**Exercise Prescription in Individuals With Hypertrophic Cardiomyopathy. What Clinicians Need to Know**

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**Abstract**

Hypertrophic cardiomyopathy (HCM) is the most frequently cited cause of exercise related sudden cardiac death (SCD) in young individuals and has claimed the lives of some high-profile athletes. The circumstantial link between exercise and SCD from HCM has resulted in conservative exercise recommendations which focus on activities that should be avoided rather than the minimal amount of physical activity required to reap the multiple rewards of exercise. Consequently, most patients with HCM are confined to a sedentary lifestyle through fear of SCD, with accruing risk factors such as obesity and low cardiorespiratory fitness, that confer a worse prognosis. Recent exercise programmes in asymptomatic and symptomatic individuals with HCM have shown that mild and moderate exercise is safe and accompanied by increased functional capacity and improved quality of life. Population studies also reveal that individuals with HCM in the higher quartiles of self-reported physical activity have lower total cardiovascular mortality compared with those in the lower quartiles. The impact of vigorous exercise on the natural history of HCM is unknown, although current experience suggests that affected adults with mild morphology and absence of high-risk factors may partake in such activity without adverse events. This review highlights the evidence base that has resulted in a paradigm shift in the approach to exercise in HCM and liberalised recent international exercise guidelines in HCM. Practical tips for prescribing exercise in symptomatic patients, and relevant precautions are provided to aid clinicians when recommending exercise as part of the management plan for all patients with HCM.

**Introduction**

Exercise is a free and valuable therapy for curtailing risk factors for atherosclerosis, improving cardiorespiratory fitness and increasing longevity.1 Participation in vigorous exercise however, may promote fatal arrhythmias in predisposed individuals with underlying cardiovascular disease. Hypertrophic cardiomyopathy (HCM), a genetic disorder characterised by left ventricular hypertrophy, myocyte disarray and a propensity for fatal arrhythmias is an established cause of exercise related sudden cardiac death (SCD) in young (≤35-years-old) athletes.2–5 In the largest series of sudden deaths in young athletes from the United States, HCM accounted for 36% of 690 confirmed cardiac deaths. Almost 90% of deaths occurred during or immediately after exercise and over 80% occurred in individuals aged ≤ 25-years-old.4 Some studies also indicate that resuscitation rates among vigorously exercising individuals with HCM are relatively poor compared with older individuals with coronary artery disease.6 Whereas pharmacological interventions with beta-blockers or calcium channel antagonists increase left ventricular filling and reduce oxygen demands on the LV myocardium, none have been associated with a reduced risk of fatal events.7 Despite a progressive refinement in risk stratification algorithms for identifying high risk individuals, it should be emphasised that none are derived from the athletic population.8 Whether data from an exercise laboratory can be extrapolated to the athletic arena, which is associated with a higher probability of circulating catecholamines, electrolyte shifts, acid-base disturbance or markedly raised core temperature, is also questionable. Even among athletes with morphologically mild HCM, the long terms effects of vigorous exercise on acceleration of fibrosis and left ventricular dysfunction are unknown.

Although the past 5 decades have reported an increasingly favourable prognosis in HCM and emerging reports reveal that most deaths from HCM occur at rest,9–11 the circumstantial link between exercise and SCD from HCM and several of the aforementioned knowledge gaps have resulted in prohibitive exercise recommendations with most affected individuals being confined to low intensity physical activity only.12–14 Over the past few years there is emerging data to support the notion that moderate exercise has beneficial effects in HCM and some individuals with morphologically mild disease and a conventional low risk profile may partake in more vigorous exercise after a comprehensive discussion and shared planning process that highlights the unpredictable risk and remaining knowledge gaps. The current exercise and sports cardiology guidelines from the European society of Cardiology15 and the American Heart Association (AHA) and American College of Cardiology (ACC) guidelines on the management and treatment of HCM16 support a more liberal approach to exercise and sports participation in HCM. This review will examine the evidence base for the benefits of exercise in HCM and focus on how to prescribe safe exercise in affected individuals.

**Detrimental Effects of Sedentary Behaviour in HCM**

Historical exercise recommendations for individuals with HCM have neither promoted or encouraged physical activity and guidance on the amount of safe exercise has been elusive.12 Physicians generally focus on activities to avoid to minimise the risk of SCD than endorsing a minimal recommendation of physical activity. These factors have cultivated a sedentary lifestyle among patients with HCM, with accumulation of associated CV comorbidities that may confer a higher risk and worse prognosis than HCM itself and may affect up to 20 million patients worldwide.17 Over 55% of patients with HCM do not meet the minimal physical activity recommendations for general well-being18,19; one third of patients with HCM have hypertension20 and 70% of patients with HCM are obese or pre-obese.17 Obesity contributes to increased left ventricular mass, obstructive physiology, heart failure and increased risk of atrial fibrillation.17,21 Sedentary lifestyle for individuals with HCM also confers a greater risk for developing atherosclerosis. Among patients with HCM and concomitant severe coronary artery disease there is a 2-fold increase in the risk of reduced 10-year survival and cardiac death and almost 3 fold increase in the risk of SCD compared with patients with HCM who have mild or no coronary artery disease.22 Furthermore, patients with HCM who have low cardiorespiratory fitness, have a significantly worse prognosis compared to patients with higher fitness levels.9,23–27

**Effect of Exercise on the General Population with HCM**

Regular exercise in HCM has the potential for curbing obesity alongside other risk factors for atherosclerosis, and increasing fitness through improvements in left ventricular compliance, endothelial function and peripheral oxidative capacity.28 A murine research model using transgenic mice with a pathogenic variant in the myosin heavy chain gene revealed that exercising early in life could confer a protective effect on the pathological substrate by reducing myocyte disarray and collage deposition in the extracellular tissue.29

The optimal dose of safe exercise in the general population of HCM patients is unknown, however, the randomised RESET HCM study of 136 middle aged and predominantly asymptomatic patients showed that moderate exercise was beneficial and safe.30 The study group (67 patients) participated in a 16 week home based exercising programme involving up to 4-7 60 minute sessions with a heart rate reserve (HRR) of 70% and revealed a modest (1.35 ml/kg/min) but significant increase in peak oxygen consumption (pVO2) and improved quality of life scores compared with 69 patients randomised to usual care, without any adverse events.30 Another single centre supervised cardiac rehabilitation study of 20 symptomatic older patients with HCM showed that participation in 60 minutes sessions of moderate to vigorous exercise with a HRR of 85% twice a week for almost 6 months was associated with an increase in functional capacity of 2.5 METS (equivalent to pVO2 of 8.75 mg/kg/min) and an improvement in NYHA class without any adverse effects.31 Both studies provide reassurance about the safety and beneficial effects of moderate exercise in HCM, however, information pertaining to a safe dose of vigorous exercise is still limited.

A recent Korean population study of 7666 middle aged patients with HCM (mean age 59.5 years; 30% females) examined the relationship between self-reported exercise volume and all cause and CV mortality. Individuals who engaged in any physical activity were included and divided into 3 quartiles where the lowest quartile performed 1.46 ± 0.46 METS per day of exercise, intermediate quartile performed 3.4 ± 0.7 METS per day and the highest quartile performed 8.4 ± 3 METS per day. All 3 groups contained over 2,400 patients each. All-cause mortality and CV mortality decreased with increasing physical activity from 9.1% and 4.7% respectively in the lowest quartile to 6.4% and 2.7% respectively in the highest quartile (p 0.014 and 0.002 respectively). Compared with the intermediate quartile group, patients in the high physical activity quartile group did not show an increased risk of all cause or CV mortality (HR 0.78 v 0.75). It is noteworthy that the highest quartile group was exercising 3 times greater than the current exercise physical activity recommendations for CV benefits (Table 1).32

There remains a significant knowledge gap about the general risks and benefits of more vigorous exercise, however, there is an ongoing randomised control trial comparing the efficacy of high intensity and moderate intensity exercise intervention to improve cardiorespiratory reserve in patients with HCM, which could provide invaluable information in the future.33

**HCM and Competitive Sport**

Historical recommendations have only permitted competitive sport in low static and low dynamic disciplines, however, the heterogeneous morphology and pathophysiology of HCM means that some individuals are capable of participating in vigorous exercise including high intensity competitive sports.34,35 Maron and Klues36 first reported a case series of 14 individuals who survived participation in high level endurance sports, including marathons and triathlons, for a mean of 15 years before an incidental diagnosis of HCM. The majority had LVH localised to the septum. Our own experience of evaluating the clinical profile in 106 young asymptomatic competitive athletes (mean age 24.3 ± 6.9 years), 81% of whom were competing at regional, national, or international level at the time of diagnosis revealed mild morphology. Just over half of the athletes had a left ventricular wall thickness ≤ 16mm and one third showed hypertrophy confined to the LV apex. Compared with sedentary counterparts athletes with HCM had a larger LV cavity, superior indices of diastolic function and none revealed LV outflow tract obstruction at rest.35 A subsequent study of 187 middle aged individuals, of whom 44 were considered to represent athletes also revealed that the athletes showed a larger LV volume and superior diastolic function compared with the sedentary group.37

An Italian study reported outcomes in a cohort of 88 adult athletes (median age 31 years) with a low risk profile (ESC 5-year SCD risk 2.2%) following a diagnosis HCM. 27 (31%) individuals continued to engage in competitive sport despite medical advice and during a follow up period of 7 years, there were no adverse events in the exercising group, or any differences in the annual prevalence (1.3%) of new symptoms or non-sustained ventricular tachycardia compared with the relatively sedentary group. There were two cardiac arrests which occurred in the detrained group.38 In a subsequent study the authors could not identify any echocardiographic differences in cardiac dimensions or function between the two groups during the follow up period, however, there was no assessment of myocardial fibrosis.39 Overall these studies indicate that participation in vigorous exercise and competitive sport may be considered in a select group of predominantly adult patients who have mild morphology and a low risk profile.

A multi-national sports safety ICD registry report which originally included 75 individuals with HCM showed no adverse event rates during a 44 month follow up period.40 Although more individuals received appropriate and inappropriate shocks during physical activity than during resting conditions, there was no difference in shock rate between usual physical activity and competitive sport. This study suggests that even individuals deemed to be at high risk may be able to participate in vigorous exercise with an ICD in situ. However, only 16% of the group were considered to represent genuine competitive athletes, 75% had an ICD implant for primary prevention purposes which is associated with an annual appropriate shock rate of only 3% and almost 70% were receiving beta blockers. Furthermore, dynamic sports involving explosive sprints such as basketball and soccer, which are associated with the highest risk of HCM related exercise deaths4 were selected out due to the risk of damaging the generator box during collision. Neither of these studies examining the effect of vigorous exercise, or moderate to high intensity competitive sport on the natural history of HCM were designed or powered adequately to address the question.

**Contemporary Exercise and Sports Participation Recommendation in Individuals with HCM**

The 2015 AHA/ACC position statement for competitive sport in HCM focussed solely on competitive athletes and maintained a conservative approach.12 However the recently published ESC guidelines in sports cardiology and the updated AHA/ACC guidelines in management and treatment of HCM15,16 advocate light to moderate exercise in all individuals with HCM and provide more liberal recommendations for competitive sport in individuals who are deemed to be at low risk (Table 3). Most individuals with HCM may also engage in recreational sports of low to moderate intensity and competitive sports of low intensity. Among individuals who wish to engage in more vigorous exercise or competitive sport of high intensity, a comprehensive assessment is recommended by an expert, which considers symptomatic status, family history, functional capacity, cardiac morphology, and risk profile (Figure 1). A full complement of cardiac investigations is recommended including an echocardiogram, exercise stress test, cardiovascular magnetic resonance (CMR) and prolonged ECG monitor (Figure 2).

An asymptomatic individual with a good functional capacity and low-risk profile may engage in high intensity exercise (Table 4) including competitive sport (exercising to a heart rate ≥ 90% of the maximum predicted for age) except where syncope may cause a traumatic fatality or harm others. In such cases a shared decision-making approach is recommended following discussions that outline the rare occurrence of an adverse cardiac event but also emphasise the knowledge gaps in risk stratification in athletes, and the unpredictability of sudden cardiac arrest in athlete. This precaution is especially relevant to specific high-risk populations such as adolescent and young adult males competing in sport requiring frequent bouts of explosive activity and young male athletes of African or Afro-Caribbean origin.4,41–43 Most exercise related SCDs from HCM occur in adolescent and young adult male athletes involved in dynamic explosive sports such as basketball and soccer and black ethnicity also appears to confer higher risk.4,41–43 It is noteworthy that the ESC guidelines utilise information from the ESC HCM 5-year risk of SCD calculator even though it was not derived from the athletic population because it incorporates data from well-established high-risk factors in HCM.

Individuals with symptoms attributed to HCM with no clear association with exercise or who have one or more risk parameters may participate in no more than moderate intensity sport (exercising to heart rate <75% of maximum age predicted). Individuals considered to be high risk including those who have survived a cardiac arrest, experienced unexplained syncope, report exercise induced symptoms, or have multiple high-risk features should confine themselves to low intensity (exercising at a heart rate <55% of their maximum age predicted) only (Figure 3).

**Genotype positive/phenotype negative patients**

Evolution in the molecular genetics of HCM has led to the detection of an increasing number of asymptomatic individuals with pathogenic variant who do not exhibit phenotypic features of the disease. Former ESC recommendations adopted a more conservative approach on the theoretical possibility that physiological and metabolic stresses of exercise in genetically predisposed individuals could promote arrhythmogenesis or accelerate the phenotype.44 This approach has been supported by imaging studies that reveal mild impairment of myocardial relaxation and modest increases in the extracellular cardiac matrix in such individuals,45,46 although two studies have failed to show any detrimental effects of vigorous exercise in genotype positive and phenotype negative individuals.37,47 In one study adolescents who were genotype positive/phenotype negative revealed a low penetrance of disease over a 12-year follow-up period with only 2 of 36 (6 %) showing the phenotype.48 Based on these findings, both the contemporary ESC and 2015 AHA/ACC recommendations for competitive sport in HCM permit participation in all sports for these individuals, including those with high dynamic and high static components, although annual surveillance is recommended.15,16

**Leisure Exercise in Symptomatic Patients with HCM**

There are some symptomatic patients with HCM who aspire to engage in physical activity. We recommend that all patients with HCM should engage in the minimal physical activity recommendations of 150 minutes of moderate exercise per week divided over 5 sessions and preferably 300 minutes per week in able individuals, if symptoms permit, to reap the benefits of exercise.

An exercise stress test is particularly useful when prescribing safe exercise because it provides relevant information about functional capacity, anaerobic threshold, exercise induced arrhythmias and haemodynamic response to exercise. Apart from walking, patients without symptoms or complex ventricular arrhythmias during moderate exercise may engage in gentle cycling, stationary cycling, treadmill, doubles tennis, moderate hiking or low intensity weights, preferably at a heart rate commensurate with the anaerobic threshold, which is associated with relatively low blood catecholamine concentration.49 Where anaerobic threshold is unknown, we advise exercising at a heart rate below 75% of the maximum predicted for age and to avoid any exercise that induces symptoms. Participation in low intensity competitive sport such as bowling, archery, golf, gentle yoga, or pilates is possible.

Participation in sudden explosive exertion such as sprinting should be avoided.50 Individuals should avoid exercise programmes that involve regular systematic training with increasing workloads focussed on achieving high levels of conditioning and excellence. All patients with HCM should warm for at least 10 minutes before commencing systematic exercise.50,51 Individuals should abstain from exercising in extreme adverse environmental conditions particularly if they are not acclimatised such as temperatures >25oC or <0oC although this will vary depending on the climate, they live in. Exercise during febrile episodes, gastroenteritis or diarrhoeal illness can precipitate syncope and arrhythmias and should be avoided. Finally, patients with HCM should not engage in intensive static isometric exertion using free weights due to the potential risk of serious injury in the event of a syncopal episode. Advice for static exercise include six repetitions up to three times followed by 2 minutes of rest to prevent an exponential rise in blood pressure. Individuals should not push more than 20% of the body weight with the upper limbs and more than 50% of their body weight with the lower limbs in the initial stages of weight training, although this may be increased if at a later stage it does not result in a heart rate exceeding 70% of the maximum predicted for age (Figure 4).

**Conclusion:**

Whereas historical guidelines have focussed predominantly on elite young athletes and provided prohibitive recommendations, it is now well recognised that a sedentary lifestyle has a detrimental effect in all individuals with HCM. All able patients with HCM should adhere to the current minimal physical activity recommendations, whilst others should perform symptom limited physical activity. Moderate exercise appears to be safe. Large scale, long term observational studies in athletes with HCM are necessary to bridge the knowledge gaps pertaining to the impact of vigorous exercise on the natural history of the disease (Figure 5).

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**Key Messages:**

* Exercise is beneficial for cardiovascular health and light and moderate exercise should be encouraged in all able individuals with hypertrophic cardiomyopathy (HCM)
* A detailed comprehensive risk evaluation of all individuals with HCM is recommended to formulate a safe exercise prescription plan.
* The current European Society of Cardiology guidelines and the 2020 AHA/ACC guideline for the diagnosis and treatment of patients with HCM recommend a liberal approach to exercise in HCM. Asymptomatic individuals with mild a phenotype and absence of high-risk features for SCD may engage in all competitive sports
* Longer term follow-up studies are required in individuals with HCM who exercise vigorously with important considerations to age, sex, ethnicity and sporting disciplines and ESC-risk score.

**Figure Legend:**

**Figure 1:** Comprehensive clinical evaluation and risk stratification of individuals with hypertrophic cardiomyopathy for sudden cardiac death.

Abbreviations: BP, blood pressure; CPET, cardiopulmonary exercise test; ECG, electrocardiogram; HR, heart rate, MRI, magnetic resonance imaging

**Figure 2:** Parameters to Evaluate in Hypertrophic Cardiomyopathy

Abbreviations: BP, blood pressure; ECG, electrocardiogram; LA, left atrium, LV, left ventricular; LVOT, left ventricular outflow tract

**Figure 3:** European Society of Cardiology sports cardiology guidelines for exercise in HCM.

Abbreviations: BP, blood pressure; HCM, hypertrophic cardiomyopathy; LVOT, left ventricular outflow tract; SCD, sudden cardiac death

**Figure 4:** Exercise recommendations in symptomatic patients with hypertrophic cardiomyopathy. Adapted from D’Silva et al52

**Figure 5:** Relationship between exercise and hypertrophic cardiomyopathy

**Tables:**

**Table 1: Summary of key studies investigating the effect of exercise in patients with HCM**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **First Author** | **Year** | **Type of Study** | **Individual Characteristics** | **Exercise program** | **Summary of findings** |
| **Klempfner et al**31 | **2015** | **Single centre Study** | * **20 patients with HCM** * **Mean age 62±13 years old** * **Symptomatic in NYHA class II or III** | * **2 x 60 mins supervised exercise sessions at a HRR 85%** * **Completed 41±8 hours of aerobic exercise** | * **Increase in functional capacity 2.5METS (pVO2 8.75ml/Kg/min)** * **Improvement in NYHA class** * **No adverse events** |
| **Saberi et al**30 | **2017** | **Randomised clinical trial** | * **67 patients with HCM** * **69 controls with HCM** * **Mean age 50.4±13.3 years old** * **Asymptomatic** | * **16-week home based exercise program** * **4-7 x 60 mins at HRR= 70%** | * **Modest increase in peak VO2 (1.35ml/Kg/min)** * **Improved quality of life scores** * **No adverse events** |
| **Kwon et al**32 | **2020** | **Clinical observation study** | * **7666** * **Mean age 59.5 years** * **Follow-up 5.3±2 years** | * **Self-reported exercise volume in quartiles** * **Low 1.46±0.46 METS/day** * **Intermediate 3.4±0.7 METS/day** * **High 8.4±3 METS/day** | * **Reduction in all-cause mortality** |

Abbreviations: HCM, hypertrophic cardiomyopathy; HRR, heart rate reserve; METS, metabolic equivalents; NYHA, New York Heart Association; pVO2, peak oxygen consumption

**Table 2: Summary of key studies investigating athletes with HCM**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **First Author** | **Year** | **Type of Study** | **Individual Characteristics** | **Exercise program** | **Summary of findings** |
| **Sheikh et al**35 | **2015** | **Clinical Observational study** | * **106 asymptomatic athletes competing at regional level or above** * **102 patients with HCM** * **Mean age 24.3±6.9 years old** | * **81% competing at regional, national, or international level** | **Compared with patients with HCM, 96% of athletes with HCM exhibited**   * **milder LVH (36% confined to apex)** * **Large LVEDD** * **Superior indices of diastolic function** |
| **Dejgaard et al**37 | **2018** | **Clinical observational study** | * **187 asymptomatic patients with HCM (44 athletes)** * **Mean age 49±16 years old** | * **>6MET = vigorous exercise** * **>4hours/week for >6 years (in the athletic range)** | **Exercise associated with**   * **Larger LV volumes** * **Superior diastolic function** * **Larger stroke volume** * **No change in LVOT gradient** * **No increase in VAs** |
| **Pelliccia et al**38 | **2020** | **Clinical observational study** | * **88 asymptomatic athletes with HCM** * **Median age 31 years** * **ESC 5-years SCD risk 2.2%** * **Follow up 7±5 years** | * **27 (31%) continued competitive sport** * **61 (69) stopped competitive sport** | * **No adverse events in the HCM trained athletes** * **2 SCA in the HCM detrained group** * **No difference in annual prevalence of new symptoms (1.3%)** |

Abbreviation: ESC, European society of cardiology; HCM, hypertrophic cardiomyopathy; LV, left ventricle; LVEDD, left ventricular end-diastolic dimension; LVH, left ventricular hypertrophy; LVOT, left ventricular outflow tract; METS, metabolic equivalents; NYHA, New York Heart Association; pVO2, peak oxygen consumption; SCA, sudden cardiac arrest; VAs, ventricular arrhythmias

|  |  |  |
| --- | --- | --- |
| Table 3. Contemporary AHA/ACC and ESC Guidelines for Sport Participation with HCM | | |
| **Guideline** | **ESC Sports Cardiology (2020)** | **AHA/ACC HCM (2020)** |
| High-intensity exercise including competition | Participation in all competitive sport may be considered after expert assessment, (except those where syncope may be associated with harm or death) in asymptomatic individuals without any markers of increased risk\* (II, C).  Participation in high intensity recreational exercise or competitive sport is not recommended in individuals with markers of increased risk\* (III, C) | High-intensity recreation / moderate-high-intensity competition may be considered after comprehensive evaluation and shared discussion, repeated annually with an expert provider who conveys that the risk of sudden death and ICD shocks may be increased, and with the understanding that eligibility decisions for competitive sports often involve third parties (IIb, C) |
| Low-moderate intensity exercise including competition | Participation in low-moderate intensity recreational exercise may be considered in individuals who have markers of increased risk\* (IIb, C) | Mid-moderate-intensity recreational exercise is beneficial to improve cardiorespiratory fitness, physical functioning, and quality of life, and for their overall health in keeping with physical activity guidelines for the general population (I, B)  Low-intensity competition is reasonable in most patients with HCM (IIa, C) |
| Genotype (+) / phenotype (-) | Participation in all competitive sports may be considered for individuals who are gene positive for HCM but phenotype negative (IIb, C) | Participation in competitive sports of any intensity is reasonable for individuals who are gene positive for HCM but phenotype negative (IIa, C) |
| ICDs for sole purpose of participation | Not recommended (III C)\*\* | Not recommended (III, B) |
| Participation in competitive sport with an ICD in situ | Shared discussion should be considered during decisions relating to continuation of intensive or competitive sports participation in individuals with an ICD, taking into account the effect of sports on the underlying substrate, the fact that intensive sports will trigger more appropriate and inappropriate shocks, the psychological impact of shocks on the athlete/patient, and the potential risk for third parties (IIa C) | May be considered after comprehensive evaluation and shared discussion with an expert provider who conveys that the risk of sudden death and ICD shocks may be increased. |
| Evaluation and follow-up | Annual follow-up is recommended for individuals who exercise on a regular basis including genotype positive and phenotype negative individuals (I, C)  Six-month follow-up should be performed for adolescents and young adults who are more vulnerable to exercise-related SCD (IIa C) | Comprehensive evaluation and shared discussion of potential risks of sports participation by an expert  provider is recommended on an annual basis (I C) |

Abbreviations: ICD; implantable cardiac defibrillator

\*Markers of increased risk include: (i) cardiac symptoms or history of cardiac arrest or unexplained syncope; (ii) moderate ESC risk score (>\_4%) at 5 years; (iii) LVOT gradient at rest >30 mmHg; (iv) abnormal BP response to exercise; (v) exercise-induced arrhythmias.

\*\* Not specifically tabulated in the table of exercise recommendations for HCM but documented in the table of recommendations for exercise in individuals with an implantable cardioverter defibrillator.

**Table 4: Indices of exercise intensity15**

|  |  |  |  |
| --- | --- | --- | --- |
| Intensity | HRmax (%) | HRR (%) | VO2max |
| **Light** | **<55** | **<40** | **<40** |
| **Moderate** | **55-74** | **40-69** | **40-69** |
| **High** | **75-90** | **70-85** | **70—85** |
| **Very High** | **>90** | **>85** | **>85** |

Abbreviations: HRmax = maximum heartrate; HRR = heart rate reserve (HRmax-HRrest); VO2 maximal oxygen consumption.

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