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Effects of continuous, interval, and combined training methods on middle- and long-distance runners' performance

Efectos de los métodos de entrenamiento continuo, interválico y combinado en corredores de media y larga distancia

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Abstract. Introduction: Running performance is largely influenced by training methods, including Continuous, Interval, and combined training methods. However, which training method that best improves the performance has not been identified. Aim: This study was to investigate how training methods continuous, interval, and combined training affect distance running performance. Methods: A total of thirty (n=30) athletes from the Ethiopia Hotel Athletics Club were selected as subjects. The studies included trained runners without previous injuries. Interventions lasted at least 12 weeks, with participants allocated to Interval, Continuous or combined training groups. The athletes' performance was assessed through cooper 12 min run test, wall squat test and multiple sprint test using pre- and posttest interventions. MANOVA was performed using SPSS to determine the mean difference with 95% confidence intervals (CIS) between continuous, interval (CIS), and combined training, and the effect sizes were calculated. Results: All training methods significantly improved VO2max, strength endurance, and speed. Moreover, there was no significant difference between the interval and combined training during the VO2max test (MD = 0.2, P > 0.1). There was no significant difference between continuous and interval training during the posttests VO2max test. During the wall squat test, there was no significant difference between the training methods (p > 0.1). Moreover, there were no significant differences between the continuous and combined, training groups or between the interval and combined training groups at the level of the multiple sprint test (p = 1, MD = 0.53). However, there was a significant difference between the continuous and interval training groups on the multiple sprint test (P = 0.024, MD = -1.75), with an effect size was 0.356. Conclusion: Interval and combined training are better strategies than continuous training for improving athlete performance.
Key words: Athletics, continuous, interval, combined training methods, performance

Resumen. Introducción: El rendimiento en carrera se ve influido en gran medida por los métodos de entrenamiento, entre los que se incluyen el entrenamiento continuo, por intervalos y combinado. Sin embargo, no se ha identificado qué método de entrenamiento mejora mejor el rendimiento. Objetivo: Este estudio tenía como objetivo investigar cómo los métodos de entrenamiento continuo, por intervalos y combinado afectan al rendimiento en carreras de distancia. Métodos: Un total de treinta (n=30) atletas del Ethiopia Hotel Athletics Club fueron seleccionados como sujetos. Se incluyeron corredores entrenados sin lesiones previas. Las intervenciones duraron al menos 12 semanas, y los participantes fueron asignados a grupos de entrenamiento por intervalos, continuo o combinado. El rendimiento de los atletas se evaluó mediante la prueba de carrera de Cooper de 12 minutos, la prueba de sentadillas en la pared y la prueba de sprints múltiples mediante intervenciones antes y después de la prueba. Se realizó un MANOVA con SPSS para determinar la diferencia de medias con intervalos de confianza del 95% (CIS) entre el entrenamiento continuo, por intervalos (CIS) y combinado, y se calcularon los tamaños del efecto. Resultados: Todos los métodos de entrenamiento mejoraron significativamente el VO2máx, la resistencia a la fuerza y la velocidad. Además, no hubo diferencias significativas entre el entrenamiento a intervalos y el combinado durante la prueba de VO2máx (DM = 0,2, P > 0,1). No hubo diferencias significativas entre el entrenamiento continuo y el de intervalos durante la prueba de VO2máx postest. Durante la prueba de sentadilla de pared, no hubo diferencias significativas entre los métodos de entrenamiento (p > 0,1). Además, no hubo diferencias significativas entre los grupos de entrenamiento continuo y combinado ni entre los grupos de entrenamiento por intervalos y combinado en la prueba de sprint múltiple (p = 1, DM = 0,53). Sin embargo, hubo una diferencia significativa entre los grupos de entrenamiento continuo y de intervalo en la prueba de sprint múltiple (p = 0,024, DM = -1,75), con un tamaño del efecto de 0,356. Conclusiones: El entrenamiento por intervalos y el entrenamiento combinado son mejores estrategias que el entrenamiento continuo para mejorar el rendimiento de los atletas.
Palabras clave: Atletismo, continuo, intervalo, métodos combinados de entrenamiento, rendimiento.

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Introduction

Success in athletic , especially in middle- to long-distance running is known to be determined by physiological parameters such as maximal aerobic power (VO_{2max}), sustainable percentage of VO_{2max}, velocity at lactate threshold (LT), velocity at VO_{2max}, and running economy (RE) (Yalcin, Sahin, Coskun, & Yalcin, 2022). Training methods to improve these determinants of performance have been developed with varying success, with two modes of training typically identified: continuous training and interval training (Gonzalez-Mohino et al., 2016) . Both methods of training elicit physiological adaptations that facilitate endurance performance, however, the physiological structures targeted differ (Iaia & Bangsbo, 2010) Therefore, continuous running is one of the usual training methods in which the athletes continuously perform long distances without a break during a training program. Indeed, continuous training has many

advantages to improve and increase the capacity for their performance, viz., cardiovascular, respiratory, maximum oxygen uptake, capillary network, mitochondrial enzymes in aerobic energy systems, and also increase the energy-producing system (Mazoochi, Fateminezhad, & Mazoochi, 2013). Whereas interval training method is characterized by repeated high-intensity efforts (above ventilatory threshold2) interspersed with periods of recovery (Zafeiridis, Sarivasiliou, Dipla, & Vrabas, 2010). Although much is known about the physiological effects of training on endurance performance, there is a lack of information relating to the interval training practices of elite endurance runners (Parmar, Jones, & Hayes, 2021).

Even though success in athletics performance is linked to several elements, training plays better than others factors (Smart & Steele, 2012)**.** In fact athlete's endurance, according to the type of exercise, is affected by factors such as aerobic power, efficiency, biomechanical, neuromuscular and cardiovascular adaptations, anaerobic power, lactate threshold and adaptation of the endocrine system (Mazoochi et al., 2013). Therefore, the physiological differences between elite and novice athletes' endurance depend on training methods they use (Mazoochi et al., 2013).

Therefore coaches and athletes are constantly employing several training methods, continuous and interval training methods, for improving athletes' fitness level based on physiology and exercise science (Mazoochi et al., 2015).

Interval training is one of the best training methods which a practice interchangeably between training and work with break period at low intensity in a training platform, that may give many benefits as follows:- careful in controlling the strain occurred, as the systematic approach day by day will enable and easy to observe the progress, further in improving the potential energy than the other condition method, the training program can be implemented everywhere and no need special instruments,(MacInnis & Gibala, 2017; Yunus, Wahjuni, & Supriatna, 2019). Viz .a viz to applying interval training, coaches and athletes must consider the five principles as a major concern to improve performance, such as size and distance of work interval, repetition of each training, interrupt or time between work interval, activities during the interrupt interval, and training frequency per weeks (Yunus et al., 2019).Whereas high intensity training (HIT) involves repeated short-to- long bouts of rather high-intensity exercise interspersed with recovery periods and has been used by athletes for almost a century now. For example, in 1920, Paavo Nurmi, one of the best middle- and long-distance runners in the world at that time, was already using some form of HIT in his training routines (Buchheit & Laursen, 2013). Because of its alleged and proven advantages, high-intensity interval training, or HIIT, has gained popularity in the realms of athletics, fitness, and rehabilitation. Short bursts of high-intensity training typically defined as at least 90% of VO2peak—are combined with shorter rest intervals to form the high-intensity interval training (HIIT) training protocol (Girard, Feng, & Chapman, 2018).

It is also important to note that few studies have compared the effects of continuous training versus interval training on the performance of middle- and long-distance runners. There is evidence that continuous exercise improves endurance performance, Vo_{2max}, capillary density, oxidative enzyme activity, and plasma volume in individuals without training; however, it is ineffective in people with training. It has been argued by the researcher that interval training is a more effective way of enhancing Vo_{2Max} in trained athletes than continuous training (Mazoochi et al., 2013). However, both continuous and interval training method significantly improve $VO_{2\ max}$, similarly (Gharbi et al., 2008; Yunus et al., 2019). However, another researcher has found that interval method improves VO_{2max} much more than continuous training (Boullosa et al., 2020; Mande, 2016). Even though the training methods were balanced and did not receive the same stimulus, interval training resulted in much higher gains in VO_2max than continuous training (MacInnis & Gibala, 2017). Both continuous training and interval training improve aerobic fitness (endurance), it is still unclear whether continuous and interval training can improve an athlete's aerobic capacity more effectively (Grivas, 2020). Remarkably, much previous research on continuous, interval, and combination training has focused on verifying that there is still uncertainty about how to improve athletes' performance, particularly in raising vo_{2max}.As a result, this study looked into how distance running performance was affected by 12 weeks of continuous, interval, and combined training. This study expected that interval and combined training might significantly improve distance running performance. Thus, the purpose of this study was to investigate how training methods continuous, interval, and combined training affect distance running performance.

Methods

Study design and participants

The study's design was quasi-experimental. The study was conducted the Sekela Woreda in the West Gojam zone by the ethiopian hotel athletics. ethiopia hotel athletics club athletes participating in these events were randomly selected and invited to participate in the study according to the three training groups. The participants (17.53 ± 0.34years) were informed about the purpose of the study and the research protocol, and they signed informed consent forms. Thirty athletes were examined in between November December 2022.The participants' training regimes and demographic characteristics are presented in figure 1. The study has been approved by the ethical committee review board (No. 1182/2022)

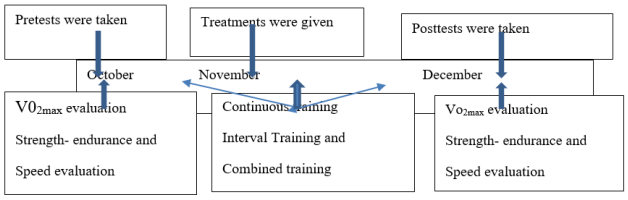

Figure 1. Training methods and its intervention periods

After having obtained ethical approval from Bahir Dar University Sport Academy and the Research Council Approval Committee, the researcher prepared a concept for the clubs that would allow the athletes to participate in the study. Before the measurements began, the researcher had explained the procedure for conducting the test, and the objective of the study had also been presented. In direct contact with the participants, the researcher had explained the training procedure for the participants and how to perform the tests at the scheduled time. The test is conducted twice, with a pretest and a posttest of VO_{2max} test, wall squat test, and multiple sprint tests. In the study, subjects were exposed to three treatment conditions for 12 weeks. During the treatment, the middle- and long-distance runners receive one continuous, one interval, and one combined continuous and interval training for each group. A training frequency of three days per week, lasting from 30 minutes to one hour, is likely to produce the best results (Gordon, 2009).

Training procedures

Before the study began, all subjects were introduced to the staff who carried out the study and all the experimental procedures, and were subsequently tested on three different days on their training field. On the first day, vo_{2max} was measured with measured using the Cooper test (a 12-minute running test). This test checks how far an athlete can run/walk in 12 min, and the assistant is responsible for recording the total distance covered. The performance evaluation was based on the distance covered. The athlete's VO2max can be calculated using the following formula: VO_{2max} = (distance traveled in meters-504.9) ÷44.73.

This procedure was explained by a pediatrician who supervised all the procedures, which were performed respecting the privacy of the participants and promoting their comfort level during the evaluation. The process was carried out for an athlete can run in 12 min in a specially assigned 400m track.

On the second day, strength endurance was measured using a wall squat test (Mackenzie, 2005). Subjects were instructed to stand comfortably with both feet shoulder-width apart, backs against a smooth wall. They then slid their backs down the wall until their hips and knees formed 90-degree angles. In this position, they lifted one foot 5 cm off the ground.

All measurements were conducted between 7:00 and 8:00 a.m. on the same day of the week (Thursday) by the same field assistant. For comfort and accurate measurement, athletes wore only underwear during the test. Finally, the results of the wall squat test were compared with previously collected data from other tests to assess strength endurance.

On the third day, a multiple sprint test was conducted to measure the athletes' speed (Mackenzie, 2005). Each athlete performed six 40-meter sprints with a 30-second recovery period between each. Their times were recorded, and the procedure was repeated three times. The average time was then calculated. To estimate the optimal sprint time, the researchers took the fastest individual time and multiplied it by six.

All measurements were taken under standardized conditions by specially trained researchers and coaching staff. Notably, the same investigator conducted both pre- and post-test measurements to minimize variability. To avoid circadian variation in the parameters, the measurements after the observation period were performed at the same time each day. Additionally, to eliminate external influences, coaches instructed participants to avoid intense exercise, caffeine consumption, and alcohol for 12 hours prior to the pre-test day.

Data Analysis

Normality of the data was assessed using the Shapiro–Wilk test, and the homogeneity of the variance was also determined using the Levene test. A MANOVA (differences in pre- and post-test scores between groups) was used. The results were reported as mean and standard deviation (M±SD) and mean difference (MD). The level of significance was set at α=0.05, $P < .05$. When statistically significant p-values were found, post hoc multiple comparisons with Bonferroni post hoc with adjusted correction were used to identify specific differences between groups.

Results

30 athletes completed the study without mentioning any harm they may have suffered as a result of the intervention training session. According to the Shapiro-Wilk test and Levene test, all variables appeared to have a normal and homogeneous distribution. The MANOVA results for CT, ITG, and CMTG revealed statistically significant differences before and after the start of the training program.

Table 1.
Estimated marginal mean of participants on the variables

Dependent Variable	GP	Mean	SE	CI	
				Lower Bound	Upper Bound
pretest of vo2max	Continuous Training	53.761	.240	53.269	54.253
	Interval Training	53.979	.240	53.487	54.471
	Combined Training	54.283	.240	53.791	54.775
posttest of vo2max	Continuous Training	57.000	.413	56.153	57.847
	Interval Training	59.400	.413	58.553	60.247
	Combined Training	59.200	.413	58.353	60.047
pretest of strength endurance	Continuous Training	105.300	1.321	102.589	108.011
	Interval Training	106.500	1.321	103.789	109.211
	Combined Training	106.100	1.321	103.389	108.811
posttest of strength endurance	Continuous Training	107.900	1.279	105.275	110.525
	Interval Training	108.300	1.279	105.675	110.925
	Combined Training	107.900	1.279	105.275	110.525
pretest of speed	Continuous Training	37.320	.491	36.313	38.327
	Interval Training	36.660	.491	35.653	37.667
	Combined Training	37.380	.491	36.373	38.387
Posttest of speed	Continuous Training	37.440	.433	36.552	38.328
	Interval Training	35.160	.433	34.272	36.048
	Combined Training	36.910	.433	36.022	37.798

Note: GP = (group of participants), SE = (Std. Error),CI = (95% confidence interval).
The results of the table 1 show that all three groups of athletes improved their performance in all three variables after the start of the training program. However, the combined training group showed the greatest improvement in VO2max and strength endurance, whereas the interval training group showed the greatest improvement in speed. Overall, the results of the table suggest that the combined training program is the most effective for improving overall athletic performance. However, the interval training program may be more beneficial for athletes who are specifically interested in improving their speed.

Table 2.
The combinations of training methods with in the groups.

Effect		Value	F	HD		Sig.	PES	OP
Intercept	Pillai's Trace	1.000	34687.389[b]	3.000	25.000	.000	1.000	1.000
	Wilks' Lambda	.000	34687.389[b]	3.000	25.000	.000	1.000	1.000
	Hotelling's Trace	4162.487	34687.389[b]	3.000	25.000	.000	1.000	1.000
	Roy's Largest Root	4162.487	34687.389[b]	3.000	25.000	.000	1.000	1.000
Group	Pillai's Trace	.679	4.451	6.000	52.000	.001	.339	.973
	Wilks' Lambda	A.414	B4.613[b]	C6.000	D50.000	E.001	F.356	H.977
	Hotelling's Trace	1.189	4.757	6.000	48.000	.001	.373	.980
	Roy's Largest Root	.954	8.268[c]	3.000	26.000	.001	.488	.982

Note: Hd = (Hypothesis df), Ed = (Error df), PES = (Partial Eta Squared), OP = (Observed Power).
The MANOVA revealed that there was a statistically significant difference among the three groups in terms of Vo2max, strength endurance, and speed on the basis of the combined dependent variable (Wilks' A=414, F (6,50) = 4.613, p<05 Partial Eta =.356, observed power =.977= 27.677). Based on these results, there is sufficient evidence to support the rejection of the null hypothesis and that athlete performance, as measured by the Cooper test, strength endurance test, and speed test, significantly differs based on the type of training used to improve athlete performance. The effect size was large. The observed power was .977, including a 100% chance that the results would be significant.

Table 3.
Analysis MANOVA tests of between subjects on the athlete's performance variable in addition to the standardized effects sizes (partial eta squared).

Source	DV	TSS	df	MS	F	Sig.	PES	OP
Corrected Model	post Test of vo2max	35.467[a]	2	17.733	10.409	.000	.435	.978
	posttest of strength endurance	1.067[b]	2	.533	.033	.968	.002	.054
	Posttest of speed	28.473[c]	2	14.236	7.600	.002	.360	.920
Intercept	post Test of vo2max	102784.533	1	102784.533	60330.052	.000	1.000	1.000
	posttest of strength endurance	350136.033	1	350136.033	21393.240	.000	.999	1.000
	Posttest of speed	39974.800	1	39974.800	21340.127	.000	.999	1.000
Group	post Test of vo2max	A35.467	B2	C17.733	D10.409	E.000	F.435	H.978
	posttest of strength endurance	1.067	2	.533	.033	.968	.002	.054
	Posttest of speed	28.473	2	14.236	7.600	.002	.360	.920

Note: DV= (Dependent Variable), TSS = (Type III Sum of Squares), MS = (Mean Square),PES = (Partial Eta Squared),OP =(Observed Power).

There was sufficient evidence to reject the null hypothesis regarding the vo2max and speed of athletes' performance during the interval and combined training methods. However, the results demonstrated evidence to support the strength-endurance of athletes' performance null hypothesis, F (2, 27) =10.409, p <.05. Partial =435, observed power=.978; f (2, 27) =7.600, p< .05; partial.360, observed power=.920; and F (2.27) =.033, p< .05; partial =.002, observed power= .054, for all training methods. All MANOVA tests showed large effect sizes for posttest of vo2max and posttest of speed, but small effect sizes for posttest of strength. The relationship between the three training programs and an athlete's performance, viz.VO2max and speed, was strong. However, the strength of the relationship between the three training programs and athletes' strength endurance was low. The observed powers of .054 and .920 for vo2max and speed, respectively, were 100% of the chance that the results would be significant in all analyses. Further research is needed to identify the most effective training type and time required for athletes to determine their full benefits. Additional studies should be conducted to assess the long-term effects of these training programs.

Table 4
Multiple comparisons of the participants within the groups

DV	IGP	JGP	MD(I_J)	SE	Sig.	CI	
						LB	UB
pretest of vo2max	Continuous Training	Interval Training	-.2180	.33899	1.000	-1.0833	.6473
		Combined Training	-.5220	.33899	.406	-1.3873	.3433
	Interval Training	Continuous Training	.2180	.33899	1.000	-.6473	1.0833
		Combined Training	-.3040	.33899	1.000	-1.1693	.5613
	Combined Training	Continuous Training	.5220	.33899	.406	-.3433	1.3873
		Interval Training	.3040	.33899	1.000	-.5613	1.1693
post Test of vo2max	Continuous Training	Interval Training	-2.4000*	.58373	.001	-3.8899	-.9101
		Combined Training	-2.2000*	.58373	.002	-3.6899	-.7101
	Interval Training	Continuous Training	2.4000*	.58373	.001	.9101	3.8899
		Combined Training	.2000	.58373	1.000	-1.2899	1.6899
	Combined Training	Continuous Training	2.2000*	.58373	.002	.7101	3.6899
		Interval Training	-.2000	.58373	1.000	-1.6899	1.2899
pretest of strength endurance	Continuous Training	Interval Training	-1.2000	1.86885	1.000	-5.9702	3.5702
		Combined Training	-.8000	1.86885	1.000	-5.5702	3.9702
	Interval Training	Continuous Training	1.2000	1.86885	1.000	-3.5702	5.9702
		Combined Training	.4000	1.86885	1.000	-4.3702	5.1702
	Combined Training	Continuous Training	.8000	1.86885	1.000	-3.9702	5.5702
		Interval Training	-.4000	1.86885	1.000	-5.1702	4.3702
posttest of strength endurance	Continuous Training	Interval Training	-.4000	1.80924	1.000	-5.0180	4.2180
		Combined Training	.0000	1.80924	1.000	-4.6180	4.6180
	Interval Training	Continuous Training	.4000	1.80924	1.000	-4.2180	5.0180
		Combined Training	.4000	1.80924	1.000	-4.2180	5.0180
	Combined Training	Continuous Training	.0000	1.80924	1.000	-4.6180	4.6180
		Interval Training	-.4000	1.80924	1.000	-5.0180	4.2180
pretest of speed	Continuous Training	Interval Training	.6600	.69397	1.000	-1.1113	2.4313
		Combined Training	-.0600	.69397	1.000	-1.8313	1.7113
	Interval Training	Continuous Training	-.6600	.69397	1.000	-2.4313	1.1113
		Combined Training	-.7200	.69397	.926	-2.4913	1.0513
	Combined Training	Continuous Training	.0600	.69397	1.000	-1.7113	1.8313
		Interval Training	.7200	.69397	.926	-1.0513	2.4913

Posttest of speed	Continuous Training	Interval Training	2.2800*	.61208	.003	.7177	3.8423
		Combined Training	.5300	.61208	1.000	-1.0323	2.0923
	Interval Training	Continuous Training	-2.2800*	.61208	.003	-3.8423	-.7177
		Combined Training	-1.7500*	.61208	.024	-3.3123	-.1877
	Combined Training	Continuous Training	-.5300	.61208	1.000	-2.0923	1.0323
		Interval Training	1.7500*	.61208	.024	.1877	3.3123

Note: DV= (Dependent Variable),IGP=((I) Group of participants),JGP= (J) Group of participants),MD=(Mean Difference (I-J),SE=(Std. Error),CI =(95% Confidence Interval),LB =(Lower Bound) and UB =(Upper Bound). As shown in the table, interval training significantly improved speed compared to the continuous and combined training groups, but there was no statistically significant difference between the continuous and combined training groups. Interval training was the most effective training method for improving speed, and the results of the study suggest that it should be included in any training program to maximize speed gain.

The three groups showed improvement on the 12-minute run test (Cooper test), indicating that all three types of training can enhance performance. However, the study suggests that interval and combined training may be more effective than continuous training for improving performance in the Cooper test. The findings indicate that a combination of interval and combined training can lead to significant improvements in performance on the Cooper test compared with either type of training alone.

The MANOVA demonstrated a significant increase in strength endurance in all training groups, indicating that all types of training were equally effective in improving this aspect. Therefore, the hypothesis that one form of training is more effective than the other was not supported by the results.

Our findings in terms of speed improvement, interval training significantly outperformed continuous and combined training. No significant differences were observed between the continuous and combined training groups. These findings suggest that interval training should be included in training programs to maximize speed gains. It is important to note that combining interval training with other forms of training may yield improved results.

Discussion

The primary goal of this study was assessed the effect of continuous interval training and combined training on performance metrics, including VO2max, strength, endurance, and speed of Ethiopia Ethiopian hotel athletics club. After 12 weeks of training, all three training groups showed a significant improvement in the VO2max values at posttest. However, both interval and combined training methods were found to be more effective in improving VO2max and speed compared with continuous training. In line with this study Babu and Kumar (2014) finding showed that continuous and interval training obtained better improvement in $vo_{2max.}$ Additionally, the strength endurance of athletes improved significantly in the combined and interval training groups compared with the continuous training group. These results indicate that combined and interval training methods can be more effective in enhancing athletes' performances (Johnson, 1970).

Interestingly, there were no significant differences in the pre-test performance of athletes across all three groups. However, in the posttest, all three training methods showed a significant improvement in V02max compared with the pretest. This finding supports the effectiveness of continuous, interval, and combined training methods, which is consistent with previous studies (Yunus et al., 2019). Our study found that continuous training may not enhance athletes' performance, which contradicts the findings (Astorino et al., 2017; Kadono, Enomoto, & Ae, 2007; Parmar et al., 2021).

Moreover, the results indicate that interval and combined training methods are more effective than continuous training in improving athletes' performance, reducing the risk of injury, and enhancing aerobic and anaerobic power. These findings align with those of previous research (MELAKU, 2019). Therefore, further investigation is needed to explore the potential benefits and optimal use of interval and combined training methods in optimizing athletes' performance. Future studies should also examine the long-term effects of these training methods.

Additionally, the post hoc test revealed that the mean value of the interval training and combined training groups was significantly higher than that of the continuous training group in terms of maximum oxygen consumption (VO2max). This finding supports the notion that both interval and combined training methods have a greater impact on improving athletes' performance compared with continuous training (Johnson,1970).These results highlight the importance of implementing interval and combined training methods to enhance VO2max.

It is worth mentioning that no previous studies have investigated the differences between continuous, interval, and combined training methods in Ethiopia or using the Gauntlet itself. Nonetheless, our study aligns with previous research conducted by (Deol & Singh, 2013; Mazoochi et al., 2013; Yunus et al., 2019). These studies can provide valuable insights into the most effective training methods for individuals with different fitness goals. Moreover, the long term effects of these training methods should be investigated. In summary, this study demonstrates that interval and combined training methods result in significant improvements in athletes' performance, particularly in terms of VO2max, speed, and strength endurance. Continuous training, how-

ever, did not yield significant improvements. Future research should explore these training methods in greater depth and assess their long-term effects on athletes' performance.

Overall, the discussion sections of this study provide valuable insights for athletes and coaches seeking to improve their performance in terms of VO2max, strength endurance, and speed. Interval training appears to be the most effective method; however, combining it with other training protocols may further enhance the results.

Conclusion

In conclusion, while both interval and combined training methods improved distance running performance, this study demonstrated that adding combined training method significantly improved VO2max, strength endurance, and speed compared to the other methods. Notably, all three methods offered some performance benefits. Additionally, interval and combined training methods were found to be more time-efficient options. To some extent, reasonably high volumes of continuous training method can be considered an important requirement precondition for tolerating and responding well to a substantial increase in athlete performance. Coaches and athletes should consider incorporating different training modalities based on specific objectives and available evidence.

Conflicts of interest

The authors declare no conflicts of interest.

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Authors' contributions

All authors contributed significantly to this study. The first and second authors took the lead in designing the study, collecting and analyzing data, interpreting results, drafting the manuscript, and revising it critically. Al l authors reviewed and approved the final version of the manuscript

Data availability

The datasets are available from the corresponding author.

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