The role of relative intensity

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Over the last decades, more attention has been paid to the effects of physical activity (PA) on health and disease, morbidity and mortality. Numerous epidemiological studies have provided strong evidence that there are inverse associations between PA and the risk for cardiovascular mortality and morbidity. An important issue in these relationships is the importance of characteristics of PA and exercise training interventions.

Characteristics of PA and exercise

In order to quantify the amount of PA or the required energy expenditure, often the term METs is used. MET is the metabolic equivalent unit, which expresses energy expenditure in multiples of resting energy cost. One MET is equivalent to an oxygen uptake (O2) of 3.5 ml/min per kg body weight, which is the amount of energy expended during 1 minute of rest.

The characteristics of PA are typically described in terms of **F**requency, **I**ntensity, **T**ime (or duration) and **T**ype of PA, the **FITT** principle of exercise. These dimensions are used to describe the dose of PA or exercise needed to exhibit particular physiological responses and outcomes. Frequency refers to the number of activity sessions per day, week, or month. The number of activity minutes in each session is described as time, while total time of activity session or of PA programme is termed duration. Intensity describes energy expenditure associated with certain PA (light, moderate, or vigorous). The type of PA or exercise includes all activities from different domains, such as active transportation, household activities, leisure-time physical activities (LTPA), and occupational physical activities. Type of exercise interventions refers also to aerobic or endurance activities, to strength or resistance exercise or flexibility or coordination exercises. Finally, the mode of PA or exercise is an important characteristic, although not mentioned in the abbreviation of the FITT principle and indicate the type of contraction (isometric, isotonic or isokinetic), the type of mechanical/physiological action (dynamic versus static; aerobic versus anaerobic and continuous versus interval exercises.

Intensity of exercise

Intensity of exercise can be expressed in many different ways, in absolute (METs; RPE scale) or in relative terms (percentage of maximal capacity or heart rate) (Table 1) (1;2) or in subjective feelings. As an example, moderate-intensity PA is usually defined as any PA level at which a

Table 1 Relationship among indices of exercise intensity and training zones

Intensity	Lactate (mmol/l)	METs	VO_{2max} (%)	HRR (%)	HR_{max} (%)	RPE scale	Training Zone
Low intensity, light effort	2-3	2-4	28-39	30-39	45-54	10-11	Aerobic
Moderate intensity, moderate effort	4-5	4-6	40-59	40-59	55-69	12-13	Aerobic
High intensity, vigorous effort	6-8	6-8	60-79	60-84	70-89	14-16	Lactate, aerobic, anaerobic
Very hard effort	8-10	8-10	>80	>84	>89	17-19	Lactate, aerobic, anaerobic

HR_{max}, maximum heart rate; HRR, heart rate reserve; METs, metabolic equivalents, 1 MET = individual metabolic resting demand, when sitting quiet, about 3.5 ml oxygen/kg/min or 1 kcal (4.2 kj/kg/h in the general population; RPE, Borg rating of perceived exertion (6-20 scale).

person experiences some increase in breathing or heart rate and a rate of perceived exertion (RPE) of 11–14 on the Borg scale. The person should be able to carry on a conversation comfortably during the activity. It is typically characterized as energy expenditure of 3–6 METs, for instance, brisk walking. Vigorous-intensity is any type of activity that is intense enough to represent a substantial challenge to an individual and results in a significant increase in heart rate, breathing frequency, and sweating. In terms of energy expenditure, it is equivalent to any activity that corresponds to more than 6 METs, for instance, jogging. Activities corresponding to less than 3 METs are characterized as light activities, but may, if the duration is sufficiently long, contribute to health.

Relative exercise intensity refers to a portion of maximal power (load) that is maintained during exercise and is usually prescribed as a percentage of maximal aerobic capacity (VO2max) on the basis of a cardiopulmonary stress test. Training intensity can also be expressed as a percentage of maximal heart rate (HRmax) recorded in a stress test or predicted on the basis of an equation stating that HRmax equals 220 minus age. We do not recommend the use of prediction equations of HRmax for individuals, because of the large standard deviation. A frequently used method to express exercise intensity is by using the Karvonen formula, which uses a percentage of a person's HR reserve (HRR = the difference between HRmax and resting HR) and adds it to the resting HR. There are caveats and cautions to the use of HR for prescribing and evaluating exercise intensity in persons under β-blocker medication. Ideally, the HR derived for training should only be used if the functional capacity (or stress test) was performed under actual medication.

Importance of intensity of exercise

Of all the basic elements of exercise prescription, exercise intensity is recently claimed to be an important factor in the development of aerobic fitness and reversion of risk factors. We have reviewed in a series of three papers the importance of characteristics and modalities of PA and exercise in the management of cardiovascular health in the general population (part I), in individuals with cardiovascular risk factors (part II) and in individuals with cardiovascular disease (part III) (1-3).

In the population at large, we could conclude from several recent reviews and meta-analyses that a dose-response curve on cardiovascular outcome has undoubtedly been demonstrated. Higher exercise intensities have greater preventive impact on total and cardiovascular mortality and on cardiovascular morbidity than no or only light intensity exercise. Moderate intensity exercise already exerts a protective effect whereas high intensity exercise has additional effects compared to moderate intensity exercise.

When targeting cardiovascular risk factors, a more divergent outcome regarding intensity became apparent from the available literature. To decrease or maintain body weight, duration of moderate intense aerobic activity is more important than high intensity activity (4). The same yields probably for decreasing plasma triglycerides and LDL cholesterol levels. On the other hand, some data suggest that for increasing HDL a sufficient amount of intense aerobic exercise is warranted. For diabetes, the best characteristic of PA and exercise is the combination of aerobic and dynamic strength exercises with sufficient intensity and performed at least every second day. Submaximal prolonged walking, jogging, cycling, and swimming are representative types of exercise, usually called aerobic or endurance. Concerning blood pressure, dynamic exercise training, as well aerobic as resistance exercise training, exerts hypotensive effects, the former clearly more expressed in hypertensive subjects. The importance of intensity of exercise in relation to blood pressure is less clear.

In patients with different cardiovascular diseases, high intensity aerobic interval exercise training was recently advocated by as well American, Canadian as European Associations on Cardiovascular Rehabilitation for patients with coronary artery disease (CAD) and patients with stable chronic heart failure (5). A recent meta-analysis confirms that aerobic interval training improves aerobic performance by on average 22% in contrast to moderate continuous training where the effect of exercise training averaged only 12% (6). The latter increase, however, is inferior to that what usably is found after cardiac rehabilitation. We have previously demonstrated an increase of on average 26% in 1909 patients with cardiac disease and determinant analysis showed that training intensity and frequency were the most important factors explaining the change in exercise capacity after exercise training (7). In other cardiovascular patient populations less data are available on the importance of exercise intensity.

Finally, it must be emphasized that intense exercise should be individually and safely prescribed and therefore, graded exercise testing is warranted in every individual with a risk profile for cardiovascular events (8).

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