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Original Article Research

The Effect of Repetition and Duration Based Circuit Training on Body Mass Index and Physical Fitness Levels among Students

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Abstract

The findings from field observations show that out of the 61 students sampled at SMK Pelayaran Baruna Pemalang, 35 students have a Body Mass Index (BMI) within the normal (healthy) category. Meanwhile, the students' overall physical fitness level is categorized as low, with 46 students included in this group. This research seeks to examine the influence of repetition-based and duration-based circuit training methods on the BMI and fitness levels of students at SMK Pelayaran Baruna Pemalang. The study utilized an experimental approach with a 2x2 factorial design and was evaluated using Multivariate Analysis of Variance. The independent variables consisted of repetition-based and duration-based circuit training, while the dependent variables included Body Mass Index (BMI) and fitness level. The population consisted of 89 students of SMK Pelayaran Baruna Pemalang, while the study involved a purposive sample of 55 students. The findings revealed that the circuit training method simultaneously had no significant effect on Body Mass Index, with a significance value of 0.879 > 0.05, whereas the circuit training method demonstrated a simultaneous significant effect on physical fitness, indicated by a significance value of 0.003 < 0.05. The study concludes that repetition-based circuit training is effective in enhancing physical fitness. In addition, there is an interaction between repetition- and duration-based circuit training on Body Mass Index and physical fitness. Future research may further develop other circuit training models to enhance fitness.

Keywords: Circuit Training, Body Mass Index, Physical Fitness.

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1. INTRODUCTION

Body Mass Index (BMI) is an important indicator for assessing the balance between a person's weight and height, which ultimately reflects their nutritional status. An ideal BMI indicates that an individual has a body proportion that supports metabolic function and physical activity. An inappropriate BMI, whether too low or too high, can negatively affect students' physical performance during training or practice. Being overweight, for instance, may limit movement and increase the risk of fatigue or injury, whereas being underweight can indicate a lack of energy reserves and muscle mass required for demanding activities.

Physical fitness refers to the capacity to perform everyday activities energetically and attentively, without excessive tiredness, while still having adequate energy reserves (Lengkana & Muhtar, 2021). It allows individuals to perform daily work without excessive exhaustion or physical injury. The better an individual's physical fitness, the stronger their ability to perform physical tasks, maintain endurance, and work efficiently. Physical fitness plays an essential role in building muscle strength and endurance; having sufficient strength enables individuals to perform daily activities optimally. Moreover, higher levels of physical fitness among students tend to correlate positively with their academic achievement (Abduh et al., 2020).

Physical fitness plays an essential role in students' everyday activities, as adequate fitness is needed not only to engage effectively in the learning process but also to perform well in activities outside of school. Broadly, physical fitness refers to an individual's capacity to complete daily tasks efficiently without experiencing undue fatigue, allowing them to still enjoy leisure time. Thus, a combination of an ideal BMI, good physical fitness, and appropriate physical training becomes an essential requirement for students. To achieve this, an effective and measurable physical training regimen is needed. One relevant method is circuit training, a structured exercise model that involves various training stations with specific repetitions and durations. Circuit training can improve children's physical fitness (Afdinda et al., 2021), enabling students with good fitness levels to perform school activities more effectively (Fikri, 2017). This training incorporates components of strength, endurance, agility, and flexibility simultaneously.

One of the missions of the National Sports Grand Design (DBON), as stated in Presidential Regulation No. 86 of 2021, is to foster students who actively participate in sports, develop superior character, possess motor skills, and maintain a high level of physical fitness. Physical fitness stimulates body growth, prevents obesity or overweight, reduces stress, and enhances happiness during adolescence (Wu et al., 2021). Therefore, it is important to deepen the understanding of the significance of physical fitness for the body. A healthy body can be achieved through a balanced diet that meets the body's activity needs (Astrup, 1999).

The Assistant Deputy for Educational Sports Management of the Ministry of Youth and Sports (Kemenpora), Ary Moelyadi, stated that the physical fitness level of Indonesian students remains low (Shanti, 2021). This statement is reinforced by Deputy III for Sports Development

at Kemenpora, Raden Isnanta, during a webinar themed "Socialization of the National Sports Grand Design (DBON)". Out of approximately 45 million students in Indonesia, only about 2.1 percent are reported to be actively engaged in sports activities (suaramerdeka.com, 2021).

The rapid advancement of technology has caused behavioral changes, particularly a decline in physical activity (Sullivan & Lachman, 2017). When food intake increases while physical activity decreases, it leads to the accumulation of excess energy in the body, typically stored as fat or triglycerides. Excessive fat accumulation increases body weight, which in turn reduces physical agility. It can also negatively affect internal organs such as the heart, lungs, and muscles by putting them under pressure, thereby disrupting blood circulation and metabolic processes, which consequently reduces physical fitness (Murphy et al., 2021). Factors that influence physical fitness include age and gender (Crosnoe, 2002; Lonsdale et al., 2013; Martínez-Vizcaíno et al., 2014), genetics, and physical activity (Agus, 2012). Among these factors, physical activity is one of the primary determinants of physical fitness (Di Maglie et al., 2022; Maravilla et al., 2023; Thomas et al., 2020).

The delivery of physical education (PE) in schools must be complemented by additional programs that help improve students' physical fitness. In reality, PE lessons are typically held only once a week for about two hours. This underscores the need for regular physical activity to strengthen and support a high-quality physical education curriculum in schools (Weemer & Ayodele, 2021). Integrating stronger physical conditioning components into the physical education curriculum can be achieved through exercise-based programs (Coates, 2011).

The significance of physical fitness for students cannot be emphasized enough, as good physical fitness helps them engage in learning activities without feeling tired, weak, or bored. However, the Physical Education, Sports, and Health (PJOK) curriculum which includes sports activities aimed at improving students' physical, mental, and emotional skills has been eliminated for grade XII students, according to Director General Regulation for Primary and Secondary Education No. 07/D.D5/KK/2018, dated June 7, 2018. This policy poses a risk of lowering the fitness levels of vocational high school (SMK) students. Several studies have reported the low physical fitness levels of senior high school students in Indonesia. For instance: 1) At SMK N 7 Padang, students' physical fitness levels were categorized as low (Mardiansyah & Zarwan, 2019). 2) At SMK N 11 Semarang, more than half of the respondents (60.7%) had very poor physical fitness (Alamsyah et al., 2017), 3) Students participating in indoor hockey extracurricular activities at senior/vocational high schools in Sidoarjo Regency had moderate levels of physical fitness (Prakoso, 2017). Based on these data, it can be inferred that the overall physical fitness level among upper secondary students in Indonesia falls into the low category.

An effective method of exercise for maintaining a stable Body Mass Index (BMI) and enhancing physical fitness is circuit training. This form of training incorporates various elements, including muscular strength, endurance, flexibility, agility, balance, and cardiorespiratory stamina. Circuit training is designed in cycles to prevent boredom, typically consisting of 6 to 15 stations. The Circuit Training System was developed by Morgan and Adamson in 1956 at the University of Leeds, England (Adamson & Morgan, 1956). The system gained popularity as coaches began experimenting with various modifications—such as repetition-based (rep) training and duration-based (time) training—adjusted to specific needs. Circuit training serves as a comprehensive exercise system that simultaneously develops overall body fitness, including components such as power, endurance, speed, flexibility, and other physical attributes.

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2. METHOD

The design used in this study was an experimental method employing a 2x2 factorial design. This approach is validation-focused, as it is designed to test how one or more variables influence other variables. Experimental research serves to uncover the relationships among multiple variables in order to determine how one variable affects another (Sudjana, 2005). A factorial design is a research design modified from the posttest-only control group or the pretest–posttest control group, with the researcher adding an additional variable (Fraenkel & Wallen, 2009). This experimental study involved two groups that received different treatments, namely static underhand passing training and dynamic underhand passing training. The following presents the research design applied in this experimental study. The research procedure followed the sequence of an experimental study, consisting of a pretest, treatment, and posttest (Afdinda et al., 2021).

2.1 Participants

The population of this study comprised around 89 male students from SMK Pelayaran Baruna Pemalang. The sample consisted of 55 male students from the same school, chosen according to specific selection and non-selection criteria. The eligibility criteria for this research were: (1) all male students of SMK Pelayaran Baruna Pemalang, and (2) male students who agreed to participate as research subjects. The exclusion criteria were: (1) male students who were absent or unwilling to participate in the study, and (2) students who were in an unhealthy condition at the time of data collection.

2.2 Research Design

This study employed a quasi-experimental design featuring a pretest–posttest control group arrangement. This design was chosen to assess the influence of repetition- and duration-based circuit training on students' BMI and physical fitness levels. In this framework, the participants were assigned to two groups: the experimental group, which underwent circuit training with variations in repetitions and duration, and the control group, which did not receive any intervention.

Before the treatment was administered, both groups underwent an initial test (pretest) to measure their BMI and physical fitness levels. Once the training phase concluded, a posttest was administered using the same measurement tools to identify any changes that had taken place. The comparison between the pretest and posttest results was used to determine the extent to which circuit training with repetition and duration variations affected the studied variables. This design was considered appropriate as it effectively illustrates changes in students' physical condition and fitness levels resulting from a structured and measurable exercise program..

2.3 Instruments

The instruments used to assess BMI and physical fitness in this study employed the Tes Kebugaran Pelajar Nusantara (TKPN) for the 9–18 age group, as provided by the Ministry of Youth and Sports of the Republic of Indonesia (Kemenpora RI, 2022).

2.4 Procedures

This research was carried out through several main stages, including preparation, pretest, treatment, and posttest. The purpose of this procedure was to obtain data regarding changes in Body Mass Index and students' physical fitness levels after participating in the circuit training

program with repetition and duration variations.

Preparation Stage

At this stage, the researcher prepared all necessary equipment and research instruments, including a height measuring device (stadiometer), a digital weight scale, a stopwatch, exercise mats, and field facilities for the implementation of the Tes Kebugaran Jasmani Pelajar Nusantara (TKPN). The students participating in the study were briefed on the research objectives, the procedures involved, and the data collection process. The researcher also confirmed that the participants were in proper physical condition and prepared to take part in the testing.

Body Mass Index (BMI) Measurement

BMI measurement was conducted to determine students' body weight status based on the proportion between body weight and height. The measurement steps were as follows: 1) Students were asked to remove footwear and any metallic objects before the measurement. 2) Height was assessed using a stadiometer with a precision of 0.1 cm. 3) while body weight was assessed using a digital scale accurate to 0.1 kg.

The BMI value is determined using the following formula:

$$\text{BMI} = \frac{\text{weight (Kg)}}{\text{Height Squared } (m^2)}$$

BMI results are categorized based on the standards of the Indonesian Ministry of Health:

Category	BMI
Very thin	< 17,0
Light skinny	17,0 – 18,4
Normal	18,5 – 25,0
Lightly fat	25,1 – 27,0
Heavy fat	> 27,0

Nusantara Student Physical Fitness Test (TKPN)

The physical fitness test was conducted based on the official guidelines of the Tes Kebugaran Jasmani Pelajar Nusantara (TKPN) published by the Kementerian Pemuda dan Olahraga (Kemenpora RI). This assessment was designed to evaluate students' overall physical fitness through the following four test components: 1) V Sit and Reach Test, 2) 60-Second Sit-Up Test, 3) 30-Second Squat Thrust Test, 4) PACER Test

Each test item was administered in accordance with the technical instructions in the TKPN manual, including procedures, rest intervals between tests, and scoring methods. The final physical fitness score was obtained by summing the scores of each test item, which were then converted into the following categories: Excellent, Good, Fair, Poor, or Very Poor.

Treatment Stage

After the pretest, the experimental group was given a circuit training program with

repetition and duration variations for a specific period according to the research design. The training consisted of several stations that combined exercises for strength, agility, and endurance, performed repeatedly within a predetermined time duration. The control group was not provided with this training intervention.

Posttest Stage

After completing the entire treatment program, both groups underwent BMI measurement and the Nusantara Student Physical Fitness Test (TKPN) again, following the same procedures as in the pretest. The posttest data were then compared with the pretest data to determine the changes resulting from the training program.

2.5 Data Analysis

The data analysis method employed to examine the hypotheses in this study was Multivariate Analysis of Variance (MANOVA). The hypothesis tests were carried out using a significance level of $\alpha = 0.05$. Furthermore, to compare the mean differences between treatment pairs, the Tukey test was employed. Since the data analysis utilized MANOVA, several prerequisite tests were carried out beforehand, including data reliability testing and assumption tests, which included tests for normality and homogeneity of variance.

3. RESULTS

The descriptive data from the pretest and posttest measurements of Body Mass Index (BMI) among male students of SMK Pelayaran Baruna were collected after they underwent circuit training based on repetition and duration. These data illustrate the changes in BMI values before and after the intervention, thereby showing the extent to which the circuit training influenced the students' BMI condition. This information offers a thorough overview of the effectiveness of the training program implemented. The full details of these measurements are shown in the table below:

Table 1.

Description of pretest and posttest data on Body Mass Index (BMI) measurements after circuit training based on repetition and duration among male students of SMK Pelayaran Baruna

Repetition Circuit Training Method Group	Body Mass Index (BMI)				
	Pre Test	Criteria	Post Test	Criteria	Change
Mean	20.58	Normal	20.33	Normal	-0.25
Stadar Deviasi	1.11		1.00		0.37
Circuit Training Method Group Duration	Body Mass Index (BMI)				
	Pre Test	Criteria	Post Test	Criteria	Change
Mean	20.29	Normal	20.27	Normal	-0.02
Stadar Deviasi	0.69		0.66		0.10

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This study employs the MANOVA analysis method to examine differences that occur simultaneously across multiple variables. The use of MANOVA was chosen because it offers a more thorough picture of the effects of the treatment being investigated. The results of the MANOVA analysis have been processed and systematically summarized, and they are presented in the following table to facilitate data interpretation and understanding:

Table 2.

Multivariate Test of Circuit Training Method Repetition and Duration on BMI Results

Effect		***Value***	***F***	***Hypothesis df***	***Error df***	***Sig.***
Circuit Training Method Repetitions and Duration	Roy's Largest Root	.568	3.813[c]	7.000	47.000	.002

Based on the multivariate test results presented above, the analysis shows that the significance values for the effects of repetition-based and duration-based circuit training on the BMI of students at SMK Baruna Putra Pemalang are mostly below 0.05 (Sig. < 0.05). This suggests that the two circuit training methods produce significantly different effects on students' BMI results.

Table 3.

Tests of Between-Subjects Effects of Circuit Training Repetition and Duration on BMI in Students of SMK Baruna Putra Pemalang.

Source	*Dependent Variable*	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	IMT	31.693[a]	7	4.528	.429	.879
Intercept	IMT	22383.149	1	22383.149	2122.865	.000
Circuit Training Method Repetitions and Duration	IMT	31.693	7	4.528	.429	.879
Error	IMT	495.560	47	10.544		
Total	IMT	23216.570	55			
Corrected Total	IMT	527.253	54			

The findings shown in the 'Tests of Between-Subjects Effects' table indicate a significance value of 0.879, which exceeds 0.05 (Sig. > 0.05). This result was evaluated using the F table,

where the degrees of freedom for the numerator (N1) = k (number of independent variables) – 1 = 6 – 1 = 5, and the degrees of freedom for the denominator (N2) = n (number of samples) – k – 1 = 55 – 6 – 1 = 48. Thus, the F table value at the 0.05 significance level is 2.41. Since the obtained F value is lower than the F table value (0.429 < 2.41), it can be inferred that the repetition-based and duration-based circuit training methods do not produce a significant difference in students' BMI outcomes at SMK Pelayaran Baruna. The descriptive data from the pretest and posttest measurements of physical fitness following the application of both training methods for male students at SMK Pelayaran Baruna are presented in the table below:

Table 4.

Descriptive Data of Pretest and Posttest Results of Physical Fitness Measurements After Repetition- and Duration-Based Circuit Training for Male Students at SMK Pelayaran Baruna.

Repetition Circuit Training Method Group	Fitness Level				
	Pre Test	Criteria	Post Test	Criteria	Change
Mean	2.01	Enough	2.39	Enough	0.38
Stadar Deviasi	0.17		0.30		0.13
Circuit Training Method Group Duration	Fitness Level				
	Pre Test	Criteria	Post Test	Criteria	Change
Mean	1.86	not enough	2.19	Enough	0.33
Stadar Deviasi	0.07		0.20		0.13

The MANOVA test results on the fitness measurements of the male students at SMK Pelayaran Baruna were obtained after they underwent circuit training based on repetition and duration. This analysis was carried out to identify the differences and the effects of the training on various components of the students' physical fitness. The resulting data were then processed to provide a clearer picture of the effectiveness of the implemented training program. All of these analysis results are presented in the following table to facilitate understanding and data interpretation:

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Table 5.

Multivariate Test of the Repetition and Duration Circuit Training Method on the Fitness Level of Sailing Vocational School Students

Effect		*Value*	*F*	*Hypothesis df*	*Error df*	*Sig.*
Circuit Training Method Repetitions and Duration	Roy's Largest Root	.568	3.813[c]	7.000	47.000	.002

The Multivariate Test results show that the significance values for the effects of repetition-based and duration-based circuit training on students' physical fitness levels at SMK Pelayaran Baruna Pemalang are mostly below 0.05 (Sig. < 0.05). This indicates that the two circuit training methods produce significantly different effects on the physical fitness levels of these students.

Table 6.

Tests of Between-Subjects Effects of Repetition-Based and Duration-Based Circuit Training on the Physical Fitness Level of Students at SMK Pelayaran Baruna Pemalang.

Source	*Dependent Variable*	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	Kebugaran	3.536[b]	7	.505	3.734	.003
Intercept	Kebugaran	295.669	1	295.669	2185.812	.000
Circuit Training Method Repetitions and Duration	Kebugaran	3.536	7	.505	3.734	.003
Error	Kebugaran	6.358	47	.135		
Total	Kebugaran	303.610	55			
Corrected Total	Kebugaran	9.893	54			

The data presented in the 'Tests of Between-Subjects Effects' table show a significance value of 0.003, which is below 0.05 (Sig. < 0.05). This result was compared with the F-table, where the degrees of freedom for the numerator (N1) = k (number of independent variables) – 1 = 6 – 1 = 5, and the degrees of freedom for the denominator (N2) = n (number of samples) – k – 1 = 55 – 6 – 1 = 48. Using these values, the F-table value at the 0.05 significance level is 2.41.

Since the calculated F-value exceeds the F-table value (3.734 > 2.41), it can be concluded that repetition-based and duration-based circuit training methods have a significantly different effect on the physical fitness levels of students at SMK Pelayaran Baruna.

4. DISCUSSIONS

Based on the results of the statistical analysis, the significance value (Sig) of 0.879 is higher than the 0.05 threshold. This indicates that circuit training has no significant effect on changes in Body Mass Index (BMI). Statistically, when the significance value exceeds 0.05, the null hypothesis (H_0) which states that circuit training has no effect on BMI—is accepted. Thus, the circuit training applied in this study did not lead to a meaningful change in participants' BMI.

Further analysis reveals that the calculated F-value (0.429) is lower than the F-table value (2.41). This provides additional confirmation that circuit training does not significantly influence BMI. In MANOVA, when the computed F-value is less than the F-table value, it signifies that the independent variable (circuit training) does not produce a significant impact on the dependent variable (BMI). Consequently, the results of this study indicate that circuit training does not directly result in either an increase or a decrease in BMI

Several studies have reported that physical exercise, such as circuit training, does not always have a significant effect on reducing BMI, especially when it is not accompanied by dietary regulation or when performed with limited duration or intensity. Circuit training is indeed effective in improving cardiorespiratory fitness and muscular strength; however, in terms of changes in body composition such as BMI, its effect may be insignificant if the intervention duration is short (e.g., less than eight weeks) or if the training frequency is insufficient. For instance, a study by Al-Eisa published in the Journal of Physical Therapy Science stated that exercise alone without dietary modification results in only minor changes in BMI (Al-Eisa et al., 2013). Similarly, research published in Obesity Reviews by Shaw showed that although exercise offers general health benefits, significant weight and BMI reductions usually require a combination of exercise and dietary interventions (Shaw et al., 2006). This is further supported by Donnelly in Medicine & Science in Sports & Exercise, who reported that weight loss achieved through exercise alone tends to be minimal unless combined with dietary control (Donnelly et al., 2009). Furthermore, Keating highlighted that shifts in body composition such as decreases in visceral fat and increases in muscle mass can take place even without noticeable changes in BMI (Keating et al., 2014). Therefore, although circuit training provides important fitness benefits, its impact on BMI may be limited, particularly when the training intervention is of low intensity, short duration, or not accompanied by adjustments in overall energy intake.

The absence of differences in circuit training effects on BMI may be attributed to several factors. One possible explanation is that the duration and intensity of the training program were not sufficient to induce significant changes in body composition. Moreover, BMI is calculated based on body weight and height without taking into account the proportion of fat mass and muscle mass. Thus, even if participants underwent changes in body composition, such as gaining muscle mass and reducing fat mass, these changes might not be reflected in a significant alteration of BMI. Another influencing factor is the participants' dietary patterns and lifestyle habits, which play an important role in BMI variation.

The findings of this study indicate that circuit training alone is not sufficient to produce a significant change in BMI. To achieve more substantial results, it is necessary to combine the

training program with other factors such as dietary regulation, longer training duration, and a more targeted approach toward body composition improvement.

Based on the results showing a significance value (Sig) of 0.003, which is lower than the 0.05 significance level, and an F-value of 3.734 that exceeds the F-table value of 2.41, it can be inferred that circuit training significantly influences students' physical fitness levels at SMK Pelayaran Baruna Pemalang. This finding suggests that circuit training effectively improves students' physical fitness and can therefore be recommended as an appropriate training method to enhance their physical capacity.

Circuit training combines various exercise types into a single sequence performed at high intensity with minimal rest intervals. This approach has been demonstrated to enhance multiple components of physical fitness, such as cardiovascular endurance and muscular strength, speed, and flexibility (Sonchan et al., 2017). For maritime vocational students who are required to maintain optimal physical condition to support their professional activities, improving fitness through circuit training is particularly important. With a systematic and progressive training structure, students can enhance their cardiovascular and pulmonary endurance, which are essential for sustaining physical performance during demanding maritime activities (Pocaan, 2024).

In addition, circuit training contributes to improved metabolic efficiency and muscular endurance (Al Furqan et al., 2025). In the maritime field, students frequently encounter physically demanding tasks that require strong muscular endurance and strength. By engaging in regular circuit training, students can improve the muscular stamina necessary to handle these physical challenges during both training and onboard work. The improvement in physical fitness resulting from this training can also help reduce the risk of injury and fatigue associated with prolonged heavy physical activity.

The effectiveness of circuit training in enhancing students' physical fitness can also be attributed to the principle of varied and non-monotonous exercises. The dynamic nature of circuit training helps enhance students' motivation to engage in physical activities, leading to greater consistency in following the training program (Ananda & Nugroho, 2025). With higher levels of student engagement during circuit training, the outcomes become more optimal in improving their overall physical fitness.

Therefore, the results of this study affirm that circuit training significantly impacts students' physical fitness levels at SMK Pelayaran Baruna Pemalang. Therefore, this training method can be incorporated into the physical education curriculum or used as part of a structured training program to enhance students' physical endurance. The implementation of systematic and continuous circuit training programs can help develop a physically prepared, healthy, and resilient maritime workforce capable of meeting the physical demands and challenges of the maritime work environment.

5. CONCLUSIONS

The results of this study suggest that circuit training methods based on repetition and duration do not produce significantly different effects on Body Mass Index (BMI), meaning both methods are equally effective in maintaining a normal BMI. However, regarding physical fitness, the two training approaches show a significant difference, with repetition-based circuit training resulting in greater improvements compared to duration-based training. These results imply that

the choice of training method can be adjusted according to specific fitness improvement goals, while BMI management can utilize either approach effectively. However, this study is not without limitations. The modest sample size and the brief duration of the intervention may limit the degree to which the findings can be generalized. Therefore, future studies are encouraged to include larger participant groups, prolong the training duration and include additional variables, such as body composition and exercise motivation, to provide a more complete understanding of the effectiveness of circuit training.

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