Superior Physiological Adaptations After a Microcycle of Short Intervals Versus Long Intervals in Cyclists

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Purpose: To compare the effects of a 1-week high-intensity aerobic-training shock microcycle composed of either 5 short-interval sessions (SI; n = 9, 5 series with 12 × 30-s work intervals interspersed with 15-s recovery and 3-min recovery between series) or 5 long-interval sessions (LI; n = 8, 6 series of 5-min work intervals with 2.5-min recovery between series) on indicators of endurance performance in well-trained cyclists. ***Methods:*** Before and following 6 days with standardized training loads after the 1-week high-intensity aerobic-training shock microcycle, both groups were tested in physiological determinants of endurance performance. ***Results:*** From pretraining to posttraining, SI achieved a larger improvement than LI in maximal oxygen uptake (5.7%; 95% confidence interval, 1.3–10.3; $P = .015$) and power output at a blood lactate concentration of 4 mmol·L^{-1} (3.8%; 95% confidence interval, 0.2–7.4; $P = .038$). There were no group differences in changes of fractional use of maximal oxygen uptake at a workload corresponding to a blood lactate concentration of 4 mmol·L^{-1}, gross efficiency, or the 1-minute peak power output from the maximal-oxygen-uptake test. ***Conclusion:*** The SI protocol may induce superior changes in indicators of endurance performance compared with the LI protocol, indicating that SI can be a good strategy during a 1-week high-intensity aerobic-training shock microcycle in well-trained cyclists.

Keywords: endurance training, high-intensity aerobic training, intense exercise

There are a number of variables to consider when designing an endurance training program aiming to improve endurance performance, including training frequency, training duration, and training intensity.[1] The importance of high-intensity aerobic training (HIT) to improve endurance performance in well-trained endurance athletes is established (eg, Laursen and Jenkins's study[2]). During the past years, focus has been shed on the potential endurance performance benefits of block periodization,[3] wherein shorter training periods are dedicated to focus on improving a few selected abilities in well-trained endurance athletes.[4] Furthermore, it has been observed that 5- to 14-day of HIT shock microcycle leads to improvement in measurements of aerobic fitness following 5 to 14 days of reduced load.[5,6] However, it remains to be investigated whether different HIT intervals during a short HIT shock micro-cycle induce different training responses.

The HIT can roughly be divided into longer work intervals of ~3 to 5 minutes at a high exercise intensity or shorter work intervals of ~15 to 45 seconds at even higher exercise intensities.[7] Different work–recovery ratios have been used, and 2:1 or 1:1 ratios are frequent choices.[8] Both short intervals[9,10] and long intervals[11] have been demonstrated to improve endurance performance or performance-related parameters in already endurance-trained participants. The few studies that have compared the training effects of shorter and longer intervals in endurance-trained participants usually report similar performance improvements.[12,13] However, differences in volume of HIT and matching training regimens on total energy expenditure make it somewhat difficult to interpret the results. For example, matching interventions on energy consumption has been suggested to artificially constrain the training in a manner that is not representative of how athletes perform their training in real life.[14] We have previously demonstrated that effort- and volume-matched that is based on rate of perceived exertion (RPE) score and duration, short intervals improves performance in well-trained cyclists to a greater extent than longer intervals.[15,16] However, whether this is also the case during a short HIT block remains unexplored. Therefore, the present study investigates the effects of performing short intervals versus long intervals during a 1-week HIT shock microcycle consisting of 5 HIT sessions. Based on our previous results, we hypothesized that short intervals would induce superior improvement in indicators of endurance performance.

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Methods

Subjects

A total of 17 male participants at a national level and a mix of road and cross-country mountain bike cyclists volunteered for the study and all completed the study. Based on the maximal oxygen uptake ($\dot{V}O_2$max), peak aerobic power output, measured as 1-minute peak power output from the $\dot{V}O_2$max test (W_{max}), and training characteristics, the cyclists were regarded as trained to well trained.[17] The cyclists were assigned and counterbalanced to create 2 homogenous groups based on absolute $\dot{V}O_2$max: a short-interval group (SI; n = 9, age = 28 [8] y, body height = 180 [5] cm, body mass = 70.6 [4.3] kg) and a long-interval group (LI; n = 8, age = 27 [5] y, body height = 182 [3] cm, body mass = 78.0 [5.6] kg). The study was performed according to the ethical standards established by the Declaration of Helsinki 1975 and was approved by the ethical committee at Norwegian School of Sport Sciences (ref 38-191217). All cyclists signed an informed consent form prior to participation.

Experimental Design

The main objective of the present study was to compare the effect of a short, 1-week HIT shock microcycle composed by 5 HIT sessions performed as either multiple short intervals or long intervals followed by a 1-week recovery period on indicators of endurance performance in well-trained cyclists. Therefore, no control group that continued their usual training was included. All testing was performed on 1 day and started with an incremental cycle test for determination of gross efficiency (GE), power output, and fractional utilization of $\dot{V}O_2max$ at a blood lactate concentration ([La$^-$]) of 4 mmol·L^{-1}. After a 10-minute recovery period, a $\dot{V}O_2max$ test was performed. The intervention was completed during the cyclists' preparatory period.

Testing Procedures

Training during the 2 days preceding pretest was limited to low exercise intensity. Participants were also instructed to finish the same type of meal 2 hours preceding the pretest and posttest. All tests were performed under similar environmental conditions (16°C–19°C) with airflow of 2 to 3 m·s^{-1} toward the participants' frontal surface). Strong verbal encouragement was given during all tests to ensure maximal effort. All tests for the individual cyclists were conducted at the same time of day (±1 h) to avoid influence of circadian rhythm. The individual amount of water and sports drink consumed during the pretest was replicated during the posttest. All testing was performed on the same electromagnetically braked cycle ergometer (Lode Excalibur Sport; Lode B.V., Groningen, The Netherlands), which was adjusted according to each cyclist's preference for seat height, horizontal distance between tip of seat and bottom bracket, and handlebar position. Identical seating positions were used during all tests.

The testing started with a blood lactate profile initiated with 5-minute cycling at 125 W followed by 50 W increases every 5 minutes. Blood was sampled from a fingertip at the end of each 5-minute bout and analyzed for whole blood [La$^-$] using a Biosen C-line lactate analyzer (EKF Diagnostic GmbH, Barleben, Germany). When reaching a [La$^-$] of 3 mmol·L^{-1}, every 5 minute bout increased by 25 W, and the test was terminated when a [La$^-$] of 4 mmol·L^{-1} or higher was measured. $\dot{V}O_2$, respiratory exchange ratio, and heart rate (HR) were measured during the last 3 minutes of each bout. HR was measured using a Polar S610i HR monitor (Polar, Kempele, Finland). $\dot{V}O_2$ was measured (30 s sampling time) using a computerized metabolic system with mixing chamber (Oxycon Pro; Erich Jaeger, Hoechberg, Germany). The gas analyzers were calibrated with certified calibration gases of known concentrations before every test. The flow turbine (Triple V; Erich Jaeger) was calibrated before every test with a 3-L, 5530 series, calibration syringe (Hans Rudolph, Kansas City, MO). The same metabolic system with identical calibration routines was used on all tests. From this cycling test, power output and fractional use of $\dot{V}O_2max$ at 4 mmol·L^{-1} [La$^-$] was calculated. At the power output of 225 W during this incremental test,[18] GE was calculated by the oxygen equivalent[18] and the matching respiratory exchange ratio values to establish the energy expended ($\dot{V}O_2$ L·s^{-1}; 4840 J·L^{-1} respiratory exchange ratio + 16,890 J·L^{-1})[19] and divide this by the power output and multiply by 100. After termination of the blood lactate profile test, the cyclists had 10 minutes of recovery before completing another incremental cycling test for determination of $\dot{V}O_2max$. The test was initiated with 1 minute of cycling at a power output of 200 W. Power output was subsequently increased by 25 W every minute until exhaustion, defined as a cadence below 60 rpm. $\dot{V}O_2max$ was calculated as the average of the 2 highest consecutive 30-second $\dot{V}O_2$ measurements. W_{max} was calculated as the mean power output during the last minute of the incremental $\dot{V}O_2max$ test. Peak HR and [La$^-$] were measured immediately and 1 minute after the $\dot{V}O_2max$ test, respectively.

Training Intervention

The training intervention was performed during the cyclists' preparatory period. During the 2 weeks prior to the intervention, the performed training was categorized based on the 3-zone model presented by Sylta et al.[20] SI and LI performed 10.0 (5.4) and 7.9 (8.1) hours per week ($P = .20$), respectively, of low-intensity training (60%–82% of peak heart rate [HR_{peak}]); 1.5 (1.0) and 1.4 (0.9) hours per week ($P = .96$), respectively, of moderate-intensity training (83%–87% of HR_{peak}); 0.9 (0.6) and 0.9 (1.0) hours per week ($P = .20$), respectively, of HIT (88%–100% of HR_{peak}); and 0.2 (0.4) and 0.2 (0.3) hours per week, respectively, with strength/core training with no differences between groups ($P = .63$). There were also no differences between SI and LI in training duration or intensity distribution during the 12 weeks prior to the study; low-intensity training: 8.5 (4.9) versus 6.9 (3.1) hours per week ($P = .63$), respectively, moderate-intensity training: 1.4 (0.9) versus 2.2 (1.1) hours per week ($P = .31$), respectively, HIT: 1.2 (0.7) versus 1.2 (0.6) hours per week ($P = .91$), respectively, and strength/core: 0.3 (0.3) versus 0.3 (0.6) hours per week ($P = .85$), respectively. If training was performed below 60% of HR_{peak}, it was registered as low-intensity training.

During the 1-week HIT shock microcycle, both groups performed one daily HIT session for the 3 first consecutive days, followed by a recovery day and then another HIT session on day 5, recovery on day 6, and the final HIT session on day 7. During the subsequent recovery week, both groups had complete rest on the 2 first days, followed by 60 minutes easy cycling on the third day, the fourth day contained 15 minutes of warm-up followed by 4 × 5 minutes of moderate intensity (75%–85% of HR_{peak}), while the fifth day was a rest day. On the sixth day, 30-minute easy cycling was performed followed by 3 × 1 minute with gradually increasing intensity toward W_{max}. The final test session was on day 7. During the HIT sessions, the participants in both groups were instructed to achieve a RPE after each series equal to 17 to 19 on Borg's 6 to 20 scale.[21] Power output and HR during all work series were recorded. Power output during recovery was around 50% of the work intervals. All HIT sessions were performed with the participants' own bikes mounted on an electromagnetically braked roller (Computrainer LabTM; Racer Mate Inc, Seattle, WA). The HIT sessions in the SI group were designed as 5 series consisting of 12 work intervals lasting 30 seconds separated by 15-second recovery periods. Each series was followed by 2.5-minute recovery period. The LI group performed 6 × 5-minute work intervals separated by 2.5-minute recovery periods. Thus, the total time of work intervals in one interval session for SI and LI was 30 minutes, while the total recovery period was 20 and 12.5 minutes (in order to balance total work interval duration), respectively. Fifteen minutes after the last work interval, both groups rated a session RPE score.[22] Similar effort during both the SI and LI training was evident via similar mean RPE across all work intervals (P value range: .06–.35) and similar session RPE across all HIT sessions (P value range: .42–.81; Table 1). All HIT sessions were supervised.

Each interval session started with an individual 15-minute warm-up that was concluded by 2 to 3 submaximal sprints lasting 20 to 30 seconds. The individual SI sessions were programmed in

Table 1 Mean and 95% CI for Mean Power Output (in Watts), Relative Power Output (%W_{max}), HR_{mean}, RPE, and Session RPE Obtained During Sessions 1 to 5 in SI and LI

	Power, W		%W_{max}		HR_{mean}, beats·min^{-1}		RPE (6–20)		Session RPE	
	SI	LI	SI	LI	SI	LI	SI	LI	SI	LI
Session 1	381.4 (349.1 to 413.6)	295.8 (263.4 to 328.2)†	86.2 (81.5 to 90.8)	67.7 (63.0 to 72.4)†	170.4 (165.6 to 175.2)	170.4 (165.6 to 175.2)	17.4 (16.9 to 17.9)	17.1 (16.7 to 17.5)	6.9 (6.0 to 7.7)	6.4 (5.6 to 7.2)
Session 2	383.9 (351.9 to 415.9)	304.4 (272.2 to 336.6)	86.5 (81.9 to 91.2)	69.4 (64.7 to 74.1)	169.5 (164.7 to 174.3)	171.5 (166.7 to 176.3)	17.7 (17.4 to 18.1)	17.7 (17.4 to 18.1)	7.2 (6.4 to 8.0)	6.8 (5.9 to 7.6)
Session 3	381.6 (349.5 to 413.6)	308.4 (276.2 to 340.6)†	86.1 (81.4 to 90.7)	70.7 (66.0 to 75.3)	168.7 (163.9 to 173.5)	170.2 (165.5 to 175.0)	17.8 (17.5 to 18.1)	17.7 (17.4 to 18.0)	7.4 (6.6 to 8.2)	7.0 (6.1 to 7.8)
Session 4	390.1 (358.1 to 422.1)*	313.8 (281.6 to 346.0)†	88.1 (83.4 to 92.9)	71.6 (66.9 to 76.3)	169.5 (164.6 to 174.4)	170.0 (165.3 to 174.8)	17.7 (17.4 to 18.0)	17.7 (17.4 to 18.1)	7.2 (6.4 to 8.1)	6.8 (5.9 to 7.6)
Session 5	389.8 (357.5 to 422.0)*	315.2 (282.8 to 347.6)†	88.1 (83.4 to 92.8)	71.8 (67.1 to 76.5)	168.2 (163.2 to 173.1)*	172.3 (167.5 to 177.1)†	17.9 (17.5 to 18.2)	18.0 (17.7 to 18.4)	7.6 (6.7 to 8.4)	7.1 (6.3 to 7.9)

Abbreviations: CI, confidence interval; HR_{mean}, mean heart rate; LI, long-interval group; RPE, rating of perceived exertion; SI, short-interval group.
*Different from session 1, $P < .05$. †Significantly different from SI, $P < .05$.

the software to the roller. The power output during the work intervals was individual adjusted between each interval series to ensure correct RPE. Mean power output and relative mean power output (%W_{max}) were significantly higher in SI compared with LI at the first session (P < .05), and remained higher throughout sessions (pairwise comparisons). From session 1 to sessions 3, 4, and 5, LI increased mean power output significantly more than SI (P < .05, Table 1).

Statistical Analyses

Data are presented as mean and SD or 95% confidence interval (CI) (lower limit to upper limit) unless otherwise stated. Training session data were analyzed using linear mixed-effects models, wherein training parameters (ie, power output, %W_{max}) were used as dependent variables and session, group, and their interaction were used as fixed effects. Random intercept for subject and interval was applied to the models when appropriate. Physiological variables were fitted to a mixed-effects model containing time, group, and their interaction as fixed effects with random intercepts applied for each subject. For these variables, the standardized effect sizes (ESs) were calculated as mean differences divided by the pooled SD for the difference between group change scores (post–pre = Δ) with differences between groups calculated as ΔSI – ΔLI. Magnitudes of the standardized effects were interpreted as follows: 0.0 to 0.19, trivial; 0.20 to 0.59, small; 0.60 to 1.19, moderate; 1.20 to 1.99, large; and 2.00 to 3.99, very large. Residual plots for each model were visually inspected to see that assumptions were met. The α level was set a priori to .05. The magnitude of observed effects was interpreted from the 95% CI. All statistical analyses were conducted in R (version 3.6.1; https://www.r-project.org).

Results

From preintervention to postintervention, SI had a larger improvement than LI in $\dot{V}O_2$max (time × group P = .02, ES = 1.28; Figure 1A), concomitant with a nonsignificant mean difference between group changes in W_{max} (time × group P = .21, ES = 0.63; Figure 1B) and GE (time × group P = .09, ES = 0.85; Figure 2B). Improvement in power output at 4 mmol·L^{-1} [La$^-$] was greater in SI compared with LI (time × group P = .04, ES = 1.09; Figure 2A). LI increased fractional use of $\dot{V}O_2$max at 4 mmol·L^{-1} [La$^-$] from preintervention to postintervention (77.2% [4.2] to 79.8% [5.8]) while SI remained unchanged (77.9% [5.3] to 77.9% [5.0]) resulting in a nonsignificant mean difference between group changes ΔSI versus ΔLI –2.5% (95% CI, –5.6 to 0.6, P = .11, ES = –0.83).

The SI showed an average increase, while LI showed an average decrease in peak [La$^-$] after the $\dot{V}O_2$max test from preintervention to postintervention (14.0 [1.8] to 15.0 [1.9] vs 12.3 [2.1] to 11.8 [3.2] mmol·L^{-1} [La$^-$]) resulting in an nonsignificant mean difference between group changes ΔSI versus ΔLI 1.4 mmol·L^{-1} [La$^-$] (95% CI, –0.5 to 3.3; P = .13, ES = 0.79). There were no differences between *SI* and *LI* in peak HR after the

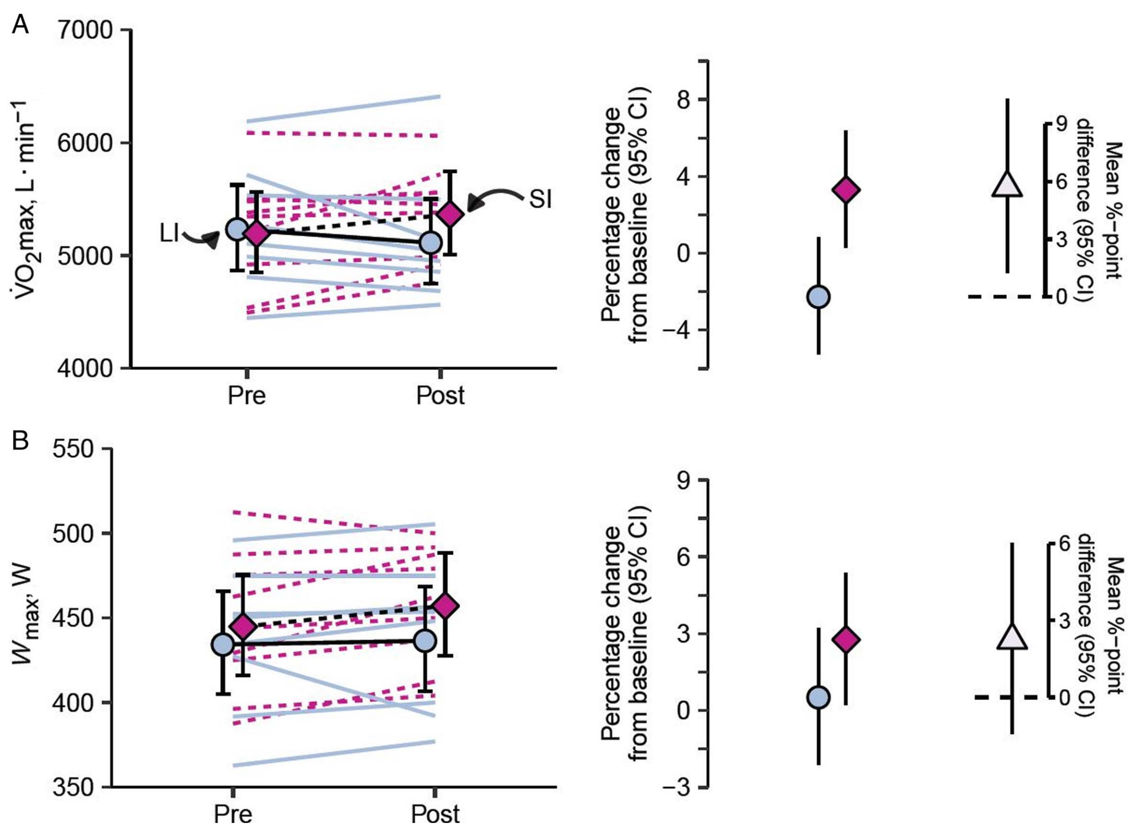

Figure 1 — Individual data and group averages (left panel) and mean group changes and differences in change scores between SI and LI (right panel) in $\dot{V}O_2$max (A) and W_{max} (B) derived from incremental cycling tests before (Pre) and after (Post) a high-intensity interval-training block. Data are presented as mean and 95% CI based on estimates from mixed-effects models. Unbroken lines in the left panel denote individual data for the LI group, and dashed lines, for the SI group. CI indicates confidence interval; LI, long-interval group; SI, short-interval group; $\dot{V}O_2$max, maximal oxygen uptake.

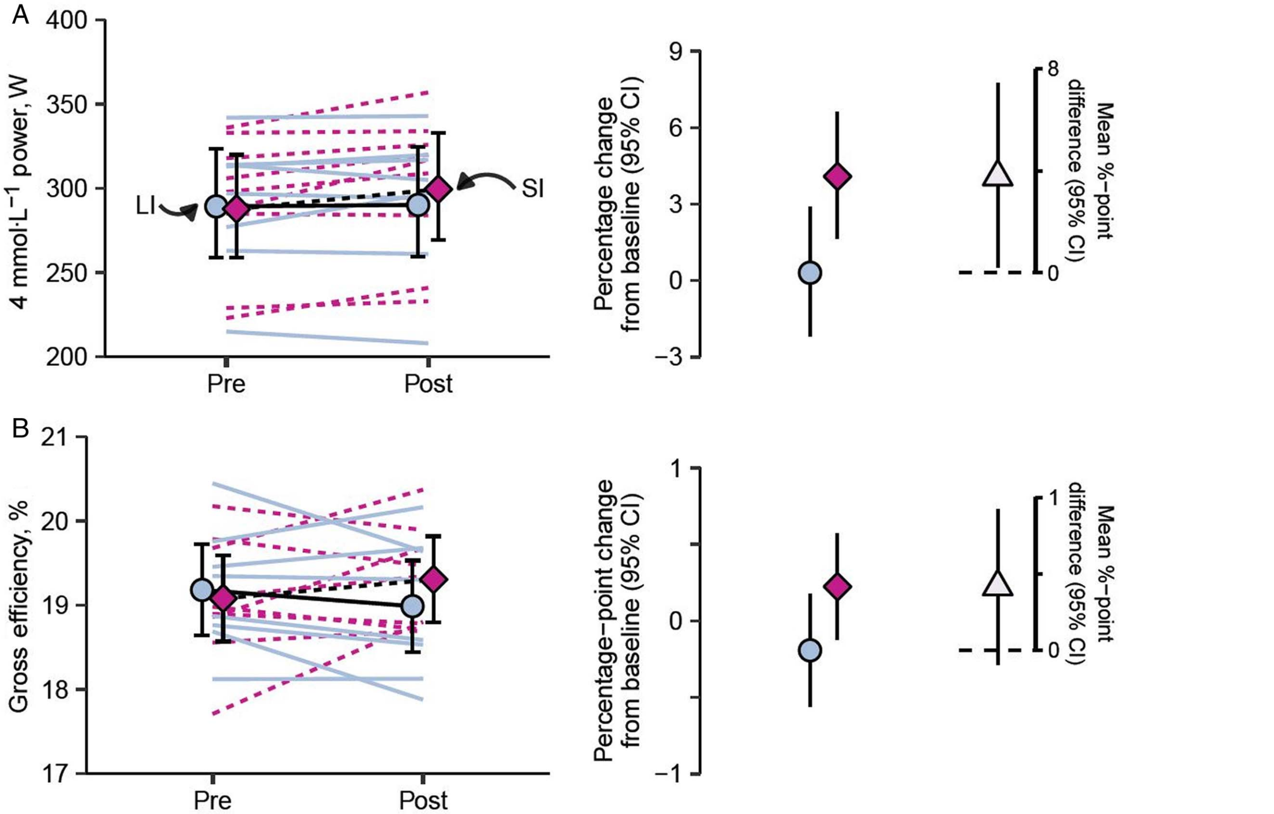

Figure 2 — Individual data and group averages (left panel) and mean group changes and differences in change scores between SI and LI (right panel) in power (in watts) at a lactate concentration of 4 mmol·L^{-1} (A) and gross efficiency (B) derived from submaximal cycling tests before (Pre) and after (Post) a high-intensity interval-training block. Data are presented as mean and 95% CI based on estimates from mixed-effects models. Unbroken lines in the left panel denote individual data for the LI group, and dashed lines, for the SI group. CI indicates confidence interval; LI, long-interval group; SI, short-interval group.

$\dot{V}O_2$max test from preintervention (191 [8] vs 186 [9] beats·min^{-1}) to postintervention (190 [9] vs 185 [8] beats·min^{-1}, $P = .99$).

Discussion

The primary findings in the present study support our stated hypothesis that a short HIT shock microcycle composed of SI induces superior improvements in indicators of endurance performance, measured by power output at 4 mmol·L^{-1} [La$^-$] and $\dot{V}O_2$max, compared with a short HIT shock microcycle of LI. Furthermore, the mean percentage change from baseline in W_{max} revealed a moderate ES of SI (ES = 0.63; Figure 1) and concomitant moderate ES of SI versus LI on changes in peak lactate concentrations (ES = 0.79).

The superior improvements in $\dot{V}O_2$max in SI compared with LI is in agreement with a 10-week study on cyclists at similar fitness level as the present study[15] and a 3-week study on cyclists at a higher fitness level than the present study.[16] However, our findings contradict previous studies that reported similar improvements following SI and LI training in trained to well-trained endurance athletes.[12,13] Some of this discrepancy can be related to the use of longer recovery periods (4.5 min) between work intervals which potentially gives a lower stimulus of the cardiovascular system, measured as mean $\dot{V}O_2$ or time above 90% of $\dot{V}O_2$max during the session,[8,23] than shorter recovery periods[24] and might therefore not be optimal for cardiovascular training adaptations. On the other hand, an argument for increased recovery period is that this increases the muscular exercise intensity during the work periods, and it has been shown an ergogenic potential of supramaximal efforts in well-trained athletes.[25]

Further evidence for greater improvements in SI compared with LI is found in the larger improvement in power output at 4 mmol·L^{-1} [La$^-$], which is related to the ability to maintain a higher power output during a long-term endurance competition (eg, Lucia et al[26]). In the current study, it seems likely that the larger increase in power output at 4 mmol·L^{-1} [La$^-$] in SI compared with LI is mainly explained by the greater improvement in $\dot{V}O_2$max in SI, since there were no significant differences between groups in changes of GE or fractional use of $\dot{V}O_2$max at power output corresponding to 4 mmol·L^{-1} [La$^-$]. The increase in $\dot{V}O_2$max in SI, but not in LI, likely explains the moderate ES of LI versus SI in fractional use of $\dot{V}O_2$max at power output corresponding to 4 mmol·L^{-1} [La$^-$]. Furthermore, the moderate ES of SI versus LI on improvement in GE can in theory contribute their superior improvement in power output at 4 mmol·L^{-1} [La$^-$] and their moderate ES in W_{max}. The moderate ES of improvements in GE in SI versus LI was somewhat surprising, since work economy is often reported to be quite stable in well-trained endurance athletes.[15] It should be noted that this observation is due to an numerical 0.2%-point improvement in SI and a 0.2%-point reduction in LI, and thus, the within-group changes seem to be minor. However, it has also been observed that 6 to 7 days in a row with daily short intervals induces improved or tendencies to improved GE in competitive cyclists.[5,6]

The quality of a HIT session can be defined by mean $\dot{V}O_2$ or accumulated training time ≥90% $\dot{V}O_2$max[8,23] possibly due to the large stimulus for myocardial morphological adaptations that increases maximal cardiac stroke volume and also more peripheral skeletal muscle adaptations.[8] In line with the latter, recreationally trained cyclists who spent ~100 seconds more time above ~90% of $\dot{V}O_2$max per training session achieved the largest improvement in $\dot{V}O_2$max and power output at the lactate threshold.[23] We have previously shown that SI acutely gives a longer time ≥90% of $\dot{V}O_2$max than approximately 3- to 5-minute work intervals.[27] Based on these rationales, it might be suggested that the training stimulus, defined as time above 90% of $\dot{V}O_2$max, was larger in the present SI than the LI and thus explains larger improvements in SI. Another highly relevant explanation for the superior improvement in SI could be related to the higher mean power output in the work intervals (approximately 86%–88% vs 68%–72% of pre W_{max}, respectively). In line herewith, it has been reported that volume-matched HIT intervals at 100% of W_{max} induce superior gene expression of peroxisome proliferator-activated receptor gamma coactivator 1-alpha, which could have led to greater mitochondrial biogenesis, compared with HIT intervals at 73% and 130% of W_{max} in recrea-tionally trained participants.[28] However, morphological changes in both cardiac and skeletal muscles are likely too time demanding to take place in the present study.[29] Indeed, increased plasma volume can occur within days and could thus theoretically contributed to the observed superior improvement in $\dot{V}O_2$max in SI.[29]

The fact that LI did not improve in any measurement after the 1-week HIT shock microcycle might be unexpected. However, it is important to acknowledge that the high training status of the included cyclists combined with the short intervention period makes it difficult to achieve significant changes. Despite both groups were closely matched for total duration and exertion of work intervals, it is possible that that the longer, continuous work intervals in LI were more demanding and induced a residual fatigue and insufficient recovery into the posttest compared with the shorter, 30-second work intervals in SI. Indeed, previous research examining the effects of short-term overreaching, by using longer work intervals similar to LI, has reported performance decrements in cyclists 1-week postintervention,[30] while studies using multiple short intervals, similar to SI, report improvements in performance-determining variables 1 week after a week with HIT.[5,6] However, adding 1-week HIT shock microcycle consisting of LI interspersed with 2 to 3 weeks with focus on low and moderate exercise intensity have shown larger improvements in performance-deter-mining physiological variables than simply distribute the same total training content evenly across each training week.[31,32] Based on the present findings, it can be hypothesized that replacing the LI shock microcycles with SI shock microcycles may have an even larger performance enhancing effect in trained athletes. Recently, a compressed performance peaking protocol was suggested. It con-sisted of 6-day HIT overload, via SI, followed by 5-day taper and was shown to be superior to a traditional 11-day taper approach (maintaining HIT sessions and reducing total training volume).[6] The present study supports the use of SI during the compressed overload period in the compressed performance peaking protocol. Furthermore, changing the exercise intensity and breaking up a monotonous exercise can increase the rate of perceived enjoy-ment[33] and may also count in favor of SI versus LI, despite no differences between groups in RPE or session RPE.

The $\dot{V}O_2$max is related to W_{max}, and therefore, it was some-what expected that there was a moderate ES of SI versus LI on W_{max} (Figure 1). However, there was a lack of a statistical difference between the 2 groups in change of W_{max} (~3%). W_{max} is influenced not only by $\dot{V}O_2$max and work economy, but also incorporates anaerobic capacity and neuromuscular characteristics,[34] which we have not measured in the present study. Notably, SI had a moderate ES of changes in peak lactate concentrations after the $\dot{V}O_2$max test. Even though there was no statistically significant difference between the groups in change of W_{max}, it could be suggested that the moderate ES in SI compared with LI is of physiological relevance in well-trained athletes.

Some limitations of the present study may be related to the experimental design, specifically the small sample size, lack of an endurance performance test, like, for example, a 40-km time trial and the short intervention period. However, the aim of the project was to investigate potential effects of a short 1-week HIT shock microcycle composed of either SI or LI, and it can also be argued that finding group differences with few and highly trained persons in each group is interesting and highly relevant in terms of both block periodization and performance peaking. Although the present groups were matched on absolute $\dot{V}O_2$max, there was a difference between groups in body mass, where SI had a lower body mass than LI. Thus, it can be argued that in terms of relative values of $\dot{V}O_2$max and W_{max}, SI had a higher training status than LI. Some may argue that a potential higher training status can induce a more rapid recovery, while, on the other hand, it can be argued that a potential higher training status leaves less room for improvements.

Practical Applications

The results of the present study indicate that a 1-week HIT shock microcycle consisting of multiple short intervals (30-s work bouts) induces a larger improvement in physiological determinants of endurance cycling performance than longer intervals (5-min work bouts). Thus, practitioners considering using HIT shock microcycle, either as a part of the regular training or as a part of performance peaking, may consider implementing multiple short-interval training, like the present SI protocol. However, the specific mechanism through which SI training improves this performance remains unclear and that is also the case for the long-term training effects.

Conclusion

The SI induced superior training adaptations in physiological determinants of endurance cycling, measured by $\dot{V}O_2$max and power output at 4 mmol·L^{-1} [La$^-$], compared with LI.

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