



The Effect of 16-Week Progressive Circuit Training Program on the Health and Skill-Related Fitness Parameters of Overweight University Students

Jordan M. Pocaan^{1ABCDE}

¹Sorsogon State University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Jordan Pocaan, E-mail: jpocaan@sorsu.edu.ph

Accepted for Publication: March 15, 2024

Published: April 30, 2024

DOI: 10.17309/tmfv.2024.2.02

Abstract

Study purpose. This study examines the effect of a 16-week interval progressive circuit training program on the skill and health-related fitness of overweight university students.

Materials and methods. A total of 72 university students underwent health and skill-related fitness tests before and after a 16-week progressive circuit training program. Paired sample t-tests and Wilcoxon signed-rank tests were used to determine differences between pre- and post-tests.

Results. Significant decrease in BMI, cardiovascular endurance, agility, speed and reaction time was observed after a 16 week progressive circuit training program ($p \leq 0.05$). In contrast, strength, flexibility, coordination and power increased significantly ($p \leq 0.05$). The 16-week interval progressive circuit training programme has a positive effect on the physical fitness among the study participants.

Conclusions. The findings encourage further research into optimized training protocols, long-term sustainability of improvements, and tailored applications for specific population groups, ultimately advancing our understanding of the multifaceted benefits of interval progressive circuit training.

Keywords: circuit training, physical fitness, training progression, overweight, university students, well-being.

Introduction

Physical fitness is a cornerstone of overall well-being (Greenlee et al., 2017), and its importance becomes obvious for university students. A growing concern for students' sedentariness is linked to the advancement of education and technology. The demands of academic life often tether students to desks and screens for extended periods, leaving little room for physical activity. The lack of movement, unhealthy eating habits and stress made the rising epidemic of overweight and obesity among university students. A worldwide trend study published in Lancet Global Health found an insufficient physical activity from 2001 to 2016 reveals that more than one in four adults worldwide fails to get the recommended levels of physical exercise (Guthold et al., 2018). Similarly, a recent study found a significant decrease in doing regular exercise during one's college years compared to the school years before (Alkhateeb et al., 2019).

The sedentary nature of modern university life is related to the surge of overweight rates among university students mirroring global trends (Hojjat, 2021). The accessibility of fast food on campuses, irregular eating patterns, and the allure of convenience contribute to unhealthy weight gain (Maillet & Grouzet, 2023). Beyond the immediate health concerns, carrying excess weight in young adulthood can lead to a cascade of long-term health issues, including diabetes, cardiovascular diseases, and a diminished quality of life (Koliaki et al., 2019). These health issues affect the present well-being of students and their future, which can negatively influence their quality of life and life expectancy.

Aside from the physical implications, excess weight has significant consequences for academic performance (Greeff et al., 2018). It was proven by Poh et al. (2019) which found a strong relationship between overweight and cognitive function, where excessive weight is associated with low academic performance. Decreased attention span and memory impairment are among the cognitive effects on students with excessive weight that hinder their ability

to absorb and retain information (Jirout et al., 2019). Furthermore, lower self-esteem and increased stress are among the major psychosocial consequences of being overweight that can further worsen academic challenges (Robinson et al., 2020). The connection between physical health and academic performance is complex. Students who prioritize their well-being are expected to experience better concentration, problem-solving skills, and overall cognitive function (Borgonovi & Pal, 2016; Barry et al., 2017). In contrast, excess weight may impede these cognitive functions and create a challenging cycle to break.

In the Philippines, the curriculum in tertiary education is considered overloaded (Ortiga, 2014; Durban & Catalan, 2012), especially for teacher education programs. This means that pre-service teachers in the country have a high chance of becoming overweight or obese. Meanwhile, the Commission on Higher Education (CHED) revised the physical education courses for tertiary education as one of their realizations during the mid-COVID-19 pandemic (Order No. 39, 2021). Among the new courses is Physical Activity Towards Health and Fitness (PATHFit) 2 which aims to provide experiences for the students to engage in a variety of exercise programs to maintain and enhance cardiorespiratory and musculoskeletal fitness. Currently, based on my knowledge, there is no study conducted about the effect of the course on the physical fitness of overweight university students, specifically the use of a progressive circuit training program. Relevant fitness programs like circuit training can provide appropriate support, promoting sustainable habits that extend beyond their university years (Seo et al., 2019).

Circuit training is a dynamic and efficient form of exercise that involves a series of structured, timed activities performed consecutively with minimal rest between exercises (Getty et al., 2018; Micielska, 2021). The principles of circuit training revolve around high-intensity intervals and a progressive structure. For the purpose of this study, a 16-week training program was conducted and participated by overweight university students during their PATHFit 2-course schedule for one whole semester. Specifically, this study examines the effect of the implemented program on health-related (body composition, cardiovascular endurance, strength and flexibility) and skill-related fitness (coordination, agility, speed, power, balance and reaction time).

Materials and Methods

Participants

Seventy-two first-year pre-service university students (male 33, female 39; age 18 (36), 19 (25), 20 (11) years old; BMI 27.7 ± 1.4 ; cardiovascular endurance 108.4 ± 12.2 HR; strength 26.9 ± 4.5 push-ups; flexibility 48.0 ± 9.9 cm; coordination 30.7 ± 6.8 hints; agility 15.8 ± 1.7 secs.; speed 22.3 ± 5.0 secs.; balance 30.9 ± 7.5 secs.; reaction time 15.7 ± 4.4 cm) volunteered to participate in the study (Table 1). The participants were from the same university in the Philippines where their physical fitness was monitored under the Physical Activity Towards Fitness and Health (PATHFit) 2 course. All the participants were handled by the researcher of this study. The present study obtained permission from the participants in the form of written consent. Approval for

Table 1. Participants characteristics

N = 72			
Sex			
Male			33 (45.8%)
Female			39 (54.2%)
Age			
18	yrs.		36 (50%)
19	yrs.		25 (34.7%)
20	yrs.		11 (15.3%)
Health-related fitness			
Body composition	Body Mass Index	BMI	27.7 ± 1.4
Cardiovascular endurance	3-minute step	bpm	108.4 ± 12.2
Strength	90° Push-up	reps.	26.9 ± 4.5
Flexibility	Sit and reach	cm	48.0 ± 9.9
Skill-related fitness			
Coordination	Juggling test	hints	30.7 ± 6.8
Agility	Hexagon agility test	secs.	15.8 ± 1.7
Speed	50m sprint test	secs.	22.3 ± 5.0
Power	Standing long jump	cm	164.4 ± 12.2
Balance	Stork balance stand test	secs.	30.9 ± 7.5
Reaction time	Stick drop test	cm.	15.7 ± 4.4

Abbreviation: yrs., years; BMI, body mass index; bpm, beats per minute; reps., repetitions; cm., centimeter; secs., seconds.

conducting the study was secured from the recommending and ethics committee of the Sorsogon State University.

Study Design

The participant's physical fitness (health and skills-related fitness) was tested before and after the 16-week interval progressive circuit training program (Table 2). The tests and program were conducted at Sorsogon State University-Main Campus once a week during the scheduled PATHFIT 2 course of the participants. The course is equivalent to 2 units or 2 hours per week. The participants came from 5 sections that were scheduled every 7:30 to 9:30 from Monday to Friday. The pre-test was a regular physical fitness test conducted before the start of the course. All the participants were instructed to reduce caffeine and high-caloric foods during the semester.

For the purpose of the study, qualified participants were determined by the initial BMI result as overweight (BMI 25-29.9) based on the WHO BMI cut-off (Lim et al., 2017; Muc Da Encarnacao, & NCD Risk Factor Collaboration, 2017) and have no exposure to fitness training in the last 6 months. During the second week of the first semester of 2022-2023 (August 15 to 19, 2022) the pre-test was conducted guided by the researcher-made Physical Fitness Test (PFT) form (body mass index, 3-minute step test, 90° push-up, sit and reach, juggling, hexagon agility test, 50 m sprint, standing long jump, stork balance stand test, and stick drop test). Three trials were conducted to select the best performance of the participants for each test.

The circuit training started after the pre-test (August 22 to December 9, 2022); the participants were given 15 mins. warm-up and 15 mins. cooldown stretching exercises and

were hydrated before, during and after the conduct of the experiment for safety. Moreover, the participants were instructed to jog in place during rests. The post-test was conducted after 16 weeks, which was the final week of the first semester (December 12 to 16, 2022). The results of the tests were also made transparent to the participants for their awareness and confirmation.

Materials and Test Procedure

To record the body composition, the BMI was assessed using a weight machine and tape measure and used the formula for accuracy. To test the cardiovascular endurance, the 3-min. step test was conducted on a sturdy step approximately 12 inches (30 cm) high. Moreover, the agility test was conducted on a flat surface with a hexagonal tape pattern while the 50m sprint was conducted on a straight track and the stork balance stand test was on a flat surface in a quiet area. All time-based fitness tests used a stopwatch to record the performance.

A tape measure was used (cm) and conducted in a flat area to record flexibility for sit and reach and standing long jump for power. Push-ups to measure the strength was also conducted on a flat surface and recorded according to the number of repetition (rep). The reaction time was measured through a stick-drop test using a ruler (cm) positioned on an armchair at a comfortable height in a quiet, well-lit testing area with no distractions. Finally, the coordination was measured by the number of hints in juggling tests using 3 balls in a designated testing area with enough space to juggle safely. All the tests were administered 3 times with an interval of 30 mins. in the same testing areas and select the best performance per test. A similar procedure was implemented during the post-tests.

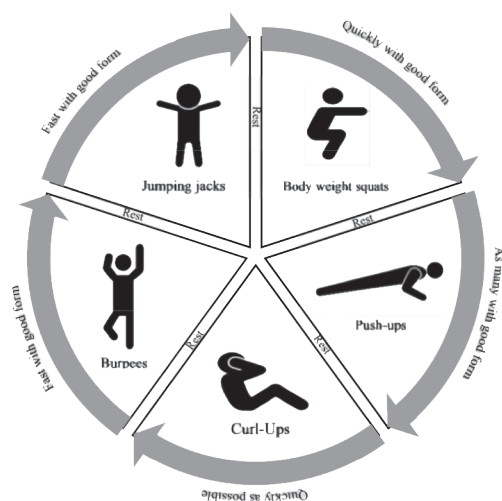


Fig. 1. Circuit training design

The 16-week interval progressive circuit training program was composed of 5 stations (Figure 1) with different intensities: jumping jacks (fast with good form), body weight squats (quickly with good form), push-ups (as many with good form), curl-ups (as quickly as possible), and burpees (as quickly as possible). The duration per station in the first week was 15 secs. and was increased by 5 secs. every 5 weeks. The number of sets per week started from 10 sets during the initial week and was increased by 1 set every 5 weeks. The rest

per station in the first week was 10 secs. and was decreased by 1 sec. every 5 weeks (Table 2). In general, the interval progressive circuit training program of this study gradually increases the duration and sets while gradually decreasing the rest. The program also prioritizes proper form and gradually increases the intensity to minimize the risk of injury.

Table 2. Training program timeline

Weeks	1 to 5	6 to 10	11 to 15	16
Sets	10	11	12	13
Duration	15 secs	20 secs	25 secs	30 secs
Rest per station	10 secs	9 secs	8 secs	7 secs

Statistical Analysis

Data are presented as mean $\pm$ standard deviation for continuous variables and number (n) with percentage (%) for categorical variables. The Shapiro-Wilk test was performed to assess the normality of the distribution. To assess the difference between the pre-test and post-test, paired sample t-tests were used for normal data and Wilcoxon signed-rank tests for non-normal data. Statistical significance was accepted at $p \leq 0.05$. Cohen's d effect size (ES) was computed to display the magnitude of differences between variables and interpreted as trivial (0-0.19), small (0.20-0.49), medium (0.50-0.79), and large (≥ 0.80) (Cohen, 1988). Welch's t-test was used to compare the mean difference by sex and age. The statistical analysis was performed using IBM SPSS version 27 (IBM company, Armonk, New York, USA).

Results

The participants completed the 16-week training program with 100% attendance.

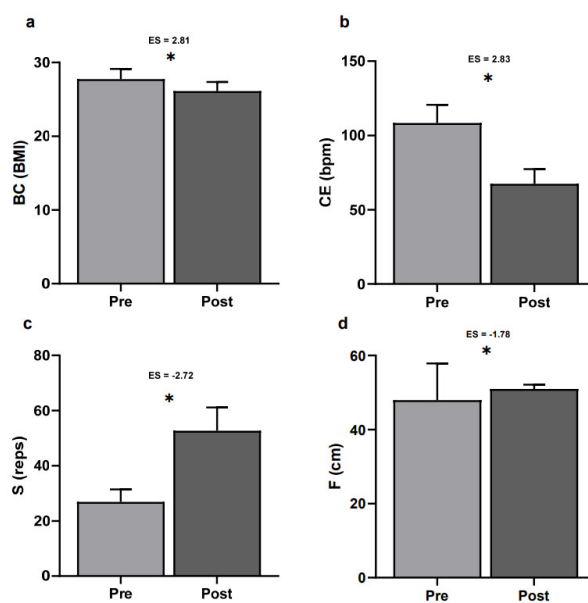


Fig. 2. Health-related fitness performance variables pre-and post-test
Abbreviation: BC, Body Composition; BMI, Body Mass Index; CE, Cardiovascular Endurance; bpm, beats per minute; S, Strength; reps, repetitions; F, Flexibility; cm, centimeter. * Indicated significant change comparing pre-and post-test. ES, Effect Size. $p = 0.05$

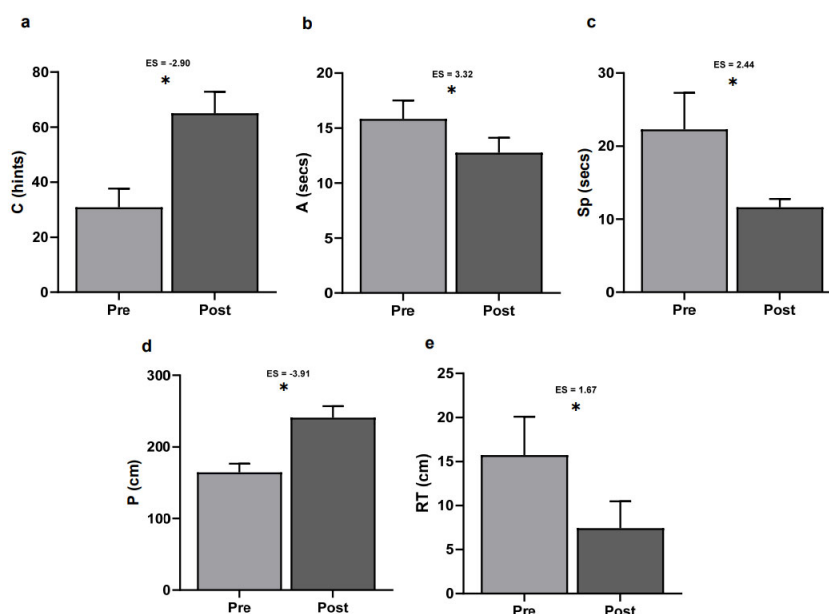


Fig. 3. Skill-related fitness performance variables pre-and post-test

Abbreviation: C, Coordination; A, Agility; secs., seconds; Sp, Speed; P, Power; cm, centimeters; RT, Reaction time.

* Indicated significant change comparing pre-and post-test. ES, Effect Size. $p = 0.05$

According to the results on health-related fitness performance, there was a significant decrease with a large effect size in BMI (27.74 ± 1.38 vs 26.11 ± 1.25 [n]; ES = 2.81) and cardiovascular endurance (108.35 ± 12.23 vs 67.42 ± 9.90 [bpm]; ES = 2.83), as well as increase with large effect size in strength (26.88 ± 4.54 vs 52.72 ± 8.42 [rep]; ES = -2.72) and flexibility (47.96 ± 9.89 vs 50.97 ± 1.16 [cm]; ES = -1.78) at $p < 0.05$ (See Figure 2).

The performance in pre-and post-test results of skill-related fitness performance shows a significant increase with a large effect size in coordination (30.86 ± 6.83 vs 65.07 ± 7.81 [hints]; ES = -2.90) and power (164.36 ± 12.17 vs 240.78 ± 16.16 [cm]; ES = -3.91), as well as significant decrease with large effect size in agility (15.84 ± 1.67 vs 12.77 ± 1.35 [secs]; ES = 3.32), speed (22.30 ± 4.99 vs 11.61 ± 1.16 [secs]; ES = 2.44), and reaction time (15.72 ± 4.36 vs 7.44 ± 3.04 [cm]; ES = 1.67) at $p \leq 0.05$ (See Figure 3).

Discussion

My findings showed that the 16-week interval progressive circuit training program has a large effect on the physical fitness of the participants. In line with health-related fitness, there was a significant increase in strength and flexibility and a significant decrease in BMI and cardiovascular endurance. A significant increase in coordination and power and a significant decrease in agility, speed, and reaction time were also observed in skill-related fitness.

Health-related Fitness Performance

The decrease in BMI suggests that the overweight participants in my study showed improvement. Previous studies indicated that progressive training programs positively reduced weights (Čvorović et al., 2021; Arrieta et

al., 2022). Although the mean score of the participants in the BMI post-test (Figure 2) was still included in the overweight category, it can be noted that the effect size was at large magnitude size. In applied terms, high-intensity workouts elevate heart rate and metabolic rate significantly during intense bursts of exercise (Grace et al., 2018). This increased intensity results in a higher calorie burn during the workout compared to lower-intensity exercises (Moro et al., 2020).

The decrease in bpm in the post-tests (Figure 2) shows a positive impact on the cardiovascular endurance of the participants. The gradual increase of reps. and sets of the training program trained the cardiovascular system of the participants to be more efficient at delivering oxygen-rich blood to the muscles during physical activity, allowing them to sustain exercise for longer periods without experiencing excessive fatigue or stress. This improved endurance can lead to various health benefits, including increased stamina, reduced risk of heart disease, and an overall improvement in their ability to engage in physical activities (Wibowo et al., 2022; Lan et al., 2021).

The increase in strength and flexibility with a large effect size shown in the post-test indicated a positive effect on the participants' skill-related fitness (Figure 2). The increase in strength may linked to the intensity of the workout and execution in the push-up station. While burpees station involves several dynamic movements that require the participants' joints and muscles to move through a range of motion. Kojić et al. (2021) in their experimental study, mentioned that burpees help improve joint flexibility over time, particularly in areas like the hips, knees, and shoulders. These improvements suggest that the training program of this study was successful in promoting muscle development and joint mobility. In addition, previous studies indicated that muscle development and joint mobility are essential components of a healthy and active lifestyle (Guldass et al.,

2023; Russo et al., 2021). It is worth mentioning that the intensity of the training program of this study helps the participants to improve their overall health-related fitness performance.

Skill-related Fitness Performance

A significant increase with a large effect size in coordination and power was also observed in the post-test (Figure 3). My findings underscore the substantial impact of the training program on participants' motor skills and explosive strength. It must be noted that the training program used in this study incorporates a mix of dynamic and strength-based exercises and provides a well-rounded approach to improving coordination and power. The combination of diverse movements, quick transitions, full-body engagement, and neuromuscular adaptations makes the training program an effective method for enhancing coordination and power (Cvetković et al., 2018; Kostikiadis et al., 2018; Laursen & Buchheit, 2019) of the participants.

A significant decrease with a large effect size was also shown in the post-test agility, speed, and reaction time performance of the participants (Figure 3). The effect is due to a dynamic blend of cardiovascular conditioning, strength development, neuromuscular coordination, and functional movement patterns gained from the training program. Studies have indicated that high-intensity training program promotes rapid force generation, improving explosive power and speed (Suchomel et al., 2018; Kunz et al., 2019). The incorporation of varied exercises challenges participants to transition swiftly, sharpening their reaction time. Meanwhile, the enhancement of neuromuscular coordination, core strength, and overall fitness contributes to greater agility (Sighamoney et al., 2018), enabling participants to move with precision and quickness.

In general, my findings suggest that the combination of diverse exercises, quick transitions, and neuromuscular adaptations in high-intensity circuit training can effectively enhance multiple aspects of physical performance. Therefore, future research may delve into the optimization of such training programs for specific groups and explore potential long-term health and performance outcomes for overweight individuals. Furthermore, investigating the sustainability and maintenance of these improvements over extended periods could provide insights into the long-term benefits of interval progressive circuit training programs. Finally, this research offers practical implications for fitness professionals and university students seeking to improve their physical fitness comprehensively, as it highlights the potential of well-structured high-intensity circuit training for achieving multifaceted fitness goals.

Conclusions

The study found that the 16-week interval progressive circuit training program positively affected various components of health and skill-related fitness among the participants. The findings underscore the versatility and effectiveness of high-intensity circuit training as a means of enhancing overall physical fitness, encompassing weight management, cardiovascular health, and skill-related attributes crucial for physical activities. The results of my study

hold a valuable implication for fitness professionals, coaches, and individuals seeking well-rounded fitness enhancement. Additionally, my research encourages further exploration of optimized training protocols, long-term sustainability of improvements, and tailored applications for specific populations, ultimately advancing our understanding of the multifaceted benefits of interval progressive circuit training.

Conflict of Interest

The author declares that there is no conflict of interest.

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Вплив 16-тижневої програми прогресивного кругового тренування на показники стану здоров'я та фізичної підготовленості студентів університету з надмірною вагою

Джордан М. Покаан

Сорсогонський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 2 табл., 3 рис., 36 джерела.

Мета дослідження. Дослідження спрямоване на вивчення впливу 16-тижневої інтервальної програми прогресивного кругового тренування на фізичну підготовленість та стан здоров'я студентів університету з ожирінням.

Матеріали і методи. Загалом 72 студенти університету пройшли тестування на визначення стану здоров'я та фізичної підготовленості до і після 16-тижневої програми прогресивних кругових тренувань. Для визначення відмінностей між показниками до і після тестування було застосовано t-тести парних вибірок та критерій знакових рангів Уїлкоксона.

Результати. Після проходження 16-тижневого прогресивного кругового тренування спостерігалось значне зниження показників ІМТ, витривалості серцево-судинної системи, спритності, швидкості та часу реакції ($p \leq 0,05$). Натомість показники сили, гнучкості, координації та результативності значно зросли ($p \leq 0,05$). 16-тижнева інтервальна програма прогресивного кругового тренування позитивно впливає на фізичну підготовленість учасників дослідження.

Висновки. Отримані результати спонукають до подальших досліджень оптимізованих тренувальних протоколів, довготривалої сталості покращень та адаптованих програм для конкретних груп населення, що в кінцевому підсумку поглиблює наше розуміння багатограних переваг інтервального прогресивного кругового тренування.

Ключові слова: кругове тренування, фізична підготовленість, прогресія тренування, надмірна вага, студенти університету, стан здоров'я.

Information about the authors:

Pocaaan, Jordan M.: jpocaaan@sorsu.edu.ph; <https://orcid.org/0000-0002-6155-3990>; College of Teacher Education, Sorsogon State University, Magsaysay St, Sorsogon City, Sorsogon, Philippines.

Cite this article as: Pocaaan, J.M. (2024). The Effect of 16-Week Progressive Circuit Training Program on the Health and Skill-Related Fitness Parameters of Overweight University Students. *Physical Education Theory and Methodology*, 24(2), 198-204. <https://doi.org/10.17309/tmf.2024.2.02>

Received: 23.12.2023. Accepted: 15.03.2024. Published: 30.04.2024

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