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Adding intermittent vibration to varied-intensity work intervals: no extra benefit

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Abstract

Varied-intensity work intervals have been shown to induce higher fractions of maximal oxygen uptake during high-intensity interval training compared with constant-intensity work intervals. We assessed whether varied-intensity work intervals combined with intermittent vibration could further increase cyclists' fraction of maximal oxygen uptake to potentially optimise adaptive stimulus. Thirteen cyclists ($\dot{V}O_{2max}$: 69.7±7.1 ml·kg^{-1}·min^{-1}) underwent a performance assessment and two high-intensity interval training sessions. Both comprised six 5-minute varied-intensity work intervals within which work rate was alternated between 100% (3x30-second blocks, with or without vibration) and 77% of maximal aerobic power (always without vibration). Adding vibration to varied-intensity work intervals did not elicit longer time above ninety percent of maximal oxygen uptake (415±221 versus 399±209 seconds, *P*=0.69). Heart rate- and perceptual-based training-load metrics were also not affected (all *P*≥0.59). When considering individual work intervals, no between-condition differences were found (fraction of maximal oxygen uptake, *P*=0.34; total oxygen uptake, *P*=0.053; mean minute ventilation, *P*=0.079; mean heart rate, *P*=0.88; blood lactate concentration, *P*=0.53; ratings of perceived exertion, *P*=0.29). Adding intermittent vibration to varied-intensity work intervals does not increase the fraction of maximal oxygen uptake elicited. Whether intermittent exposure to vibration can enhance cyclists' adaptive stimulus triggered by high-intensity interval training remains to be determined.

Keywords: vibration training, athletic performance, physiological responses, elite cycling, physical conditioning, exercise tolerance.

1. Introduction

The maximal oxygen uptake ($\dot{V}O_{2max}$), fractional utilization of $\dot{V}O_{2max}$ (%$\dot{V}O_{2max}$), and mechanical efficiency have been considered the main determinants of endurance performance as these variables set the highest work rate an individual can sustain over long distances [1, 2]. In particular, there has been a lot of interest in how high-intensity interval training (HIIT) can be programmed to maximise $\dot{V}O_{2max}$ and performance of endurance athletes [3, 4]. It has been suggested that in order to promote further cardiovascular and metabolic adaptations, athletes should accumulate several minutes above 90%$\dot{V}O_{2max}$ (time >90%$\dot{V}O_{2max}$) during HIIT session [3, 4].

The prescription of HIIT involves decisions on several parameters that affect time >90%$\dot{V}O_{2max}$, such as the intensity and duration of both work and recovery intervals [3, 4]. Another less explored variable that may influence the acute physiological responses to HIIT is the work rate distribution within the work intervals [5-7]. For instance, we have shown that varied-intensity work intervals (i.e., 3 x 30-second higher-intensity blocks within each 5-minute work interval) induce a higher %$\dot{V}O_{2max}$ and longer time >90%$\dot{V}O_{2max}$ during HIIT compared with constant-intensity work intervals [7]. However, time >90%$\dot{V}O_{2max}$ in that study [7] was still much less than the highest values reported in the literature for workouts of similar duration [3, 4, 8, 9]. While differences in average exercise intensity may explain this observation, it prompts the question of whether HIIT with varied-intensity work intervals can be optimised to further enhance time >90%$\dot{V}O_{2max}$.

A potential strategy to increase the oxygen cost of cycling is to add vibration as an extra stressor [8, 10-13]. In particular, Rønnestad, et al. [8] reported that adding vibration to the work intervals of a HIIT session increased time >90%$\dot{V}O_{2max}$ and electromyography (EMG) activity of the vastus lateralis compared with the non-vibration condition. Mechanistically, vibration may increase the activation of primary afferent endings of muscle spindles, eliciting an excitatory effect upon alpha motoneurons and ultimately contracting previously inactive fibres [14, 15]. This increment in the number of recruited fibres would theoretically increase the oxygen cost of exercise [8, 13]. Some authors have also suggested that vibration increases the recruitment of fast-twitch fibres [15, 16], which are known for their lower efficiency compared with slow-twitch fibres [17, 18]. As in cycling fast-twitch fibres tend to be recruited mostly at intensities >90%$\dot{V}O_{2max}$ [19, 20], adding vibration to the 30-second higher-intensity blocks of varied-intensity work intervals may further increase the recruitment of these fibres, potentially maximising time >90%$\dot{V}O_{2max}$. However, evidence suggests that vibration affects cycling comfort [21, 22] and may lead to premature exhaustion in some circumstances [11, 23, 24], which could offset its potential benefits. Therefore, minimising exposure to vibration, while still increasing %$\dot{V}O_{2max}$ sustained during HIIT, would be advantageous for cyclists.

This study assessed whether varied-intensity work intervals combined with intermittent vibration could increase the %$\dot{V}O_{2max}$ sustained during HIIT compared with a non-vibration condition. Consistent with previous findings [7], we hypothesised that adding intermittent vibration to varied-intensity work intervals would prolong time >90%$\dot{V}O_{2max}$, but without affecting blood lactate concentration ([La]), ratings of perceived exertion (RPE), or training load metrics, as markers of the homeostatic stress experienced by cyclists [25].

2. Materials & Methods

2.1.Participants

Thirteen well-trained male cyclists, unfamiliar with vibration training, volunteered for this study during their off-season (Table 1). The present study was performed according with the ethical standards established by the International Journal of Sports Medicine [26] and it was approved by the Human Research Ethics Committee at the Inland Norway University of Applied Sciences. All participants provided written informed consent.

Table 1 Participants' characteristics and preliminary testing results (mean ± SD)

Age (years)	25 ± 6
Height (cm)	184 ± 5
Body mass (kg)	75.0 ± 5.0
$\dot{V}O_{2max}$ (ml·kg^{-1}·min^{-1})	69.7 ± 7.1
$\dot{V}O_{2max}$ (L·min^{-1})	5.21 ± 0.52
$\dot{W}_{max}$ (W·kg^{-1})	5.77 ± 0.67
$\dot{W}_{max}$ (W)	431 ± 38
MAP (W·kg^{-1})	5.19 ± 0.58
MAP (W)	389 ± 42
HR_{max} (b·min^{-1})	192 ± 8
$[La]_{peak}$ (mmol·L^{-1})	13.2 ± 1.3
$\dot{V}E_{peak}$ (L·min^{-1})	214 ± 15
RER_{peak}	1.18 ± 0.04
RPE_{peak}	19.4 ± 0.6
4 mmol·L$^{-1}{}_{LT}$ (W·kg^{-1})	3.76 ± 0.59
4 mmol·L$^{-1}{}_{LT}$ (W)	281 ± 41
CEI	26 ± 6
Races in the previous season	11 ± 11
Training in the previous season (h)	543 ± 223
Current training (h·week^{-1})	10 ± 6

$\dot{V}O_{2max}$: maximal oxygen uptake; $\dot{W}_{max}$: maximal work rate during the incremental test; MAP: maximal aerobic power; HR_{max}: maximal heart rate; $[La]_{peak}$: peak blood lactate concentration; $\dot{V}E_{peak}$: peak minute ventilation; RER_{peak}: peak respiratory exchange ratio; RPE_{peak}: peak rating of perceived exertion; LT: lactate threshold; CEI: cycling experience index (see text for details)

2.2.Study design

Participants visited the laboratory on three occasions at the same time of the day, separated by at least 48 hours. In the first visit, participants completed a submaximal lactate threshold test and a maximal incremental test to characterize their cycling ability and physiological profile. They were also familiarised with the vibration and HIIT workout used during subsequent visits. In visits two and three, participants performed two identical HIIT sessions with varied-intensity work intervals, as proposed by Bossi, et al. [7]. However, in randomized order, intermittent vibration was employed in one of the two HIIT sessions (see details below). Acute physiological and perceptual responses were compared between vibration and non-vibration conditions. Because this investigation was part of a large project designed to address separate research questions, the non-vibration data of twelve participants is partially reproduced elsewhere [7].

Participants were instructed to refrain from all types of intense exercise 24 hours before each laboratory visit and to prepare as they would for competition. They were instructed to consume identical meals 1 hour before testing and to refrain from caffeine during the preceding 3 hours. All tests were performed free from distractions, under similar environmental conditions (16°C-17°C), with participants being cooled with a fan.

2.3.Ergometer set-up

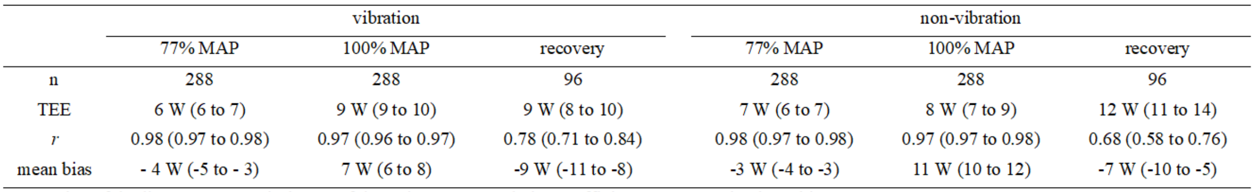
The ergometer set-up can be seen in Figure 1. Operational details can be found elsewhere [7]. Participants used the same bike (2017 Roubaix One. 3 size 56, Fuji, Taichung, Taiwan) equipped with a crank-based power meter (SRAM S975, SRM, Jülich, Germany). The bike was mounted on a cycle ergometer (KICKR, Wahoo Fitness, Atlanta, USA) that was attached to a vibration platform (PneuVibe Pro, Pneumex, Sandpoint, USA). With this set-up, a 45-Hz sinusoidal vibration was applied to the bike frame (the 40-Hz frequency has been factory-calibrated to ± 2 Hz), with both sides of the platform moving up and down at the same time (i.e., synchronous vibration). The frequency chosen lies within the range typically associated with an increase in EMG activity (i.e., 25-45 Hz) [15]. In our lab, this vibration platform has been shown to generate a peak-to-peak displacement of 3 mm with an external load of 100 kg [27], resulting in a peak acceleration of 119.9 ms^{-2}. While this set-up has proved effective in delivering vibration to the cyclists' body [8], the exact characteristics of the transmitted vibration are unknown, due to distortion and attenuation effects [28], associated with: a) the damper pads and mobile arm extensions of the KICKR ergometer, and b) the dynamic nature of cycling exercise.

Figure 1 Ergometer set-up. The bike frame is mounted on the cycle ergometer, which is attached to the vibration platform with ratchet straps. The vibration platform is screwed on the floor. The front wheel of the bike is on a riser block, which is on top of a fitness step. The cyclist is breathing through a mouthpiece connected to the metabolic cart.

To examine the validity of the power outputs generated by the KICKR ergometer through this set-up, individual targets determined for each HIIT session were compared with SRM power meter readings.

A freely available spreadsheet was used to assess data of the work (77% and 100% of maximal aerobic power [MAP]; see details below) and recovery intervals for agreement [29]. These data are summarised in Table 2 and suggest: a) a satisfactory agreement between devices, particularly at the highest power outputs of the work intervals, and b) no detrimental effects of the vibration platform use on the functioning of the KICKR ergometer.

Table 2 Validity of the power outputs generated by the KICKR ergometer as compared with the SRM powermeter (90% CI)



	vibration			non-vibration		
	77% MAP	100% MAP	recovery	77% MAP	100% MAP	recovery
n	288	288	96	288	288	96
TEE	6 W (6 to 7)	9 W (9 to 10)	9 W (8 to 10)	7 W (6 to 7)	8 W (7 to 9)	12 W (11 to 14)
r	0.98 (0.97 to 0.98)	0.97 (0.96 to 0.97)	0.78 (0.71 to 0.84)	0.98 (0.97 to 0.98)	0.97 (0.97 to 0.98)	0.68 (0.58 to 0.76)
mean bias	- 4 W (-5 to - 3)	7 W (6 to 8)	-9 W (-11 to -8)	-3 W (-4 to -3)	11 W (10 to 12)	-7 W (-10 to -5)

n: number of duplicates; TEE: typical error of the estimate; r: correlation coefficient; MAP: maximal aerobic power

2.4.Preliminary testing

In the first visit, participant's height and body mass were measured, and they completed a cycling experience index questionnaire [30] as well as standalone questions about their training habits. Subsequently, participants completed a lactate threshold test, which started at 125 W, increasing by 50 W every fifth minute (25 W if [La] was ≥ 3 mmol·L^{-1}), and terminating when [La] reached ≥ 4 mmol·L^{-1}. Blood samples were taken from a fingertip at the last 30 seconds of each 5-minute bout, being immediately analysed (Biosen C-Line, EKF Diagnostics, Penarth, UK). At the start, cyclists chose their cadence, which they subsequently held constant throughout the remainder of the test. Power output at 4 mmol·L^{-1} [La] [31] was calculated from the relationship between [La] and power output in the last two stages, by using linear regression. Pulmonary gas exchanges were measured during the last 3 minutes of each stage (15-second sampling time) using a computerized metabolic system with a mixing chamber (Oxycon Pro, Erich Jaeger, Hoechberg, Germany). Prior to every test, the gas analyser was calibrated with certified calibration gases of known concentrations, and the flow turbine (Triple

V, Erich Jaeger, Hoechberg, Germany) was calibrated with a 3-L syringe (5530 series, Hans Rudolph, Shawnee Mission, USA).

Following the lactate threshold test, cyclists pedalled for 10 minutes at a power output between 50 and 100 W before performing the maximal incremental test to determine $\dot{V}O_{2max}$, MAP, and maximal work rate ($\dot{W}_{max}$). The test started at 200 W, with work-rate being increased by 25 W every minute until volitional exhaustion, or cyclist's inability to maintain cadence above 70 rev·min^{-1} despite verbal encouragement. Cadence was freely chosen, but participants were instructed to avoid abrupt changes. Pulmonary gas exchanges were continuously measured, and $\dot{V}O_{2max}$ was calculated as the highest 60-second mean oxygen uptake ($\dot{V}O_2$). MAP was calculated according to Daniels [32]. Power output was recorded continuously throughout the test, with $\dot{W}_{max}$ calculated as the mean of the last 60 seconds. Immediately after the incremental test, a blood sample was taken from a fingertip to determine [La]. Cyclists reported their peak RPE using Borg's 6-20 scale [33] immediately after terminating the test.

2.5. HIIT sessions

In the second and third visits, participants started with a 15-minute warm-up based on Borg's 6-20 RPE scale [33]. Specifically, the warm-up consisted of 5 minutes at an RPE of 11 (i.e., light), followed by three 1-minute intervals at 16 (i.e., between hard and very hard), interspersed with two 2-minute blocks and a final 3 minutes at 9 (i.e., very light) (Figure 2a). The power output profile of the actual HIIT sessions was identical, starting with 5 minutes at 50%MAP, and followed by six 5-minute, varied-intensity work intervals at the mean intensity of 84%MAP, interspersed with 2.5-minute recovery at 30%MAP (Figure 2b). The varied-intensity work intervals consisted of three 30-second blocks at 100%MAP, interspersed with two 1-minute blocks, and a final 1.5-minute block at 77%MAP [7]. Vibration was applied during all 30-second blocks at 100%MAP of only one of the HIIT sessions, randomly (Figure 2b). The platform was switched on 3 seconds earlier to match with the beginning of the 30-second blocks, and it was switched off at 30 seconds. Participants were not allowed to stand on the pedals to facilitate consistent vibration transmission.

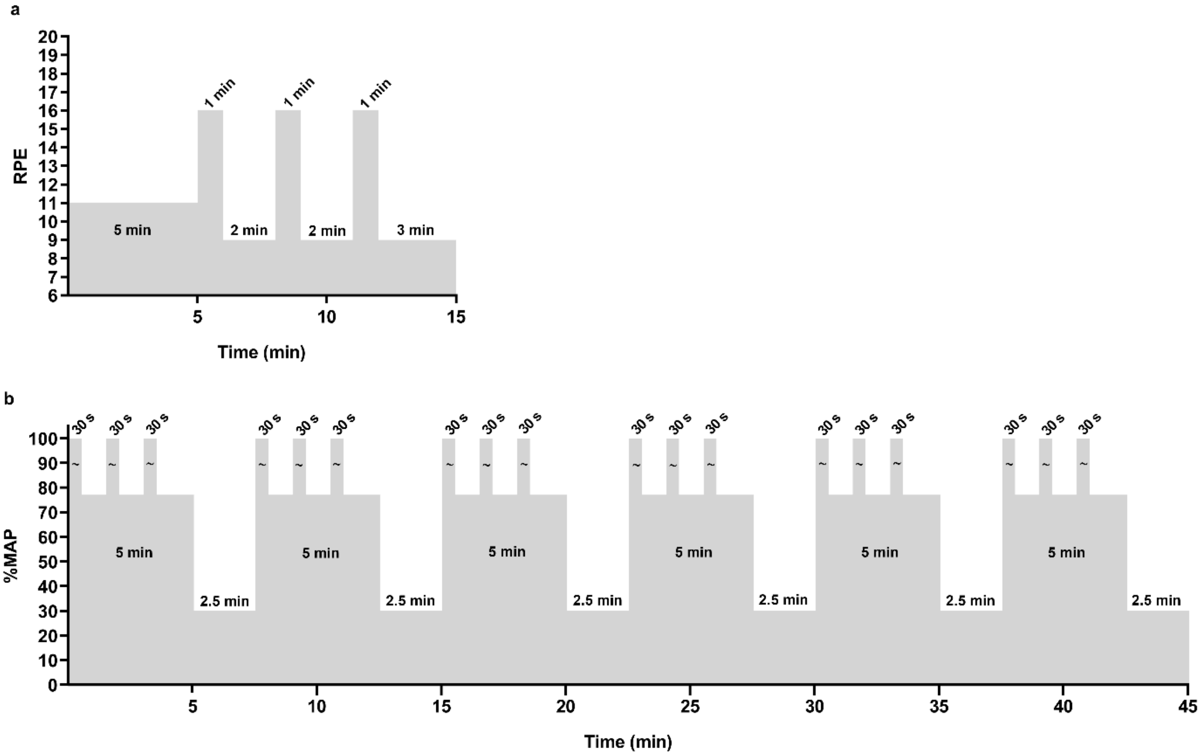


Figure 2 a Warm-up procedure based on ratings of perceived exertion (RPE) that was performed prior to both high-intensity interval training (HIIT) sessions. **b** HIIT sessions with varied-intensity work intervals. The intensity of both sessions was prescribed as a percentage of the individual's maximal aerobic power (%MAP). Both sessions had identical power output profiles, with the only difference being the addition of vibration during the 30-s blocks at 100%MAP (see tilde symbol). HIIT sessions started with 5 minutes at 50%MAP, which is omitted from the figure for clarity.

HR was continuously measured during the entire HIIT sessions. Pulmonary gas exchanges were measured during the 5-minute work intervals (5-second sampling time) using the same equipment and following the calibration procedures adopted in the preliminary testing. Time >90%$\dot{V}O_{2max}$ was calculated by summing all raw $\dot{V}O_2$ samples above the established cut-off. At the end of each work interval, fingertip blood samples were taken to determine [La], and RPE was noted. Participants self-selected their cadence, and water consumption was not restricted. Twenty minutes after finishing the HIIT sessions, session RPE (sRPE) was noted [34]. An individualised training impulse (iTRIMP) was also calculated for each session [35]. Both sRPE and iTRIMP are training load metrics used by cyclists to quantify the "dose" associated with individual exercise sessions [36].

2.6.Statistics

Dependent variables were assessed for normality using Shapiro-Wilk tests. Paired *t*-tests were used to compare time >90%$\dot{V}O_{2max}$, sRPE, and iTRIMP between HIIT sessions. Two-way repeated-measures analysis of variance (ANOVA) (vibration condition × work interval number) was performed to test for differences in mean %$\dot{V}O_{2max}$, total $\dot{V}O_2$, mean minute ventilation ($\dot{V}E$), mean HR, [La], and RPE. Following the analysis of variance, Bonferroni pairwise comparisons were used to identify where significant differences existed within the data. In addition, Cohen *d* or partial eta squared (η_p^2) were computed as effect size estimates. Ninety percent confidence limits (CL) of the differences were calculated when appropriate. Data were analysed using dedicated software (SSPS Statistics 25, IBM, Armonk, USA), and significance level was set at $P \leq 0.05$. Data are presented as individual values or mean ± standard deviation (SD).

3. Results

There were no differences between HIIT sessions for time >90%$\dot{V}O_{2max}$ ($P = 0.69$; d = 0.12; CL = -53 – 84 s; Figure 3a), sRPE ($P = 0.59$; d = -0.08; CL = -1.0 – 0.8; Figure 3b), or iTRIMP ($P = 0.88$; d = -0.04; CL = -12 – 10; Figure 3c). The mean $\dot{V}O_2$ responses to varied-intensity work intervals with and without vibration are presented in Figure 4.

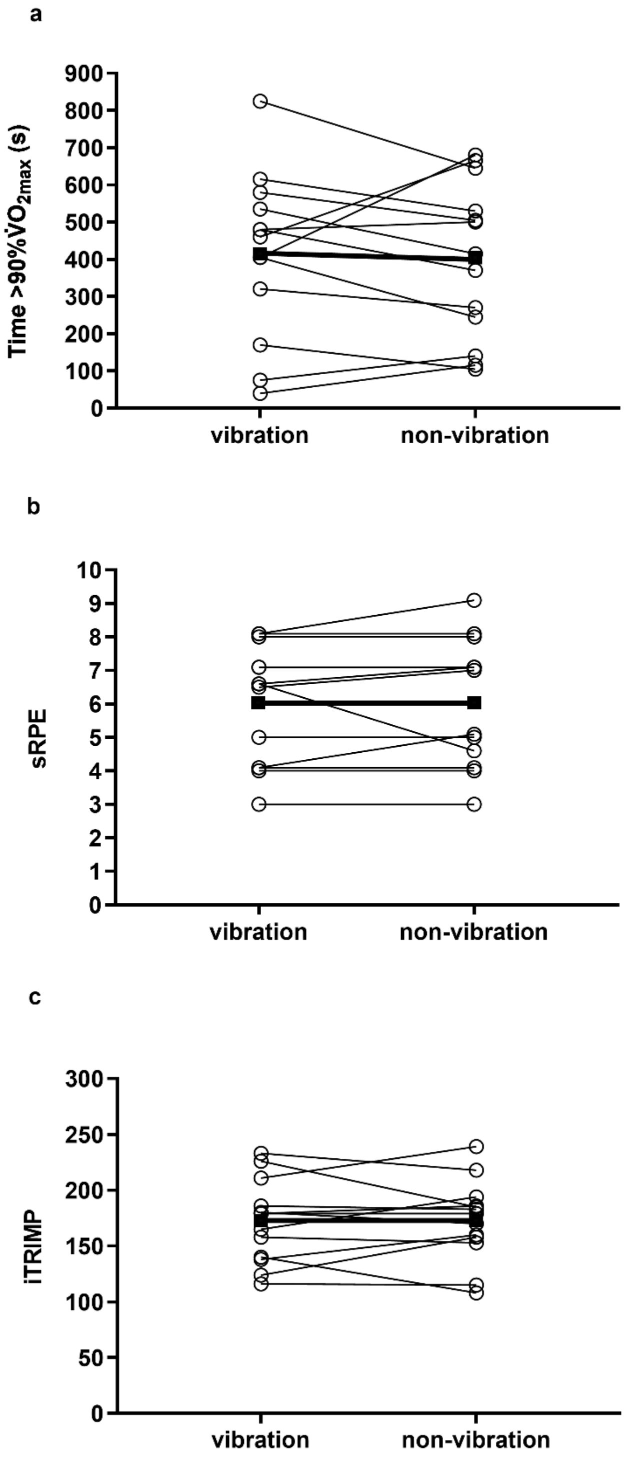


Figure 3 **a** Time spent above 90% of maximal oxygen uptake (time >90%$\dot{V}O_{2max}$), **b** Session ratings of perceived exertion (sRPE), and **c** Individualized training impulse (iTRIMP) for high-intensity interval training sessions with (vibration) and without (no-vibration) intermittent vibration. Open circles represent individual participants, and black squares represent means.

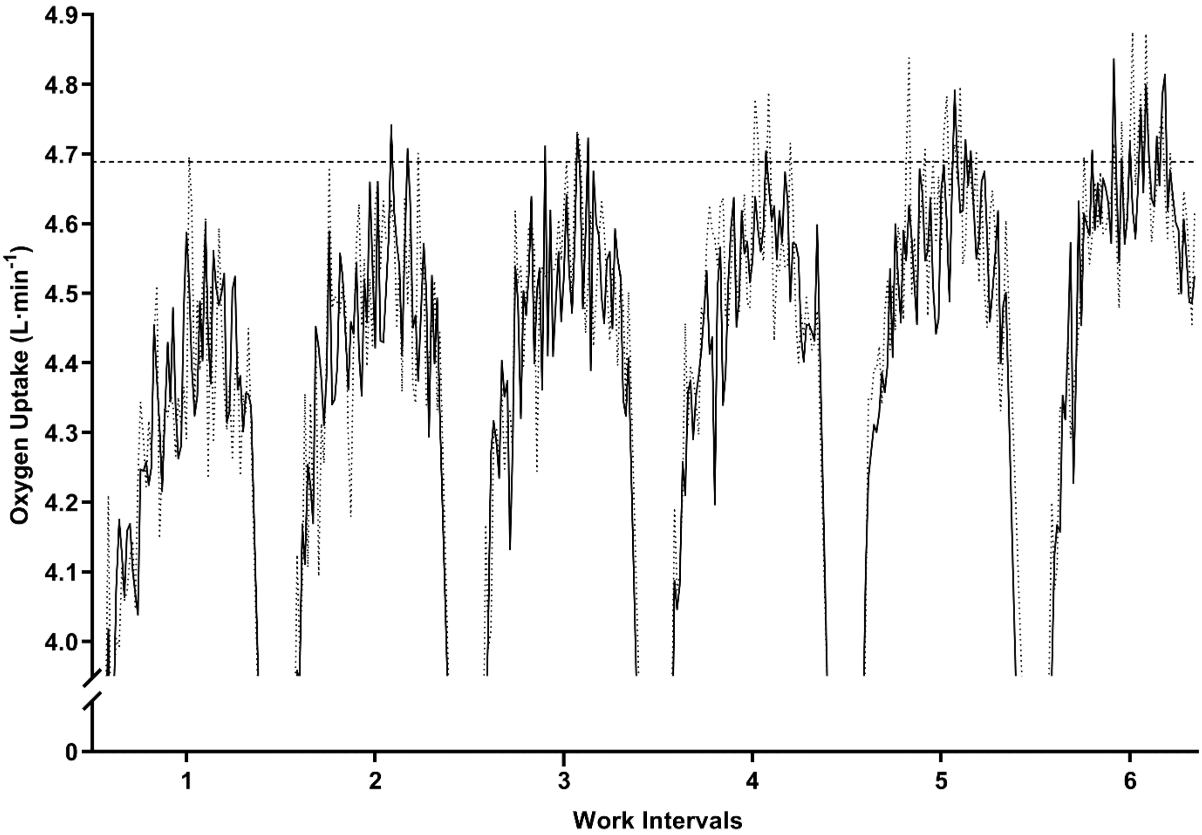


Figure 4 Mean oxygen uptake responses (5-s sampling time) to varied-intensity work intervals with (dotted line) and without intermittent vibration (solid line). The horizontal dashed line represents 90% of maximal oxygen uptake (mean of all participants). SD is omitted from the figure for clarity.

No interactions between vibration condition and work interval number were found for $\%\dot{V}O_{2max}$ (P = 0.46; η_p^2 = 0.07; Figure 5a), total $\dot{V}O_2$ (P = 0.63; η_p^2 = 0.06; Figure 5b), $\dot{V}E$ (P = 0.83; η_p^2 = 0.02; Figure 5c), HR (P = 0.24; η_p^2 = 0.11; Figure 5d), [La] (P = 0.66; η_p^2 = 0.05; Figure 5e) or RPE (P = 0.88; η_p^2 = 0.03; Figure 5f). There was also no main effect of vibration condition for $\%\dot{V}O_{2max}$ (P = 0.34; η_p^2 = 0.08), total $\dot{V}O_2$ (P = 0.053; η_p^2 = 0.28), $\dot{V}E$ (P = 0.11; η_p^2 = 0.20), HR (P = 0.88; η_p^2 < 0.01), [La] (P = 0.53; η_p^2 = 0.03) or RPE (P = 0.29; η_p^2 = 0.09). A main effect of work interval number was observed for all variables (all $P < 0.001$; $\eta_p^2 \geq 0.64$).

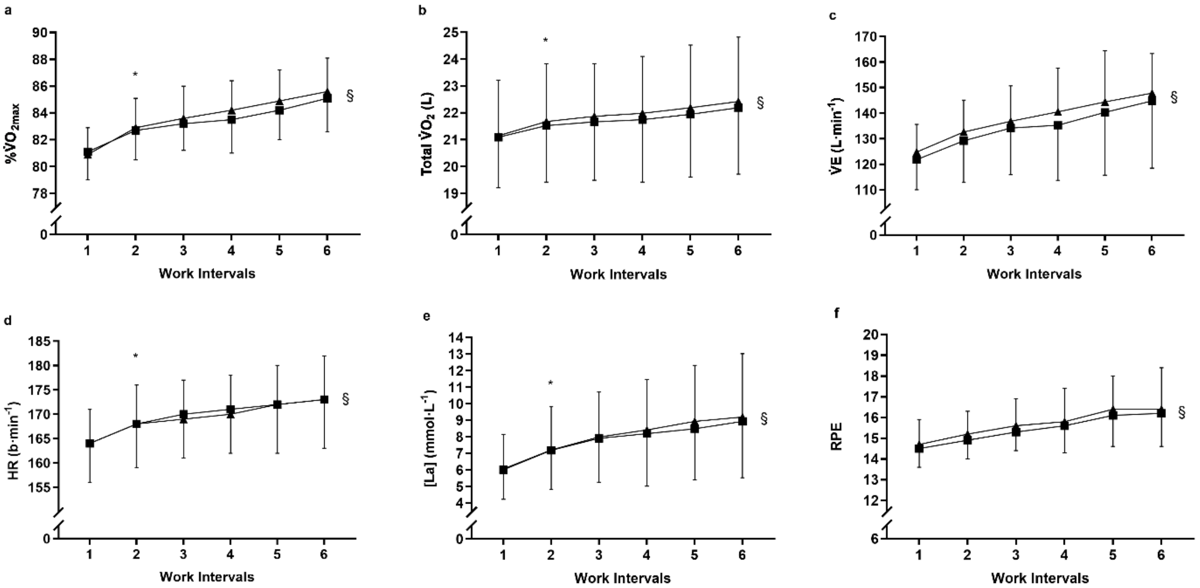


Figure 5 a Mean fractional utilization of maximal oxygen uptake (%V̇O$_{2max}$), **b** Total oxygen uptake (total V̇O$_2$), **c** Mean minute ventilation (V̇E), **d** Mean heart rate (HR), **e** Blood lactate concentration [La], and **f** Ratings of perceived exertion (RPE) for high-intensity interval training sessions with (triangles) and without (squares) intermittent vibration. Data are displayed per work interval as mean ± SD. *Different from previous work interval (all $P \leq 0.004$). §Main effect of work interval number (all $P < 0.001$).

4. Discussion

Contrary to our hypothesis, adding intermittent vibration to varied-intensity work intervals as proposed by Bossi, et al. [7] did not increase time >90%V̇O$_{2max}$ compared with the non-vibration condition. Furthermore, %V̇O$_{2max}$, total V̇O$_2$, V̇E, HR, [La], RPE, sRPE and iTRIMP did not differ between HIIT sessions, confirming that participants experienced similar cardiovascular stress and perceptual strain.

Rønnestad, et al. [8] first reported that adding vibration to HIIT increases time >90%V̇O$_{2max}$ by 58% compared with the non-vibration condition. In the present study, however, we did not observe differences in time >90%V̇O$_{2max}$ or %V̇O$_{2max}$ sustained between HIIT sessions—despite a trend of increased total V̇O$_2$ for the vibration condition (P = 0.053). The reason for this discrepancy might be associated with the total time of exposure to vibration. In the present study, exposure time within each 5-minute work interval amounted to 90 seconds, making up a total of 9 minutes for a 6 x 5-minute HIIT session. However, in the study of Rønnestad, et al. [8] vibration was applied throughout the 5-minute work intervals, making up a total of 30 minutes for a 6 x 5-minute HIIT session. In another study, Sperlich, et al. [10] reported increased $\dot{V}O_2$ compared with the non-vibration condition only after more than 15 minutes of exposure to vibration (i.e., in the last stages of an incremental test to exhaustion). Collectively, these results may suggest that total exposure to vibration is critical for prolonging time >90%$\dot{V}O_{2max}$.

Interestingly, Rønnestad, et al. [8] also showed that vibration increased %$\dot{V}O_{2max}$ sustained during the first half of work intervals, but not during the second half, indicating that approximately 2.5 minutes of vibration per 5-minute work interval may be required to maximise time >90%$\dot{V}O_{2max}$. However, no %$\dot{V}O_{2max}$ difference between HIIT sessions was observed for the first 15 seconds of work intervals only [8]. These results, along with the fact that vibration was added intermittently for 30 seconds in the present study, may suggest that there is also a minimum continuous exposure to vibration (i.e., > 30 s) that triggers %$\dot{V}O_{2max}$ and time >90%$\dot{V}O_{2max}$ increases. Future studies are therefore required to identify the best protocols to maximize time >90%$\dot{V}O_{2max}$ while minimizing exposure to vibration.

The literature on vibration training is equivocal [8, 10-13, 23, 37]. While some studies report an increased oxygen cost of cycling when vibration is added [8, 10-13], others do not [23, 37]. It is therefore conceivable that mechanisms unrelated to exposure time may be associated with our findings. In general, the $\dot{V}O_2$ increments due to vibration may reflect an increased recruitment of fast-twitch muscle fibres [14], which are known to have a larger oxygen cost per work unit compared with slow-twitch fibres [17, 18]. This is supported by the observation that whole-body vibration reduces the recruitment threshold of fast-twitch fibres [38], which would, in turn, increase the %$\dot{V}O_{2max}$ sustained during cycling exercise [8, 10-13]. However, as in our study the vibration platform was only switched on during the 30-second blocks at 100%MAP, it seems reasonable to assume that a large proportion of fast-twitch muscle fibres were already recruited as a consequence of the high intensity [19, 20], rendering vibration ineffective.

It has been suggested that, during maximal voluntary contractions, vibration may not cause a further increase in Ia afferent inflow because the fusimotor-driven Ia afferent discharge would have reached a saturation threshold [39]. As such, resistance training investigations have demonstrated that vibration does not increase EMG activity during maximal contractions [40, 41]. Our results with cycling exercise are therefore consistent with previous research [39-41]. In contrast, it has been proposed that, during submaximal contractions, vibration may induce an Ia afferent inflow that exceeds the pre-existing fusimotor-driven Ia afferent discharge, resulting in more motor units being recruited [39]. This, coupled with the fact that vibration has been found to reduce the recruitment threshold of fast-twitch fibres [38], supports the idea that vibration may increase the recruitment of motor units during cycling at submaximal intensities only. We therefore wonder whether adding vibration to the 77%MAP blocks would increase the $\%\dot{V}O_{2max}$ sustained during varied-intensity work intervals, and further increase time $>90\%\dot{V}O_{2max}$. Future studies should test this hypothesis.

This study is not without limitations. No accelerometers were available to ascertain whether the vibration generated by our platform conformed with the nominal parameters [42]. Likewise, it was not possible to verify the vibration frequency and amplitude transmitted to the pedals, saddle, or cyclists' body [42]. However, by using this identical set-up, we have observed increased EMG activity of the vastus lateralis, indicating that the vibration amplitude is transduced to the working muscles [8]. Nevertheless, the vibration experienced by cyclists, especially in the more proximal muscles, was likely lower than elicited by the platform, which could potentially explain our findings (at least partially). Addressing these limitations may be required to elucidate some of the insights described in this article.

In summary, adding vibration during the 30-second blocks at 100%MAP of varied-intensity work intervals neither increase $\%\dot{V}O_{2max}$ sustained nor prolong time $>90\%\dot{V}O_{2max}$ during HIIT compared with a non-vibration condition. Similarly, adding intermittent vibration to varied-intensity work intervals does not affect HR, [La], and RPE. The total time and continuous amount of exposure to vibration as well as the intensity (i.e., % MAP) at which vibration is added are possibly critical factors for increasing time $>90\%\dot{V}O_{2max}$, although this should be subjected to further investigation. Whether intermittent exposure to vibration can enhance the adaptive stimulus triggered by high-intensity interval training remains to be determined.

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