Progressive Circuit Training Program to Improve Aerobic Capacity, Abdominal Endurance, and Lower Body Strength of Low-Fit Students

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Abstract

The issue that adults and adolescents are not engaging in the prescribed amounts of physical activity is becoming a major global health concern. 26 low-fit students (31% male, 69% female) who had no medical issues and had not recently engaged in physical activity participated in this study intervention. Experimental study pre- and post-tests is conducted using the uncontrolled trial approach. Normality was confirmed through the Shapiro-Wilk test and descriptive statistics (mean, standard deviation). Paired t-tests and Cohen's d was employed to reveal significant change and effect magnitude because the data was normally distributed. Following the exercise training, there was a noticeable increase in lower body strength, core strength, and cardiovascular fitness. Significant performance gains (19.62%, 93.73%, 55.77%, and 22.24%) and large effect sizes was also noted. In addition, up to 92% of the diversity in lower body strength and core strength can be explained through aerobic fitness. A balanced cardio and resistance circuit is a time-efficient methods in developing overall fitness and support lifelong health and physical activity, as revealed by the four-week progressive circuit training that successfully increased aerobic fitness, core strength, and lower body power.

Keywords: low-fit, body capacity, inactivity, public health

Introduction

Despite the health benefits of physical activity, majority of youth and adults worldwide remain physically inactive. Adolescents aged 11–17 do not meet the recommended guidelines for physical activity (Strain et al., 2024). This global concern has a significant threat to their health that contribute the issue of obesity, weaker bones, poor cardiometabolic health, and increased risk for chronic diseases later in life. Gender disparities persist, with adolescent girls typically being less active than boys (Telford et al., 2016; Pocaan, 2023). This issue of inactivity was driven by different factors, including increase in screen time, unsafe neighborhoods, and limited access to recreational spaces, together with individual factors such as low self-efficacy and a decline in organized sports participation.

To improve the well-being of both the youth and adults, international organizations published recommendations for physical activity and exercise that highlighted the importance of increasing maximal strength, cardiovascular fitness, and body composition (Garber et al., 2011; Izquierdo et al., 2021). These also show how beneficial they are to enhance the quality of life for people with illnesses, such as diabetes, cancer, and kidney disease. Concurrent training refers to the practice of performing strength and endurance exercises together as part of an organized or periodized training plan for a variety of medical problems and sports. Resistance circuit training (CT) integrates strength development, muscular endurance, neuromuscular enhancements, and aerobic conditioning in a single session, which is popular types of concurrent training (Seo et al., 2019; Getty et al., 2018). With this training method, one or more sets of various exercises are performed consecutively with little to no rest in between. These exercises can be performed with low, moderate, or heavy loads, either for a predetermined amount of time or with a high number of repetitions, and they always allow for extremely brief rest intervals between movements.

Concurrent training can develop both upper-body maximum strength and VO_2 max, making it an excellent training option for beginners and persons with poor baseline fitness levels (Muñoz-Martínez et al., 2017). It is also used as an introductory method in athletic training programs to improve cardiovascular fitness and one-repetition maximum (1-RM) strength. However, the effectiveness of CT in trained athletes remains debated. Some research suggests that aerobic improvements are less significant in individuals who are already highly fit (Wilmore et al., 1978), while other studies report that performing CT with heavier loads is more effective for increasing strength and cardiorespiratory fitness in trained populations (Alcaraz et al., 2011; Ramos-Campo Et al., 2018). Hence, the researchers of this study implement a progressive circuit training program to improve aerobic capacity, abdominal endurance, and lower body strength of low-fit students. The findings of this research may provide valuable evidence for educators, coaches, and health professionals in designing efficient and accessible training interventions for populations with low physical fitness. Moreover, it contributes to the growing body of knowledge supporting cost-effective and scalable exercise programs that can be implemented in school or community settings to promote long-term health and well-being.

Methodology

Participants and Baseline Data

The intervention was participated in by 26 students (8 males (31%) and 18 females (69%)) who were categorized as low-fit based on their aerobic capacity ($VO2_{max}$), no existing medical conditions, and no participation in any exercise or fitness program in the recent six months. Informed written consent was obtained from all participants. Baseline data analysis indicates a normal distribution across all anthropometric and performance measures ($p < 0.05$) (Table 1).

Table 1

Group Anthropometrics and Performance

	Average	N (μ, σ)
Age	20.58 ± 1.33	0.080
Weight	59.69 ± 6.31	0.150
Height	164.81 ±8.36	0.187
VO_2 Max	34.89 ± 1.37	0.100
Reps	11.654 ± 1.85	0.159
Peak Power	5045.27 ± 154.74	0.106
Average Power	795.769 ± 48.58	0.054

Mean ± SD; N (μ, σ) at $p < 0.05$ for normal distribution; significant difference at $p \geq 0.05$.

Design and Procedure

Experimental study pre- and post-tests was conducted by using uncontrolled trial approach. Three stage comprised the study: pre-tests and orientation for one week, movement competency training for eight weeks, and post-tests for one week. Pre- and post-tests followed the same protocols as field tests. To meet the fitness needs of children with low levels of physical activity, a training program was created. Aerobic capacity, core strength (abdominal endurance), and lower body power were the three fitness components that were the focus of the program.

The vertical leap test was used to assess lower body performance and gauge the legs' explosive power. In order to provide clear directions, the researchers demonstrate the reach height and jump height. The following formula was used to convert the average and peak scores into power: peak power (W) = (61.9 x jump height (cm)) + (36 x body mass (kg)) + 1822; average power (W) = (21.2 x jump height (cm)) + (23.0 x body mass (kg)) – 1393.

Participants were instructed to abstain from large meals, caffeinated beverages, and intense activity 48 hours prior to evaluation in order to control testing circumstances. A stopwatch, a yoga mat, and a meter stick made up the testing apparatus. Two 25-minute progressive circuit modules make up the exercise portion. Circuit 1 combines upper-body activities (knee push-up, plank → shoulder tap), core workouts (bird-dog, bicycle crunch), and posterior-chain exercises (glute bridge march). It is recommended at five rounds of 12–20 repetitions with a controlled tempo and 15 seconds between exercises (Table 1).

Table 2

Workout

Circuit 1	Reps	Tempo	Rest	Sets	Interval
Glute Bridge March	12	2:0:2	15 s	5	60 s
Bird-Dog	16	2:0:2	15 s	5	60 s
Knee Push-Up	12	2:1:1	15 s	5	60 s
Plank → Shoulder Tap	16	1:0:1	15 s	5	60 s
Bicycle Crunch	20	2:0:2	15 s	5	60 s
10-minutes rest and water break					
Circuit 2	**Reps**	**Tempo**	**Rest**	**Sets**	**Interval**
Single-Leg Glute Bridge	12	2:0:1 2	15 s	5	60 s
Spiderman Plank	12	2:0:1	15 s	5	60 s
Standard Push-Up	15	2:1:1	15 s	5	60 s
Reverse Crunch	20	2:0:2	15 s	5	60 s
Side Plank Hip Dip	12	2:0:1	15 s	5	60 s

Single-leg glute bridges, reactive core exercises (spiderman plank), and body-weight strength exercises (regular push-up, reverse crunch, side-plank hip dip) make Circuit 2 more difficult (Table 2). It keeps the total volume somewhat greater while maintaining matched rep ranges. Through the use of the mild walking and static stretches (hamstrings, quadriceps, hip flexors, chest), a 10-minute cool-down brings participants back to baseline. This helps metabolite clearance and maintains flexibility.

Table 3

Training Periodization

Training variables	Week 2		Week 3		Week 4	
	↑	↓	↑	↓	↑	↓
Reps	2		2		2	
Rest		3		3		4
Sets	1		2		3	

The periodization outlines progressive weekly changes in training volume and intensity, adjusting repetitions, sets, rest, and work intervals (Table 3).

Statistical Analysis

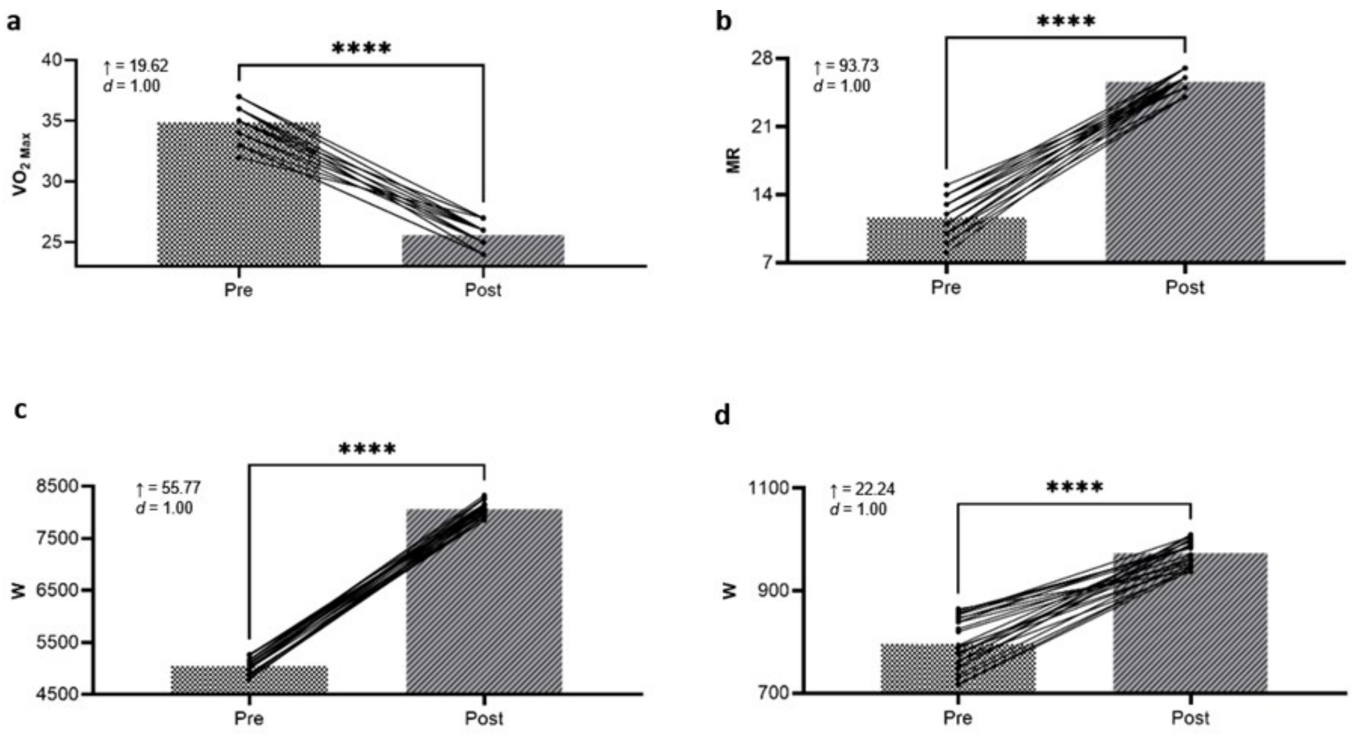
Descriptive statistics such as mean, standard deviation, and the Shapiro-Wilk test for normality were considered. Mean score, standard deviation, and the Wilk test result were used in predicting the homogeneity of the data. Since the data were found to be normally distributed, the paired-sample t-tests and Cohen’s *d* effect size were used to evaluate the magnitude and significance of observed changes.

Results

The results show that the exercise training program significantly improved a number of fitness metrics. Comparative comparisons of pre- and post-test data revealed considerable increases on the aerobic capacity, core strength, and both peak and average lower-body strength. These changes direction and size show that the training intervention resulted in significant physiological adaptations in every evaluated domain.

Figure 1

Effect of exercise training on ***(a)*** *aerobic fitness,* ***(b)*** *core strength,* ***(c)*** *lower body strength (peak), and* ***(d)*** *lower body strength (average) of the students*

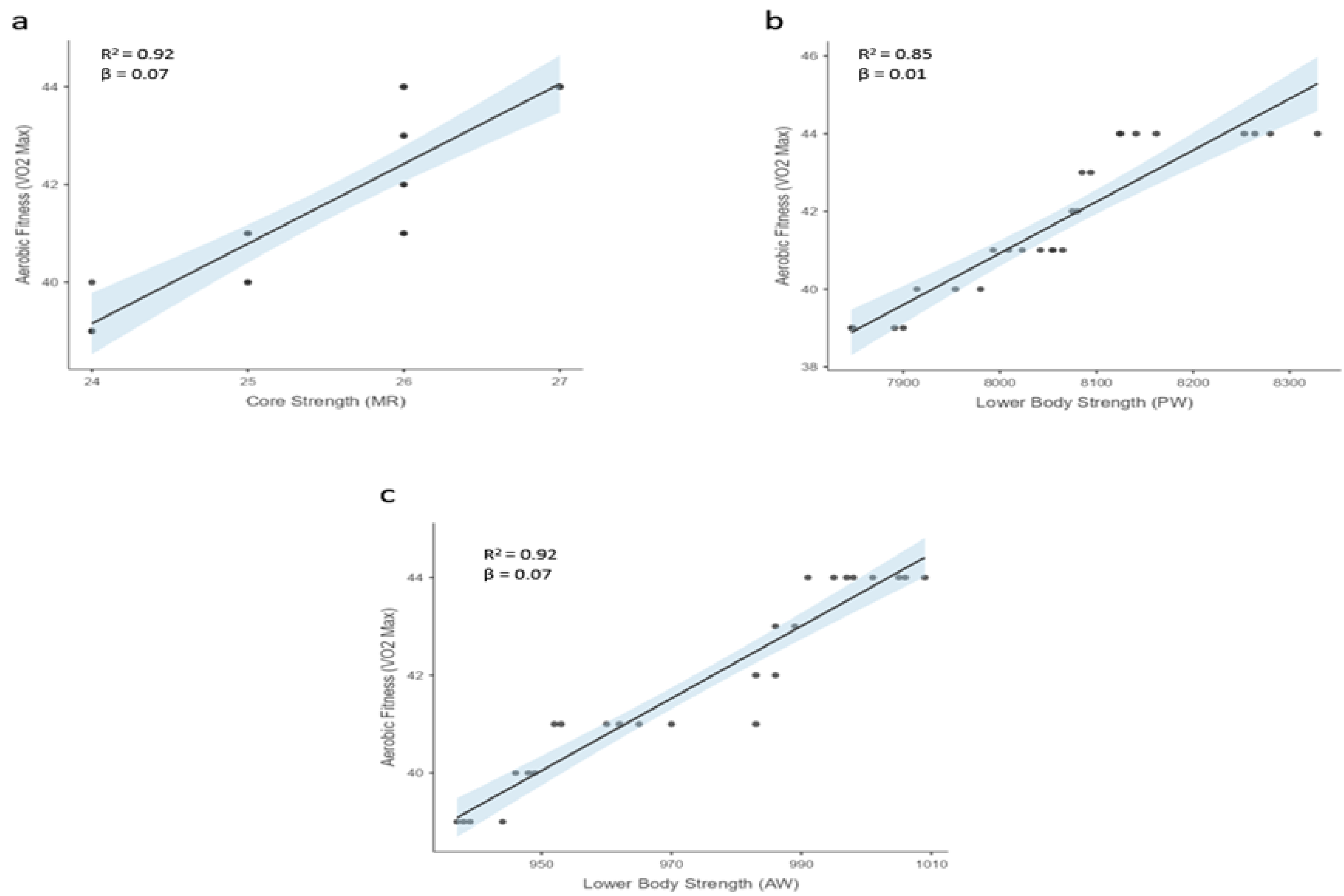


Note: ****, significant at $p \leq 0.001$; ↑, percentage increase; *d*, effect size

A significant difference was found in participants' aerobic fitness (VO2 max = 34.89 ± 1.37 vs 41.73 ± 1.87), core strength (MR = 11.65 ± 1.85 vs 25.58 ± 1.03), and lower body strength ([Peak W = 5045.27 ± 8061.00] [Average W = 795.77 ± 789.50 vs 972.77 ± 24.20]) after the implementation of the exercise training. Additionally, a large effect size (*d* = 1.00) and a positive increase in performance (19.62%, 93.73%, 55.77%, 22.24%) were observed, respectively (Figure 1).

Figure 2

Linear regression between aerobic fitness (VO2 max) and (a) core strength (MR); (b) lower body strength (PW); (c) lower body strength (AW), at p ≤ .001.



Aerobic fitness has a positive relationship with core strength (β = 0.07; *p* < .001) and lower body peak (β = 0.01; *p* < .001) and average (β = 0.07; *p* < .001) strength. Aerobic fitness accounts for 92%, 85%, and 92% of the variances among the mentioned fitness components (Figure 2).

Discussions

The participants executed the workouts well at their maximum performance with 100% attendance in four sessions. This study is effective to enhance the students' aerobic fitness, core strength, and lower body strength. A circuit training program with cardiovascular exercises was performed in a high-intensity periodization and found to be effective in improving aerobic fitness (Turri-Silva et al., 2021; Pocaan, 2024).

The VO_2 max of the participants increased from 34.89 ± 1.37 to 41.73 ± 1.87, showing a 19.62% improvement. This improves the oxygen consumption and cardiorespiratory efficiency. Similar to the results of other researches, circuit-based training, combines aerobic and muscular loading, improves capillary perfusion, mitochondrial density, and stroke volume, particularly in previously sedentary people (Michalski et al., 2023; Jesus et al., 2021). The overload and the adaptability were sustained by the weekly progression and regulated intensity.

Core endurance increased 93.73% from 11.65 ± 1.85 to 25.58 ± 1.03. The rectus abdominis and obliques have almost twice as much muscle endurance. Exercises that repeatedly activate core stabilizers include reverse crunches, bicycle crunches, and planks (Pierce, 2017; Pocaan, 2024). This activity assesses resistance to fatigue and neuromuscular coordination. The robust response of the low-fit individuals to incremental core training is supported by the substantial effect size.

Average power was improved from 795.77 ± 789.50 W to 972.77 ± 24.20 W, a 55.77% and 22.24% increase respectively, while peak power climbed from 5045.27 ± 8061.00 W to higher post-test levels. The musculature of the lower limbs is strengthened, and the stretch-shortening cycle was used during explosive movements more effectively. The improvements are in line with the idea that multi-joint, bodyweight training improves neuromuscular efficiency and force output (Paoli et al., 2017).

Regression study shows that among students who are not physically fit, aerobic fitness is a significant predictor of lower body power and muscular endurance. Aerobic fitness showed a significant positive relationship with core strength ($\beta = 0.07$; $p < .001$), peak lower body power ($\beta = 0.01$; $p < .001$), and average lower body power ($\beta = 0.07$; $p < .001$). The findings suggest that improvements in muscular power and endurance are more likely to follow increases in aerobic capacity. Furthermore, 92% of the variation in core strength, 85% in peak leg power, and 92% in average leg power was explained by aerobic fitness. These high coefficients of determination point to a significant relationship between musculoskeletal performance and cardiovascular efficiency. Increased aerobic capacity supports increased muscular output and endurance by improving oxygen delivery, metabolic efficiency, and recovery between muscle contractions (Booth et al., 2014; Hargreaves & Spriet, 2020). This result supports the idea that improved phosphocreatine resynthesis and lactate clearance are facilitated by well-developed aerobic systems, allowing for sustained muscle performance during high-volume circuit training (Bompa et al., 2012).

Gains in cardiovascular conditioning may result more widespread gains in a variety of physical fitness domains, according to the significant predictive value of aerobic fitness. (Romero-Arenas et al. 2013). This supports circuit training, where resistance and aerobic components work together to achieve integrated physiological adaptation rather than separately.

The program progressive design is responsible for its efficacy. Gradual overload was sustained without extreme tiredness; it has a controlled rest intervals and incremental increases in sets and repetitions. Aerobic, core, and strength exercises combined in a circuit pattern simultaneously increased cardiovascular effort, muscle recruitment, and metabolic stress. This strategy made the intervention quick and appropriate for people that are not very fit and have little experience with in exercise. Furthermore, the results of the study shows that a circuit training program is an effective way in increasing key elements of physical fitness in learning environments. Its efficiency, affordability, and scalability facilitate its incorporation into healthpromoting campus programs and physical education programs, particularly for students with low levels of physical activity.

Limitations and Recommendations

Despite likely results, the absence of a control group limits causal inference. The sample size was small and was composed of a single population group, reducing generalizability. Future studies should incorporate randomized controlled trials, longer intervention periods, and additional physiological measures (e.g., heart rate variability, lactate threshold) to further validate the effectiveness of circuit training in diverse populations.

Conclusions

This study concluded that four-week progressive circuit exercise training has effective impact to the enhancement of the participants aerobic fitness, core strength, and lower body power. These shows that cardiovascular and resistance circuit training provide a balance and time efficient method in developing fitness. The connected relationship of aerobic capacity, muscular strength, and endurance is essential for daily functioning. Thus, the use of this training program in physical education courses is very highly recommended to promote comprehensive health benefits and encourage lifelong engagement in physical activity.

Conflict of Interests

The authors declare that there is no conflict of interest in the conduct of the study.

References

Alcaraz, P. E., Perez-Gomez, J., Chavarrias, M., & Blazevich, A. J. (2011). Similarity in adaptations to high-resistance circuit vs. traditional strength training in resistance-trained men. *Journal of strength and conditioning research*, *25*(9), 2519–2527. https://doi.org/10.1519/JSC.0b013e3182023a51

Bompa, T. O., Di Pasquale, M., & Cornacchia, L. (2012). *Serious strength training*. Human Kinetics.

Booth, F. W., Ruegsegger, G. N., Toedebusch, R. G., & Yan, Z. (2014). Endurance exercise and the regulation of skeletal muscle metabolism. *Progress in Molecular Biology and Translational Science*, *135*, 129-151. https://doi.org/10.1016/bs.pmbts.2015.07.016

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., ... & Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *American College of Sports Medicine,* 4307-1334. https://doi.org/10.7916/D8CR5T2R

Getty, A. K., Wisdo, T. R., Chavis, L. N., Derella, C. C., McLaughlin, K. C., Perez, A. N., DiCiurcio, W. T., Corbin, M., & Feairheller, D. L. (2018). Effects of circuit exercise training on vascular health and blood pressure. *Preventive Medicine Reports*, *10*, 106-112. https://doi.org/10.1016/j.pmedr.2018.02.010

Hargreaves, M., & Spriet, L. L. (2020). Skeletal muscle energy metabolism during exercise. *Nature Metabolism*, *2*(9), 817-828. https://doi.org/10.1038/s42255-020-0251-4

Izquierdo, M., Merchant, R. A., Morley, J. E., Anker, S. D., Aprahamian, I., Arai, H., ... & Singh, M. F. (2021). International exercise recommendations in older adults (ICFSR): expert consensus guidelines. *The journal of nutrition, health & aging*, *25*(7), 824-853.

Jesús, D., Andreu Caravaca, L., & Ángel, J. (2021). Effects of resistance circuit-based training on body composition, strength and cardiorespiratory fitness: A systematic review and meta-analysis. *Biology*, *10*(5), 377. https://doi.org/10.3390/biology10050377

Michalski, A. C., de Freitas Fonseca, G., Midgley, A. W., Billinger, S. A., Costa, V. A., Dos Santos, T. R., ... & Cunha, F. A. (2023). Can mixed circuit training elicit the recommended exercise intensity and energy expenditure in people after stroke?. *Topics in stroke rehabilitation, 30*(8), 751-767. https://doi.org/10.1080/10749357.2023.2178128

Muñoz-Martínez, F. A., Rubio-Arias, J. Á., Ramos-Campo, D. J., & Alcaraz, P. E. (2017). Effectiveness of Resistance Circuit-Based Training for Maximum Oxygen Uptake and Upper-Body One-Repetition Maximum Improvements: A Systematic Review and Meta-Analysis. *Sports medicine (Auckland, N.Z.)*, *47*(12), 2553–2568. https://doi.org/10.1007/s40279-017-0773-4

Paoli, A., Gentil, P., Moro, T., Marcolin, G., & Bianco, A. (2017). Resistance training with single vs. multi-joint exercises at equal total load volume: Effects on body composition, cardiorespiratory fitness, and muscle strength. *Frontiers in Physiology, 8*, 322368. https://doi.org/10.3389/fphys.2017.01105

Pierce, S. E. (2017). *Electromyographical comparison of the abdominal crunch to planks performed with and without a suspension trainer*. California State University, Fresno.

Pocaan, J. (2023). The LGBTQA intercollegiate experiences in higher education institutions in the Philippines: basis for an institutional inclusive sports plan. *Dalat University Journal of Science*, 59-76. https://doi.org/10.37569/DalatUniversity.13.3.1054(2023)

Pocaan, J. (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/tmfv.2024.2.02

Pocaan, J. M. (2024). Effect of Tabata resistance training program on body capacities and 50m sprint performance of intermediate swimmers. *Journal of Physical Education and Sport*, *24*(4), 846-854.

Ramos-Campo, D. J., Martínez-Guardado, I., Olcina, G., Marín-Pagán, C., Martínez-Noguera, F. J., Carlos-Vivas, J., Alcaraz, P. E., & Rubio, J. Á. (2018). Effect of high-intensity resistance circuit-based training in hypoxia on aerobic performance and repeat sprint ability. *Scandinavian journal of medicine & science in sports*, *28*(10), 2135–2143. https://doi.org/10.1111/sms.13223

Romero-Arenas, S., Martínez-Pascual, M., & Alcaraz, P. E. (2013). Impact of resistance circuit training on neuromuscular, cardiorespiratory and body composition adaptations in the elderly. *Aging and Disease*, *4*(5), 256. https://doi.org/10.14336/AD.2013.0400256

Seo, G., Noh, M., & Kim, S. Y. (2019). Weight loss effects of circuit training interventions: A systematic review and meta-analysis. *Obesity Reviews*, *20*(11), 1642-1650. https://doi.org/10.1111/obr.12911

Strain, T., Flaxman, S., Guthold, R., Semenova, E., Cowan, M., Riley, L. M., ... & Stevens, G. A. (2024). National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5· 7 million participants. *The Lancet Global Health*, *12*(8), e1232-e1243. https://doi.org/10.1016/S2352-4642(19)30323-2

Telford, R. M., Telford, R. D., Olive, L. S., Cochrane, T., & Davey, R. (2016). Why are girls less physically active than boys? Findings from the LOOK longitudinal study. *PloS one*, *11*(3), e0150041. https://doi.org/10.1371/journal.pone.0150041

Turri-Silva, N., Vale-Lira, A., Verboven, K., Quaglioti Durigan, J. L., Hansen, D., & Cipriano Jr, G. (2021). High-intensity interval training versus progressive high-intensity circuit resistance training on endothelial function and cardiorespiratory fitness in heart failure: A preliminary randomized controlled trial. *PloS One*, *16*(10), e0257607. https://doi.org/10.1371/journal.pone.0257607

Wilmore, J. H., Parr, R. B., Girandola, R. N., Ward, P., Vodak, P. A., Barstow, T. J., ... & Leslie, P. H. Y. L. L. I. S. (1978). Physiological alterations consequent to circuit weight training. *Medicine and science in sports*, *10*(2), 79-84.