



Quels éléments de la cardiopathie pourraient contre-indiquer ou limiter la pratique du ski alpin ?

17e journée du Club Mont-Blanc Cœur et Sport
03 octobre 2025
Chamonix

Anthony COSTA
Grenoble

Pas de conflits d'intérêts.

Les pays leaders du tourisme de montagne

Nombre moyen de visites sur les domaines skiables par saison (en millions)*



* Moyenne 2016-2022. Visites dans une station de sports d'hiver pour toute ou partie d'une journée. Un visiteur restant une semaine entière compte pour 7 visites.

Source : Laurent Vanat



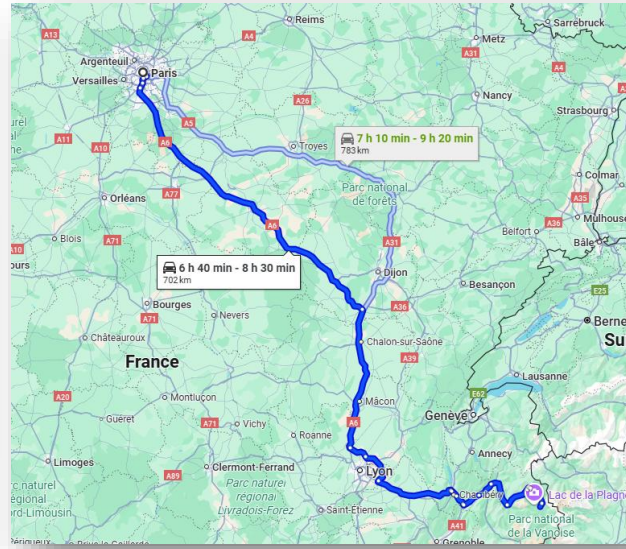
statista

Espaces touristiques	Hiver 2024		Hiver 2025	
	Nuitées (en millions)	Non-résidents (en %)	Nuitées (en millions)	Non-résidents (en %)
Massifs de montagne, dont :	25,5	27,5	24,9	29,4
<i>Alpes</i>	18,7	32,4	18,4	34,6
<i>Massif central</i>	2,1	8,4	2,0	9,0
<i>Pyrénées</i>	1,6	16,4	1,6	18,0
<i>Jura</i>	0,6	19,3	0,6	16,2
<i>Vosges</i>	0,8	26,2	0,7	26,3
<i>Corse</i>	0,3	10,2	0,2	11,5
Littoral (hors montagne)	10,2	18,0	10,0	18,3
Hors littoral et montagne	50,9	33,3	51,2	34,2
Ensemble	86,6	29,8	86,1	31,0



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Retour d'une grande douceur et de la pluie : une véritable catastrophe pour les stations de montagne ?



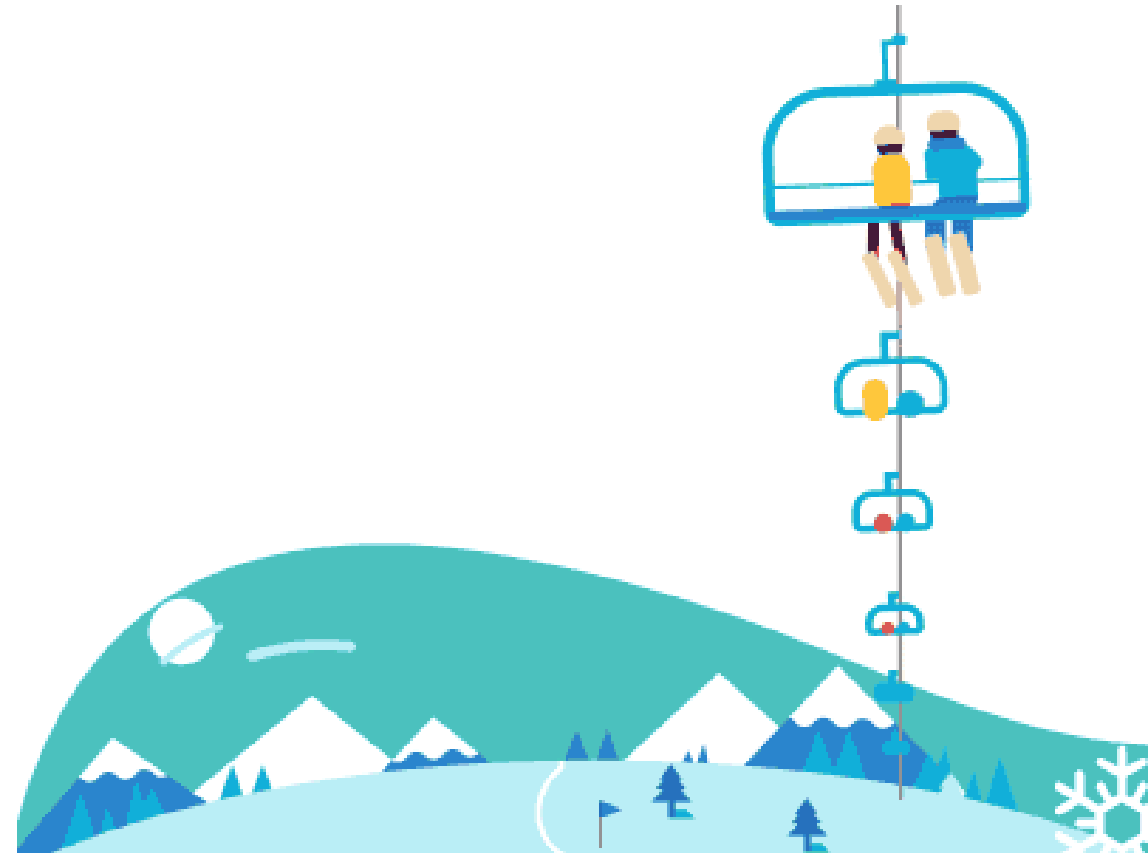
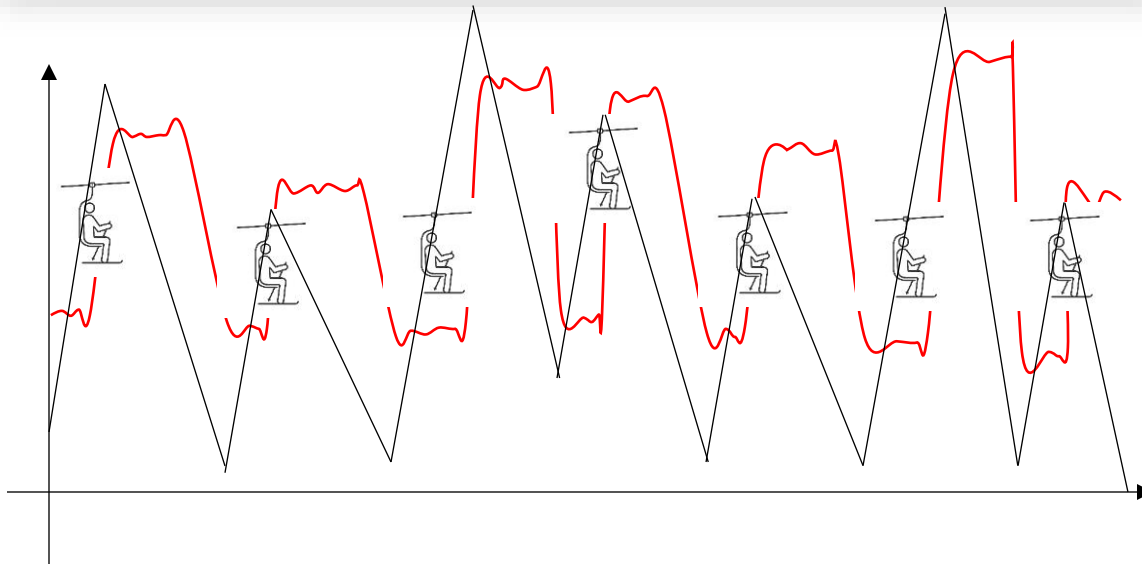


Hypoxia (altitude)

Wind

Exercise

Cold



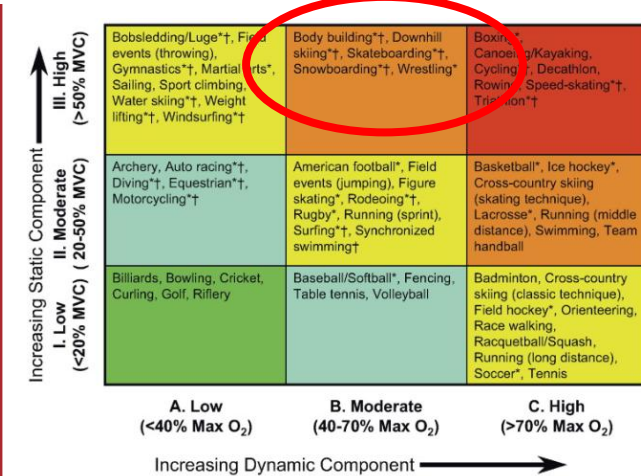
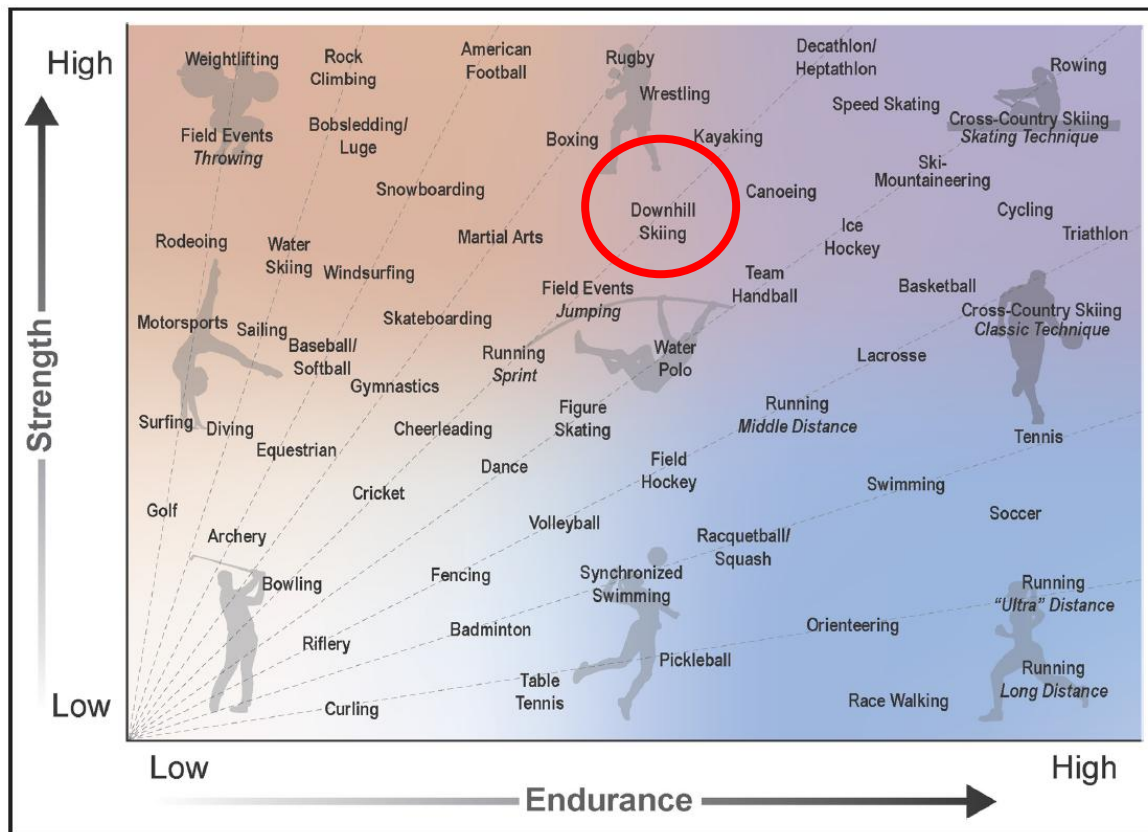


Table 3. Mean and peak relative VO₂ and %VO₂max data (±SD) during downhill skiing.

Subject	VO ₂ mean (ml.kg ⁻¹ .min ⁻¹)	VO ₂ mean (% of VO ₂ max)	VO ₂ peak (ml.kg ⁻¹ .min ⁻¹)	VO ₂ peak (% of VO ₂ max)
1	10 (1)	30 (4)	16 (2)	47 (4)
2	12 (2)	55 (9)	20 (1)	88 (5)
3	9 (1)	31 (4)	16 (2)	56 (6)
4	13 (1)	34 (3)	20 (1)	51 (3)
5	15 (1)	56 (4)	28 (2)	100 (7)
6	13 (1)	67 (3)	17 (0)	88 (1)
Mean (±SD)	12.0 (2.2)	45.5 (15.8)	19.5 (4.5)	71.8 (23.1)

	AS		
	Low	Mod	High
HR_{peak} (bpm)	138 (4)*	154 (4)	162 (3)
Rel. HR_{peak} (% HR_{max})	79 (2)*	88 (2)	93 (2)
Blood lactate (mmol·L⁻¹)	1.8 (.2)*	3.3 (.2)	4.6 (.5)
Rel. lactate (% peak lactate)	23 (3)*	37 (2)	57 (7)
Blood glucose (mmol·L⁻¹)	4.8 (.1)	4.8 (.1)	5.3 (.2)
RER_{mean}	.91 (.02)*	.95 (.01)	.98 (.02)
VO_{2peak} (ml·kg⁻¹·min⁻¹)	23.7 (.9)*	28.6 (1.1)	32.4 (1.2)
VO_{2steadystate} (ml·kg⁻¹·min⁻¹)	19.0 (.5)*	24.1 (.9)	29.1 (1.1)
Rel. VO_{2peak} %VO_{2max}	64 (3)*	74 (4)	84 (4)
EE_{steady state} (kcal·h⁻¹)	448 (21)*	590 (32)	713 (32)
EE_{4 min} (kcal)	27.9 (1.1)*	35.6 (1.8)	44.0 (1.8)
RPE_{whole-body}	9.8 (.6)*	12.3 (.6)	14.9 (.6)
RPE_{arms}	7.9 (.5)*	9.4 (.5)	10.5 (.8)
RPE_{legs}	12.6 (.5)*	16.1 (.6)	16.8 (.6)

Table 4 Indices of exercise intensity for endurance sports from maximal exercise testing and training zones

Intensity	VO ₂ max (%)	HRmax (%)	HRR (%)	RPE Scale	Training Zone
Low intensity, light exercise ^a	<40	<55	<40	10–11	Aerobic
Moderate intensity exercise ^a	40–69	55–74	40–69	12–13	Aerobic
High intensity ^a	70–85	75–90	70–85	14–16	Aerobic + lactate
Very high intense exercise ^a	>85	>90	>85	17–19	Aerobic + lactate + anaerobic

Altitude: VO₂ -6,3% / 1000m

VO₂peak low intensity AS: 23,7 ml/min/kg

VO2 max	15 ml/min/kg	20 ml/min/kg	25 ml/min/kg	30 ml/min/kg	35 ml/min/kg	40ml/min/kg	45ml/min/kg
METS	4,3	5,7	7,1	8,6	10,0	11,4	12,9
1500m	13,6	18,1	22,6	27,2	31,7	36,2	40,7
2000m	13,1	17,5	21,9	26,2	30,6	35,0	39,3
2500m	12,6	16,9	21,1	25,3	29,5	33,7	37,9
3000m	12,2	16,2	20,3	24,3	28,4	32,4	36,5

	AS		
	Low	Mod	High
HR _{peak} (bpm)	138 (4)*	154 (4)	162 (3)
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RER _{mean}	91 (.02)*	.95 (.01)	.98 (.02)
VO ₂ peak (ml·kg ⁻¹ ·min ⁻¹)	23.7 (.9)*	28.6 (1.1)	32.4 (1.2)
VO ₂ steadystate (ml·kg ⁻¹ ·min ⁻¹)	19.0 (.5)*	24.1 (.9)	29.1 (1.1)
Rel. VO ₂ peak % VO ₂ max	64 (3)*	74 (4)	84 (4)
EE _{steady state} (kcal·h ⁻¹)	448 (21)*	590 (32)	713 (32)
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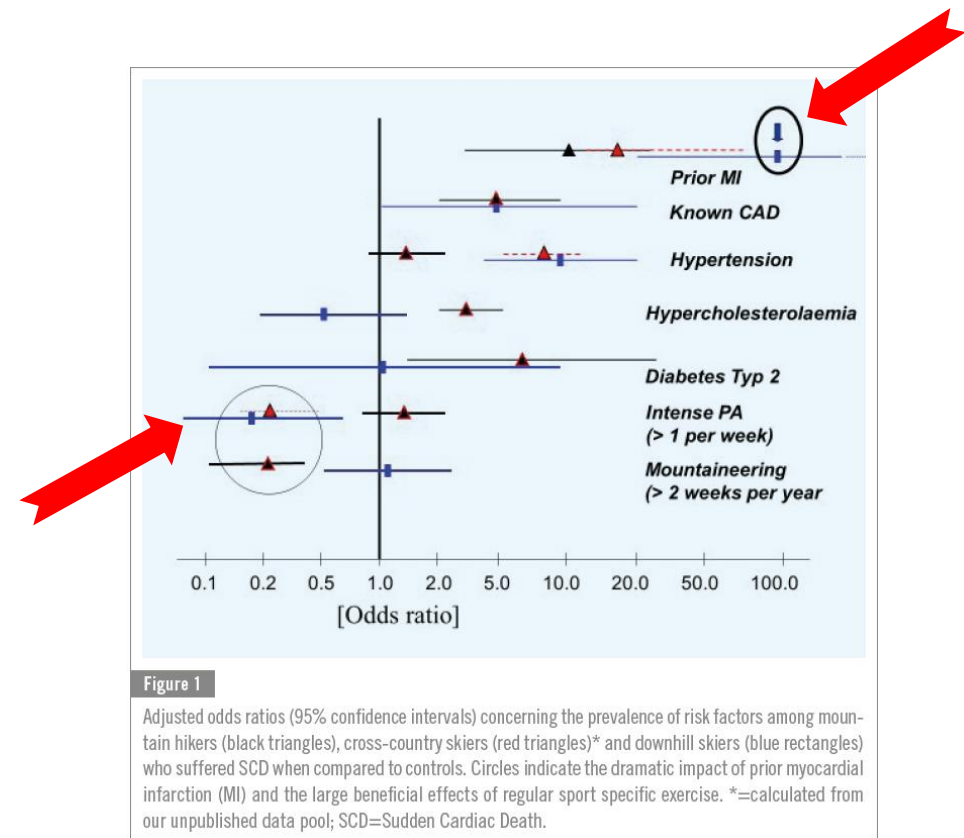
Table 1. Selected mortality rates during different sports activities in the mountains.

Mountain Sports Activity	Region/Mountain	Mortality Risk (Death Rate per 1,000,000 Exposure Days)	Time Period	Reference
Alpine (downhill) skiing and snowboarding	Austrian Alps	0.77	2000–2018	[15,17]
Cross-country skiing	Sweden Vasaloppet	0.26 ^a	1970–2005	[28] ^a
Alpine ski touring	Austrian Alps	4.4	1986–1995	[29]
Sledging	Switzerland	0.7	2000–2017	[30]

^a Based on an average race time of 8, 5, and 4 h for the 90, 45, and 30 km races, respectively.

Table 2. Main causes and risk factors in different mountain sports activities.

Mountain Sports Activity	Main Causes	Main Risk Factors
Alpine (downhill) skiing and snowboarding	Non-traumatic (mostly cardiac) death Trauma-related death (collisions, falls)	Male sex Pre-existing cardiovascular diseases Higher age Lack of fitness Risky behavior
Cross-country skiing	Non-traumatic (mostly cardiac) death Avalanches	Male sex Higher age Pre-existing diseases
Alpine ski touring	Avalanche burial Trauma-related death (falls) Non-traumatic (mostly cardiac) death	Male sex Lack of appropriate training Risky behavior Pre-existing diseases Lack of fitness
Sledging	Trauma-related death (collisions)	Lack of protective gear Lack of appropriate training



- **SCD: 99% of non-traumatic deaths**
- **50% of SCD occurred the 1st day of skiing**
- **Late morning**

Table 1

Characteristics of cardiac arrest on ski slopes compared to all cardiac arrest on other locations for a 10 year period.

	On Slope n = 136	Not on Slope n = 12500	Total n = 12636	p*
Patient characteristics				
Male gender (%)	121 (89)	8813 (70.5)	8934 (70.7)	<0.001
Age, year; median (IQR)	56 (40–65)	66 (52–79)	66 (52–78)	<0.001
Description of cardiac arrests				
Presumed Etiology of cardiac arrest (%)				
Cardiac	95 (69.9)	8092 (64.7)	8187 (64.8)	0.22
Trauma	33 (24.3)	1274 (10.2)	1305 (10.3)	<0.001
Respiratory	0 (0)	1412 (11.3)	1412 (11.2)	NA
Other/Unknown	8 (5.9)	1724 (13.8)	1732 (13.7)	0.016
Witnessed arrest (%)	107 (78.7)	9269 (74.2)	9376 (74.2)	0.23
Bystander CPR (%)	59 (43.4)	3345 (26.8)	3404 (26.9)	<0.001
First documented rhythm (%)				
Pulseless electrical activity	4 (2.9)	1502 (12)	1506 (12)	0.001
Asystole	76 (55.9)	8484 (67.9)	8560 (67.7)	0.003
Ventricular fibrillation/Ventricular tachycardia	56 (41.2)	2514 (20.1%)	2570 (20.3)	<0.001
Time from call to: (min; median (IQR))				
First CPR (min)	0 (0–5)	14 (9–20)	14 (9–20)	<0.001
First shock	7.5 (4–12.3)	14 (9–20)	14 (9–20)	<0.001
First responders' arrival	10 (5–17)	11 (8–15)	11 (8–15)	0.26

CPR: cardiopulmonary resuscitation; IQR: Inter quartile range.

* Chi² or Fisher's exact test when appropriate.

Cardiac arrest: Men (71%), mean age 66 y.o.

	All patients (n = 114)
Men	106 (93.0)
Mean age (years)	57 ± 11
Cardiovascular risk factors	
Family history of CAD	30 (26.3)
Hypertension	34 (29.8)
Active smoking	41 (36.0)
Diabetes mellitus	12 (10.5)
Hypercholesterolaemia	46 (40.4)
Obesity	13 (11.4)
Average BMI (kg/m ²)	26.5 ± 4.3
Number of risk factors	
0	10 (8.8)
1	33 (28.9)
≥ 2	71 (62.3)
Metabolic status at inclusion	
Glycosylated haemoglobin (%)	5.8 ± 1.1
Total cholesterol (g/L)	1.87 ± 0.44
LDL cholesterol (g/L)	1.11 ± 0.38
HDL cholesterol (g/L)	0.52 ± 0.16
Triglycerides (g/L)	1.23 ± 0.98
Known coronary disease	16 (14.0)
Previous myocardial infarction	11 (9.6)
Previous PCI	9 (7.9)
Previous CABG	4 (3.5)
Peripheral or carotid artery disease	5 (4.4)

	All patients (n = 114)
Physical activity within 1 hour of MI	87 (76.3)
Alpine skiing	48 (42.1)
Cross-country skiing	9 (7.9)
Snowshoe trial	6 (5.3)
Biking	8 (7.0)
Walking trial	16 (14.0)
Clinical presentation	
Typical chest pain	96 (84.2)
Atypical chest pain	4 (3.5)
Pulmonary oedema	2 (1.8)
Syncope	3 (2.6)
Cardiac arrest	9 (7.9)
Angina within 48 hours of MI	47 (41.2)
Anterior wall MI	43 (37.7)
Large MI (≥ 5 ECG leads)	47 (41.2)
Heart rate (bpm)	77 ± 22
Systolic blood pressure (mmHg)	128 ± 29
Diastolic blood pressure (mmHg)	72 ± 19
Site of medical intervention	
Ski area	46 (40.3)
Physician's office	41 (36.0)
Home/hotel	27 (23.7)
Initial SMUR intervention	45 (39.5)
Helicopter transfer	92 (80.7)

STEMI: Men (93%), mean age 57 y.o., high CV risk, 1st hour ski



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European Heart Journal (2021) 42, 17–96
doi:10.1093/eurheartj/ehaa605

ESC GUIDELINES

2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease

The Task Force on sports cardiology and exercise in patients with cardiovascular disease of the European Society of Cardiology (ESC)

Circulation

AHA/ACC SCIENTIFIC STATEMENT

Clinical Considerations for Competitive Sports Participation for Athletes With Cardiovascular Abnormalities: A Scientific Statement From the American Heart Association and American College of Cardiology



Extreme exercise environments

High-altitude travel, training, and competition are generally well-tolerated by competitive athletes with most forms of established asymptomatic cardiovascular disease. However, competitive athletes with pulmonary arterial hypertension (mean pulmonary artery pressure >25 mm Hg, pulmonary vascular resistance >3 WU) or congenital defects with right-to-left shunting may be at elevated risk of adverse events and should be evaluated clinically before consideration of high-altitude travel, training, and competition.



Extreme Exercise Environments

Competitive sports participation at high altitude (>2500 meters) is generally well-tolerated by competitive athletes, but those with CAD, pulmonary hypertension, or congenital heart disease may face increased cardiac risk while at altitude.²⁶⁷ Acclimatization may help reduce cardiac risks, but at-risk competitive athletes should undergo a clinical assessment before engaging in high-altitude activities.



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European Society
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European Heart Journal (2018) **39**, 1546–1554

doi:10.1093/eurheartj/ehx720

CURRENT OPINION

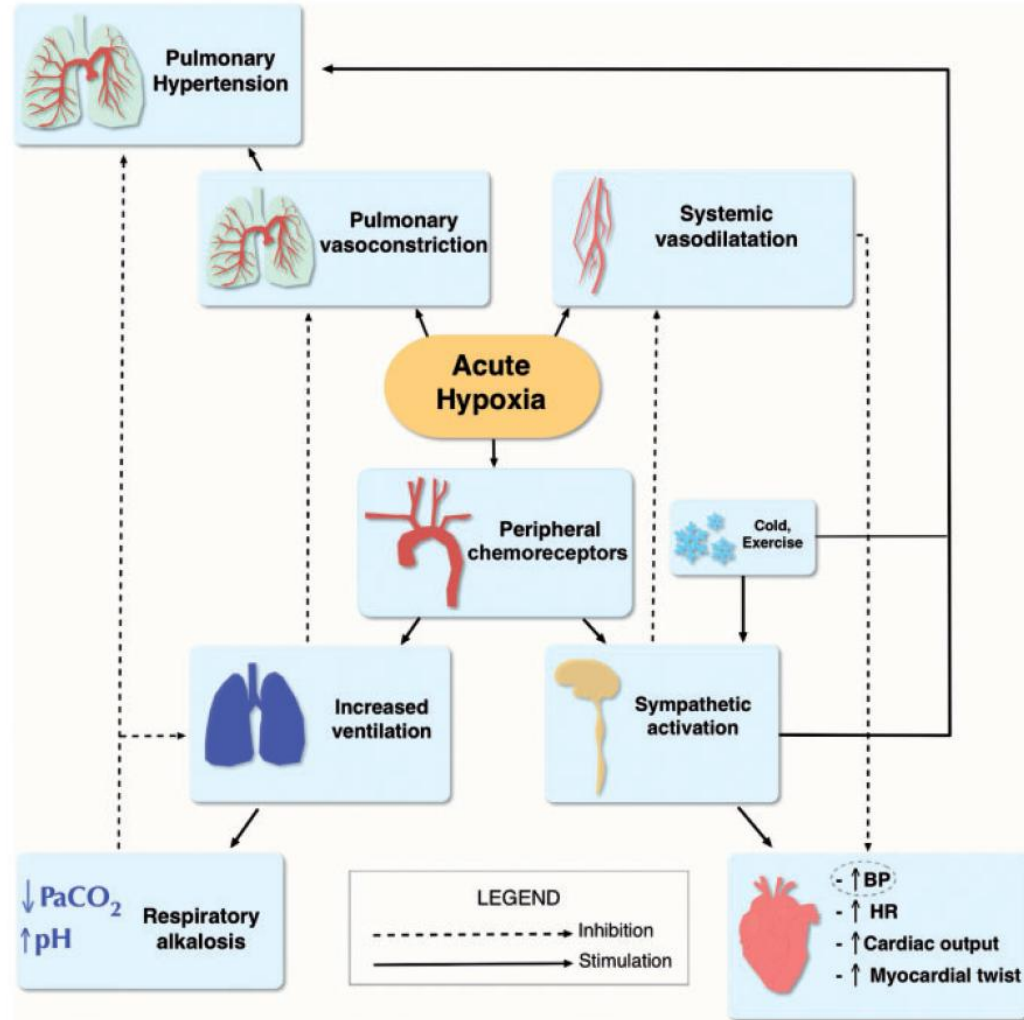
Disease management

Clinical recommendations for high altitude exposure of individuals with pre-existing cardiovascular conditions

Pulmonary hypertension



Bleeding

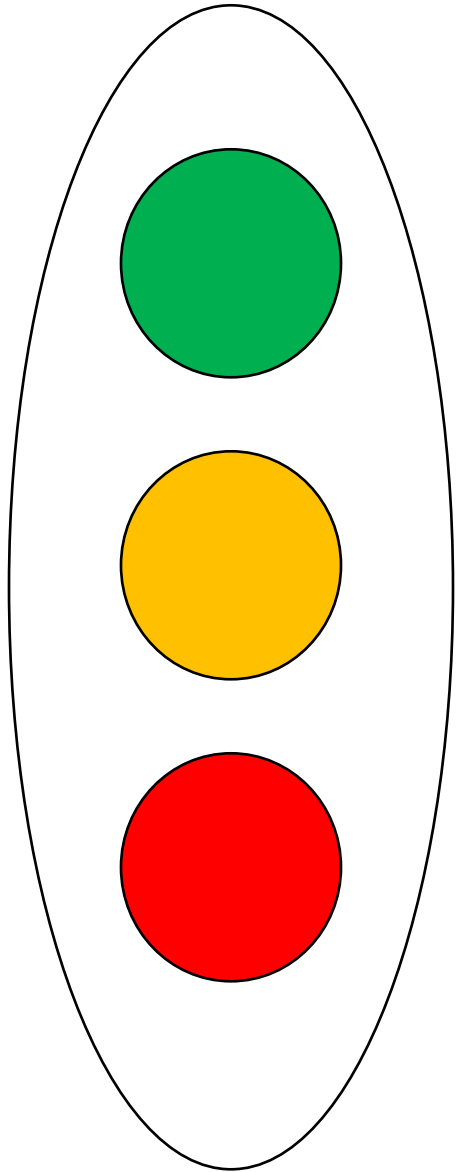


Sympathetic activation:

- Ischaemia
- Arrhythmias
- Blood pressure



KNOWN CARDIOPATHY



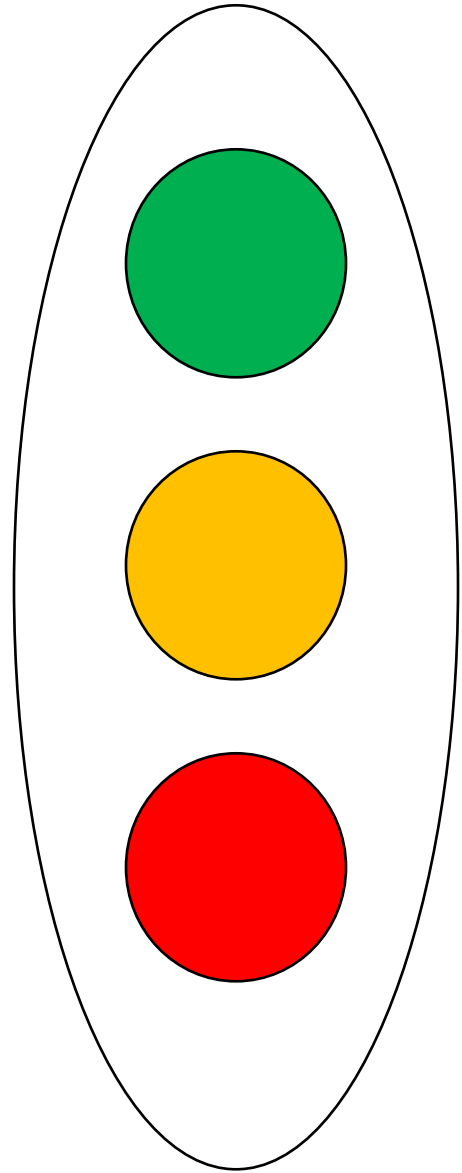
Stable NYHA I-II (up to 3500m) – moderate PA

Stable NYHA III (up to 3000m) – light PA

Unstable/NYHA IV



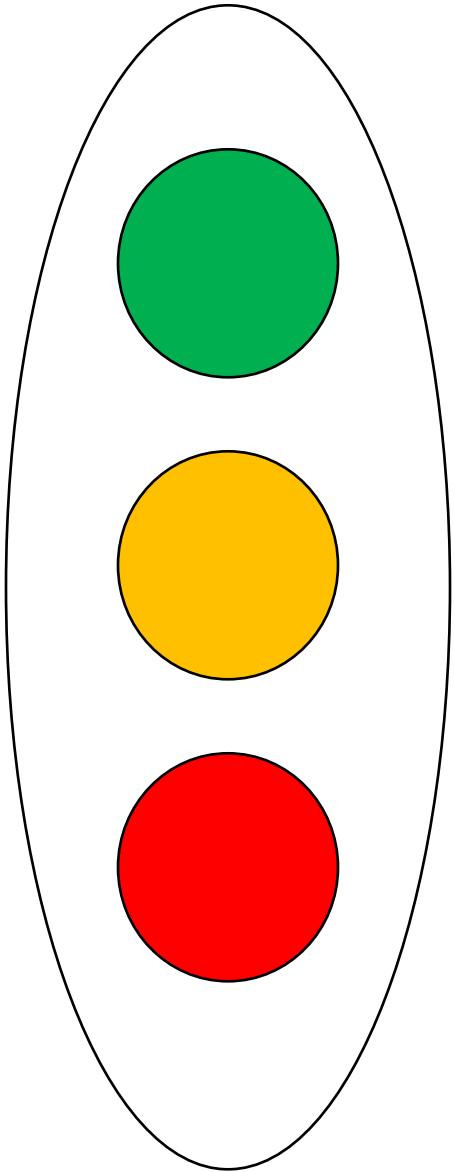
Right heart failure



Well-controlled/mild hypertension

Moderate-severe hypertension,
moderate-high CV risk: check BP
values before/during HA sojourn

Uncontrolled/severe hypertension



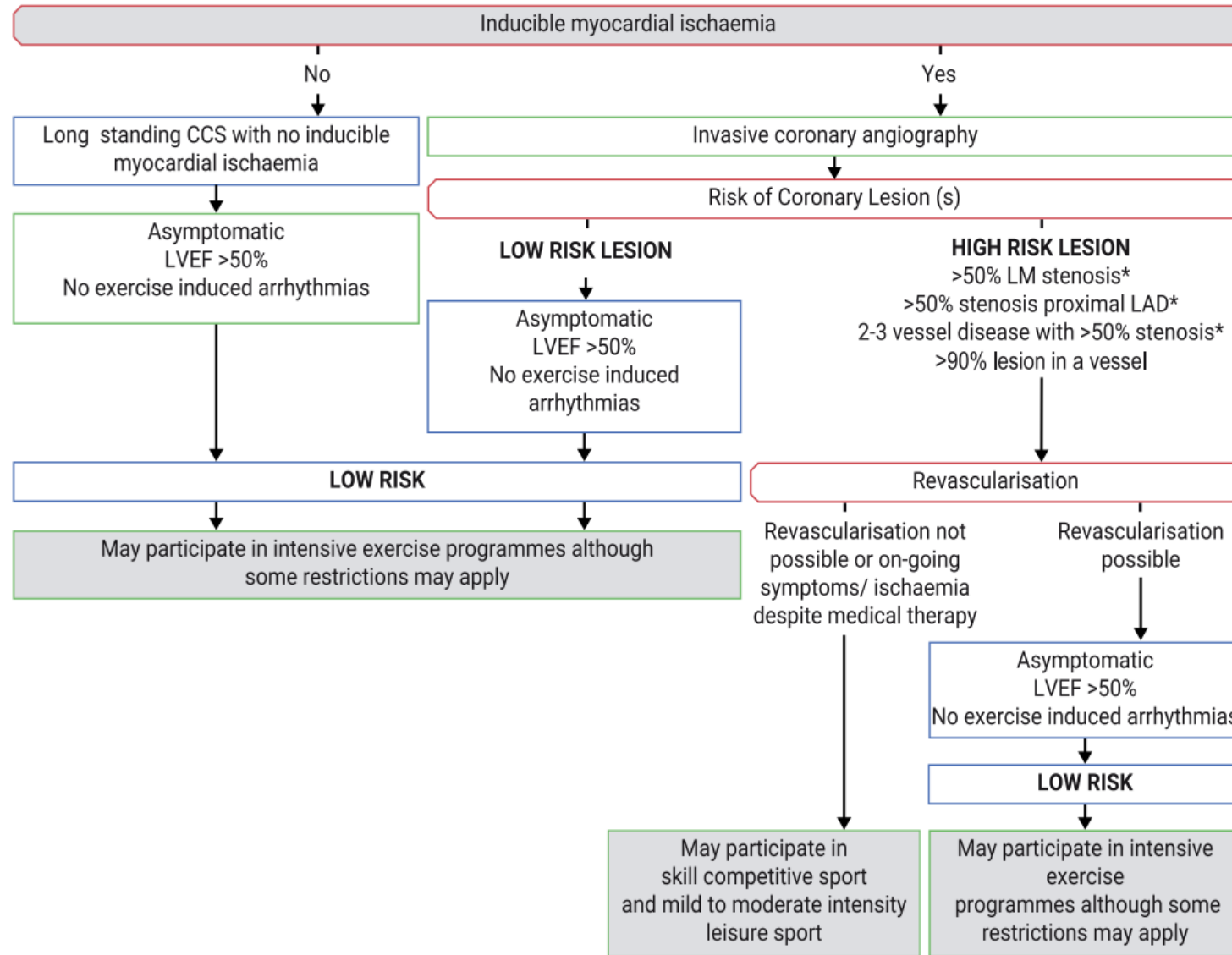
> 6 months after uncomplicated ACS/after revascularization
> 6-12 months after coronary stenting

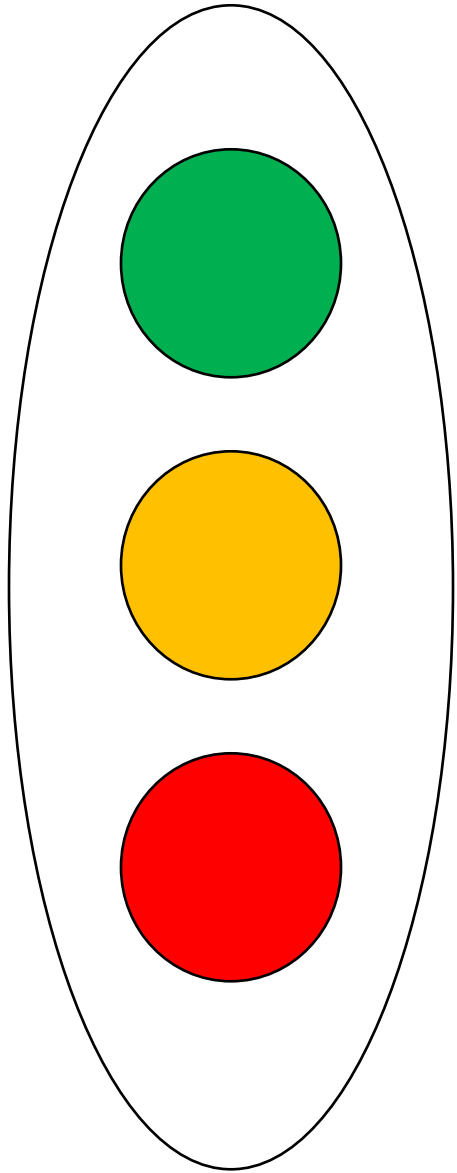
CCS 0-I: < 4200m, light-to-moderate PA
CCS II-III: <2500m, light PA

CCS IV
< 6 months after ACS

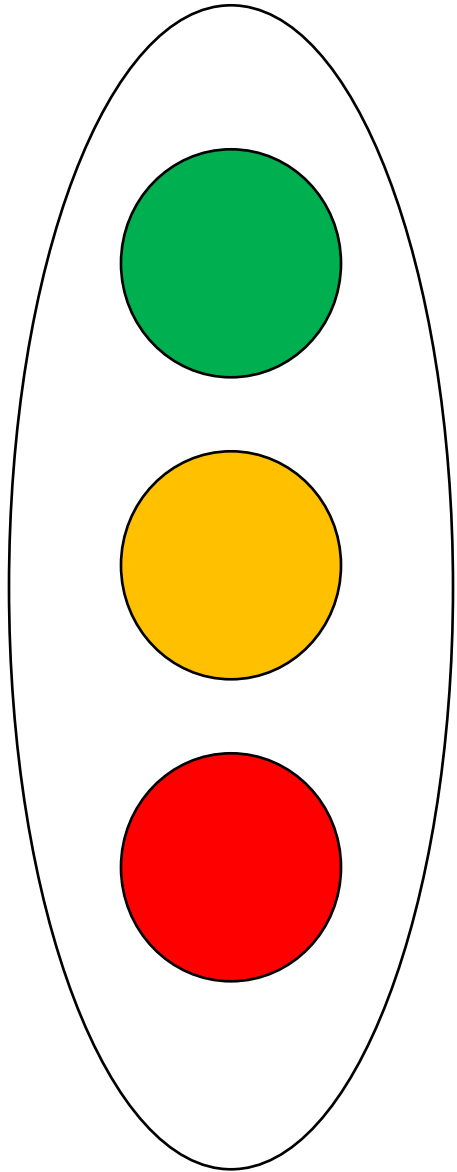
Table 5 Grading of effort angina severity according to the Canadian Cardiovascular Society

Grade	Description of angina severity ⁶⁶	
I	Angina only with strenuous exertion	Presence of angina during strenuous, rapid, or prolonged ordinary activity (walking or climbing the stairs)
II	Angina with moderate exertion	Slight limitation of ordinary activities when they are performed rapidly, after meals, in the cold, in the wind, under emotional stress, or during the first few hours after waking up, but also walking uphill, climbing more than one flight of ordinary stairs at a normal pace, and in normal conditions
III	Angina with mild exertion	Having difficulties walking one or two blocks or climbing one flight of stairs at a normal pace and conditions
IV	Angina at rest	No exertion is needed to trigger angina





Serious arrhythmias: < 3000-3500m
Avoid remote locations



Pacemaker, ICDs... if not contraindicated by medical condition

Participation in sports and exercise (except collision sports) should be considered in individuals with pacemaker therapy who do not have pathological substrates for fatal arrhythmias.

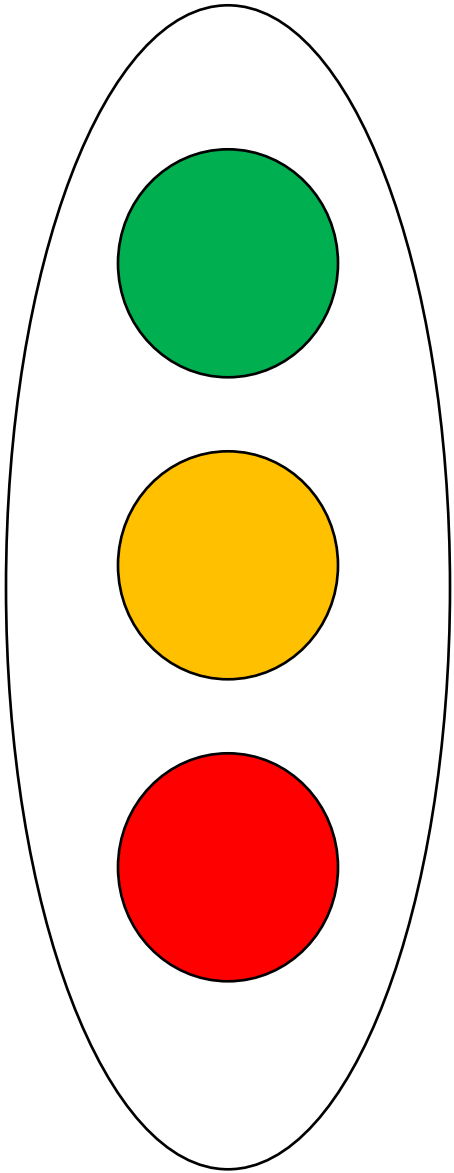
IIa

C

Competitive sports participation for competitive athletes with an ICD who participate in collision or impact competitive sports (see Section I) can be considered with SDM that addresses the potential risk of ICD system damage or malfunction.

Pulmonary hypertension

Hypoxic exercise test ?



WHO-FC III-IV: <2000m

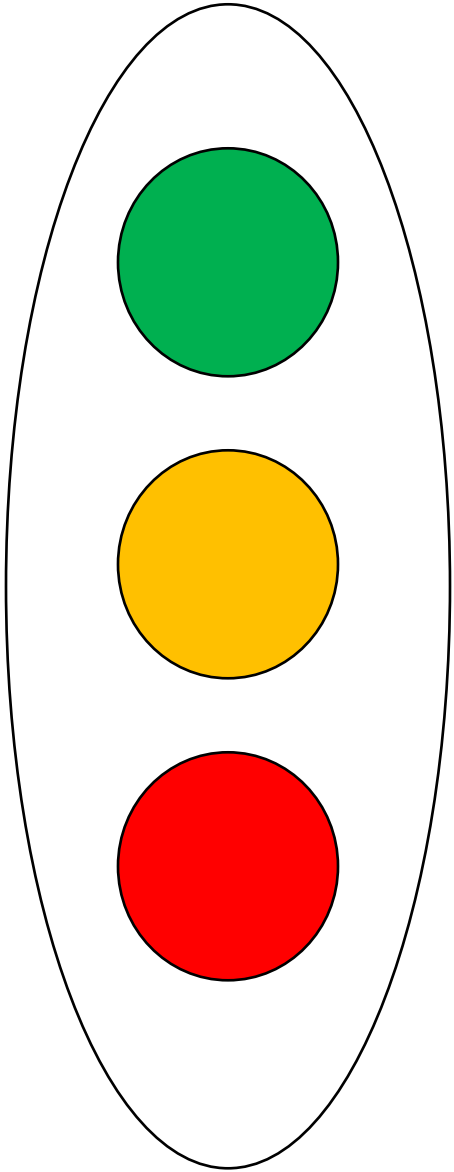
O2 supplementation >1500m

Ability to contact local PAH clinics

I	Patients without limitation of physical activity. Ordinary physical activity does not cause undue dyspnea or fatigue, chest pain or near syncope.
II	Patients with slight limitation of physical activity. Comfortable at rest. Ordinary physical activity causes undue dyspnea or fatigue, chest pain or near syncope.
III	Patients with marked limitation of physical activity. Comfortable at rest. Less than ordinary physical activity causes undue dyspnea or fatigue, chest pain or near syncope.
IV	Patients with inability to carry out any physical activity without symptoms. Signs of right heart failure. Dyspnea and/or fatigue may be present at rest. Discomfort increased by any physical activity.

Congenital Heart Diseases

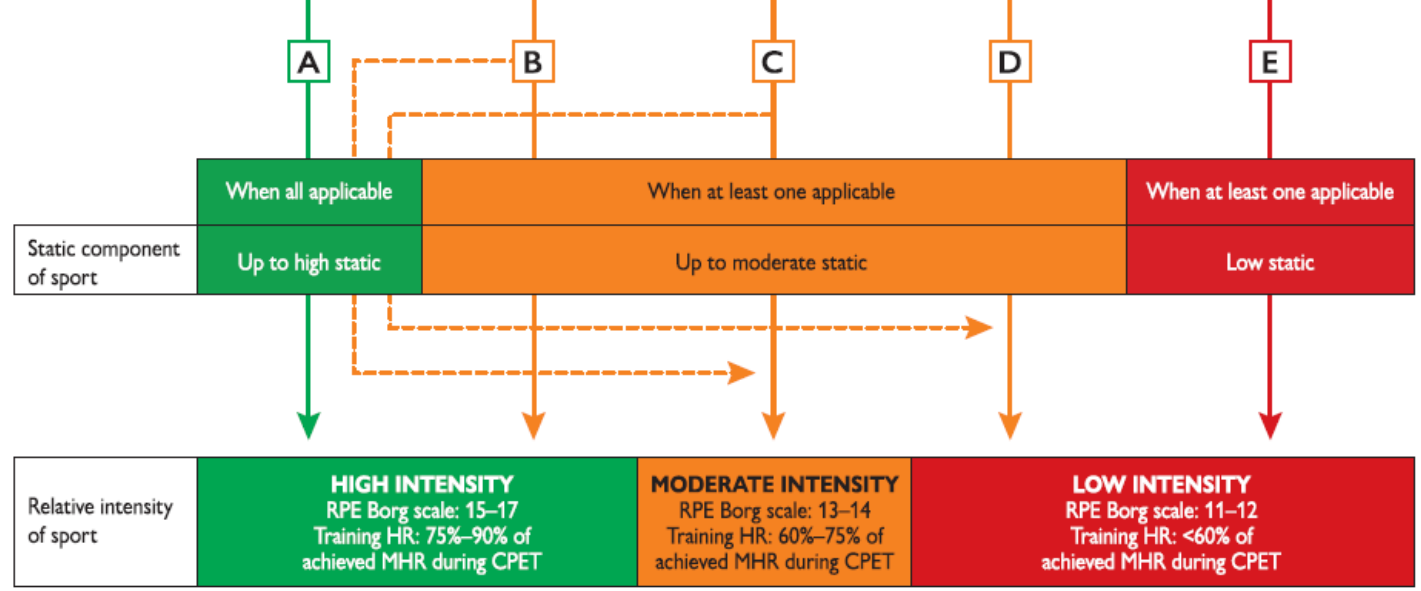
Hypoxic exercise test ?



Simple CHD, surgically treated

CHD with left-to-right shunt: < 1500m

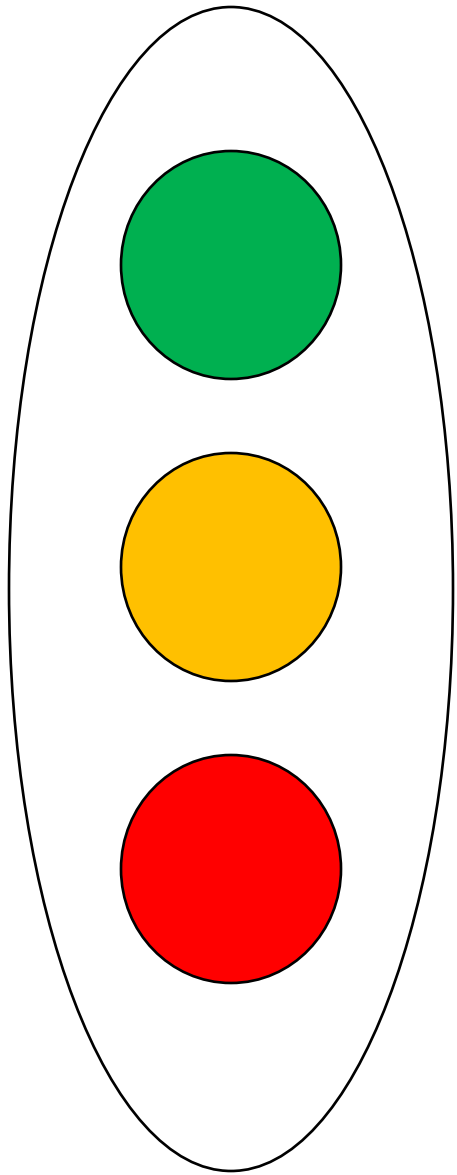
1. Ventricles	No systolic dysfunction No hypertrophy No pressure load No volume load	No systolic dysfunction No hypertrophy Mild pressure load Mild volume I	Mild systolic dysfunction Mild hypertrophy Single ventricle physiology Systemic right ventricle	Moderate systolic dysfunction Moderate hypertrophy Moderate pressure load	Severe systolic dysfunction Severe hypertrophy Severe pressure load Moderate/severe volume load
2. Pulmonary artery pressure	Low pulmonary artery pressure	Low pulmonary artery pressure	Mildly elevated pulmonary artery pressure		Moderately/severely elevated pulmonary artery pressure
3. Aorta	No/mild dilatation	Moderate dilatation	Severe dilatation	Dilatation approaching indication for repair	
4. Arrhythmia	No arrhythmia	No arrhythmia	Mild arrhythmic burden Non-malignant arrhythmia		Significant arrhythmic burden Malignant arrhythmia
5. Saturation at rest/during exercise	No central cyanosis	No central cyanosis	No central cyanosis	Central cyanosis	



Solid lines indicate recommendation; if option for sports with high static component, reduce intensity (dotted lines).

Anatomy and physiology	Definition	Diagnoses	Additional clinical evaluations*	Reassuring clinical findings	Concerning clinical findings†	Competitive sports participation considerations in absence of concerning clinical findings‡
Left-to-right shunt						
Small	No chamber enlargement, or only enlargement consistent with expected exercise-induced cardiac remodeling	<ul style="list-style-type: none"> Small, moderate ASD Small, moderate restrictive VSD Small, moderate restrictive PDA Partial anomalous pulmonary venous connection 			<ul style="list-style-type: none"> Hypoxemia Complex arrhythmias‡ RVH on imaging 	Can participate in all competitive sports after appropriate clinical evaluation*
Moderate or large	<ul style="list-style-type: none"> Qp:Qs >1.5–2.0§ Typically asymmetric chamber enlargement due to shunt¶ 	<ul style="list-style-type: none"> Moderate, large ASD Moderate, large VSD Moderate, large PDA PAPVC 	<ul style="list-style-type: none"> CPET (or EST) is reasonable¶ Intervention likely indicated 	No evidence of pulmonary hypertension	<ul style="list-style-type: none"> Hypoxemia Complex arrhythmias‡ RVH on imaging Severely dilated RV with RV dysfunction (ASD, PAPVC)¶ Severely dilated LV with LV dysfunction (VSD/PDA)¶ 	It is reasonable to consider competitive sports participation before and after intervention, as tolerated, following an SDM model with the athlete/family*
RVOT/PA obstruction						
Less than severe	Peak echo Doppler gradient <64 mm Hg or estimated RV systolic pressure <½ systemic pressures	<ul style="list-style-type: none"> After TOF repair Before or after intervention: valvar PS, subvalvar PS, peripheral PS 	For postrepair patients, should perform CPET (or EST)¶	<ul style="list-style-type: none"> No or mild RVH on imaging Normal RV function 	<ul style="list-style-type: none"> Hypoxemia Complex arrhythmias‡ Severe RVH on imaging Substantial RV dysfunction¶ 	Can participate in competitive sports after appropriate clinical evaluation*
Severe	Peak echo Doppler gradient >64 mm Hg or RV systolic pressure >½ systemic pressures	<ul style="list-style-type: none"> After TOF repair Before or after intervention: valvar PS, subvalvar PS, peripheral PS 	<ul style="list-style-type: none"> CPET (or EST)¶ Ambulatory cardiac rhythm monitoring Consider CMR or CCT Intervention likely indicated 	<ul style="list-style-type: none"> Mild or moderate RVH on imaging Normal RV function 	<ul style="list-style-type: none"> Hypoxemia at rest or with exercise (<85% on pulse oximeter) Complex arrhythmias at rest or stress‡ Severe RVH on imaging Substantial RV dysfunction¶ 	Before intervention: risks may outweigh benefits for competitive sports participation. Clinicians should engage in SDM with patient/family. After intervention: See row above "less than severe."

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<3 months after stroke/TIA

Table 3. Competitive Sport-Specific Risks and Participation Considerations Related to Bodily Collision, Bodily Impact, and Projectile Impact

Bodily collisions or impacts are not expected or occur at low velocity	Bodily collisions or impacts occur unpredictably at moderate velocity	Bodily impacts occur unpredictably but at high velocity	Bodily collisions occur routinely and at moderate to high velocity
Athletes receiving full anticoagulation, partial anticoagulation, or aspirin monotherapy can participate in these competitive sports.	<ul style="list-style-type: none"> After SDM, these competitive sports may be reasonable for athletes receiving full anticoagulation or partial anticoagulation. Athletes receiving aspirin monotherapy can participate in these competitive sports. 	<ul style="list-style-type: none"> Risks associated with these competitive sports generally outweigh benefits for athletes receiving full anticoagulation. Risks associated with these competitive sports may outweigh benefits for athletes receiving partial anticoagulation; SDM recommended. Athletes receiving aspirin monotherapy can participate in these competitive sports. 	<ul style="list-style-type: none"> Risks associated with these competitive sports generally outweigh benefits for athletes receiving full anticoagulation. Risks associated with these competitive sports may outweigh benefits for athletes receiving partial anticoagulation; SDM recommended. Athletes receiving aspirin monotherapy can participate in these competitive sports.
Archery	Baseball/softball*	Downhill skiing	American football
Badminton	Cricket*	Cycling	Boxing
Bowling	Basketball	Triathlon (cycling portion)	Ice hockey*
Curling	Fencing	Motorsports	Lacrosse*
Cross-country skiing	Racquetball/squash*	Rodeoing	Martial arts
Dance	Cheerleading	Speed skating	Rugby
Golf	Gymnastics	Skateboarding	Wrestling
Orienteering	Figure skating	Snowboarding	
Pickleball	Soccer*	Bobsled/luge	
Race walking	Field hockey*	Rock climbing	
Riflery	Team handball*	Kayaking/canoeing	
Rowing	Diving	Equestrian	
Distance running/track & field	Surfing		
Sailing	Water skiing		
Swimming	Windsurfing		
Table tennis	Track & field (pole vault)		
Tennis			
Volleyball			
Weightlifting			



5.1.2.1 Antithrombotic treatment

Individuals with CAD should receive conventional antithrombotic treatment for secondary prevention, according to published guidelines for the general population.^{233,239,240} Individuals taking dual antiplatelet agents should avoid sports with bodily collision, especially when they are combined with oral anticoagulants, due to the risk of haemorrhage.²⁴¹

Aspirin monotherapy: OK
DAPT, anticoagulation:
risks > benefits (SDM)

Masters athletes who are initiated on oral anticoagulation and who choose to participate in competitive sports with higher risks of collisions or impacts (see Section I), temporary discontinuation of oral anticoagulation can be considered with SDM.

Masters athletes who require antiplatelet monotherapy can participate in all competitive sports.

- **Heart failure:**
 - prefer **selective betablockers**
- **Hypertension:**
 - Telmisartan or nifedipine/telmisartan
 - Acetazolamide: lower BP, improve SaO₂ and CMS symptoms
 - **Nebivolol**: lesser impairment of exercise performance
- **Ischaemic heart disease:**
 - Continue pre-existing medications at HA
 - Acetazolamide to reduce sub-endocardial ischaemia at HA (IIaC)? No data available in patients with CAD
 - **Nebivolol**: does not reduce exercise capacity (IIaB)
 - Carvedilol: reduces exercise capacity

Valvular heart diseases

Severe	Participation in all recreational sports/exercise involving low intensity, if desired, may be considered in individuals with LVEF \geq 50% and normal BP response during exercise.	IIb	C
	Participation in competitive or recreational sports/exercise of moderate and high intensity is not recommended.	III	C

Aortic stenosis

Severe	Participation in all recreational sports involving low and moderate intensity, if desired, may be considered with a mild or moderately dilated LV with LVEF $>$ 50% and normal exercise stress test.	IIb	C
	Participation in any moderate- or high-intensity recreational exercise is not recommended with LVEF \leq 50% and/or exercise-induced arrhythmias.	III	C

Aortic regurgitation

Severe	Participation in all recreational sports involving low and moderate intensity, if desired, may be considered in individuals fulfilling the following: <ul style="list-style-type: none"> • LVEDD$<$60 mm³²⁷ or $<$35.3 mm/m² in men and $<$40 mm/m² in women • LVEF\geq60% • Resting sPAP$<$50 mmHg • Normal exercise test 	IIb	C
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Mitral regurgitation

Moderate (MVA 1.0–1.5 cm ²)	Participation in all recreational sports involving low and moderate intensity, if desired, may be considered in individuals with resting sPAP $<$ 40 mmHg and a normal exercise test.	IIb	C
Severe (MVA $<$ 1 cm ²)	Participation in leisure sports of moderate or high intensity is not recommended.	III	C

Mitral stenosis

	Low risk	Low-intermediate risk	Intermediate risk	High risk
Diagnosis	<ul style="list-style-type: none"> Aorta <40 mm in BAV or tricuspid valve Turner syndrome without aortic dilatation 	<ul style="list-style-type: none"> MFS or other HTAD syndrome without aortic dilatation Aorta 40–45 mm in BAV or tricuspid valve After successful thoracic aorta surgery for BAV or other low risk situation 	<ul style="list-style-type: none"> Moderate aortic dilatation (40–45 mm in MFS or other HTAD; 45–50 mm in BAV or tricuspid valve, Turner syndrome ASI 20–25 mm/m², tetralogy of Fallot <50 mm) After successful thoracic aorta surgery for MFS or HTAD 	<ul style="list-style-type: none"> Severe aortic dilatation (>45 mm in MFS or other HTAD, >50 mm in BAV or tricuspid valve, Turner syndrome ASI >25 mm/m², tetralogy of Fallot >50 mm) After surgery with sequelae
Advice	<ul style="list-style-type: none"> All sports permitted with preference for endurance over power sports 	<ul style="list-style-type: none"> Avoid high and very high intensity exercise, contact, and power-sports. Preference for endurance over power sports 	<ul style="list-style-type: none"> Only skill sports or mixed or endurance sports at low intensity 	<ul style="list-style-type: none"> Sports are (temporarily) contra-indicated
Follow-up	Every 2–3 years	Every 1–2 years	Every 6 months to 1 year	Re-evaluation after treatment

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ASI = aortic size index; BAV = bicuspid aortic valve; HTAD = hereditary thoracic aortic disease; MFS = Marfan syndrome.

> 40 mm

Recommendations for exercise and sports participation in individuals with hypertrophic cardiomyopathy

Recommendations	Class ^a	Level ^b
Exercise recommendations		
Participation in high-intensity exercise/competitive sports, if desired (with the exception of those where occurrence of syncope may be associated with harm or death), may be considered for individuals who do not have any markers of increased risk ^c following expert assessment.	IIb	C
Participation in low- or moderate-intensity recreational exercise, if desired, may be considered for individuals who have any markers of increased risk ^c following expert assessment .	IIb	C
Participation in all competitive sports, if desired, may be considered for individuals who are gene positive for HCM but phenotype negative.	IIb	C
Participation in high-intensity exercise (including recreational and competitive sports) is not recommended for individuals who have ANY markers of increased risk ^c .	III	C

History of cardiac arrest/syncope

ESC risk score

LVOT gradient at rest

Abnormal BP response to exercise

Exercise- induced arrhythmias

Arrhythmogenic CM, NCCM

Recommendations for exercise and sports participation in individuals with arrhythmogenic cardiomyopathy

Recommendations	Class ^a	Level ^b
Exercise recommendations		
Participation in 150 min of low-intensity exercise per week should be considered for all individuals.	IIa	C
Participation in low- to moderate-intensity recreational exercise/sports, if desired, may be considered for individuals with no history of cardiac arrest/VA, unexplained syncope, minimal structural cardiac abnormalities, <500 PVCs/24 h and no evidence of exercise-induced complex VAs.	IIb	C
Participation in high-intensity recreational exercise/sports or any competitive sports is not recommended in individuals with ACM, including those who are gene positive but phenotype negative. ^{384,386}	III	B

History of cardiac arrest/syncope
 Exercise test
 Holter

Recommendations for exercise in individuals with left ventricular non-compaction cardiomyopathy

Exercise recommendations		
Participation in high-intensity exercise and all competitive sports, if desired, with the exception where syncope may cause serious harm or death, may be considered in asymptomatic individuals with LVNC and LVEF \geq 50% and absence of frequent and/or complex VAs.	IIb	C
Participation in recreational exercise programmes of low to moderate intensity, if desired, may be considered in individuals with LVEF 40–49% in the absence of syncope and frequent or complex VAs on ambulatory Holter monitoring or exercise testing.	IIb	C
Participation in high- or very high-intensity exercise including competitive sports, if desired, may be considered for individuals who are gene positive for LVNC but phenotype negative (with the exception of lamin A/C or filamin C carriers).	IIb	C
Participation in high-intensity exercise or competitive sports is not recommended in individuals with any of the following: symptoms, LVEF<40% and/or frequent and/or complex VAs on ambulatory Holter monitoring or exercise testing.	III	C

LVEF
 History of cardiac arrest/syncope
 Exercise test
 Holter

Recommendations for exercise in individuals with dilated cardiomyopathy

Recommendations	Class ^a	Level ^b
Participation in low- to moderate-intensity recreational exercise should be considered in all individuals with DCM, regardless of the EF, in the absence of limiting symptoms, and exercise-induced VAs.	IIa	C
Participation in high- or very high-intensity exercise including competitive sports (with the exception of those where occurrence of syncope may be associated with harm or death) may be considered in asymptomatic individuals who fulfil all of the following: (i) mildly reduced LV systolic function (EF 45–50%); (ii) absence of frequent and/or complex VAs on ambulatory Holter monitoring or exercise testing; (iii) absence of LGE on CMR; (iv) ability to increase EF by 10–15% during exercise; and (v) no evidence of high-risk genotype (lamin A/C or filamin C).	IIb	C

Participation in all competitive sports may be considered in individuals with DCM who are genotype positive and phenotype negative, with the exception of carriers of high-risk mutations (lamin A/C or filamin C).

IIb**C**

Participation in high- or very high-intensity exercise including competitive sports is not recommended for individuals with a DCM and any of the following: (i) symptoms or history of cardiac arrest or unexplained syncope; (ii) LVEF<45%; (iii) frequent and/or complex VAs on ambulatory Holter monitoring or exercise testing; (iv) extensive LGE (>20%) on CMR; or (v) high-risk genotype (lamin A/C or filamin C).

III**C**

History of cardiac arrest/syncope

LVEF

Exercise test

Holter

LGE

Genotype

Myocarditis/pericarditis

Recommendations for exercise in individuals with myocarditis

Return to all forms of exercise including competitive sports should be considered after 3–6 months in asymptomatic individuals, with normal troponin and biomarkers of inflammation, normal LV systolic function on echocardiography and CMR, no evidence of ongoing inflammation or myocardial fibrosis on CMR, good functional capacity, and absence of frequent and/or complex VAs on ambulatory Holter monitoring or exercise testing. ^{430,434,453,459,460,464}	IIa	C
Among individuals with a probable or definitive diagnosis of recent myocarditis, participation in leisure-time or competitive sports while active inflammation is present is not recommended. ^{459,460}	III	C
Participation in moderate- to high-intensity exercise for a period of 3–6 months after acute myocarditis is not recommended. ^{459–461,467}	III	B
Participation in leisure exercise or competitive sports involving high intensity in individuals with residual myocardial scar and persistent LV dysfunction is not recommended.	III	C

Active inflammation
Scar

LVEF/Exercise test/holter

Recommendations for exercise in individuals with pericarditis

Recommendations	Class ^a	Level ^b
Return to all forms of exercise including competitive sports is recommended after 30 days to 3 months for individuals who have recovered completely from acute pericarditis, depending on clinical severity. ^{459,460}	I	C
Participation in leisure-time or competitive sports is not recommended for individuals with a probable or definitive diagnosis of recent pericarditis while active inflammation is present, regardless of age, sex, or extent of LV systolic dysfunction. ^{459,460}	III	C
Participation in moderate- to high-intensity exercise, including competitive sports, is not recommended for individuals with constrictive pericarditis.	III	C

Arrhythmias and channelopathies

Atrial fibrillation: contra-indications of sports with **direct bodily contact or prone to trauma (IIIA)**

WPW: if ablation impossible/not desired → risk of fatality from loss of consciousness ?

PVC/NSVT: associated heart disease? Induction/aggravation by exercise?

LQTS: genetic testing? SDM if QTc < 470/480 ms (men/women). No predictive value of exercise testing. Hypokaliemia+++

Brugada: avoid triggering drugs, electrolyte imbalances

- Resolution of cardiopulmonary symptoms
- TEE: PH? RV dysfunction?
- Anticoagulation therapy



**APPARENTLY
HEALTHY PEOPLE**

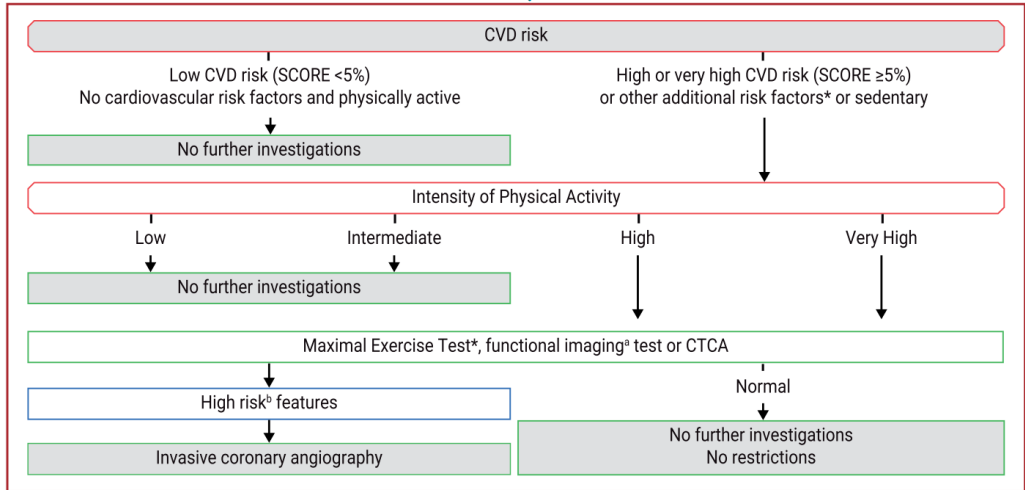
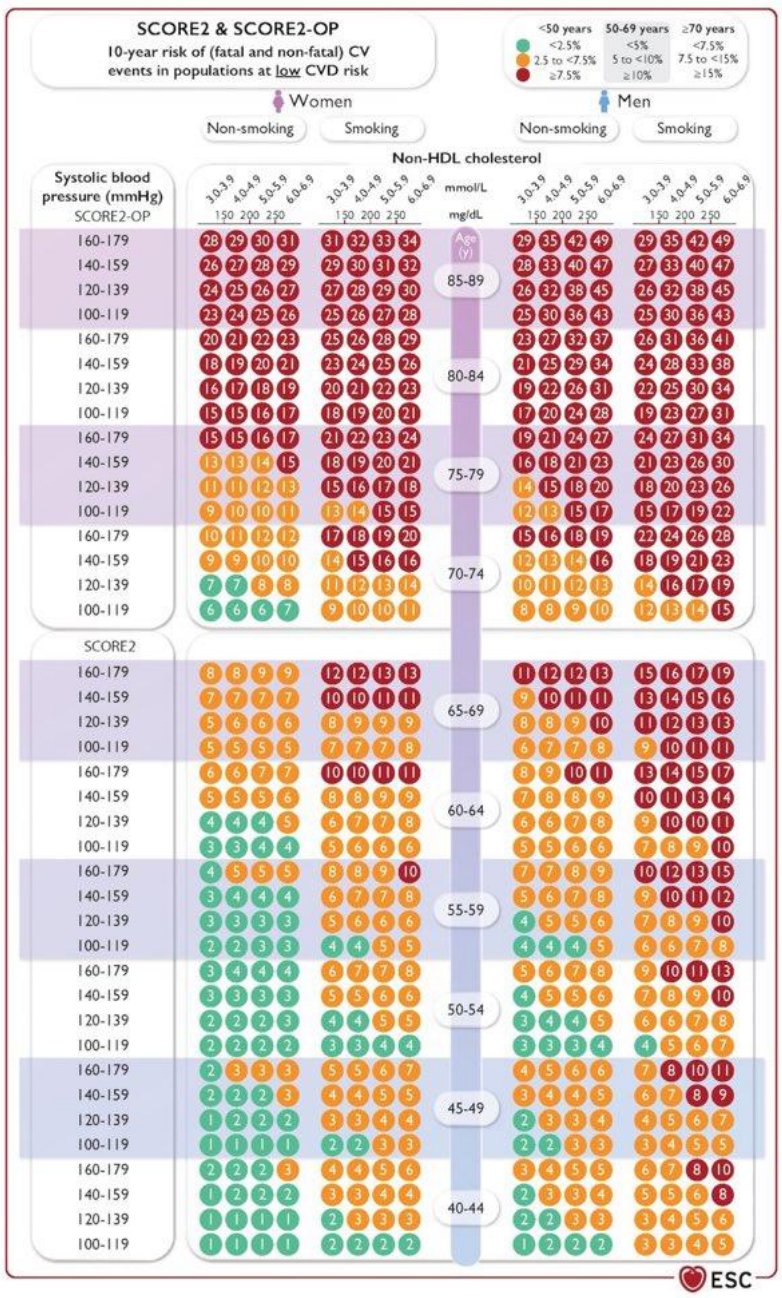


Table 4 Indices of exercise intensity for endurance sports from maximal exercise testing and training zones

Intensity	VO ₂ max (%)	HRmax (%)	HRR (%)	RPE Scale	Training Zone
Low intensity, light exercise ^a	<40	<55	<40	10–11	Aerobic
Moderate intensity exercise ^a	40–69	55–74	40–69	12–13	Aerobic
High intensity ^a	70–85	75–90	70–85	14–16	Aerobic + lactate
Very high intense exercise ^a	>85	>90	>85	17–19	Aerobic + lactate + anaerobic

VO_{2peak} low intensity AS: 23,7 ml/min/kg

VO2 max	15 ml/min/kg	20 ml/min/kg	25 ml/min/kg	30 ml/min/kg	35 ml/min/kg	40ml/min/kg	45ml/min/kg
METS	4,3	5,7	7,1	8,6	10,0	11,4	12,9
1500m	13,6	18,1	22,6	27,2	31,7	36,2	40,7
2000m	13,1	17,5	21,9	26,2	30,6	35,0	39,3
2500m	12,6	16,9	21,1	25,3	29,5	33,7	37,9
3000m	12,2	16,2	20,3	24,3	28,4	32,4	36,5



Conclusion

Known cardiopathy

- Stable?
- Severity?
- Arrhythmia/syncope?
- Pulmonary hypertension?
- Bleeding risk

TEE, (hypoxic) exercise testing, Holter...

Apparently healthy people

- Accurate personal history
- CV risk factors
- Fitness level
- Symptoms at SL/HA
- Ski level

Exercise testing

Education and prevention !