Table1: Simulated Altitude Protocols and Physiological Effects

Hypoxia High Intensity Interval Training (HHIIT)

	Simulated altitude	Hypoxia (FiO_2)	Intensity	Duration	Vo2 max ($mL.kg^{-1}.min^{-1}$)	Anaerobic performance	Physiology effects	Participants	Authors
1	≈ 2,500-2,600m	15.2%	• intensity 95% WR_{LT}	3 WKS	↑67.8 -> 70.5, 3.98%*	• ↑average generated power • ↑average speed	• ↑VO_{2LT}, ↑MCV • ↑WR_{max}, ↑WR_{LT}, ↑ΔLA • No effect on hematological variables: RBC, HGB, HCT	well-trained cyclists, 20 males elite cyclists,	Czuba et al., [1]
2	≈2500m		• HIIT, 3 sessions/week	3 WKS	↑52.6 ->56.7, 7.8%		• ↑WRmax, absolute (4.5%) and relative (6.2%) • ↓ΔLA • No effect in hematological variables in hypoxic	well trained basketball players 20 males	Czuba et al., [29]
3	≈3000m	14.6%	• 8 cycling repeated sprint interval	4 WKS /12times	↑59.3 -> 62.9 6.1 %	↑average power	• ↑RSH • ↑mRNA concentrations of HIF-1a (+55%), • ↑carbonic anhydrase III* (+35%) • ↑monocarboxylate transporter-4 (+20%) • molecular adaptations • larger blood perfusion variations in active muscles • changes in hemoglobin variations during sprints throughout RSA	trained male cyclists, 50 moderately	Faiss et al., [19]
4	≈2500m	15.3%	3 high-intensity training sessions	5 WKS	• ↑0.11±0.18 l/min, 4.2 ±7.0% • No effect in nomoxia 0.16 ± 0.23 l/min, 6.4 ±8.1%	• ↑power output • ↑swimming velocity		Sixteen well-trained collegiate and Masters swim- mers (10 women, 6 men)	Truijens et al.,[31]

5	≈3,000m		• The interval training in: consisted of 6 – 8 reps of 2–3 min duration at 100% PPO during the first 4 wk • increased to 5 reps of 5– 6 min at 90% of PPO, then 4 reps of 8 min at 90% of PPO in the last week of training • IHT: hypoxic training conditions • IHIT: performed the warm-up, the cool-down, and the recovery from each interval in hypoxia, high-intensity exercise in normoxia	• 7-wk training program	• ↑IHIT : VO_{2max} ($L \cdot min^{-1}$) (8.7 ± 9.1%; $P < 0.05$)		• IHT: No statistic effect in V O_{2max} 4.62 ± 0.33 ->5.02 ±0.42, 8% P > .05 • NOR : V O_{2max} 4.47 ± 0.36 ->4.69 ± 0.29 4%	Thirty-three well-trained cyclists and triathletes	Roels et al., [30]
6	N/A	15.2%	HIIT	3 WKS	↑ maximal oxygen uptake		• ↑Serum hypoxia-inducible factor • ↑nitric oxide levels • ↑vascular endothelial growth factor • ↑transforming growth factor- • No effect on serum baseline angiogenic factors and cytokines	Twelve physically active male subjects	Żebrowska et al., [32]
7	≈2,500m	15%	• SIT consisted of six WAnT sessions over a 2-week period with 24–48 h between each session	2 WKS recovery; 4–7 repetitions)	↑$\dot{V}O_{2\ peak}$ +11.9%	• ↑power at AT and TTE performance ↑anaerobic threshold +13.3%	• ↑TTE improved +32.2% • ↑interleukin-6 (IL-6) +17.4% • ↑AT: anaerobic threshold ($mL.kg^{-1}.min^{-1}$) +9.5% • ↑TNF-α +10.8% * • No between group change occurred in 30s sprint performance or Hb and Hct.	Forty-two untrained, but recreationally active individuals (27 males, 15 females) age 21 ± 1	Richardson et al., [22]

Hypoxia Training in Incremental protocol

	Simulated altitude	Hypoxia (FiO_2)	Intensity	Duration	Vo2 max ($mL.kg^{-1}.min^{-1}$)	Anaerobic performance	Physiology effects	Participants	Authors
8	≈2,500 - 3,000 m	FIO_2 17% on day 1 to 14% on day 10; the SpO_2 value was controlled at 88% on days 1-2, 84% on days 3-4, and 82% on days 5-10.	• interval training • 3 times per week • 4 sets of all-out 30-second sprint intervals	3 WKS	increased by 3.98%	• ↑lactate threshold, • ↑power output • ↑average speed	• no differences in hematological variables	trained cyclist	Czuba et al., [1]
9		• D1-5: 12% • Days 6 to 10: 11% • Days 11 to 15: 10. 9%	The weekly schedule in nomoxia • 7-km race, 6 paddling sessions at aerobic threshold, • 4 interval paddles at race-specific intensities, • 2 resistance-training sessions	2 WKS		• 6.8% enhancement in peak power* • 8.3% improvement in mean repeat sprint power *	• 3.6% increase in hemoglobin concentration	10 sub-elite male short-distance sprint light-boat athletes	Bonetti et al.,[16]
10	≈2,000 m		• first phase: consisted of 30 min of low-intensity continuous exercise (e.g., walking) at 60-70% of maximum HR • second phase: consisted of eight sets of 2-min high-intensity exercise with 1-min rest between sets at 85-95% of maximum HR.	8 WKS			• increase in FMD • increase in DPA • reduce arterial stiffness * • reduce baPWV		Nishiwaki et al., [34]

Hypoxia Submaximal Exercise training and Combined Training

Simulated altitude	Hypoxia (FiO_2)	Intensity	Duration	Vo2 max ($mL.kg^{-1}.min^{-1}$)	Anaerobic performance	Physiology effects	Participants	Authors

11	≈3,000 m	submaximal exercise: 90 min, 3 days per week for six weeks, ergometer exercise load 80% HRmax	6 WKS			• ↑maximal oxygen uptake • ↑the hemodynamic function (e.g., oxygen uptake, oxygen pulse, and cardiac output) • ↑ hemodynamic and ANS function • not adversely affect immune function • ↓VO_2	20 athletes	Jung et al., [37]
12	≈3,000 m	submaximal exercise: 30 mins endurance exercise, cycle ergometer with HR level corresponding to 70% HRmax	30 mins		↑ anaerobic metabolism: oxygen inflow into skeletal muscle tissue	• lower exercise load with the same RPE • a lower SpO_2, VO_2, oxygen pulse, oxhb, and StO_2, and a higher RER and dxhb during exercise	12 healthy men	Park et al., [15]
13	≈3200m~4400m	Sixteen well-trained athletes completed 90 min of endurance training (60–70% of heart rate reserve), followed by two 30-s all-out sprints (Wingate test), daily, for 10 consecutive days.	10 days	V_E 14.5 ± 16.6 Vo_2 – 0.52 ± 0.52	the mean power during the 30-s Wingate test increased by 3.0% 2 days, and 1.7% 9 days post-IHT	• oxygen cost –8.0% • During the time trial, the IHT participants' blood lactate concentration, respiratory exchange ratio, and SpO_2, relative to the placebo group, was substantially increased at 2 days post-intervention. • IHT to the normal training program of well- trained athletes produced worthwhile gains in 30s sprint performance possibly through enhanced glycolysis.	Sixteen well-trained athletes in variety of cycling backgrounds	Hamlin et al., [21]
14	≈3,000 m	Multi Component: training: Running, Cycling, and Resistance training	6 WKS	↑54.6 -> 60.1 +13.3%	peak anaerobic power ↑50 m free-style 28.2 s -> 27.2 s	• Muscular function and hormonal response parameters GH, insulin like growth factor-1; IGF-1, and vascular endothelial growth factor, VEGF have interaction effects	20 swimmers (10,10)	Park & Lim, [2]

15	≈3,000 m		3sessions of sub-intensity (60% VO_2max) aerobic endurance training; interval training consisted of three sets of 2 intervals at a peak power-output (PPO) intensity of 100% for 2 min, 2-min rest state between intervals	3 WKS sessions	• No difference in $V O_{2\ max}$	• ↑ power output (P_{aver})	• ↑ PPO in nomoxia 7.2 % • ↑ PPO in hypoxia 11.3%	19 well cycling athletes	Roels et al., [45]

Exposure hypoxia environment in Recovery and Sleep state

	Simulated altitude	**Hypoxia (FiO_2)**	**Intensity**	**Duration**	**Vo2 max ($mL.kg^{-1}.min^{-1}$)**	**Anaerobic performance**	**Physiology effects**	**Participants**	**Authors**
16	≈3000m		• The interval training in: consisted of 6 – 8 reps of 2–3 min duration at 100% PPO during the first 4 wk • increased to 5 reps of 5– 6 min at 90% of PPO, then 4 reps of 8 min at 90% of PPO in the last week of training • IHT: hypoxic training conditions • IHIT: performed the warm-up, the cool-down, and the recovery from each interval in hypoxia, high-intensity exercise in normoxia •	• 7-wk training program	• ↑IHIT : VO_{2max} ($L·min^{-1}$) (8.7 ± 9.1%; $P < 0.05$)		• IHT: No statistic effect in $V O_{2max}$ 4.62 ± 0.33 ->5.02 ±0.42, 8% P > .05 • NOR : $V O_{2max}$ 4.47 ± 0.36 ->4.69 ± 0.29 4%	Thirty-three well-trained cyclists and triathletes	Roels et al., [17]

17	≈2000m	12.3%	• submaximal exercise in nomoxia, exposure to hypoxia during a resting state in tent.	3h per day for 14 consecutive days	• ↑IHIT 55.8 -> 59.7 7.0%*		HR (beats/min^{-1}) * • All hematological no changed through out the experimental period in both groups	15 trained male endurance runners	Katayama et al., [38]
18	≈2,000- to 3,100-m	14.3%	• (LHTL) compared lived low trained low (LLTL). • 20 nights of sleeping at	3 WKS /9 times simulated altitude while training at 600-m altitude	• 54.7 -> 61.5 ↓whole body VO_2		• no effect on Hb_{mass} • ↑running economy • O_2 (l/min) averaged across the three submaximal running speeds was 3.3% lower (LHTL)	elite distance runners	Saunders et al., [40]
19	≈3,000m	14.3%	• LHTL • 23 nights in simulated moderate altitude (3000 m)			Muscle buffer capacity and metabolites 17.7 ± 4.9%	• VO_{2peak} fell after LHTL 7% • Submaximal VO_2 ↓ and effciency improved 0.8% • improved exercise effciency is a fundamental adaptation to LHTL.	13male athletes (triathletes, cross-country skiers and cyclists)	Gore et al., [39]
20	≈4,000–5,500 m		Individualized training plans	4 WKS	• no effect on VO_{2max}, l/min, 3.7±0.6 ->3.8±0.7		• no change in economy • no differences in submaximal HR, La^-, VE, or velocity at VO_{2max}	13swimmers, 10 runners	Truijens et al., [41]

ANS = Autonomic Nervous System, baPWV = brachial–ankle pulse wave velocity, COi = cardio output, DPA = diameter of the popliteal artery, Epo = erythropoietin, FiO_2 = O_2 fraction, FMD = flow-mediated vasodilation, GH = Growth Hormone, Hb = hemoglobin, Hct = haematocrit value, HIF-1a = Hypoxia-Inducible Factor 1-alpha, HIIT =high intensity interval training, HGB = hemoglobin concentration, HR=heart rate, HRmax = maximal heart rate, IGF-1 = Insulin-Like Growth Factor-1, IHT = intermittent hypoxia training, IHIT = intermittent hypoxic interval training, LHTL = live high train low, LLTL = live low train low, mRNA = messenger ribonucleic acid, MS = hemoglobin mass, , NOR = normoxia , O_2 = oxygen, PPO = peak power out-put, RBC = number of erythrocytes, RSA = repeated sprint ability, RSH = number of sprints to exhaustion, SIT = Sprint interval training, TTE = time to Exhaustion, SpO^2 = Peripheral Oxygen Saturation, TNFα = tumor necrosis factor-α, VE = Ventilation, VEGF = vascular endothelial growth factor, VO_2 = oxygen consumption, VO_{2peak} = peak oxygen consumption , VO_{2LT} = Ventilatory Threshold for Oxygen Uptake, VO_{2max} = maximal oxygen consumption, WR_{LT} = threshold workload, WR_{max} = Wattage Resistance Maximum, ΔLA= Delta lactate acid, La^- = capillary lactate concentration