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Conference Abstract

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Traditional Resistance Training versus Torque Training: A Randomized Controlled Trial

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Abstract

Resistance training (RT) has been shown to improve endurance performance in cycling. Notably, it has been recommended that cyclists perform heavy (>70% of one-repetition maximum [1RM]) RT sessions off the bike to optimize neuromuscular adaptations. On the other hand, the so-called "torque" training (i.e., low-cadence efforts performed against an allegedly high pedaling intensity) has become increasingly popular as an on-bike alternative to conventional (off-bike) RT for enhancing lower-limb muscle strength and cycling performance. However, recent evidence suggests that the force demands of this torque training on lower-limb muscles are relatively low (i.e., <50% of the cyclists' maximal lower-limb dynamic force), and its effectiveness compared to training at similar relative intensities but with self-selected cadences remains unclear. This study compared the effects of off-bike RT (squats) and torque training on endurance-related parameters in well-trained cyclists. Twenty-seven male cyclists were randomly assigned to off-bike RT (n = 9), torque training (n = 9), or a control group (n = 9) for 10 weeks. The RT group performed 5 sets of 7 squats at 70% 1RM twice per week, with a 4-minute intraset recovery, while the torque group completed 5 sets of 4-minute intervals at 70% VO_2max power output at a target cadence of 50rpm, with a 2-minute intraset recovery, twice a week. Measured outcomes included VO_2max, maximal aerobic power (MAP), ventilatory thresholds (VT, RCP), and time to exhaustion at RCP. Off-bike RT significantly improved MAP ($p = 0.05$, ES = 0.60), VT ($p < 0.05$, ES = 0.47), and RCP ($p = 0.05$, ES = 0.48). No significant changes were observed in the torque training group and control group. These findings indicate that off-bike RT is a superior method for improving pedaling performance, highlighting its importance in cycling training. Future research should refine torque training protocols to enhance its efficacy.

Keywords

resistance training; torque; training; cycling

1 Introduction

Resistance training (RT) has been shown to enhance performance in endurance sports, particularly cycling (Beattie et al., 2014; Rønnestad et al., 2014). Furthermore, RT is known to contribute to improvements in body composition (Rønnestad et al., 2014, Vikmoen et al., 2016). In recent years, torque training has gained popularity as an on-bike alternative to traditional (off-bike) RT for increasing lower-limb muscle strength and enhancing cycling performance (Koninckx et al., 2010; Paton et al., 2009; Kristoffersen et al., 2014; Whitty et al., 2016; Nimmerichter et al., 2012). However, recent evidence suggests that the force demands of this RT approach on lower-limb muscles are relatively low (i.e., below 50% of the cyclists' maximal lower-limb dynamic force) (Barranco-Gil et al., 2024), and there is unclear evidence regarding its effectiveness compared to training at similar relative intensities but with self-selected cadences (Kristoffersen et al., 2014). Therefore, this study aimed to compare the effects of traditional torque training and off-bike resistance training (RT) on endurance cycling performance. Given that torque training is often promoted as an on-bike alternative to RT, it is essential to determine whether it elicits comparable physiological adaptations or if its effectiveness is limited by the relatively low force demands it imposes on the lower-limb muscles. Clarifying these aspects will help optimize training strategies for endurance cyclists and provide evidence-based recommendations for integrating strength-oriented methods into their programs.

2 Material and Methods

2.1 Participants

Twenty-seven well-trained male cyclists were randomly assigned to one of three groups for a 10-week intervention.

2.2 Methodology

The first group (n = 9, VO_2max = 64.4 ± 5.6 mL/kg/min) performed off-bike resistance training (RT) twice per week, consisting of 5 sets of repetitions of full squats (multipower modality) at 70% of their one-repetition maximum (1RM). The recovery time was 4 minutes between sets and 72 hours between sessions. Both squat load (% of 1RM) and intraset volume were programmed by using the level of effort strategy, which has been proven to be a precise, reliable, and practical alternative to velocity-based training for programming RT. Thus, subjects had to put a weight on the bar with which they could complete a maximum of 15 repetitions (at 70% of 1RM) but only performed seven repetitions.

The second group (n = 9, VO_2max = 60.5 ± 4.8 mL/kg/min) followed a traditional torque training program, completing 5 sets of 4-minute intervals at 70% of their VO_2max power output at a target cadence of 50 rpm. The recovery time was 2 minutes between sets and 72 hours between sessions.

The third group served as a control (n = 9, VO_2max = 61.7 ± 5.9 mL/kg/min) and did not perform any RT. However, all groups maintained a cycling training regimen with the same volume and intensity. The cycling training volume across different intensity zones was matched among the three groups throughout the study. Intensity zones were defined based on power output (PO) using the participants' results from the graded exercise test conducted at baseline (detailed below): Zone I (PO below the ventilatory threshold [VT]), Zone II (PO between VT and the respiratory compensation point [RCP]), and Zone III (PO above RCP). Adherence to the target zones was verified by analyzing each participant's cycling training sessions using the WKO5 software (Peaksware LLC, Lafayette, CO) (Table 1).

Table 1. Cycling training volume per week of the three groups

	TRADITIONAL TORQUE	%	RT (SQUAT)	%	CONTROL	%
Total training (hr)	10.6 ± 1.3		11 ± 1		11 ± 1	
1Training volume < VT (hr)	7.6 ± 0.8	72	7.4 ± 1	70	7.4 ± 2	69
269Training volume VT-RCP (hr)	2.6 ± 0.5	25	2.8 ± 1	26	2.9 ± 1	27
Training volume > RCP (hr)	0.4 ± 0.2	3	0.4 ± 0	4	0.5 ± 0	5

VT: Ventilatory threshold, RCP: Respiratory compensation point

The measured outcomes included maximal oxygen uptake (VO_2max), VO_2max power output, VT, RCP, and time to exhaustion at RCP.

2.3 Statistical Analysis

A one-way (group) ANOVA was used to identify possible differences between the three groups on cycling training volume and intensity distribution. A three (group) by two (time: baseline, postintervention) factorial analysis of covariance, controlled by the score of each dependent variable at baseline, was conducted to examine between group differences. The Bonferroni's post hoc adjustment was applied when significant main effects ($P \leq 0.05$) were detected. The effect size was obtained from mean postintervention minus baseline difference and corrected for small sample bias. All statistical analyses were performed using the SPSS software.

3 Results

3.1 VO_2max

No significant time-by-group interaction was found for any group (Torque: 60.5 ± 4.8 vs. 61.8 ± 5.9 mL/kg/min, ES = 0.23; RT: 64.4 ± 5.6 vs. 64.3 ± 5.4 mL/kg/min, ES = -0.02; Control: 61.7 ± 5.9 vs. 61.7 ± 5.7 mL/kg/min, ES = 0.00).

3.2 Maximal Aerobic Power (MAP)

A significant time-by-group interaction ($p < 0.01$) was found between the RT group and the other two interventions (Torque and Control). The RT group showed a significant PRE-POST 5% increase (408 ± 30 vs. 430 ± 40 W, $p < 0.05$, ES = 0.60). No significant changes were found in the Torque group (397 ± 34 vs. 406 ± 41 W, ES = 0.22) or the Control group (406 ± 21 vs. 413 ± 20 W, ES = 0.36).

3.3 VT

A significant time-by-group interaction ($p < 0.05$) was found between the RT group and the other two interventions (Torque and Control). The RT group showed a significant 4% increase (224 ± 22 vs. 234 ± 20 W, $p < 0.05$, ES = 0.47). No significant effects were found in the Torque group (242 ± 28 vs. 247 ± 20 W, ES = 0.23) or the Control group (217 ± 25 vs. 217 ± 30 W, ES = 0.01).

3.4 RCP

A significant time-by-group interaction ($p < 0.05$) was found between the RT group and the other two interventions (TORQUE and Control). A significant 4% increase was observed in the RT group (332 ± 30 vs. 344 ± 26 W, $p < 0.05$, ES = 0.42). No significant differences were found in the Torque group (350 ± 35 vs. 358 ± 33 W, ES = 0.24) or the Control group (333 ± 13 vs. 336 ± 13 W, ES = 0.18).

3.5 Time to Exhaustion at RCP

No significant time-by-group interaction was found for any group. The RT group showed a 12% increase, although it did not reach statistical significance (193 ± 44 vs. 215 ± 48 s, $p = 0.17$, ES = 0.48). Likewise, no significant differences were observed in the Torque group (197 ± 43 vs. 205 ± 53 s, $p = 0.18$, ES = 0. 17) or the Control group (196 ± 63 vs. 205 ± 65 s, $p = 0.27$, ES = 0.14).

4 Discussion

This study suggests that off-bike resistance training (RT) is more effective than torque training for improving endurance cycling performance. The RT group showed significant gains in VO_2max power output and ventilatory thresholds, and a non-significant trend toward improvement in time to exhaustion. The low force demands of torque training may limit its effectiveness compared to RT.

5 Practical Applications

Cyclists seeking performance gains should consider RT as a key component of training, given its impact on power output and fatigue resistance. Torque training may serve as a supplementary method but requires modifications to enhance its effectiveness.

6 Conclusions

Off-bike RT effectively enhances endurance-related metrics in cyclists, whereas torque training has limited benefits. Future research should explore ways to optimize torque training strategies for better performance outcomes.

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