Definition of Athletes and Classification of Sports

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Learning Objectives

1. Understand the meaning of the term athlete.
2. Be able to provide a complete description of a population of athletes including level of commitment, exercise training parameters and epidemiological characteristics.
3. Understand both the clinical and scientific need and the value of classifying athletes into subgroups based on various exercise stimuli.
4. Be aware of the main objectives, characteristics and limitations of the most used classifications of sports.

1.1 Definition of Athletes

The term athlete comes from the Greek word "athlos", which means "achievement" [1]. Indeed, athletes are commonly considered individuals with superior physical and psychological conditions leading them to athletic excellence. Within medical research, the term has been used with completely different meanings and without consensus between international guidelines [2–4].

For the purpose of this chapter, an athlete is considered to be an individual who is engaged in physical activity and exercise on a regular basis. This definition is intentionally much wider than previous ones, as we believe it is the responsibility of the medical and scientific community to engage and include all those individuals regularly participating in some type of physical activity. They are the one that will likely benefit the most, in terms of health enhancement, from sport participation.

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There is a need for a cultural change, and this can only be achieved through education and direct engagement. The objective is to bring sport back to the people at grass root level. Therefore, we need a much more inclusive definition of what an athlete is. The population of athletes is thus quite heterogeneous and as such, further descriptors should be included when describing an athlete. The following are necessary descriptors to define a population of athletes:

- Level of commitment:
  - Recreational athletes: individuals engaged in recreational or open sport.
  - Competitive athletes: individuals engaged in exercise and training on a regular basis and participating in official sports competition, at any level.
  - Elite and professional athletes: constitute a subgroup within competitive athletes who achieve athletic excellence and usually compete at an international level, earning a living out of their sport participation.
- Exercise training parameters:
  - Frequency (days/week): the number of days per week an individual exercises or performs physical activity.
  - Intensity: can be measured or estimated using different methods (see below).
  - Duration (time per session, per day, per week): the amount of exercise performed.
  - Type of activity: describes the type of activity performed based on the discipline's characteristics and cardiovascular main adaptations.
  - Volume (Metabolic equivalent of tasks (MET)-min/week, kcal/week): the product of frequency (days/week), intensity (based on, e.g., heart rate (HR), heart rate reserve (HRR), maximal oxygen uptake (VO_2max), oxygen reserve (VO_2R)), and duration (of each training session/day or /week).
  - Sport discipline and role/position within this discipline.
  - Global exercise training load: years of exercise training in the specified sport discipline.

Regarding exercise intensity, the preferred method is the direct measurement of physiological responses to exercise through an incremental cardiopulmonary exercise test (i.e. maximal HR—HR_{max}, VO_2max). For exercise prescription purposes the HRR, %HR_{max} or %VO_2max can be adopted [5]. Other indirect methods of estimating exercise intensity use the predicted HR_{max} formulas (e.g. $HR_{max} = 220 - age$; $HR_{max} = 208 - (0.7 \times age)$) [6, 7]. These methods, although easier to use, can underestimate or overestimate measured HR_{max}. Measured or estimated values of absolute exercise intensity include caloric expenditure (kcal/min), absolute oxygen consumption (mL/min or L/min), and METs which is roughly the energy expended in resting conditions, set by convention at 3.5 mL of oxygen per kilogram body weight per minute, or 1 kcal/kg body mass per hour. Nevertheless, these methods do not take into consideration individual factors such as body mass, sex and fitness level and can cause misclassification of exercise intensities. For ease of reference and adoption of METs, activities have been listed and classified, according to the measured METs, in a compendium of physical activities [8–10].

Measures of perceived effort can also be used to modulate and indirectly estimate the exercise intensity. These measures of affective valence (i.e. pleasantness of exercise) include the Borg Rate of Perceived Exertion (RPE) Scales [11, 12] and the Talk Test [13]. The Talk Test is based on the concept that exercising at or above the lactate or ventilatory thresholds prevents a comfortable conversational speech and thus constitutes a valid and reliable method for estimating exercise intensities [14–19] (see also Chaps. 11 and 45).

Regarding exercise volume, it can be used to estimate the individual's energy expenditure [20]. The volume of exercise usually increases progressively with the level of competition from ≥500–1000 MET-min/week in recreational athletes to ≥10,000 MET-min/week in competitive and elite athletes. However, this is not always the case and may vary depending on the sport discipline requirements and even on individual motivation (Table 1.1).

- Epidemiological characteristics:
  - Gender
  - Age: young or adolescents (12–17), adult (18–35) and master athletes (above 35 years old).

Regarding age, the above-mentioned traditional classification may be subject to changes according to each sport rules and regulations [21]. The current division between adult and master athletes is mainly based on the fact that 35 years is the age at which ischemic cardiovascular events tend to become a greater cause of mortality

Table 1.1 Energy expenditure induced by various sports (arbitrarily selected from [8–10])

Activity/sports	Intensity/type	METs
Cycling	Leisure	4.0
	General	7.5
	Vigorous	10.0
	Mountain, uphill	14.0
Conditioning exercise	Cycling, stationary, general	7.0
	Calisthenics, moderate	3.8
	Resistance training, 8–15 repetitions	3.5
	Rowing, stationary, general	6.0
Running	Jogging, general	7.0
	Marathon	13.0
Basketball	General	6.5
Soccer	Competitive	8.0
Golf	General	4.8
Hockey, ice	General	8.0
Horseback riding	General	5.5
Martial arts	Different types, moderate	10.3
Rock climbing	Moderate difficulty	5.8
Tennis	General	7.3
Walking	Hiking, cross-country	6.0
Water activities	Swimming, breaststroke, recreational	5.3
Winter activities	Skiing, general	7.0

in the athlete's population while the separation between young and adult athletes at 18 years is related with the age at which puberty is usually completed.

Recreational athletes and those individuals participating in physical activity for health purposes, in some cases, might as well reach exercise training volumes and intensities as competitive or even elite athletes. Therefore, they may develop similar structural and electrical cardiovascular adaptations in response to the exercise stimulus. Thus, when describing an athlete, exercise training parameters described previously become mandatory.

1.2 Classification of Sports

According to the objective of the classification, sport disciplines have been classified in various ways. Existing classifications consider different aspects of the sport such as:

- physical demands induced by different sports
- impact of different exercise stimuli on performance and body composition
- cardiovascular adaptations induced by different modalities and intensities of exercise
- the potential consequences of a syncope while exercising.

For the purpose of this chapter we will present the two mainly adopted and recent classifications of sports.

1.2.1 Mitchell Classification of Sports

One of the most referred-to classifications is the Mitchell classification of sports [22] that was developed with the objective of clarifying whether an athlete with a specific cardiovascular abnormality was eligible to participate in competitive sport. The Mitchell classification considers:

1. the type and intensity of the sport
2. the risks of injuries from body collision
3. the consequences of a syncope.

The main components of each sport considered are **static** and **dynamic**. These terms refer to the exercise activities characteristics and are based on the biomechanical action of the muscles involved. These features do not consider the metabolic pathway mostly used (aerobic or anaerobic). Dynamic exercises involve changes in muscle length and joint movement through rhythmic contractions that usually develop a relatively small force. Static exercises, on the other hand, are characterized by relatively large forces, with very little or no change in muscle length and joint movement.

Based on these two "opposite" components of exercise, the Mitchell classification characterizes different sports according to their percental proportion of static and dynamic exercise stimuli and summarizes disciplines with similar proportions into particular subgroups (Fig. 1.1). It was first developed with the objective of defining whether an athlete with a specific cardiovascular abnormality is eligible to participate in a competitive sport. It provides clinical support when deciding whether certain cardiovascular adaptations observed in an athlete are likely to be sufficiently explained by the type of sports he or she is performing.

Although comprehensive and including most sports, the Mitchell classification:

- does not take into consideration the extent to which the physical fitness components are trained in successful athletes,
- carries a risk of underestimating the real work intensity, and
- might not be so intuitive for the clinician with less experience in sports cardiology.

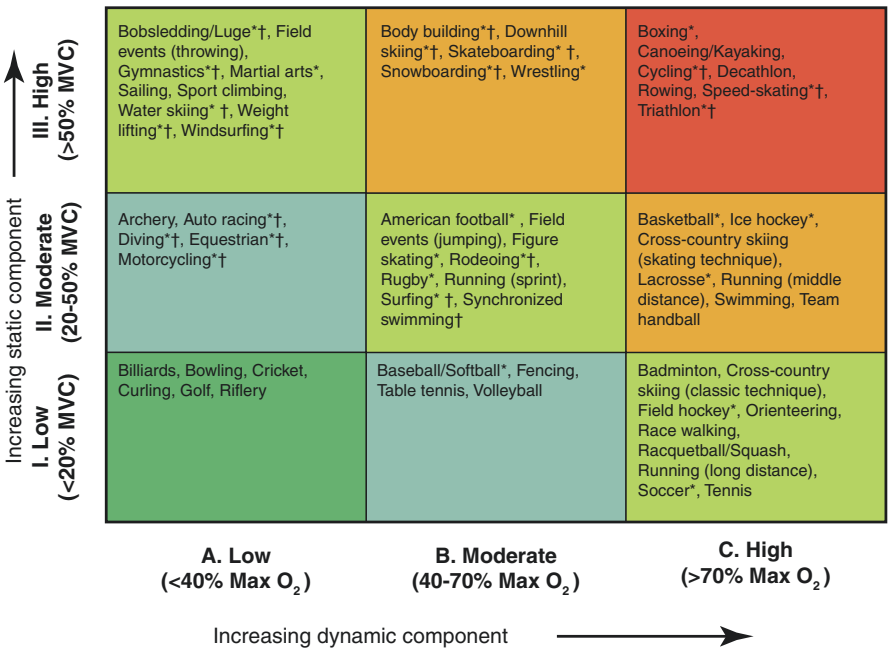

Fig. 1.1 Classification of sports. This classification is based on peak static and dynamic components achieved during competition. It should be noted, however, that higher values may be reached during training. The increasing dynamic component is defined in terms of the estimated percent of maximal oxygen uptake (VO_2max) achieved, resulting in increasing cardiac output. The increasing static component is related to the estimated percent of maximal voluntary contraction (MVC) reached, resulting in an increasing blood pressure load. The lowest total cardiovascular demands (cardiac output and blood pressure) are shown in green and the highest in red. Blue, yellow and orange depict low moderate, moderate and high moderate total cardiovascular demands. (Modified from Mitchell and colleagues [22]). ∗Danger of body collision, †Increased risk if syncope occurs

1.2.2 Cardiovascular Classification of Sports

Another way in which sports have been also frequently classified is based on the **isotonic** and **isometric** exercise components and the resulting cardiovascular adaptations induced by exercise (Fig. 1.2 and [23]). Isotonic exercise mainly involves disciplines that are characterized by a predominant change in muscular length rather than tension, whereas isometric refers to the opposite. As such, this is rather similar to the Mitchell classification. However, apart from this, the classification also considers whether a particular discipline requires specific technical skills beyond muscular work to be performed successfully, such as the complex movement required to hit a golf ball or the concentration and reactivity to control a racing car.

Although comprehensive from a cardiovascular perspective, this type of classification

- does not take into consideration most of the physiological components defining different sports,
- relies mostly on imaging findings with the objective of facilitating the clinical sports cardiologists evaluating the athlete.

All types of classifications look at sports from different perspectives resulting in different positive sides and limitations. Therefore, depending on the objective of the evaluation, one type of classification might be more appropriate than another one. Nevertheless, it should be reminded that classifying sports remains an academic exercise that, currently, does not take into account all the sports characteristics and adaptations, at least until a universal theory of sports will be able to describe all variables.

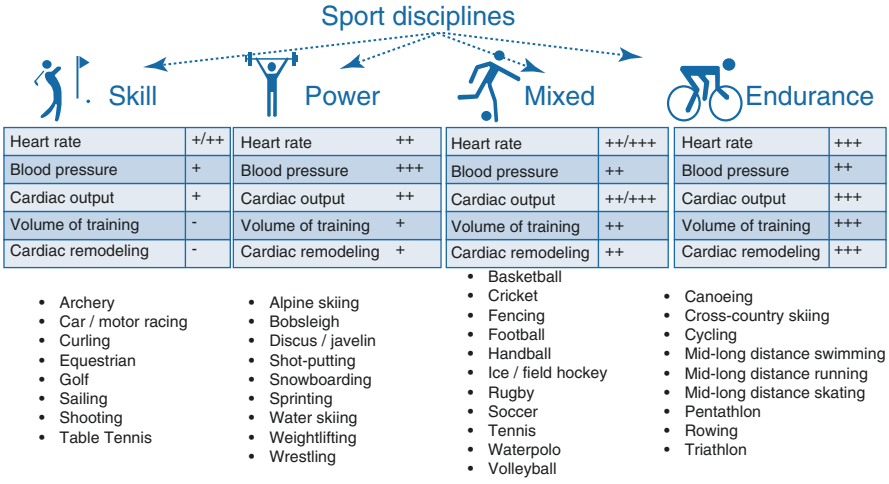

Fig. 1.2 Simplified classification of the most common Olympic sport disciplines, according to the relative isometric and isotonic components of exercise and resulting cardiovascular adaptation. (Modified from Pelliccia and colleagues [23])

It should also be reminded that in many cases, training could be more demanding, from a cardiovascular perspective, than competition. Training regimens in most sports now include both static and dynamic components that might not be a specific part of that sport. The concept that training load could induce a greater cardiovascular load than competition must be considered also for non-competitive athletes who might reach large training volumes but do not compete.

Clinical Pearls

- An athlete is considered to be an individual who is engaged in physical activity and exercise on a regular basis. This definition is intentionally wide, to include all those individuals regularly participating in some type of physical activity.
- Variables to consider when describing exercise and athletic populations:
  - Level of commitment
  - Exercise training parameters
  - Epidemiological characteristics
- All types of classifications look at sports from different perspectives, have different positive sides and limitations. Therefore, depending on the objective of the evaluation, one type of classification might be more appropriate than another one.

Review

Questions

1. A 48-year old male triathlete reports an average training volume of 4–5 h per week. He used to perform a variety of sports during his adolescence without particular focus and with only occasional competitions. After a break over several years he started with more or less regular running roughly at the age of 36 with increasing frequency, added by cycling and swimming about 3–4 years later. This was also the time when training became more systematic, and he started to participate in his first short distance events. Over several years he then performed 3–4 Olympic distance triathlons per year and is now preparing for his first ironman distance. What would be your definition of this athlete in terms of level of commitment, exercise training parameters and, particularly, the potential impact of this training history on cardiovascular adaptation?
2. According to the Mitchell classification, how would you classify an athlete who is performing triathlon during summer and cross-country skiing (classic technique) during winter, taking part in long-distance competitions in both sports?
3. A 44-year old marathon runner presents with concentric left ventricular hypertrophy (12 mm). He started regular running at the age of 25 and finished his first marathon a few years thereafter. Since then he has participated in 1–2 marathons per year. How would you classify this athlete? Is the type of hypertrophy explained by your classification?

Answers

1. A major issue in sports cardiology is to decide whether the presence of certain cardiovascular adaptations in athletes are adequately explained by their particular training histories. Regarding this, defining an athlete as either "recreational" or "competitive" and evaluating his exercise parameters and the accumulated training years is of clinical significance. Middle-aged athletes having started their regular training only during adulthood are particularly difficult to judge. In this borderline case, apart from taking part in competitions, the training volume is usually not sufficient to result in detectable clinical changes (although it cannot fully be excluded). In other words, in case of equivocal alterations, a more extensive diagnostic workup is reasonable. Since these athletes usually aim at goals during competition that may exceed realistic estimations, they should be regarded as competitive in order to carefully account for the excessive demands they tend to expose themselves to.
2. Many ambitious recreational or competitive athletes engage in more than one sports and can thus sometimes not be assigned to a particular subgroup. This indicates the limitations of these approaches. For clinical assessment or scientific purposes, it is reasonable to assign this athlete to Mitchell subgroup IB covering the best mixture between the different exercise stimuli he or she is exposed to.
3. This athlete perfectly suits into Mitchell subgroup IC, or into the "endurance" group according to the cardiovascular classification. These athletes may develop mild hypertrophy over time; thus, a value of 12 mm is at least possible. However, one would usually expect a more eccentric type of hypertrophy, with the left ventricular diameter also being markedly enlarged. If this is not the case, this athlete requires further evaluation, e.g. with respect to the presence of hypertension.

References

1. Araujo CG, Scharhag J. Athlete: a working definition for medical and health sciences research. Scand J Med Sci Sports. 2016;26(1):4–7.
2. Maron BJ, Zipes DP, Kovacs RJ. Eligibility and disqualification recommendations for competitive athletes with cardiovascular abnormalities: preamble, principles, and general considerations: a scientific statement from the American Heart Association and American College of Cardiology. Circulation. 2015;132(22):e256–61.
3. Solberg EE, Borjesson M, Sharma S, Papadakis M, Wilhelm M, Drezner JA, et al. Sudden cardiac arrest in sports – need for uniform registration: a position paper from the Sport Cardiology Section of the European Association for Cardiovascular Prevention and Rehabilitation. Eur J Prev Cardiol. 2015;23(6):657–67.
4. Pelliccia A, Fagard R, Bjornstad HH, Anastassakis A, Arbustini E, Assanelli D, et al. Recommendations for competitive sports participation in athletes with cardiovascular disease: a consensus document from the Study Group of Sports Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. Eur Heart J. 2005;26(14):1422–45.

5. Mezzani A, Hamm LF, Jones AM, McBride PE, Moholdt T, Stone JA, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation. Eur J Prev Cardiol. 2013;20(3):442–67.
6. Fox SM III, Naughton JP, Haskell WL. Physical activity and the prevention of coronary heart disease. Ann Clin Res. 1971;3(6):404–32.
7. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol. 2001;37(1):153–6.
8. Ainsworth BE, Haskell WL, Leon AS, Jacobs DR Jr, Montoye HJ, Sallis JF, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc. 1993;25(1):71–80.
9. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000;32(9 Suppl):S498–504.
10. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc. 2011;43(8):1575–81.
11. Borg GA. Perceived exertion. Exerc Sport Sci Rev. 1974;2:131–53.
12. Noble BJ, Borg GA, Jacobs I, Ceci R, Kaiser P. A category-ratio perceived exertion scale: relationship to blood and muscle lactates and heart rate. Med Sci Sports Exerc. 1983;15(6):523–8.
13. Persinger R, Foster C, Gibson M, Fater DC, Porcari JP. Consistency of the talk test for exercise prescription. Med Sci Sports Exerc. 2004;36(9):1632–6.
14. Brawner CA, Vanzant MA, Ehrman JK, Foster C, Porcari JP, Kelso AJ, et al. Guiding exercise using the talk test among patients with coronary artery disease. J Cardpulm Rehabil. 2006;26(2):72–5; quiz 6–7.
15. Ballweg J, Foster C, Porcari J, Haible S, Aminaka N, Mikat RP. Reliability of the talk test as a surrogate of ventilatory and respiratory compensation thresholds. J Sports Sci Med. 2013;12(3):610–1.
16. Gillespie BD, McCormick JJ, Mermier CM, Gibson AL. Talk test as a practical method to estimate exercise intensity in highly trained competitive male cyclists. J Strength Cond Res. 2015;29(4):894–8.
17. Lyon E, Menke M, Foster C, Porcari JP, Gibson M, Bubbers T. Translation of incremental talk test responses to steady-state exercise training intensity. J Cardiopulm Rehabil Prev. 2014;34(4):271–5.
18. Rodriguez-Marroyo JA, Villa JG, Garcia-Lopez J, Foster C. Relationship between the talk test and ventilatory thresholds in well-trained cyclists. J Strength Cond Res. 2013;27(7):1942–9.
19. Woltmann ML, Foster C, Porcari JP, Camic CL, Dodge C, Haible S, et al. Evidence that the talk test can be used to regulate exercise intensity. J Strength Cond Res. 2015;29(5):1248–54.
20. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43(7):1334–59.
21. Allen SV, Hopkins WG. Age of peak competitive performance of elite athletes: a systematic review. Sports Med. 2015;45(10):1431–41.
22. Mitchell JH, Haskell W, Snell P, Van Camp SP. Task Force 8: classification of sports. J Am Coll Cardiol. 2005;45(8):1364–7.
23. Pelliccia A, Adami PE, Quattrini F, Squeo MR, Caselli S, Verdile L, et al. Are Olympic athletes free from cardiovascular diseases? Systematic investigation in 2352 participants from Athens 2004 to Sochi 2014. Br J Sports Med. 2017;51(4):238–43.