Original Article

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Effects of partial substitution of endurance training with strength training on anaerobic and aerobic threshold velocity in competitive youth triathletes: a pilot study

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract: *Background:* High volumes of endurance training in triathlon impose substantial time and recovery demands, creating a need for more efficient training strategies. The aim of this study was to compare the effects of partially replacing endurance training with strength training on aerobic threshold velocity and anaerobic threshold velocity in competitive youth triathletes, with a particular focus on time efficiency. *Methods:* Eight competitive youth triathletes (17.3 ± 0.6 years) were allocated to an experimental group (n = 4) or a control group (n = 4). Over an 8-week intervention, both groups followed similar training programmes, differing only in two weekly sessions: strength training (~65 min) in the experimental group versus continuous running (~85 min) in the control group. Spiroergometric testing was performed before and after the intervention. Owing to the pilot nature of the study, changes were evaluated descriptively. *Results:* The experimental group demonstrated numerically greater improvements in both anaerobic and aerobic threshold velocity despite the shorter duration of the two substituted weekly training sessions. Anaerobic threshold velocity increased from 15.47 ± 0.21 to 16.80 ± 0.53 km·h^{-1} (Δ = +1.33 ± 0.61 km·h^{-1}) in the experimental group and from 15.09 ± 0.38 to 15.92 ± 0.18 km·h^{-1} (Δ = +0.83 ± 0.19 km·h^{-1}) in the control group. Aerobic threshold velocity increased from 13.26 ± 0.24 to 14.09 ± 0.77 km·h^{-1} (Δ = +0.83 ± 0.64 km·h^{-1}) and from 13.36 ± 0.19 to 13.94 ± 0.24 km·h^{-1} (Δ = +0.58 ± 0.21 km·h^{-1}), respectively. Heart rate at both thresholds decreased in both groups, indicating the ability to sustain higher running speeds at lower relative cardiovascular strain. Changes in VO_2max were inconsistent between participants. Interpretation of these findings is limited by the pilot study design and the different durations of the substituted training sessions. *Conclusions:* Partial substitution of endurance training with strength training may improve threshold velocity while reducing training time. However, because of the pilot nature of the study and its methodological limitations, these findings should be considered preliminary and require confirmation in larger controlled trials.

Keywords: triathlon; strength training; anaerobic threshold velocity; aerobic threshold velocity; time efficiency

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INTRODUCTION

Triathlon performance is determined by a complex interaction of physiological and training factors, with the optimization of the training process representing a key prerequisite for further performance progress [1,2]. Performance enhancement in endurance sports results from the cumulative effect of training load, which is often associated with a high volume of work and can lead to fatigue accumulation, an increased risk of overtraining, and health complications [3,4]. For these reasons, the appropriate integration of strength training into an existing endurance program appears to be a potential strategy for optimizing training load [2].

Strength training represents a highly debated topic in endurance sports. In recent decades, it has established itself as an effective strategy for improving performance, and its inclusion in the training process is commonly recommended [5,6]. Among the important physiological determinants of triathlon endurance performance are maximal oxygen uptake (VO_2max) together with aerobic and anaerobic threshold characteristics, while strength training has been shown to improve movement economy in both cycling and running [5,7,8]. Strength training leads to neuromuscular adaptations, including more efficient motor unit recruitment and changes in fast-twitch muscle fiber function, which may contribute to improved movement economy [5]. At higher VO_2max levels (~70 $ml \cdot kg^{-1} \cdot min^{-1}$), running performance is determined to a greater extent by running economy, which represents a key physiological determinant of endurance performance [9,10].

During prolonged exertion, running economy can be negatively affected by fatigue, emphasizing the importance of mechanisms that allow the maintenance of movement efficiency during long-term performance [11,12]. A significant determinant of endurance performance is the anaerobic threshold, which is closely related to the ability to maintain a high fractional utilization of VO_2max over an extended period, thereby delaying the onset of metabolic acidosis and enabling the maintenance of high power output [9]. Improvement in the anaerobic threshold has also been observed when combining strength and endurance training, suggesting a potential transfer of adaptive changes into the ability to maintain higher training intensity over a longer period [10,13].

The combination of strength and endurance training represents a complex model in which adaptive processes may influence each other, a phenomenon known as the interference effect [14,15]. However, current scientific knowledge suggests that a properly programmed strength training does not cause negative adaptation but, conversely, stimulates neuromuscular mechanisms crucial for endurance athletes [16]. Nevertheless, most available intervention studies utilize a model in which strength training is added to the existing endurance load without reducing it, while the endurance training remains preserved [17]. A model where strength training replaces a portion of the endurance volume remains insufficiently explored in the literature. At the same time, only a limited number of studies have been conducted on highly trained or elite athletes, in whom even relatively small changes in training structure can lead to significant differences in performance [8]. This gap highlights the need for further research focused on the effect of substituting endurance training with strength training in elite sports, as the current practice of elite endurance athletes still relies on extremely high volumes of low-intensity training [18].

Given the limited number of available studies on competitive triathletes and the logistical complexity of interventions in this specific population, this pilot study serves as a crucial step to test the hypothesis regarding the time efficiency of the substitution training model before its broader application in competitive triathletes. The aim of this pilot study was to compare the effects of partially replacing endurance training with strength training on aerobic and anaerobic threshold velocity in competitive youth triathletes, with an emphasis on time efficiency. The primary outcomes were running velocity at the aerobic

and anaerobic thresholds. We hypothesized that partial substitution of endurance training with strength training would result in numerically greater improvements in threshold velocity despite a lower training-time investment.

MATERIAL AND METHODS

Participants

Eight competitive youth triathletes (six males and two females; age: 17.3 ± 0.6 years) competing at national and international levels participated in this pilot study. Participants were allocated to either the experimental group (n = 4; three males and one female) or the control group (n = 4; three males and one female). Baseline anthropometric characteristics were comparable between groups. The experimental group had a mean age of 17.45 ± 0.51 years, body height of 176.5 ± 5.9 cm, body mass of 62.3 ± 6.6 kg, and training experience of 4.25 ± 0.83 years. The corresponding values for the control group were 17.08 ± 0.64 years, 175.0 ± 8.51 cm, 64.15 ± 4.6 kg, and 4.00 ± 1.22 years, respectively.

Two participants were members of the wider Slovak national team selection, whereas the remaining six athletes had achieved top-six placements at the Slovak National Championships in triathlon, duathlon, or aquathlon. All participants were members of the TRIAN ŠK UMB triathlon club (Banská Bystrica, Slovakia).

The inclusion criteria were: age between 15 and 19 years, at least two years of structured triathlon training, participation in a minimum of 9 h of organized training per week during the preceding 12 months, regular participation in national or international competitions, absence of injury during the previous three months, and the ability to complete the prescribed training programme. Exclusion criteria included missing more than 20% of the prescribed training sessions, injury or illness lasting longer than seven days during the intervention period, the use of ergogenic substances affecting physical performance, or failure to complete either pre- or post-intervention testing.

Adherence to the intervention was 100% in both groups. No training sessions were missed, and no participants withdrew from the study or were excluded from the final analysis.

Participants were assigned to the experimental and control groups by the head coach using a matched allocation procedure based on baseline VO_2max, aerobic threshold velocity, anaerobic threshold velocity, training experience, sex, and competitive level to obtain comparable baseline characteristics. The two athletes belonging to the wider Slovak national team selection and the two female athletes were distributed equally between the groups.

Testing procedures

All measurements were performed before and after the intervention using a breath-by-breath metabolic analysis system (Ergostik™, Geratherm Respiratory GmbH, Bad Kissingen, Germany) with Blue Cherry® software. The system was calibrated before each test according to the manufacturer's recommendations using standard volume and gas calibration procedures.

Baseline testing was conducted between 10 and 12 January 2024, whereas post-intervention testing was performed between 13 and 15 March 2024 under identical laboratory conditions (ambient temperature 19–20°C). All measurements were carried out in the morning, beginning at 09:00.

Before testing, participants completed a standardized warm-up consisting of myofascial release, dynamic stretching of the lower limbs, and a 5-minute treadmill run. They subsequently performed an incremental treadmill test adapted from Formánek [19]. The test began at 9 km·h^{-1}, with running speed increasing by 1 km·h^{-1} every minute while maintaining a constant 5% incline until volitional exhaustion. The initial running speed was identical during the pre- and post-intervention tests.

The highest oxygen uptake value recorded during the test was accepted as VO_2max. Achievement of VO_2max was confirmed using standard physiological criteria, including the presence of a VO_2 plateau, respiratory exchange ratio (RER) > 1.10, heart rate within 10 beats·min^{-1} of the age-predicted maximum, and volitional exhaustion.

Aerobic threshold velocity was identified using the ventilatory equivalents method as the first increase in VE/VO_2 without a simultaneous increase in VE/VCO_2. Anaerobic threshold velocity was determined using the V-slope method and confirmed by the second disproportionate increase in VE/VCO_2 and ventilation.

Threshold identification was performed visually by one experienced evaluator using identical criteria for all measurements to minimize inter-rater variability. The evaluator was blinded to group allocation, although blinding to the testing time point (pre- vs. post-intervention) was not possible. Running velocity (km·h^{-1}) and heart rate (bpm) at both thresholds were recorded for subsequent analyses.

Training intervention

The intervention was conducted during the preparatory period (16 January–7 March 2024) and lasted eight weeks. Both groups followed the same weekly training programme, differing only in two training sessions performed each week (Tuesday and Thursday). The weekly training structure of both groups is presented in Table 1.

Apart from the two substituted sessions, all swimming, cycling, and running sessions were identical between groups and were supervised by the same coaching staff. Formal quantification of training-intensity distribution was not performed.

In the experimental group, the two weekly continuous endurance-running sessions were replaced by strength-training sessions. Including warm-up and cool-down, each strength-training session lasted approximately 65 min, whereas the corresponding continuous endurance-running sessions in the control group lasted approximately 85 min. Consequently, the experimental group accumulated approximately 40 minutes less planned training time per week.

The strength-training programme consisted of 12 whole-body exercises divided into two sessions (six exercises per session). The complete strength-training protocol is presented in Table 2.

Table 1. Weekly training structure of both groups during the intervention period

Training modality	Experimental group	Control group
Swimming	4 × 60 min	4 × 60 min
Cycling	2 × 90 min	2 × 90 min
Running	4 x 60 min	4 x 60 min
Strength training	2 × 65 min	0 min
Continuous endurance running (replaced sessions)	0 min	2 × 85 min
Total weekly training duration	790 min	830 min

Table 2. Structure of the strength-training intervention

Session 1	Session 2
Back squat	Romanian deadlift
Dead bug	Pallof press
Single-leg Romanian deadlift	Bulgarian split squat
Chin-up	Bench press
Seated calf raises	Single-leg calf raises
Half-kneeling overhead press	Half-kneeling single-arm cable row

Each training session consisted of three circuits separated by 2-minute recovery periods. Exercises were performed using an interval format of 30 s work followed by 30 s recovery. The work interval increased progressively by 5 s each week until reaching 45 s in week four. During weeks 5–8, the progression cycle was repeated using higher external resistance while maintaining approximately 3–4 repetitions in reserve (RIR).

Six-repetition maximum (6RM) testing was performed for the back squat, romanian deadlift, chin-up, and bench press. One-repetition maximum (1RM) values were estimated from the 6RM results and used to prescribe the target exercise intensity of approximately 45–55% 1RM. For exercises not directly assessed during 6RM testing, resistance was selected individually by the supervising coach based on comparable bilateral exercises while maintaining the intended relative intensity and correct exercise technique.

The relatively low external load combined with the circuit-based organization and short recovery periods enabled participants to perform continuous work intervals without reaching muscular failure. Participants were instructed to maintain approximately 3–4 repetitions in reserve throughout the intervention. The control group performed continuous running below the individually determined anaerobic threshold velocity. All training sessions in both groups included a standardized warm-up consisting of mobility exercises, core activation, and dynamic stretching, followed by a 10-minute cool-down.

Session rating of perceived exertion (RPE; Borg CR-10 scale) was monitored throughout the intervention. Mean RPE values were comparable between groups (approximately 4–6). However, objective measures of internal training load (e.g., heart-rate-derived indices, TRIMP, or blood lactate concentration) were not collected; therefore, physiological equivalence between the two training programmes cannot be assumed.

Statistical analysis

Because of the pilot nature of the study and the very small sample size, inferential statistical analyses were intentionally not performed. Instead, changes were evaluated descriptively using means, standard deviations, absolute changes (Δ), and relative changes (%). Percentage changes were calculated individually for each participant and subsequently averaged within each group.

To facilitate interpretation of the magnitude of between-group differences, Cohen's *d* effect sizes were calculated using the between-group differences in absolute change scores divided by the pooled standard deviation of the change scores. Ninety-five percent confidence intervals (95% CI) were additionally calculated for all effect-size estimates to illustrate the uncertainty associated with the observed effects.

Ethical committee statement

All participants (or their legal guardians, where applicable) provided written informed consent prior to the commencement of the study. The research was approved by the Ethics Committee of Matej Bel University in Banská Bystrica (Approval No. 1079/2024) and conducted in accordance with the Declaration of Helsinki.

RESULTS

Baseline characteristics

Baseline physiological characteristics were broadly comparable between groups. Anaerobic threshold velocity was 15.47 ± 0.21 $km \cdot h^{-1}$ in the experimental group and 15.09 ± 0.38 $km \cdot h^{-1}$ in the control group. Aerobic threshold velocity was 13.26 ± 0.24 and 13.36 ± 0.19 $km \cdot h^{-1}$, respectively, whereas VO_2max amounted to 60.13 ± 10.83 and 61.70 ± 8.40 $ml \cdot kg^{-1} \cdot min^{-1}$ in the experimental and control groups, respectively.

Table 3. Changes in performance variables following the intervention

Variable	Group	Pre (mean ± SD)	Post (mean ± SD)	Δ absolute (mean ± SD)	Δ (%) (mean ± SD)
Anaerobic threshold velocity (km·h⁻¹)	E	15.47 ± 0.21	16.80 ± 0.53	+1.33 ± 0.61	+8.62 ± 3.98
	C	15.09 ± 0.38	15.92 ± 0.18	+0.83 ± 0.19	+5.55 ± 1.42
Aerobic threshold velocity (km·h⁻¹)	E	13.26 ± 0.24	14.09 ± 0.77	+0.83 ± 0.64	+6.22 ± 4.76
	C	13.36 ± 0.19	13.94 ± 0.24	+0.58 ± 0.21	+4.31 ± 1.57
Heart rate at anaerobic threshold *(*bpm*)*	E	182.5 ± 1.30	177.0 ± 2.21	−5.50 ± 1.29	−3.02 ± 0.70
	C	183.3 ± 2.10	179.0 ± 3.70	−4.25 ± 2.22	−2.33 ± 1.18
Heart rate at aerobic threshold *(*bpm*)*	E	156.8 ± 2.50	152.0 ± 1.60	−4.75 ± 0.96	−3.02 ± 0.56
	C	157.0 ± 2.90	151.8 ± 1.30	−5.25 ± 2.50	−3.33 ± 1.52
VO_2max (ml·kg^{-1}·min^{-1})	E	60.13 ± 10.83	63.20 ± 9.07	+3.08 ± 6.07	+6.3 ± 10.34
	C	61.70 ± 8.40	61.63 ± 8.44	−0.08 ± 0.51	−0.15 ± 0.91

E – Experimental, C – Control

Changes in performance variables

Descriptive statistics for all outcome variables before and after the intervention are presented in Table 3. Following the intervention, both groups demonstrated improvements in anaerobic and aerobic threshold velocity. However, the experimental group showed numerically greater mean improvements than the control group. Anaerobic threshold velocity increased by 1.33 ± 0.61 km·h^{-1} (8.62 ± 3.98%) in the experimental group and by 0.83 ± 0.19 km·h^{-1} (5.55 ± 1.42%) in the control group. Aerobic threshold velocity increased by 0.83 ± 0.64 km·h^{-1} (6.22 ± 4.76%) and 0.58 ± 0.21 km·h^{-1} (4.31 ± 1.57%), respectively.

Heart rate measured at both physiological thresholds decreased in both groups. At the anaerobic threshold, heart rate decreased by 5.50 ± 1.29 bpm in the experimental group and by 4.25 ± 2.22 bpm in the control group. At the aerobic threshold, the corresponding decreases were 4.75 ± 0.96 and 5.25 ± 2.50 bpm, respectively (Table 3). VO_2max responses were variable, with a mean increase observed in the experimental group (+3.08 ± 6.07 ml·kg^{-1}·min^{-1}) and virtually no change in the control group (−0.08 ± 0.51 ml·kg^{-1}·min^{-1}).

Individual responses

Individual responses varied considerably between participants, particularly within the experimental group. Individual changes in anaerobic and aerobic threshold velocity are presented in Figure 1. Although improvements were observed in both groups, the magnitude of adaptation differed substantially among individuals, with one participant in the experimental group showing only minimal improvement in aerobic threshold velocity (Figure 1).

Between-group differences

Between-group comparison showed a numerically larger improvement in anaerobic threshold velocity in the experimental group (Cohen's d = 1.10; 95% CI: −0.42 to 2.62), suggesting a potentially meaningful practical effect despite the wide confidence interval. For aerobic threshold velocity, the between-group difference was smaller (Cohen's d = 0.52; 95% CI: −0.90 to 1.94). Because of the pilot design and very small sample size, these effect sizes should be interpreted cautiously.

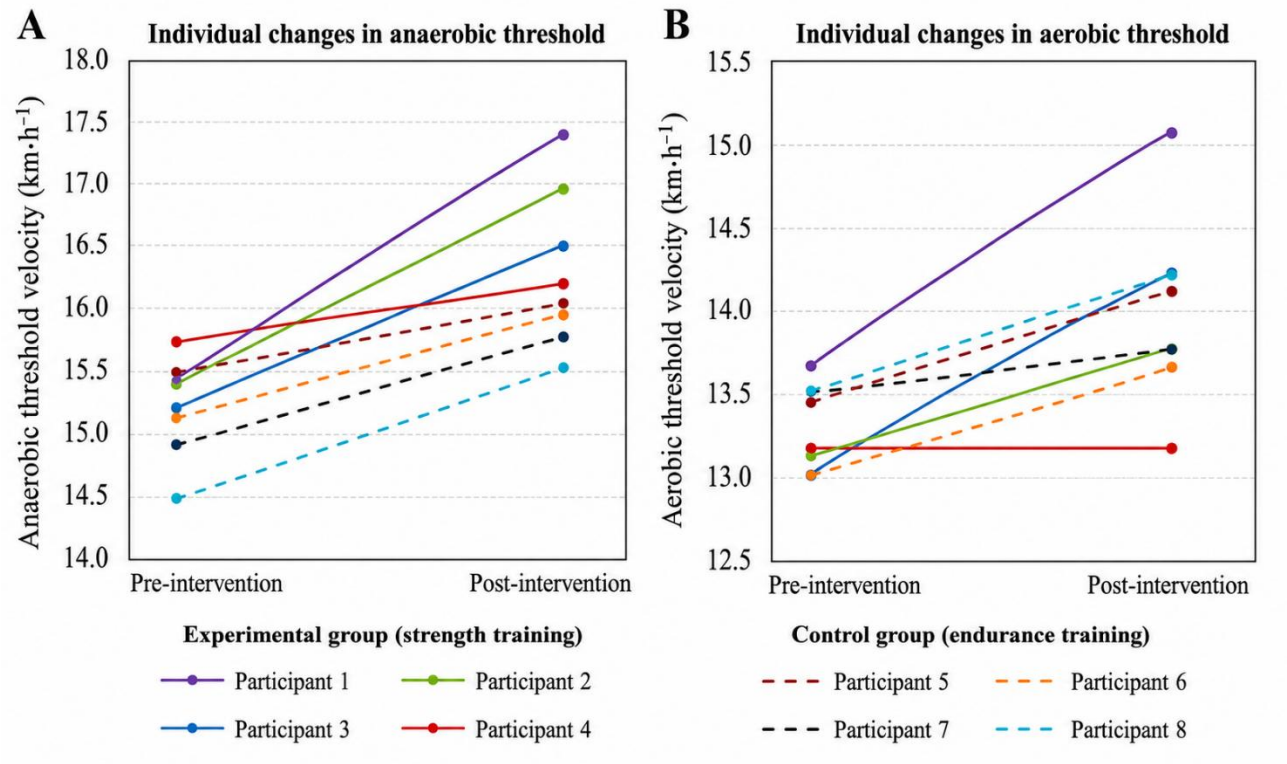


Figure 1. Individual changes in (A) anaerobic threshold velocity and (B) aerobic threshold velocity before and after the intervention. Solid lines indicate the experimental group; dashed lines indicate the control group.

Time-efficiency analysis

The two weekly sessions that differed between groups lasted approximately 65 min in the experimental group and 85 min in the control group, resulting in approximately 40 min less planned training time per week in the experimental group. Across the eight-week intervention, this corresponded to approximately 105.3 h of planned training in the experimental group compared with 110.7 h in the control group.

Despite this lower training-time investment, the experimental group demonstrated numerically greater mean improvements in both aerobic and anaerobic threshold velocity (Table 3). These observations are descriptive only and should not be interpreted as evidence of superior training efficiency.

VO_2max response

Changes in VO_2max were inconsistent across participants and showed considerable individual variability, particularly within the experimental group. Therefore, no clear pattern of adaptation was observed.

DISCUSSION

The aim of this study was to investigate the effect of partial substitution of endurance training with strength training on threshold indicators in competitive triathletes. The primary finding was that the experimental group demonstrated numerically greater mean improvements in aerobic threshold velocity and anaerobic threshold velocity despite a slightly lower total weekly training duration (790 vs. 830 min·week^{-1}) and an approximately 24% shorter duration of the two substituted weekly sessions (65 vs. 85 min

per session), corresponding to approximately 5.3 fewer hours of planned training across the eight-week intervention. These findings should, however, be interpreted in the context of the substantial inter-individual variability observed, particularly within the experimental group. Furthermore, the interpretation of the results is limited by the differing durations of the substituted training sessions between the groups. This study does not isolate the effect of the training modality from the training volume; rather, it reflects a real-world trade-off between time investment and performance outcomes. Although no formal analysis of training efficiency was performed, these descriptive findings suggest the potential of the substitution model as a time-efficient training approach.

From a practical perspective, these findings suggest that a portion of endurance training time may be replaced by strength training in some athletes without obvious detrimental effects on threshold indicators. Recent evidence also indicates that modifying training content over relatively short intervention periods can improve physiological performance indicators while maintaining overall training effectiveness [20]. This may be particularly relevant under high-volume training conditions, where the optimization of time and recovery represents a key performance factor [4,7,21].

Our findings are broadly consistent with previous studies reporting beneficial effects of strength training on endurance performance, which have been attributed to improvements in movement economy and neuromuscular adaptations [5,8,16]. Systematic reviews and meta-analyses suggest that the inclusion of strength training can lead to improvements in running economy and performance without a negative effect on VO_2max [5,16].

However, most available studies utilize a model in which strength training is added to the existing endurance load [8,17], whereas a partial substitution model was employed in our study. In this context, our results indicate that some athletes may achieve numerically greater improvements in threshold indicators despite a lower time investment in the substituted sessions, although substantial variability in responses suggests that this approach may not be equally effective for all individuals.

A potential mechanism underlying the observed changes may involve improvements in neuromuscular efficiency and movement economy, both of which have previously been associated with strength training in endurance athletes [6,10]. However, neither movement economy nor neuromuscular function was directly assessed in the present study and these mechanisms should therefore be considered hypothetical explanations requiring further investigation. Improved movement economy may theoretically reduce energy demands at submaximal intensities and could contribute to a shift in both aerobic and anaerobic threshold velocity [10,13].

Similarly, improvements in motor unit recruitment patterns and muscle strength have previously been proposed as potential adaptations to strength training in endurance athletes [8,16]. These adaptations may theoretically reduce relative physiological strain at a given power output; however, muscle strength, neuromuscular function, and movement economy were not directly measured in the present study. If present, such adaptations may be particularly relevant in highly trained individuals, in whom further increases in VO_2max are often limited and endurance performance may depend more heavily on peripheral adaptations [10].

In addition, it is possible that the reduction in the duration of the substituted weekly sessions in the experimental group influenced the overall recovery–adaptation balance and may have contributed to the observed responses. However, fatigue accumulation, recovery status, and objective training load measures were not quantified and therefore this interpretation remains speculative. Nevertheless, this hypothesis is consistent with concepts related to training readiness and recovery in endurance sports [3,4], as well as with approaches to training-load optimization suggesting that higher training volumes do not necessarily result in superior adaptive responses [22].

On the other hand, no obvious negative effect associated with the concurrent inclusion of strength and endurance training was observed in the present study. However, the study was not specifically designed to investigate the interference effect and therefore no conclusions regarding its presence or absence can be drawn [14,15].

A notable finding was the high individual variability in training responses, particularly within the experimental group. In particular, some participants demonstrated pronounced improvements whereas others exhibited only minimal changes despite completing an identical intervention protocol. This phenomenon is consistent with evidence showing that adaptive responses to the identical training stimulus can vary substantially between individuals [23]. This fact suggests that the substitution model may not be universally effective for all athletes.

Limitations

This study has several limitations. The small sample size restricts the generalisability of the findings and increases the influence of individual responses on group means, thereby limiting the interpretation of group-level effects. Although weekly training duration, session frequency, and perceived training intensity (RPE) were monitored throughout the intervention period, objective internal training load measures such as heart-rate-based metrics, blood lactate responses, or session impulse (TRIMP) were not quantified. Therefore, it is not possible to unequivocally attribute the observed changes solely to the training modality or to confirm the equivalence of physiological training load between the groups. A further limitation is the determination of thresholds based on the visual analysis of ventilatory curves, which may introduce a certain degree of subjectivity. In addition, the adolescent age of the participants and the absence of biological maturation assessment should be considered when interpreting the findings. Furthermore, no direct measures of running economy, neuromuscular function, fatigue, recovery status, or objective internal training load were obtained, limiting the ability to identify the physiological mechanisms underlying the observed adaptations.

Despite these limitations, this study provides a valuable pilot insight into the substitution training model within a specific population of competitive youth triathletes.

CONCLUSION

The partial substitution of endurance training with strength training was associated with numerically greater mean improvements in threshold indicators despite spending less time in the two weekly sessions that differed between groups. This suggests that this approach may represent a potentially time-efficient training strategy for some competitive youth triathletes; however, this interpretation is based on descriptive comparisons of training time and performance outcomes, and considerable inter-individual variability in training responses should be expected. Nonetheless, given the pilot nature of this study and its inherent limitations, these findings warrant further validation through larger and more strictly controlled intervention studies.

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REFERENCES

1. Bako K, Pupiš M, Hlávek M. Performance analysis of individual disciplines in relation to overall race time in elite olympic-distance. Health sport rehabilitation 2026. doi:10.58962/HSR.1343
2. Vidar Vikestad, Dalen T. Effect of Strength and Endurance Training Sequence on Endurance Performance. Sports 2024; 12(8): 226. doi:10.3390/sports12080226
3. Li S, Kempe M, Brink M, Koen Lemmink. Effectiveness of Recovery Strategies After Training and Competition in Endurance Athletes: An Umbrella Review. Sports Med Open 2024; 10(1): 55. doi:10.1186/s40798-024-00724-6
4. Etxebarria N, Mujika I, Pyne DB. Training and Competition Readiness in Triathlon. Sports 2019; 7(5): 101. doi:10.3390/sports7050101
5. Cristian Llanos-Lagos, Ramirez-Campillo R, Moran J, Sáez E. The Effect of Strength Training Methods on Middle-Distance and Long-Distance Runners' Athletic Performance: A Systematic Review with Meta-analysis. Sports Med 2024; 54. doi:10.1007/s40279-024-02018-z
6. Šuc A, Šarko P, Pleša J, Kozinc Ž. Resistance Exercise for Improving Running Economy and Running Biomechanics and Decreasing Running-Related Injury Risk: A Narrative Review. Sports 2022; 10(7): 98. doi:10.3390/sports10070098
7. Borrego-Sánchez A, Vinolo-Gil MJ, de-la-Casa-Almeida M, Rodríguez-Huguet M, Casuso-Holgado MJ, Martín-Valero R. Effects of Training on Cardiorespiratory Fitness in Triathletes: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health 2021; 18(24): 13332. doi:10.3390/ijerph182413332
8. Rønnestad BR, Mujika I. Optimizing strength training for running and cycling endurance performance: A review. Scand J Med Sci Sports 2013; 24(4): 603-612. doi:10.1111/sms.12104
9. Rodríguez-Barbero S, José María González-Ravé, Benedicte Vanwanseele, Santos-García DJ, Muñoz V, González-Mohíno F. Effects of 20 Weeks of Endurance and Strength Training on Running Economy, Maximal Aerobic Speed, and Gait Kinematics in Trained Runners. Appl Sci 2025; 15(2): 903. doi:10.3390/app15020903
10. Barnes KR, Kilding AE. Running economy: measurement, norms, and Determining Factors. Sports Med Open 2015; 1(1). doi:10.1186/s40798-015-0007-y
11. Runar Jakobsen Unhjem. Changes in running economy and attainable maximal oxygen consumption in response to prolonged running: The impact of training status. Scand J Med Sci Sports 2024; 34(5). doi:10.1111/sms.14637
12. Zanini M, Folland JP, Blagrove RC. Durability of Running Economy: Differences between Quantification Methods and Performance Status in Male Runners. Med Sci Sports Exerc 2024. doi:10.1249/mss.0000000000003499
13. Ghosh AK. Anaerobic Threshold: Its Concept and Role in Endurance Sport. Malays J Med Sci 2004; 11(1): 24. PMC3438148. nih.gov
14. Fyfe JJ, Bishop DJ, Stepto NK. Interference between Concurrent Resistance and Endurance Exercise: Molecular Bases and the Role of Individual Training Variables. Sports Med 2014; 44(6): 743-762. doi:10.1007/s40279-014-0162-1
15. Wilson JM, Marin PJ, Rhea MR, Wilson SMC, Loenneke JP, Anderson JC. Concurrent Training: a Meta-Analysis Examining Interference of Aerobic and Resistance Exercises. J Strength Cond Res 2012; 26(8): 2293-2307. doi:10.1519/jsc.0b013e31823a3e2d
16. Blagrove RC, Howatson G, Hayes PR. Effects of Strength Training on the Physiological Determinants of Middle- and Long-Distance Running Performance: A Systematic Review. Sports Med 2017; 48(5): 1117-1149. doi:10.1007/s40279-017-0835-7
17. Rønnestad BR, Hansen EA, Raastad T. In-season strength maintenance training increases well-trained cyclists' performance. Eur J Appl Physiol 2010; 110(6): 1269-1282. doi:10.1007/s00421-010-1622-4
18. Sandbakk Ø, Hegge AM, Losnegard T, Skattebo Ø, Tønnessen E, Holmberg HC. The Physiological Capacity of the World's Highest Ranked Female Cross-country Skiers. Med Sci Sports Exerc 2016; 48(6): 1091-1100. doi:10.1249/mss.0000000000000862
19. Formánek J. Triatlon: historie, trénink, výsledky. Praha: Olympia; 2003
20. Florian J, Clemente-Suárez VJ, Pařík J, Polách M. Effects of a Nine-Week High-Intensity Interval Training Program on Anaerobic Performance and Physical Readiness in Military University Cadets. Phys Act Rev 2026;14(2):68–79. doi: 10.16926/par.2026.14.22
21. Kuberski M, Musial A, Kruzołek P, et al. Determinants of swimming performance and the physiological development of girls aged 10–12 during three years of swimming training. Phys Act Rev 2026;14(1):141–153. doi: 10.16926/par.2026.14.12

22. Seiler S. What is Best Practice for Training Intensity and Duration Distribution in Endurance Athletes? Int J Sports Physiol Perform 2010; 5(3): 276-291. doi:10.1123/ijspp.5.3.276
23. Bonafiglia JT, Rotundo MP, Whittall JP, Scribbans TD, Graham RB, Gurd BJ. Inter-Individual Variability in the Adaptive Responses to Endurance and Sprint Interval Training: A Randomized Crossover Study. PLOS ONE 2016; 11(12): e0167790. doi: 10.1371/journal.pone.0167790