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Effects of different short sprint training volumes using an optimal load on maximal anaerobic power

Hayao Ozaki *[1], Shizuo Katamoto[2]

[1] School of Sport and Health Science, Tokai Gakuen Univeristy, 21-233 Nishinohora, Ukigai, Miyoshi, Aichi 470-0207, Japan

[2] Graduate School of Health and Sports Science, Juntendo University, 1-1 Hiragagakuendai, Inzai, Chiba 270-1695, Japan

***Corresponding author:**

Hayao Ozaki

School of Sport and Health Science, Tokai Gakuen University, 21-233 Nishinohora, Ukigai, Miyoshi, Aichi, Japan

TEL: (+81) 56136-5555

FAX: (+81) 56136-9523

E-mail: ozaki.hayao@gmail.com

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ABSTRACT

Purpose: The aims of the present study were to determine whether short maximal pedaling at optimal load (L_{opt}) improved maximal anaerobic power (MAnP) with changes in force and/or velocity, and if a difference in training volume influenced training outcomes in physically active male students. This study also attempted to establish better measurements for evaluating adaptations to short sprints at L_{opt}.

Methods: Fourteen students were randomly divided into either a one-set training (OST) group or a higher volume training (HT) group. The OST group performed a single 8-s sprint. The HT group repeated 8-s pedaling until a peak power was under 90% of that in the previous set twice. To determine MAnP, participants pedal as rapidly as possible for 8-s at three different loads before, in the middle of and after the 4-week training intervention.

Results: A 2-way ANOVA revealed that MAnP similarly increased after 2 to 4 weeks of training for both groups. Optimal cadence (velocity factor) and L_{opt} (force factor) increased during the first and last 2 weeks of training, respectively. The extent of increase in peak power was significantly lower in the Wingate anaerobic test (6.5 ± 1.4 %) than in the 8-s maximal effort pedaling test at near-L_{opt} (11.5 ± 1.3 %).

Conclusion: Four weeks of a single 8-s maximal effort pedaling at L_{opt} on a cycle ergometer increased MAnP as well as high volume training. The increase resulted from an improvement in the velocity factor in the first half and force factor in the latter half of training. Furthermore, a non-specific test to training load and duration may underestimate the extent of training-induced increase in power compared to a specific test that more closely resemble a training protocol.

Keywords: Anaerobic capacity; Maximal power output; Wingate test; Cycling; Endurance training

至適負荷を用いた短時間スプリントのトレーニング量の違いが最大無酸素パワーに与える影響

尾崎　隼朗[1], 形本静夫[2]

[1]東海学園大学スポーツ健康科学部, [2]順天堂大学スポーツ健康科学研究科

本研究の目的は、活動的な男子学生を対象に、至適負荷を用いた短時間の最大ペダリングが最大無酸素パワー(MAnP)を改善させるか、また、そのトレーニング効果にトレーニング量が影響するか否かについて明らかにすることであった。さらに、至適負荷を用いた短時間スプリントに対する適応を評価するためのより良い測定方法を明らかにすることも試みた。14名の対象者は1セットトレーニング(OST)群と高トレーニング量(HT)群のいずれかに無作為に分けられた。OST群は8秒間のスプリント1回のみを実施した。HT群はその日に観察されたピークパワーの9割を2本連続で下回るまで8秒間のペダリングを繰り返した。MAnPの決定のために、対象者は3つの負荷で8秒間の最大努力でのペダリングを、4週間のトレーニング前後と中間に実施した。MAnPはトレーニング2週および4週間後に有意に向上した。至適回転数は前半の2週間で、至適負荷は後半の2週間で有意に増加した。ピークパワーの増加の程度は、8秒間の最大努力でのペダリングテスト(11.5 ± 1.3 %)と比較して、ウィンゲートテスト(6.5 ± 1.4 %)で有意に低下した。結論として、至適負荷での8秒間1セットの最大努力での4週間のペダリングトレーニングは、より高いトレーニング量のトレーニングと同様にMAnPを向上させ、この向上には前半は速度要因の増加が、後半は力要因の増加が関係しているようであった。また、こうしたトレーニング効果は、トレーニング様式により特異的な方法で評価されることが望ましいことが示唆された。

Introduction

The rate of energy release is critical to the success of athletic movements, such as sprinting and jumping, which require the production and/or short-term maintenance of high power output [1]. There is a significant association between vertical jump height and maximal anaerobic power (MAnP), which could be determined by performing maximal cycling exercise at three different loads [2]. Furthermore, higher power output results in faster performance in short sprinting in sprint cyclists [3]. Thus, the development of a training method for improving power output is very important to enhance athletic performance. Resistance-type training (Pmax training), which utilizes the load that elicits one's maximum mechanical power output in a given exercise, is known to be an effective and time-efficient method for improvement of power [4]. Although few seconds to 30-s of maximal effort pedaling training on a cycle ergometer is also used to improve power output, a given load, which frequently corresponds to 4% to 10% of the participant's body mass, is preferred [5-8]. In particular, 7.5% of the participant's body mass is one of the most commonly selected loads in pedaling training [9-11], but the highest values of anaerobic power were obtained when pedaling was performed using higher loads by both untrained and trained participants [12-14]. The load calculated to reach the highest value of anaerobic power based on the force–velocity relationship is defined as the optimal load (L_{opt}). This should be selected to maximize the training effects of cycling-type training. However, to the best of our knowledge, few studies have investigated the training effect of short sprints at L_{opt} with maximal effort [15] and the training volume, one of an important variables determining training effects, required for improving MAnP is also unclear. Furthermore, MAnP is calculated as a product of L_{opt} (force factor) and optimal cadence (C_{opt}: velocity factor) in cycle ergometer measurements, and hence, investigating training-induced changes in these factors could be informative.

Since adaptation to training stimulus is specific, measurements for evaluating the effects of training require careful selection. Although the Wingate anaerobic test, which comprises 30-s maximal effort pedaling at 7.5% of the participant's body mass, is frequently selected for evaluating the peak and/or mean values of anaerobic power, this test would not be always the best choice. Based on the assumption that specificity is the best predictor of performance, a choice of the test that more closely resembled a training program could help avoid underestimating training effects. There are also no previous studies demonstrating specific adaptation to short sprint training for improving anaerobic peak power by comparing between specific and non-specific anaerobic power tests to training protocol. We hypothesized that the 30-s Wingate anaerobic test at 7.5% of the participant's body mass (a non-specific test to the training load and duration) underestimates the extent of training-induced improvements in peak power when compared to a test that more closely resembles the training protocol, when adaptations to the training consisting of a shorter time (~ 10-s) maximal effort pedaling at L_{opt} are evaluated.

Thus, the aims of the present study were to determine whether short sprints at L_{opt} on a cycle ergometer improved MAnP with changes in force and/or velocity factors, and if a difference in training volume influenced training effects in physically active male students. The secondary objective of the present study also included an attempt to establish better measurements for evaluating adaptations to short sprints at L_{opt}.

Methods

Participants

Fourteen young male students majoring in physical education volunteered to participate in the study. Most were physically active and members of the rugby, baseball, handball, soccer, basketball, and swimming teams. Participants were instructed not to change their other physical activities and dietary patterns throughout the course of the study. They were recruited through printed advertisements and by word-of-mouth. Patients taking any medications were excluded. All participants were informed of the methods, procedures, and risks, and they provided consent before participating in the study. This study was conducted according to the principles laid down in the Declaration of Helsinki and was approved by the Ethics Committee for Human Experiments of Tokaigakuen University, Japan (Approval number: 2020-13).

Study design

Each participant visited the laboratory two separate days for measurements before the commencement of training (PRE). On the first day, the participants were allowed to become accustomed to the maximal anaerobic test followed by the Wingate anaerobic test on an electromagnetically braked cycle ergometer (Powermax VIII, Combi, Tokyo, Japan). On the second day, they underwent the two same tests again to determine anaerobic power. Participants were randomly divided into either a one-set training (OST, n=7) group or higher volume training (HT, n=7) group. Both groups trained 3 days per week for 4 weeks, except in the 3rd week (when they trained for 2 days per week). The number of training sessions per week was decreased in the 3rd week, so that the participants could undertake a test in the middle of the training period (MID) in the first session of the week. In the MID test, they performed only the maximal anaerobic test and the pedaling load in training sessions was reset again based on the results. After the training period (POST), the participants completed both measurements on a single day 2-5 days after final training session.

Training program

Before the start of each training session, participants performed 10 min of continuous cycling on an ergometer at a load corresponding to 2.5% of their body mass, including three bouts of near maximal pedaling for 5-s in the latter half as a warm-up. Five minutes after the warm-up, both groups performed sprint pedaling at L_{opt} with maximal effort with verbal encouragement. The OST group performed a single 8-s sprint in a training session as the minimum training volume. The HT group repeated 8-s sprint until the peak power was under 90% of that in the previous sprint two times in a row. They pedaled up to 10 sprints with rest intervals of 2 min during a training session. A previous study showed that peak velocity was reached in 4-8 s [15]. It was confirmed that the peak velocity was reached within 8-s in each training session for all participants. Immediately after each training session, participants consumed a protein snack (Protein Choco, 180 kcal, 15.0 g protein, 12.1 g carbohydrate, 8.5 g fat, Asahi Group Food, Tokyo, Japan) to standardize the post-exercise meal.

Maximal anaerobic test

Participants were instructed to pedal as rapidly as possible in a seated position for 8-s at three different loads to determine MAnP as previously described [2]. Verbal encouragement was provided throughout the test. The loads corresponded to 5%, 10%, and 15% of their body mass during the PRE period. Tests were performed in a load-increasing order with rest intervals of 5 min. For the three different loads and cadences in each participant, the relationship between load and cadence was represented by a linear regression equation for each participant:

$$Y = -aX + b \ (a > 0, b > 0)$$

The power output in each load was calculated using the following formula:

$$\text{Power output (W)} = \text{load (kp)} \times \text{cadence (rpm)} \times 0.98$$

After calculating the power output for each load, MAnP was determined for each participant based on the linear regression equation for three pairs of loads and cadences using the least-squares method described by Nakamura et al. (2020). L_{opt} is equal to half of the maximal load, which is the highest load at zero cadence, and C_{opt} is maximal cadence, which is the highest cadence at zero load, respectively [16]. Thus, L_{opt} and C_{opt} were calculated using the following formula:

$$L_{opt} = b/2a$$

$$C_{opt} = b/2$$

The relative MAnP and L_{opt} were calculated by dividing the absolute MAnP and L_{opt} values by body mass. Furthermore, to investigate specific adaptations to training load, training effects were compared between the three loads. L_{opt} was 10.2% of their body mass during PRE in the present study. Thus, 10% load was identified to be near-L_{opt} and 5% and 15% loads were described as lower and higher loads, respectively, compared to L_{opt}.

Wingate anaerobic cycle test

Five minutes after the maximal anaerobic test, the participants performed a 30-s Wingate anaerobic test on a cycle ergometer against a load corresponding to 7.5% of their body mass during PRE. Instruction to begin pedaling as fast as possible against the resistance of the ergometer in a seated position were given, and verbal encouragement to continue pedaling as fast as possible was provided throughout the test. The peak and mean power, and the time taken to reach peak power were used in the data analysis. To investigate the extent of specific adaptation to training-induced improvement and to establish better measurements for evaluating adaptations to short sprints at L_{opt}, % change in the highest values of anaerobic power before and after the training period was compared among a non-specific test (Wingate anaerobic test) and two specific tests (maximal anaerobic test and maximal pedaling test using load that corresponded to 10% of their body mass).

Statistical analyses

Statistical tests were performed using SPSS version 23.0 software (SPSS Inc., Chicago, IL, USA). The results are expressed as means and standard deviations. Changes in scores are represented as means and 95% confidence intervals. Baseline values and % changes were analyzed using an one-way analysis of variance (ANOVA). Training effects were analyzed using a between-subject repeated measures analysis of variance (ANOVA) with time as an independent variable for the group. In this study, no interactions were observed for any of the parameters. Thus, the main effects were analyzed with the Fisher's least significant difference test or t-test. Statistical significance was set at $p<0.05$.

Results

All participants completed the study, and the adherence was perfect (a participation rate of 100%) in both groups. No significant differences between groups were evident in any baseline values (Table 1). The mean number of sprints performed in the HT group was 8.1±2.1.

— Table 1 —

Maximal anaerobic test

There were no group × time interactions among any parameter in the maximal anaerobic test. There were significant effects over time ($p < 0.001$) in both the absolute and relative values of MAnP (Figure 1). The absolute value increased as training period changed from PRE to MID [51 (30 – 71) W, $p<0.001$] and from MID to POST [38 (13 – 63) W, $p<0.01$]. The relative values increased with changes in the training period from PRE to MID [0.7 (0.4 – 1.1) W・kg^{-1}, $p<0.001$] and from MID to POST [0.6 (0.2 – 1.0) W・kg^{-1}, $p<0.01$]. Additionally, a notable effect was observed in C_{opt} over time ($p<0.01$, Table 2). A significant ($p<0.05$) increase in values was observed with changes in the training period from PRE (118 ± 2 rpm) to MID (123 ± 2 rpm), but not with changes from MID to POST (124 ± 2 rpm). Furthermore, there were remarkable effects of time ($p < 0.05$) on both the absolute and relative values of L_{opt}. These values did not vary with changes in the training period from PRE (absolute value: 6.7 ± 0.3 kp, relative value: 0.102 ± 0.002 kp・kg^{-1}) to MID, whereas a significant ($p<0.05$) increase was noted with changes in the training period from MID (absolute value: 6.8 ± 0.3 kp, relative value: 0.104 ± 0.002 kp・kg^{-1}) to POST (absolute value: 7.1 ± 0.3 kp, relative value: 0.108 ± 0.003 kp・kg^{-1}).

The main effects of time observed for both peak and mean power in the pedaling tests using loads corresponding to 5% ($p<0.001$), 10% ($p<0.001$), and 15% ($p<0.001$) of their body mass are shown in Table 2. For the 5% load, both peak and mean power significantly increased from PRE to MID training [peak: 28 (14 – 42) W, $p<0.01$, mean: 25 (13 – 37) W, $p<0.01$] and from PRE to POST training [peak: 40 (25 – 55) W, $p<0.01$, mean: 33 (17 – 49) W, $p<0.01$], but did not alter with changes in training period from MID to POST. For the 10% load, both peak and mean power significantly increased with changes in training periods from PRE to MID [peak: 57 (37 – 77) W, $p<0.001$, mean: 63 (38 – 88) W, $p<0.001$], from MID to POST [peak: 34 (9 – 59) W, $p<0.05$, mean: 33 (2 – 65) W, $p<0.01$] and from PRE to POST [peak: 91 (67 – 115) W, $p<0.001$, mean: 96 (69 – 123) W, $p<0.001$]. For the 15% load, both peak and mean power did not vary with a change in the training period from PRE to MID, but significantly increased with changes from MID to POST (peak: 63 (25 – 101) W, $p<0.01$, mean: 92 (49 – 134) W, $p<0.01$] and from PRE to POST (peak: 107 (48 – 167) W, $p<0.01$, mean: 140 (75 – 205) W, $p<0.01$].

— Figure 1 —

— Table 2 —

Wingate anaerobic test

There was no group × time interaction among any parameter in the Wingate anaerobic test (Table 1). There were remarkable effects of time ($p < 0.01$) on both peak and mean power. Both values increased with a change in the training period from PRE to POST (peak: 51 (22 – 79) W, $p<0.01$, mean: 23 (10 – 37) W, $p<0.01$]. An important effect of time was also observed for time taken to reach peak power output ($p<0.05$), which reduced with a change in the training period from PRE (6.2 ± 0.3 s) to POST (5.4 ± 0.2 s).

Comparison of specific and non-specific anaerobic tests

The peak power in the Wingate anaerobic test (724 ± 35 W) was significantly ($p<0.001$) lower than that of MAnP (777 ± 35 W) and peak power in maximal pedaling was achieved at a load that corresponded to 10% of their body mass (789 ± 33 W) before the training period. The extent of increase in peak power in the Wingate anaerobic test (6.5 ± 1.4 %) was significantly ($p<0.05$) lower than that achieved during MAnP (11.5 ± 1.7 %) and the peak power was attained during maximal pedaling at 10% load (11.5 ± 1.3 %) (Figure 2).

— Figure 2 —

Discussion

The major finding of this study is that MAnP revealed a significant increase after training using the 8-s maximal effort pedaling at L_{opt} on an ergometer for in physically active male students. There was no significant difference in the degree of the increase between one-set and higher volume training. Increased MAnP for 4 weeks resulted from an increase in C_{opt} for the first 2 weeks and an increase in L_{opt} for the last 2 weeks. Furthermore, 8-s maximal effort pedaling at L_{opt} significantly increased peak and mean power in the 30-s Wingate anaerobic test, but the extent of the training effects were significantly lower than those achieved in the maximal anaerobic test and/or short time maximal pedaling test at near-L_{opt}.

Short-time maximal effort pedaling at L_{opt} on an ergometer significantly increased MAnP after 2 weeks for both groups: only one set of 8-s maximal pedaling was effective for improvement in MAnP among physically active male students. Our recent research demonstrated that MAnP was increased by a program comprising 8 weeks of training consisting of 5-s maximal effort pedaling at L_{opt} followed by several minutes of supramaximal and near-maximal exercise in untrained young men [14)]. Based on the assumption that even few seconds of maximal effort pedaling made a significant contribution to improving MAnP in our previous research, it is plausible that a single 8-s maximal effort pedaling could lead to increases in MAnP, as noted in the present study. An increase in power output results from an increase in force and/or velocity because power is a product of these two factors. In cycle ergometer measurements, a parabola shaped regression curve is observed between load (or cadence) and power after a linear regression analysis is performed between load (force factor) and cadence (velocity factor). The highest value achieved in the parabolic shape is MAnP, which is calculated using L_{opt} and C_{opt}. Linossier et al. (1993) demonstrated that 5-s intermittent maximal pedaling at 80% of L_{opt} significantly increased maximal anaerobic power based on the force-velocity relationship, which resulted from an increase in both force and velocity factors. However, the order of improvements in these factors was unclear, because the previous study included the measurements obtained during the periods PRE and POST, but not

MID training. The present study revealed that an increase in MAnP for 4 weeks resulted from an increase in C_{opt} for the first 2 weeks and an increase in L_{opt} for the last 2 weeks. This was due to the increase in peak power in the test of load corresponding to 5% of their body mass for the first 2 weeks and that corresponding to 15% of their body mass for the last 2 weeks, although peak power in the test of load corresponding to 10% of their body mass continued to increase throughout the training period. Given the specific adaptation to imposed demands, it is possible that peak power achieved in the 8-s pedaling test at near-L_{opt}, which is the training load, continued to increase throughout the training periods. Additionally, given that L_{opt} is associated with lean volume and strength of the leg [17-19)], these may be increased in the latter half of the training period. However, future studies are needed to corroborate this.

Previous studies have demonstrated that few seconds to 30-s of repeated maximal effort pedaling increased the peak and mean power in the Wingate anaerobic test [9,20)]. For instance, Olek et al. (2018) showed that 2 weeks (total 6 sessions) of 10-s sprint interval training (4-6 repetitions) significantly increased the peak and mean power in the Wingate anaerobic test among physically active, but not highly trained male participants [9)]. The present study is the first to show that even one set of 8-s maximal effort pedaling at L_{opt} significantly increased peak and mean power in the Wingate anaerobic test after 4 weeks. Thus, it appears that several weeks of training using low volumes exercises could increase power output in the Wingate anaerobic test, but not in highly trained participants. The effects of training were comparable between the OST and HT groups in the present study, which suggests that the difference in the training volume does not influence the outcomes in physically active male students. However, it should be noted that adaptations in the HT group could be modified when rest intervals were changed, because the work-to-rest ratios influence training-induced adaptations [10,20)].

The present study also demonstrated that the extent of increase in peak and mean power was significantly lower in the Wingate anaerobic test (a non-specific test to training load and duration) than in the maximal anaerobic test and/or 8-s maximal effort pedaling test at near-L_{opt}, which was the load corresponding to 10% of their body mass (more specific tests). The Wingate anaerobic test requires generation of peak power for the first few seconds, followed by maintenance of this power output for the rest of the duration. Longer severe exercise might have attenuated the generation, although the underlying mechanism could not be revealed in the present study. In any case, it appears that the training effects of anaerobic power are evaluated better using tests that resemble a training program more closely. This is preferred when short time maximal effort pedaling at L_{opt} is selected as a training protocol.

Although a limitation of the present study is lack of a control group to identify potential fluctuations in both training groups that might have been due to factors other than training, it is plausible that a program comprising 4 weeks of training increases MAnP, because participants were instructed not to change their other physical activities and dietary patterns throughout the course of the study. The participants also performed maximal anaerobic test and Wingate test sequentially with 5-min rest between tests. Therefore, despite the impact of maximal anaerobic test on the performance in Wingate test, the conclusions would remain similar because the tests were performed in an identical order for both before and after the training period. Additionally, because one of noted limitations in the present study includes a small sample size for each group and a short training period, it is uncertain if the results pertain in a longer training period. Furthermore, the present study did not include training groups using different training loads, and hence, it is unclear whether using L_{opt} maximizes training effects.

Conclusion

In conclusion, this study is the first to show that 4 weeks of a single 8-s maximal effort pedaling at L_{opt} on a cycle ergometer increased as well as higher volume pedaling for physically active male students. The increase resulted from an improvement in the velocity factor in the first 2 weeks and in the force factor in the latter 2 weeks. Furthermore, a non-specific test to training load and duration may underestimate the extent of training-induced increase in power compared to a specific test that more closely resemble a training protocol. Although anaerobic training using one set of exercise may afford potential adaptation benefits for athletes with limited time, this warrants further investigation.

Declarations

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Conflict of interest

The authors declare no conflicts of interest directly relevant to the content of this manuscript.

Authors contributions

This research was designed by HO and SK; data were collected by HO; data were analyzed by HO and SK; data interpretation and manuscript preparation were undertaken by HO and SK. All authors have read and approved the final version of the manuscript and agreed with the order of presentation of the authors.

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Figure Captions

Fig. 1 Changes in MAnP

a. Absolute values; b. Relative value

Data are presented as means ± SD

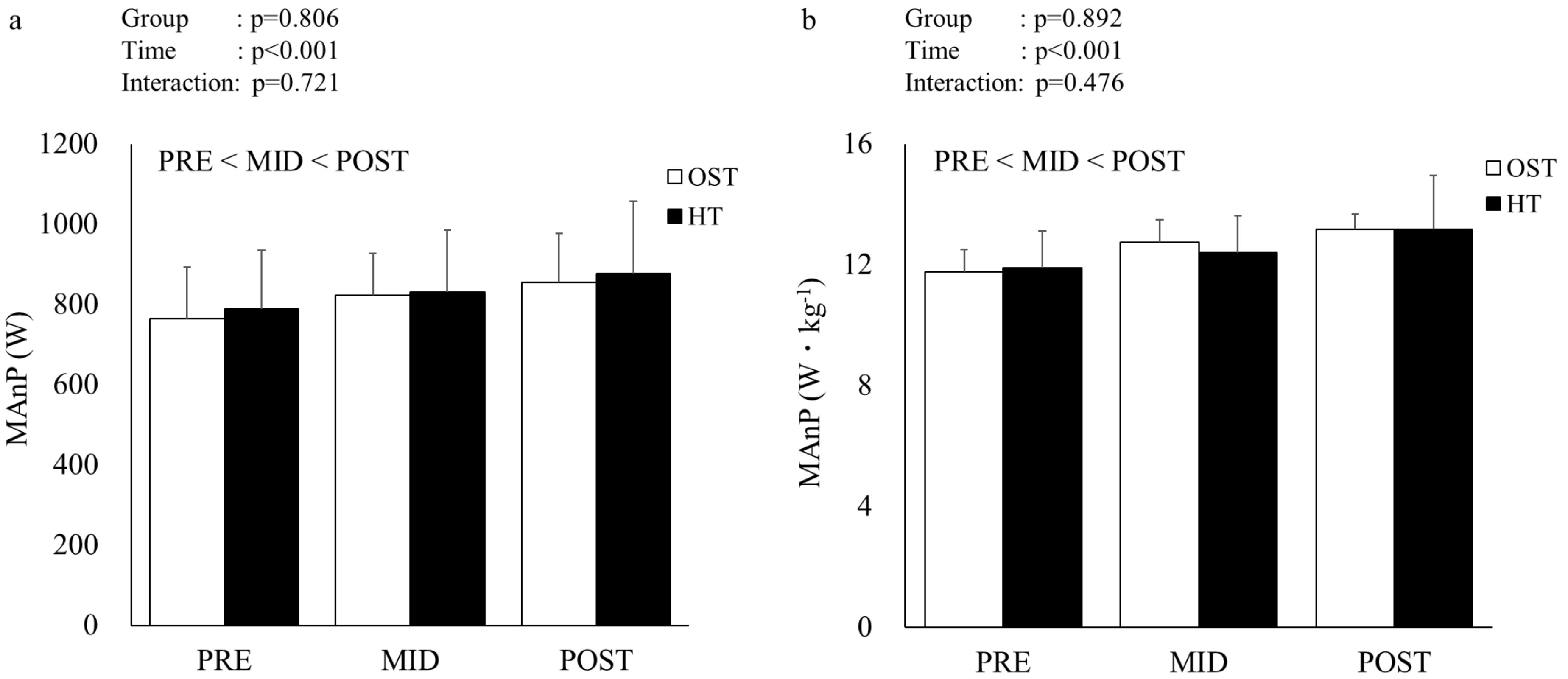
HT, higher volume training group; MAnP, maximal anaerobic power; MID, after 2 weeks of training; OST, one set training group; POST, after 4 weeks of training; PRE, before training; SD, standard deviation

Fig. 2 Changes in the highest values of anaerobic power for three pedaling tests

Data are presented as means ± SD and denotes the relative value.

MAnP, maximal anaerobic power; 10% BM, the test performed using a load that corresponded to 10% of their body mass; Wingate, Wingate anaerobic test; SD, standard deviation

Fig. 1



a
Group : p=0.806
Time : p<0.001
Interaction: p=0.721
1200
1000
800
600
400
200
0
MAnP (W)
PRE < MID < POST
OST
HT
PRE
MID
POST
b
Group : p=0.892
Time : p<0.001
Interaction: p=0.476
16
12
8
4
0
MAnP (W・kg-1)
PRE < MID < POST
OST
HT
PRE
MID
POST

Fig. 2

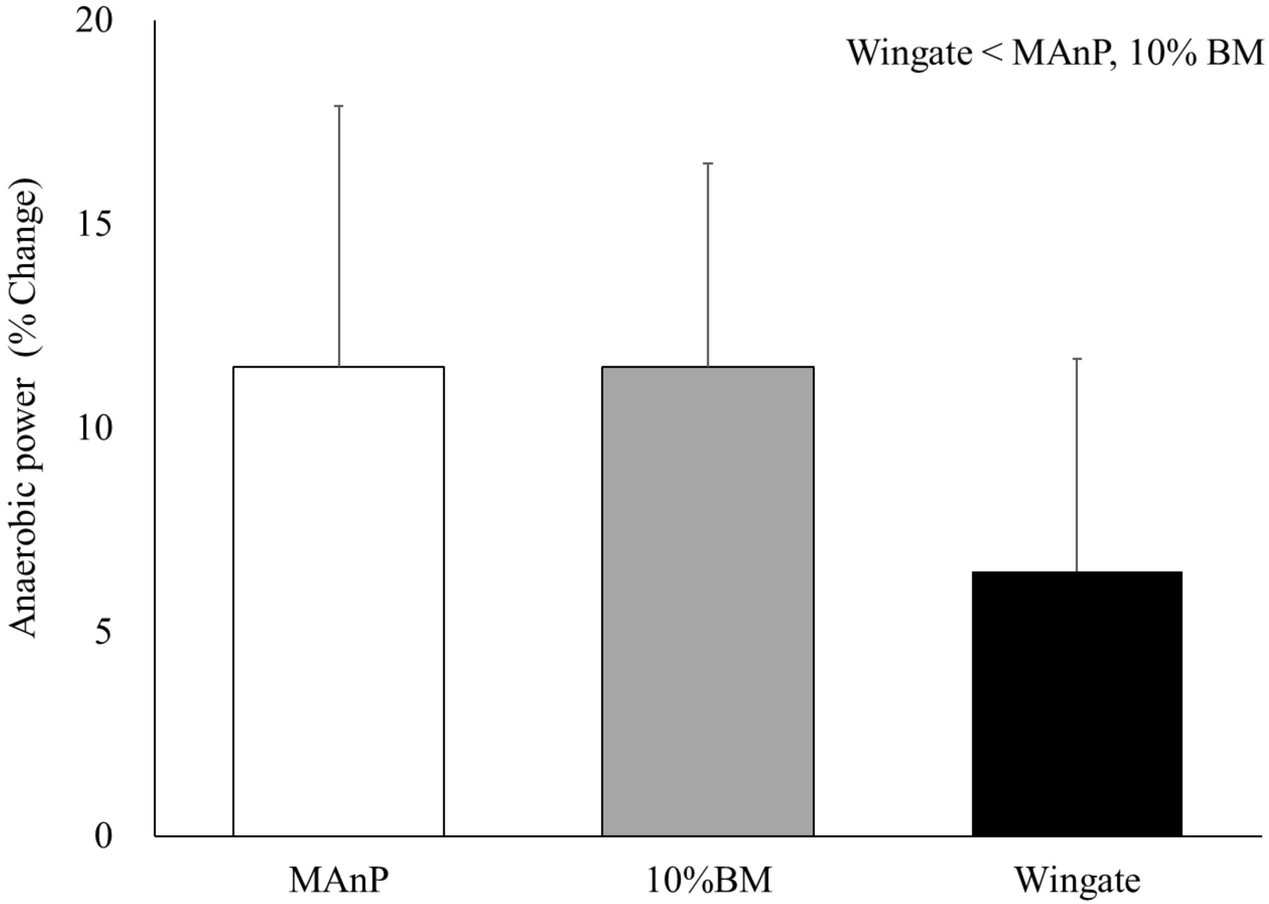

Anaerobic power (% Change)
20
15
10
5
0
Wingate < MAnP, 10% BM
MAnP
10%BM
Wingate

Table 1. Changes in anthropometric variables and the peak and mean power values in the Wingate test

	OST			HT			p value		
	PRE	MID	POST	PRE	MID	POST	Group	Time	Interaction
Anthropometric variables									
Age, y	20 (1)			23 (2)					
Standing height, m	1.73 (0.05)			1.74 (0.06)					
Body mass, kg	64.9 (10.1)	64.9 (9.6)	64.9 (9.6)	67.9 (20.7)	68.3 (19.7)	67.9 (20.1)	0.717	0.733	0.656
Body mass index, $kg \cdot m^{-2}$	21.7 (2.3)	21.7 (2.1)	21.7 (2.1)	23.4 (5.8)	23.5 (5.5)	23.4 (5.6)	0.461	0.636	0.472
Wingate test results									
Peak power, W	719 (124)		773 (134)	729 (151)		776 (209)	0.938	< 0.01	0.839
Mean power, W	576 (88)		612 (92)	570 (104)		580 (110)	0.726	< 0.01	0.064

Data are presented as means (±SD). HT, higher volume training group; MID, after 2 weeks of training; OST, one set training group; POST, after 8 weeks of training; PRE, before training.

Table 2. Changes in the peak and mean power in the different loads of the maximal pedaling test, C_{opt} and L_{opt}

	OST			HT			p value		
	PRE	MID	POST	PRE	MID	POST	Group	Time	Interaction
5% BM									
Peak power, W	568 (101)	596 (94)	610 (107)	582 (148)	609 (170)	618 (177)	0.874	< 0.001	0.887
Mean power, W	483 (92)	506 (85)	516 (97)	499 (148)	526 (162)	532 (172)	0.806	< 0.001	0.957
10% BM									
Peak power, W	787 (133)	841 (105)	887 (135)	791 (127)	852 (144)	874 (172)	0.994	< 0.001	0.544
Mean power, W	665 (102)	728 (107)	749 (108)	670 (130)	733 (143)	778 (171)	0.853	< 0.001	0.573
15% BM									
Peak power, W	570 (115)	657 (64)	687 (82)	679 (177)	680 (144)	776 (193)	0.301	< 0.001	0.183
Mean power, W	458 (69)	526 (57)	600 (69)	572 (189)	601 (143)	710 (187)	0.142	< 0.001	0.711
Maximal anaerobic test									

C_{opt}, rpm	119 (8)	124 (8)	126 (7)	117 (8)	123 (5)	122 (5)	0.450	< 0.01	0.554
L_{opt}, kp	6.5 (0.9)	6.8 (0.8)	6.9 (0.8)	6.9 (1.4)	6.9 (1.1)	7.3 (1.3)	0.564	< 0.05	0.341

Data are presented as means (±SD). BM, body mass; C_{opt}, optimal cadence; HT, higher volume training group; L_{opt}, optimal load; MID, after 2 weeks of training; OST, one set training group; POST, after 4 weeks of training; PRE, before training.