and agility. Subsequently, the available training program was implemented during the 8 weeks training periodization, which included the Continuous Run (CR) and Circuit Training (CT) methods. These were initially programmed to prevent injuries and then focused on strengthening based on the energy system. The sessions were conducted three times a week for 8 weeks (24

sessions). All participants were subjected to a strength and conditioning program incorporating CR and CT, conducted in three phases: pretest, intervention, and posttest. The intervention training lasted for 8 weeks (microcycle), with sessions occurring three times a week, one day of rest, and two active rest days (recovery run).

In all sessions, participants performed a dynamic and static warm-up before engaging in core exercises. The subsequent step involved core exercises, specifically continuous running and circuit training. Continuous running sessions lasted for 15-35 minutes. Following this, participants engaged in circuit training exercises, comprising at least 6-7 stations, designed as outlined in Table 1. The total duration for each training session ranged from 45-70 minutes (including warm-up, core exercises, and cooling down). It is noteworthy that continuous running took place on the athletic track and in natural settings (athletic track, sand surface, and natural surroundings). Meanwhile, circuit training was divided into two types: conventional continuous running (CR) utilizing body weight and another incorporating additional resistance or Circuit Resistance Training (CRT) in the campus gym facilities.

In terms of volume and intensity, it is managed in three crucial stages: 1) general preparation, where the volume is high while the intensity is low; 2) general-specific preparation, a pivotal stage transitioning from general to specific preparation, resulting in a decrease in training volume while intensity rises; the final stage, 3) specific preparation, where the volume decreases but the intensity is high. After completing the training program periodization for 8 weeks, the last stage involves conducting the final test/posttest (leg muscle strength, aerobic endurance, and agility).

Table 1.  
Design of Model Circuit Training

	Agonist	Antagonist
Upper Body	Post 1	Post 4
Trunk	Post 2	Post 5
Lower Body	Post 3	Post 6
Whole Body	Post 7	

Note: Agonist: Muscle Agonist. Antagonist: Muscle Antagonist. Post: Point where to do the form of exercise with each post that has a certain distance.

### Exercise Program Description

The CR and CT training programs are structured based on training principles. The set, repetition, recovery, and inter-set recovery in the program align with the targeted windows for training the physical fitness components. The CT exercises are designed for a comprehensive body strengthening approach, where each station addresses all training needs for the enhancement of specific muscle strength. Each CT station consists of different body component segments, trained based on the agonist and antagonist muscles. Body segments in CT exercises are categorized into 4 parts: upper body, trunk, lower body, and whole body. The whole-body segment is trained using exercises such as burpees or squat thrusts. In line with this, CRT employs a similar design but is conducted in the fitness center using 10 different tools. For the whole-body training segment, exercises like clean and jerk or power clean can be performed. For more

clarity, refer to Table 1.

Meanwhile, for the Continuous Run (CR) method, it was applied under two conditions: on an athletic track surface (ATS) and in an outdoor setting, namely, on a sand surface (SS), with the dosage adjusted for anatomical adaptation. Subsequently, the periodization of strength and conditioning for both CR and CT proceeded through the following stages: 1) general conditioning with sessions 1-3; 2) general preparation (muscle build-up) with sessions 4-12; 3) general-specific preparation (intra-muscular and transition) with sessions 13-18; 4) specific preparation (power endurance) with sessions 19-24. For a comprehensive overview, the training program details can be referenced in Table 2 (below) and 6 (Appendix 1).

Table 2. Periodization of Training Program Strength and Conditioning CR and CT.

General conditioning	General preparation Muscle build-up	General – specific preparation		Specific preparation Power/Endurance
		Intra Mus- cular	Transition	
1-3 Sessions	4-12 sessions	13-18 Sessions	19-24 sessions	

**Measurement and Procedure**

Data was collected using test and measurement with several instruments, including: 1) VO<sub>2</sub>max value measured using the Multi-Stage Fitness Test (MSFT) (Ramsbottom et al., 1988) (Figure 1). This involves shuttle run between two lines 20 m apart at a speed determined by beeps that emit tones at appropriate intervals (Marinho et al., 2022). The participant's test score is the number of shuttlecocks (20 m) completed before the subject voluntarily withdraws from the test or fails to stay within 3 meters of the finish line on two consecutive pitches (Paradis et al., 2014). The VO<sub>2</sub>max results were obtained based on the MSFT table(norm); 2) **Leg Power**. Assessment of Leg Power used the Standing Broad Jump Test. The distance achieved is correlated with the amount of force generated by the muscle fibers (Krishnan et al., 2017). Students stand behind the line marking the starting point with their feet shoulder-width apart. The exercise starts from a standing position and continuous motion. Then, students need to bend their knees, pull their arms back and jump as far as possible, landing with both feet parallel. Finally, we record the landing distance (Marinho et al., 2022). Two replicates were performed, and the best trials were selected for further analysis; 3) **Agility**. The agility assessment uses the Illinois Test (Figure 2), where the implementation is in the field and has a length and width of 10 m and 5 m, respectively (Lockie et al., 2022). Four cones mark the start, finish, and two turning points. The other four cones are in the center at equal intervals. The cones in the center are 3.3 m apart. The tester gives the "Ready" prep command before starting the "Start" command. Subjects were instructed to run as fast as possible around the track in the direction indicated to reach the finish line. Subjects were told not to cut or touch markers and had to follow a designated route during the trial. Their time was measured by photocells located from start

to finish, and the best result of the two attempts was recorded (Ozmen & Aydogmus, 2016).

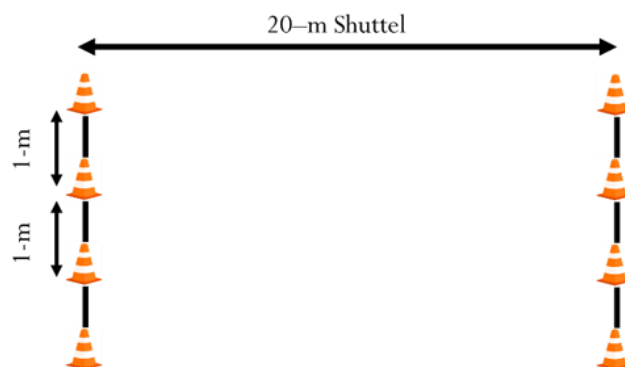


Figure 1. The Layout and Dimensions of Multi-Stage Fitness Test

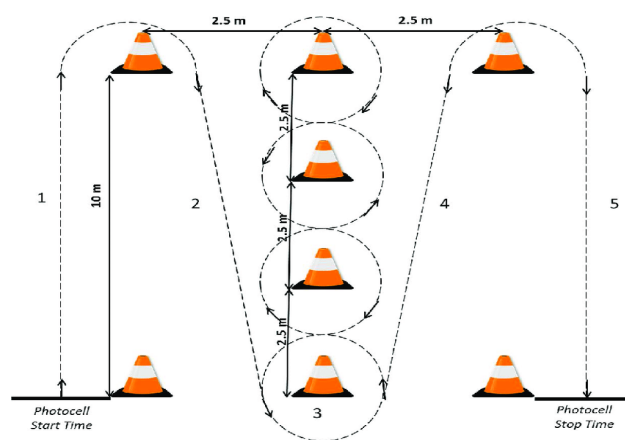


Figure 2. Layout and dimensions of Illinois Agility Test (Reina et al., 2017)

**Statistical analysis**

Statistical analysis in this study utilized the IBM SPSS version 25 application, employing a descriptive statistic to calculate the demography participant information, min, max, mean, and standard deviation (Tabel 3-5). The analysis utilized the Kolmogorov–Smirnov normality test. Additionally, due to the inconsistency of normality in some data, an inferential statistical examination was conducted using the Wilcoxon test with a significance level (P < 0.05). correlation and regression analyses were applied to establish the connection between the independent and dependent variables.

**Results**

63 Sports Science Students, with 61.9% being male and 38.1% female (n = 39 men and n = 24 women), aged 18.8±0.68 years old.

Table 3. Participant demography information.

Variable	Categories	N	%
Gender	Male	39	61.9
	Female	24	38.1
Age	18 years old	11	28.20
	19 years old	21	53.8
	20 Years old	7	17.9

Subsequently, descriptive data results include the minimum, maximum, mean, and standard deviation values for both pretest and posttest data obtained. The increase in each measured variable is also visualized, providing a clearer view in Table 3, Figure 3, and Figure 4. Normality and homogeneity tests were conducted using the relative difference and the Shapiro-Wilk test.

Our findings reveal significant improvements in VO2max and leg power following the implementation of a strength and conditioning program with circuit training combined with continuous running for males ( $35.76 \pm 5.94$  to  $41.99 \pm 5.35$ ;  $2.17 \pm 0.23$  to  $2.30 \pm 0.25$ ;  $P < 0.05$ ) (Table 4 and Figure 4). Meanwhile, for females, ( $25.97 \pm 2.78$  to  $31.10 \pm 3.09$ ;  $1.66 \pm 0.24$  to  $1.72 \pm 0.17$ ;  $P < 0.05$ ). However, the study does not identify a significant improvement in agility for both male and female participants ( $17.90 \pm 0.95$  to  $17.69 \pm 0.87$ ;  $P > 0.05$  and  $20.13 \pm 1.17$  to  $19.89 \pm 1.19$ ;  $P > 0.05$ ) (Table 5 and Figure 5).

Table 4. Descriptive statistic of pre and post-tests for VO2max, leg power, and agility in males: Increase and Decrease

Variable	C	N	Min	Max	M ± SD
VO2max	Pretest	39	25.70	49.90	$35.76 \pm 5.94$
	Posttest	39	31.00	51.60	$41.99 \pm 5.35$
Leg Power	Pretest	39	1.62	2.68	$2.17 \pm 0.23$
	Posttest	39	1.55	2.66	$2.30 \pm 0.25$
Agility	Pretest	39	16.09	20.11	$17.90 \pm 0.95$
	Posttest	39	16.09	19.87	$17.69 \pm 0.87$

Information: Min: Minimum value. Max: Maximum value. M ± SD: Mean ± Standard deviation.

Table 5. Descriptive statistic of pre and post-tests for VO2max, leg power, and agility in females: Increase and Decrease are reported

Variable	C	N	Min	Max	M ± SD
VO2max	Pretest	24	22.10	34.60	$25.97 \pm 2.78$
	Posttest	24	26.20	36.70	$31.1 \pm 3.09$
Leg Power	Pretest	24	1.21	2.30	$1.66 \pm 0.24$
	Posttest	24	1.39	2.22	$1.72 \pm 0.17$
Agility	Pretest	24	18.08	22.77	$20.13 \pm 1.17$
	Posttest	24	17.96	22.81	$19.89 \pm 1.19$

Information: Min: Minimum value. Max: Maximum value. M ± SD: Mean ± Standard deviation

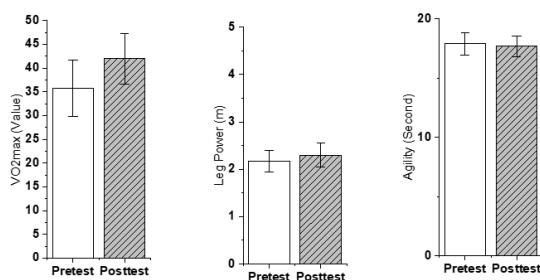


Figure 3. Graphs illustrating the average changes (increase and decrease) in VO2max, leg power, and agility for males

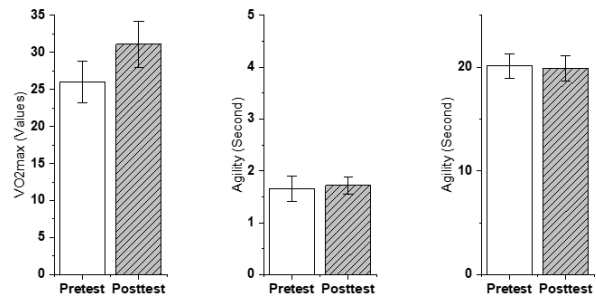


Figure 4. Graphs illustrating the average changes (increase and decrease) in VO2max, leg power, and agility for females

In VO2max, there was a significant increase in both men and women. In leg muscle strength, there was also an increase in both men and women. In agility, there was a decrease in both men and women. Before conducting inferential statistical tests, normality and homogeneity tests were performed. Due to some data inconsistency in normality, the assumptions of normality and homogeneity were disregarded. Consequently, a non-parametric test, specifically the Wilcoxon test, was conducted to assess the differences. Table 7. presents the results of the Wilcoxon test, chosen because the data obtained did not meet the normality assumption. if the  $p < 0.05$  it will be significant and if the  $p < 0.001$  it will be highly significant. Reported in this study, the p-values for each variable between pre and posttests (VO2max and Leg Power) were 0.000,  $p < 0.05$ , indicating significance. However, the test result for the difference in agility between pretest and posttest was 0.507,  $p > 0.05$ , indicating non-significance.

To enhance the understanding that each pre-posttest has a relationship, further clarification is provided in Figure 5. It illustrates a line plot forming a pattern from the bottom left to the upper right. Thus, each variable exhibits a linear and significant relationship with its respective posttest. For males ( $y = 0.697x + 17.069$   $R^2 = 0.5993$ ;  $y = 0.8598x + 0.4329$   $R^2 = 0.6008$ ; and  $y = 0.6741x + 5.6196$   $R^2 = 0.5488$ ), while for females ( $y = 0.8799x + 8.2462$   $R^2 = 0.6239$ ;  $y = 0.5447x + 0.8206$   $R^2 = 0.5571$ ;  $y = 0.7783x + 4.2222$   $R^2 = 0.5838$ ).

Table 6. Results of the wilcoxon signed rank test for pre-posttest differences

	Variable	Total	P-Value	Z
Men	Post_VO2max - Pre_VO2max	39	0.000	-5.272 <sup>b</sup>
	Post_Leg Power - Pre_Leg Power	39	0.000	-4.620 <sup>b</sup>
	Post_Agility - Pre_Agility	39	0.507	-0.663 <sup>c</sup>
Women	Post_VO2Max - Pre_VO2Max	24	0.000	-4.288 <sup>b</sup>
	Post_Leg Power - Pre_Leg Power	24	0.015	-2.434 <sup>b</sup>
	Post_Agility - Pre_Agility	24	0.278	-1.086 <sup>c</sup>

Information: b: based on positive ranks. c: based on negative ranks. The difference is significant ( $p < 0.05$ )

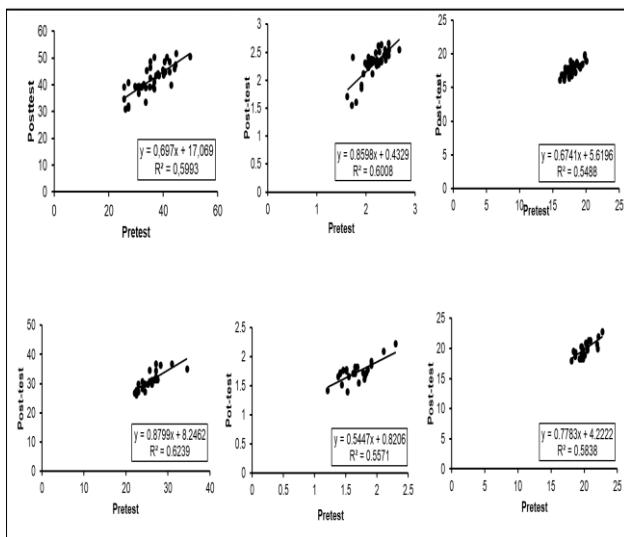


Figure 5. Linearity curve between pretest and post-test VO2max, Leg Power, and Agility in Sports Science Student men and women data.

## Discussion

This study aims to compare the effects of a strength and conditioning training program utilizing a combination of Continuous Run (CR) and Circuit Training (CT) methods on the improvement of VO2max, leg power, and agility in male and female sports science students. Recent research emphasizes the multifaceted benefits of regular physical exercise or physical conditioning, including not only physical health condition improvements but also cognitive function, mental well-being, and longevity (Arnando et al., 2023; Dimiyati, Setiawati, et al., 2023; Edmizal et al., 2023; Komaini, Anton; Saputra, Aidil; Syafrianto, Donal; Gusril; Syamsuar; Ayubi, 2022). This study demonstrates that there is a significant effect on VO2max and leg power after an 8-week strength and conditioning program. For each variable between pre and posttests (VO2max and Leg Power), the p-values were 0.000,  $p < 0.05$ , indicating significance. Except for the difference in agility pretest and posttest results, However, agility showed an increase but not significantly, which does not confirm the hypothesis 0.507,  $p > 0.05$ , both in males and females

In this regard, this research supports studies reporting that circuit training can improve various components of physical fitness such as muscle strength, agility, cardiovascular endurance, and anaerobic performance (Sonchan et al., 2017; Yendrizal et al., 2023). Additionally, Continuous Run (CR) plays a role in improving endurance, while Circuit Training (CT) is utilized for enhancement purposes. In line with that, combining leg power and agility in the form of training periodization is highly intriguing. Each component of physical fitness, aligned with its energy system, should be trained according to the training objectives aimed at enhancing the specific physical fitness component. This study is in line with previous studies that there is an increase in cardiovascular endurance capacity (VO2Max) through the continuous circuit and competitive circuit training

(Ariani et al., 2022; Rifki et al., 2022, 2023). This is consistent with research suggesting that continuous running, such as marathons, can have a positive impact on cardiovascular capacity and health (Nystoriak & Bhatnagar, 2018). Additionally, the implementation of circuit training as a strategy to improve cardiovascular endurance capacity has proven to be effective (Simonson, 2010).

Improvement in strength can be achieved through various resistance training methods and tools, such as body weight, external weights, resistance bands, or machine technology (Loturco et al., 2022). Resistance circuit-based training has been demonstrated to result in a noteworthy decrease in fat mass (average of 4.3%) and a considerable increase in muscle mass (average of 1.9%), as well as improvements in upper and lower strength (average of 20.0% and 23.0%, respectively) (Ramos-Campo et al., 2021). Moreover, this training significantly enhances various aspects of cardiorespiratory fitness, such as VO2max (average 6.3%), aerobic performance (average 2.6%), and maximum aerobic speed or power (average 0.3%) (Ramos-Campo et al., 2021).

According to (Yuliandra et al., 2020) the circuit training method with strength and speed training can increase the explosive power of the leg muscles. In line with research (Martins et al., 2020) the application of strength circuit training can also lead to an increase in upper and lower extremity strength. In line with research (Sonchan et al., 2017) that exercises with many post media involve resistance such as barbells, dumbbells, and the subject's body weight, usually, there are 9-12 posts in each post, an athlete performs a predetermined type of exercise (Adamson, 1959) can increase the explosive power of leg muscles. Agility did not show a significant overall increase. This result is similar to research (J Bovas & C. S Pradeep, 2020; Jadhav, 2020; Soares et al., 2024), where the circuit training method showed no significant effect of agility between the control and the experimental group on the subjects. In planning a circuit training program, exercises are selected according to individual needs, and each of these exercises is numbered and assigned to specific areas called stations or posts. On the other hand, concurrently physical activity and fitness are significant elements that significantly influence academic performance in ungraduated students (Dubuc et al., 2017). It happens due to different cognitive skills, such as academic performance, decision, perception, sleep habits, concentration, social development, and memory improvement, which will help with routine activities as university student (Redondo-fl & Jes, 2022). For sports science students, involving physical activity in determining physical fitness can result in better physical condition and mental health (Yendrizal et al., 2023). Besides, it can help students cope better with the stress and demands of University life. Untuk kondisi spesifik aspek fisiologis, dilaporkan bahwa regular running exercise can enhance lung capacity, blood circulation, and cardiovascular system function, which may contribute to an increase in blood oxygen saturation (Dhuha et al., 2020; Goodrich et al., 2018;

Sepriadi et al., 2023).

To achieve maximum power, the use of loading is necessary (Bompa & Buzzichelli, 2015). For example, CRT exercises using free weights are administered after undergoing an anatomical adaptation process, ensuring that the entire body is prepared to accept the load used. This supports research findings reporting that free weights are more effective in increasing leg power for those with a history of being untrained, whereas the use of resistance bands is more effective for those with trained muscles (S. Nugroho et al., 2023).

The main limitation of this study is that the variables investigated are limited to VO<sub>2</sub>max, leg power, and agility, as these components are the primary physical fitness components to support practical sports courses in the following semester of students' academic studies. Although all physical fitness components are trained in the program, they are disregarded in this study due to the focus on the main components of physical fitness being investigated. Thus, other components can be considered as areas for further research.

In addition to another paradigm regarding training sessions conducted on two surfaces or conditions, this research supports previous studies that state sand surfaces have advantages in improving endurance and power compared to grass surfaces (Dubuc et al., 2017). However, based on the data we have obtained, we believe that combining circuit training with continuous running can enhance aerobic endurance, leg power, and agility. Specifically, for agility, stations in circuit training are required to change direction with high and strong intensity or speed. Thus, we acknowledge certain limitations that should be validated in future research. These limitations include the lack of intervention in specific agility training at each circuit post. Therefore, the results of the study show that there is no significant effect of agility. So, it is necessary to add intervention to each post circuit. In addition, group division was not carried out because the pretest results showed almost the same abilities. In summary, the training program is given over 24 sessions outside of the test with the best-designed program (validated by Asian-level sports coaching experts). We believe that a longer time > 24 sessions and a better program will influence the results of this study. The sample size used is still limited, so it is necessary to involve a bigger sample size. Nonetheless, this research is significant because it can be a reference for choosing suitable exercise menus to increase aerobic and aerobic capacity for lecturers, teachers, and trainers. Therefore, programs in this study can be used to train new students in the sports science study program in preparing students' physical conditions for other physical lecture activities such as game sports (football, volleyball, or basketball), athletics, fitness management, and other practical courses. In addition, this research can also be used by coaches of various sports to prepare for the initial physical condition (general-specific preparation) and the physical condition of novice athletes. The function is to prepare for the next training window according to the sport chosen to be developed, namely specific preparation.

## Conclusions

This study concludes that the strength and conditioning program, including its various exercise variations, volume, intensity levels, and recovery, combined the CR method and CT, has significantly increased VO<sub>2</sub>max, leg power of sports science student. Specifically, for agility, there was indeed an increase based on average values, but it was not statistically significant. Further research is needed to evaluate the program's menu of exercises to enhance agility. However, our novel findings also underscore the effectiveness of strength and conditioning programs with sufficiently complex variations, such as CR on conventional tracks and natural surfaces (sand surfaces). This program comprises four well-structured main phases: general conditioning, general preparation, general-specific preparation, and specific preparation. Furthermore, both CT and CRT, with their respective stations, engage all segments of agonist and antagonist muscle groups, including harmonizing movements such as clean and jerk or power clean, as harmonizing the movements of the entire body will greatly assist sports science students in performing sport-specific performances in the following semester. Training can be carried out with clear stages, for example, it can be implemented with exercise menus that can be selected by coaches, varying intensity (low-high), and including recovery techniques that can be utilized. Training to improve aerobic endurance, for example, on athletic tracks and CR training using cross-country training methods, can significantly increase VO<sub>2</sub>max because we know endurance training is monotonous and boring, thus motivating students to train. Meanwhile, with high intensity, for example, in the specific preparation phase, the CT method contributes to increasing power. This research is essential for enhancing the physical fitness of sports science students as they prepare for practical lectures or their chosen sports disciplines in the following semesters. Sports science lecturers will also benefit from becoming acquainted with basic training programs that can be used for effective learning processes in improving students' physical fitness.

## Acknowledgments

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## Appendix 1.

Training program for Continuous Run (CR) and Circuit Training (CT) for sports science students

		Sessions 1-3		Sessions 4-6		Sessions 7-9		Sessions 10-12		Sessions 13-15		Sessions 16-18		Sessions 19-21		Session 22-24	
		Sets	Reps	Sets	Reps	Sets	Reps	Sets	Reps	Sets	Reps	Sets	Reps	Sets	Reps	Sets	Reps
CT	C	2	10 x 6 Post	-	-	3	10x6 post	-	-	4	10x7 post	-	-	-	-	-	-
	CRT	-	-	2	10x6 post	-	-	3	10x7 post	-	-	4	10x7 post	5	10x6 post	6	10x6 post
CR	ATS	1	1 x15 min	-	-	1	1x20 min	-	-	1	1x30 min	-	-	1	1x50 min	1	1x50 min
	OA (SS)	-	-	1	1x15 min	-	-	1	1x40 min	-	-	1	1x50 min	-	-	-	-

\* All participants followed the same program for 8 microcycles (24 sessions). CT: Circuit Training. CR: Continuous Run. C: Conventional. CRT: Circuit Resistance Training. AT: Athletic Track Surface. OA: Outdoor Activity. SS: Sand Surface. Reps: Repetition. Min: Minutes.

## Appendix 2.

Training program for CR and CT exercises for sports science students.

Physical Component	Energy System	Variable Methods	Training Menus
Endurance	Aerobic	CR	Continuous Running on Athletics track and Outdoor sand surface 15-50 minutes
			1. 40 m easy jog (turn again every 40 m)
			2. Jog backward 40 m
			3. Slow jog for 2 x 40 m, bend and touch the cone, then accelerate for 10-15 m
			4. Jog 50 m with high knee lift
			5. Jog 50 m with leg extension
			6. Casual jog for 50 m, periodically touching the thumb
Strength			7. Skip without a rope for 50 m
Strength Endurance			8. Walk 50 m with arms swinging forward
Power	Aerobic	CT	9. Walk 50 m with arms swinging backward
Flexibility	and an aerobic		10. Jog 50 m with tripling ankle
Strength			11. Jog 50 m with ankle jumps
Speed			12. Walk 50 m, stretch every few steps
Speed Strength			13. Walk 50 m, stretch with a partner every few steps
			14. Sprint drill 40 m with high knee lift, leg extension, ABC running, repeated with a return walk for recovery.
			15. Sprint and maintain speed for 20 m, then relax
			16. Run with hurdles (4-5 hurdles) for 40 m
			1. Shoulder press
			2. Low Bar Squats
			3. Leg press
			4. Chess press
Strength			5. Seated row
Strength Endurance			6. Leg extension
Power	Aerobic	CRT	7. Barbell lunges
Flexibility	and an aerobic		8. Prone leg curl
Strength			9. Thigh adduction
Speed			10. Leg press calf raises
Speed Strength			11. Abdominal crunches
			12. Front Squat
			13. Clean and Jerk
			14. Deadlift
			15. Power Clean