Obesity and physical exercise in adults

Obesidad y ejercicio físico en adultos

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Introduction

This paper analyses the scientific evidence on exercise in adults with overweight or obesity, and represents a consensus position of the Sociedad Española de Medicina del Deporte (Spanish Society of Sports Medicine).

It is clear that both the prevention and treatment of obesity requires a multifaceted approach focussing, to a considerable extent, on lifestyle. Within lifestyle, diet and combining it with exercise plays a key role.

In this paper, we will focus exclusively on physical exercise, given that significant changes have been witnessed in this field in recent years and a growing number of, sometimes contradictory, recommendations have been voiced.

First of all, we will address the existence of evidence regarding the role played by exercise (in its various forms) in the treatment and prevention of obesity. We will then analyse what is currently known about the functional assessment data which can be used to programme exercise in obese subjects. Finally, we will make an in-depth analysis of the evidence existing at this time regarding the role of both continuous and interval training in losing weight (and maintaining such loss) in obese subjects.

Current evidence on the role of exercise in weight loss in obese adults

Obesity is one of the biggest health problems currently faced by society and the most common factor of comorbidity in subjects with conditions which include metabolic disorders (metabolic syndrome, hypertension, dyslipidaemia, type 2 diabetes, fatty liver disease, cholelithiasis, tumours, polycystic ovaries, etc.), cardiovascular problems (hypertension, coronary heart disease and atrial fibrillation, among others), mechanical disorders (chiefly, hypoventilation, sleep apnoea and osteoarthritis) and psychosocial disorders (depression, social/job discrimination, low self-esteem, eating disorders)[1-3]. The prevalence of obesity in adults over 18 years of age in Spain is 18.2% for men and 16.7% women[4], with a sedentary population of 31.9% in men and 40.0% in women[5]. The WHO recently presented its Global Action Plan on Physical Activity 2018-2030 in an attempt at reducing physical inactivity and promoting health in the face of the worrying fact that non-communicable diseases (NCDs) are responsible for 71% of all deaths worldwide, including 15 million people aged between 30 and 70 every year[6].

Weight loss is associated with improvement in comorbidity, evidence of which has been cited for many years and has been corroborated more recently by various scientific studies, systematic reviews and meta-analyses conducted up to 2020, especially with regard the normalisation of the blood sugar level in type 2 diabetes and dyslipidaemia, decreased blood pressure[7-10] and symptoms of osteoarthritis[11], principally in obese individuals.

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Review of the most recent meta-analyses on the effect of exercise on weight loss

One way to lose weight within the field of lifestyle changes and keeping healthy is to do regular exercise[10,12-16], even before and after bariatric surgery[17].

Moderate-intensity physical activity for 150 to 250 min/week expending energy equivalent to 1,200 to 2,000 kcal/week would seem sufficient to prevent and avoid increases in weight of more than 3% in most adults, and can lead to moderate weight losses of 2 to 3 kg, the figure reaching 5 and 7.5 kg when exercise is performed for 225-420 min/week. The same recommendation applies to individuals with overweight and obesity, in which case a better response, involving greater weight loss and better weight maintenance, is likely[12].

The search for systematic reviews and/or meta-analyses until 2020 throws up several showing that exercise alone is not very effective for initial weight loss in people with obesity and that those who diet and exercise maintain their weight loss better than those who just diet, demonstrating that diet and exercise favour loss which can be maintained for at least 6 months[9,18,19].

It is important to remember that the WHO[6] defines "insufficient physical activity" in adults over 18 as moderate-intensity activity for less than 150 minutes per week and the American College of Sports Medicine (ACSM) states that there is a dose-response relationship with the prevention of weight gain, which is more pronounced when exposure to moderate-to-vigorous physical activity (≥3 METs, similar to brisk walking) exceeds 150 minutes per week[15]. There is insufficient evidence available to determine whether there is any association between light-intensity activity (<3 METs) and attenuated weight gain in adults, and moderate evidence to indicate that the relationship between greater amounts of physical activity and attenuated weight gain in adults does not appear to vary by sex.

Walking is not consistently associated with change in weight or BMI, or with the incidence of developing obesity. However, it is reported that walking 10,000 steps or more per day attenuates weight gain compared with not hitting 10,000 steps per day, which may suggest that high volumes of walking need to be achieved to attenuate weight gain[15]. In a similar vein, a significant inverse relationship has been observed between physical activity and weight gain, encompassing a broad age range including young, middle-aged and older adults of both sexes[15].

As for the amount of time per day devoted to exercise, according to the systematic review conducted by Jakicic *et al* on the relationship between the duration of physical activity and health[10], there is still reason to support the idea that physical activity accumulated in sessions lasting 10 minutes or more can improve a variety of health-related results, including the incidence of obesity, with reductions in weight, fat weight and BMI. Supplementary evidence also exists from cross-sectional and prospective cohort studies to suggest that physical activity accumulated in sessions lasting less than 10 minutes is also associated with favourable results, including mortality from all causes. With respect to the incidence of obesity, however, only one cross-sectional study indicates that sessions of less than 10 minutes are effective in terms of reducing BMI and fat weight[10].

Review of the evidence on different types of exercises and/or programmes

To improve the physical and mental health and/or fitness of most adults, the ACSM[20] recommends a comprehensive programme of exercise including cardiorespiratory, resistance, flexibility and neuromotor exercise of sufficient volume and quality (stretching, warm-up stages and gradual increase in intensity, duration and frequency), recommending effective strategies to reduce the musculoskeletal and CVD risks of exercise, including screening for and educating about prodromal signs and symptoms of cardiovascular disease[20]. In this vein, the American College of Cardiology/American Heart Association recommends a stress test for asymptomatic subjects with diabetes mellitus, men over 45 and women over 55 before starting a vigorous exercise programme to rule out cardiovascular risk factors and provide a guide for additional diagnostic tests[21].

The application of this comprehensive approach in obese adults is more complex given their sedentary lifestyle, making it essential to carry out a preliminary assessment of their functional capacity, limitations (mobility, overload/impact, impaired balance and response to heat, poorly controlled sleep apnoea, dyspnoea) and the risks to which they could be subjected (cardiovascular risks, joint and musculoskeletal injuries) in order to guide and prescribe individualised exercise[10,12-18,20-22].

When choosing the type of exercise, intensity, time and programme, recent meta-analyses to 2020 of obese adults of both sexes (chiefly, 18-to-65-year-olds) provide the following evidence:

- Resistance exercise would not appear to be an effective way to lose weight on its own, but it is associated with many other health benefits, including lowering different risk factors for chronic diseases (high blood pressure, dyslipidaemia, hyperglycaemia), increasing lean mass and decreasing fat mass, especially abdominal fat mass[10,18].
- 18 studies of exercise of up to 30 min/day lasting an average of 16 weeks (range 4-7 weeks) show a significant drop in body weight, BMI and fat weight, proving more effective when exceeding 10 weeks ($p < 0.05$) than in shorter intervention periods of ≤10 weeks[23].
- Short-term (5-16 weeks) moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) can lead to significant improvements ($p < 0.05$) in body composition in people who are overweight and obese (fat weight and waist circumference), but no changes in body weight. There are no significant differences between HIIT and MICT for any body composition measurement, their proving similarly effective. HIIT, however, requires 40% less time, which may be an advantage in terms of efficiency in weight management programmes[24].

Takeaways

- Moderate-intensity activity from 150 to 250 min/week, expending energy equivalent to 1,200-2,000 kcal/week seems sufficient to prevent and avoid weight gain.
- Exercise alone is not very effective for initial weight loss in obese individuals. Those who both diet and do exercise hold their weight loss better than those who only diet or only do exercise.
- There is a dose-response relationship between exercise and weight gain prevention, which is more pronounced for moderate-to vigorous-intensity physical activity.
- Physical activity accumulated in sessions of 10 minutes or more can improve a range of health-related results, including the incidence of obesity, lowering weight, fat weight and BMI.
- Exercise of up to 30 min/day leads to a significant reduction in body weight, fat weight and BMI. This is more effective when done for more than 10 weeks.
- Interval exercise and continuous exercise do not seem to have very different effects. In the short term (5-16 weeks), both lead to significant improvements in body composition in people with overweight and obesity (fat weight and waist circumference).

Bibliography

1. Gorgojo Martínez, JJ. Otras comorbilidades asociadas a la obesidad. Bellido Guerrero, D. Ed. Sobrepeso y obesidad. Madrid, SEEDO (Sociedad Española para el Estudio de la Obesidad). 2017;259-79.
2. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *JAMA*. 2013;309:71-82.
3. Albury Ch, Strain WD, Le Brocq S, Logue J, Lloyd C, Tahrani A. The importance of language in engagement between health-care professionals and people living with obesity: a joint consensus statement. *Lancet Diabetes Endo*. 2020;8:447-55.
4. Vocalía asesora para la estrategia NAOS. Prevalencia de sobrepeso y obesidad en España en el informe "The heavy burden of obesity" (OCDE 2019) y en otras fuentes de datos (12/11/2019). Disponible en: http://www.aecosan.msssi.gob.es/AECOSAN/docs/documentos/nutricion/observatorio/Resumen_resultados_informe_OCD-NAOS.pdf
5. Determinantes de salud (sobrepeso, consumo de fruta y verdura, tipo de lactancia, actividad física). INE 2017. Disponible en: file:///C:/Users/PC/Downloads/4_6_Determinantes_de.pdf
6. Organización Panamericana de la Salud (OPS) - Organización Mundial de la Salud (OMS). Plan de acción mundial sobre actividad física 2018-2030. Más personas activas para un mundo sano. World Health Organization (WHO), Ginebra 2018, OPS, Washington, D.C 2019. Disponible en: https://apps.who.int/iris/bitstream/handle/10665/327897/WHO-NMH-PND-18.5-spa.pdf?sequence=1&isAllowed=y
7. Mandai N, Akazawa K, Hara N, Ide Y, Ide K, Dazai U, *et al.* Body Weight Reduction Results in Favorable Changes in Blood Pressure, Serum Lipids, and Blood Sugar in Middle-Aged Japanese Persons: A 5-Year Interval Observational Study of 26.824 Cases. *Glob J Health Sci.* 2015;7:159-70.
8. Ma C, Avenell A, Bolland M, Hudson J, Stewart F, Robertson C, *et al*. Effects of weight loss interventions for adults who are obese on mortality, cardiovascular disease, and cancer: systematic review and meta-analysis. *BMJ*. 2017;359:j4849.
9. Dombrowski SU, Knittle K, Avenell A, Araújo-Soares V, Sniehotta FF. Long term maintenance of weight loss with non-surgical interventions in obese adults: systematic review and meta-analyses of randomised controlled trials. *BMJ*. 2014;348:g2646.
10. Jakicic JM, Kraus WE, Powell KE, Campbell WW, Janz KF, Troiano RP, *et al.* 2018 Physical Activity Guidelines Advisory Committee. Association between bout duration of physical activity and health: systematic review. *Med Sci Sports Exerc.* 2019;51:1213-9.
11. Hall M, Castelein B, Wittoek R, Calders P, Van Ginckel A. Diet-induced weight loss alone or combined with exercise in overweight or obese people with knee osteoarthritis: A systematic review and meta-analysis. *Semin Arthritis Rheum*. 2019;48:765-77.
12. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK; American College of Sports Medicine. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. [published correction appears in Med Sci Sports Exerc. 2009;41:1532]. *Med Sci Sports Exerc.* 2009;41:459-71.
13. Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, *et al*. American College of Cardiology/American Heart Association Task Force on Practice Guidelines; Obesity Society. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Circulation*. 2014;129(25 Suppl 2):S102-38.
14. Manonelles Marqueta P, De Teresa Galván C (coordinadores), Alacid Cárceles F, Álvarez Medina J, Del Valle Soto M, Gaztañaga Aurrekoetxea T, *et al.* Deporte recreacional saludable. Documento de consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE). *Arch Med Deporte.* 2016;33(Supl. 2):8-40.
15. Jakicic JM, Powell KE, Campbell WW, Dipietro L, Pate RR, Escatello LS, Collins KA, Bloodgood B, Piercy KL; 2018 Physical Activity Guidelines Advisory Committee. Physical Activity and the Prevention of Weight Gain in Adults: A Systematic Review. *Med Sci Sports Exerc.* 2019;51:1262-9.
16. Blay Cortés VA, Casajús Mallén, Blay Cortés MG. Actividad física en el paciente obeso. Bellido Guerrero, D. Ed. Sobrepeso y obesidad. Madrid, SEEDO (Sociedad Española para el Estudio de la Obesidad), 2017;259-79.
17. Marshall S, Mackay H, Matthews C, Maimone IR, Isenring E. Does intensive multidisciplinary intervention for adults who elect bariatric surgery improve post-operative weight loss, co-morbidities, and quality of life? A systematic review and meta-analysis. *Obes Rev.* 2020;21:e13012.
18. Fock K, Khoo J. Diet and exercise in management of obesity and overweight. *Gastroenterol Hepatol.* 2013;28 Supl 4:59-63.
19. Hassan Y, Head V, Jacob D, Bachmann MO1, Diu S, Ford J. Lifestyle interventions for weight loss in adults with severe obesity: a systematic review. *Clin Obes.* 2016;6:395-403.
20. Garber CE, Blissmer B , Deschenes MR , Franklin BA , Lamonte MJ, Lee IM , *et al.* American College of Sports Medicine. 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;43:1334-59.
21. Thomas S. Metkus, Jr, MD, Kenneth L. Baughman, MD, Paul D, Thompson, MD. Exercise prescription and primary prevention of cardiovascular disease. *Circulation.* 2010;121:2601-4.
22. Manonelles Marqueta P, Luengo Fernández E, Franco Bonafonte L (coordinadores), Álvarez-Garrido H, Alvero Cruz JR, Archanco Olcese M, *et al.* Contraindicaciones para la práctica deportiva. Documento de consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE). *Arch Med Deporte.* 2018;35(Supl. 2):6-45.
23. Kim H, Reece J, Kang M. Effects of Accumulated short bouts of exercise on weight and obesity indices in adults: A meta-analysis. *Am J Health Promot*. 2020;34:96-104.
24. Sultana RN, Sabag A, Keating SE, Johnson NA. The effect of low-volume high-intensity interval training on body composition and cardiorespiratory fitness: a systematic review and meta-analysis. *Sports Med.* 2019;49:1687-721.

The contribution of stress tests when prescribing exercise in obese patients

Stress tests on overweight or obese people provide us with the same functional and health information as they do with any other subject, but with these patients they also supply extremely valuable information on energy expenditure.

We know that carbohydrates are the most important metabolic substrate during prolonged moderate-to-high-intensity exercise[1] and that the muscle glycogen stores are emptied when the exercise is sufficiently intense and lasts long enough[2,3]. Humans store an average of 740 g of glycogen, which represents about 3,000 kcal at 4 kcal/g[4].

However, fat reserves in humans are virtually limitless when exercising. A subject weighing 70 kg with a fat component of only 10% (7 kg) stores 68,250 kcal at 9.75 kcal/g[5].

Optimising fat oxidation, therefore, is not only of paramount interest for long-distance competitions and military operations, but also for health, its relationship with markers such as insulin sensitivity or weight gain having been demonstrated[6].

Indirect calorimetry

A subject's energy expenditure can be studied at rest or during exercise at a specific intensity or at different intensities. In constant load tests, the intensity is kept at a set value while, fundamentally, the effects of duration are explored.

Whichever the case, energy expenditure is studied by indirect calorimetry. Indirect calorimetry is the method by which the type and rate of substrate utilisation and energy metabolism are estimated *in vivo* based on gas exchange measurements[7]. This technique provides unique information, is not invasive and can be advantageously combined with other experimental methods to investigate numerous aspects of nutrient assimilation, thermogenesis, exercise energy and the pathogenesis of metabolic diseases.

Indirect calorimetry was fundamentally a research method until the 1980s and '90s, when it began to be used for clinical applications of interest[8]. It is now an essential tool to understand the mechanisms underlying overweight and obesity[9], and is considered the "gold standard" method to determine energy expenditure, by measuring lung gas exchange[10,11].

Different attempts have been made at predicting energy expenditure without any need for calorimetry (e.g. using HR), but to date none of these has been successful[12], meaning that for the time being indirect calorimetry is still indispensable in order to determine it.

First ventilatory threshold and Fatmax

In an incremental test, the fat oxidation rate (FOR) for each load, expressed in g/min, is obtained using the equation 1,695•VO_2-1,701 VCO_2-1.77n for any intensity[13]. In this equation, "n" represents the urinary nitrogen excretion, which we assume is negligible and, therefore, n = 014. With the data from this equation, a 2nd order polynomial fit between FOR and exercise intensity is constructed. The highest FOR value in the entire intensity range is called Maximal Fat Oxidation (MFO) and the exercise intensity at which MFO occurs is called Fatmax. The range of intensities 10% either side of Fatmax is called the "Fatmax zone"[13].

The first ventilatory threshold (VT1) was first described by Hollmann at the Third Pan-American Congress for Sports Medicine held in Chicago in 1959[15], although the concept (and its implications) was subsequently consolidated by Wasserman and McIlroy in 1964[16]. The technique used today was definitively described by Reinhardt, Müller and Schmülling in 1979[17]. Since these pioneering studies, we have known that the metabolic meaning of the first ventilatory threshold lies precisely in the fact that it is the exercise intensity as of which glycolysis is activated (and, therefore, blood lactate accumulation begins) due to a drop in the fat oxidation rate. Therefore, VT1 and Fatmax conceptually describe very proximate, if not the same, intensities.

In fact, in obese subjects there is no significant difference between the intensities at which VT1 and Fatmax appear[13] ,and so the VT1 intensity is also a good indicator for exercise prescription in this population[13,18].

There are, however, methodological differences. While VT1 calls for incremental ramp tests or incremental step tests with very small steps, for Fatmax, each load needs to reach a steady state in order to establish the respiratory exchange ratio (RER).

In 2002, Achten *et al.*[19] developed a test to determine the intensity at which maximal fat oxidation (Fatmax) occurs. They proposed 5-min stages with 35-W increments until RER = 1 was reached. However, it is very likely that sedentary subjects need more time to reach a steady state[6].

Since then, the protocols have evolved and different adaptations and variations for both cycle and treadmill have appeared[6].

It should be borne in mind that the measurement of Fatmax can be influenced by the protocol used in the test[20,21] and other circumstances which cause great variability. These include[6,22]: sex, level of training, nutritional status (acute and chronic), type of exercise and other data related to performance of the test, such as ignorance of the muscle glycogen content beforehand. Different studies have also shown that the fat oxidation rate determined with short stages does not correlate with that occurring with longer exercises (for example, 1 hour)[23].

As for the values that we could expect in obese subjects, Maunder's review[6] reveals percentiles of normality for different situations. In men, Fatmax appears at a mean intensity of 43% VO_2max, with a FOR of 0.28 g/min (p50) and a range between 0.16 (p20) and 0.39 g/min (p80). In women, however, the mean is at an intensity of 61% VO2max, with a FOR of 0.16 g/min (p50) and a range between 0.12 (p20) and 0.20 g/min (p80).

Regarding modification depending on training, the authors of this review have found that:

– MFO increases in response to specific training while Fatmax remains unchanged;
– MFO changes are observed in sedentary populations, but not in previously active populations;
– MFO changes occur both with interval training and continuous training at moderate intensity, and are independent of body mass.

It has also been described that Fatmax-intensity training in class II and III obese subjects gives the same results as high-intensity interval training (HIIT), with the difference that during Fatmax training a reduction in insulin resistance is detected which does not appear with HIIT[24].

As for changes in VT1, we know that the intensity at which it appears improves with training not only in athletes, but also in subjects with obesity[25].

Takeaways

– Indirect calorimetry is the methodology for determining the energy variables to use when prescribing or controlling physical activity in overweight subjects.
– VT1 and Fatmax conceptually describe very proximate, if not the same, intensities and both can be used to prescribe and control exercise in this population.
– VT1 is determined with incremental ramp tests or incremental step tests with small steps.
– Fatmax is determined using incremental tests with longer loads.
– Fatmax does not seem to change with training, but the maximal fat oxidation (MFO) rate does.
– VT1 intensity changes with training.
– The changes in MFO and VT1 occur with both continuous and high-intensity interval training.

Bibliography

1. Romijn J A, Gastaldelli A, Horowitz J F, Endert E, Wolfe RR. Regulation of endogenous fat and carbohydrate metabolism in relation to exercise intensity and duration. *Am J Physiol Endocrinol Metab*. 1993;265:380–91.
2. Bergström J, Hultman E. A study of the glycogen metabolism during exercise in man. *Scand J Clin Lab Invest.* 1967;19:218–228.
3. Bergström J, Hermansen L, Hultman E, Saltin B. Diet, muscle glycogen and physical performance. *Acta Physiol Scand.* 1967; 71:140–50.
4. Gonzalez JT, Fuchs CJ, Betts JA, van Loon LJC. Liver glycogen metabolismduring and after prolonged endurance-type exercise. *Am J Physiol Endocrinol Metab*. 2016; 311:E543–E553.
5. Jeukendrup AE, Wallis GA. Measurement of substrate oxidation during exercise by means of gas exchange measurements. *Int J Sports Med.* 2005; 26(1 Suppl. 1):S28–37.
6. Maunder E, Plews DJ, Kilding AE. Contextualising Maximal Fat Oxidation During Exercise: Determinants and Normative Values. *Front Physiol.* 2018;9:599.
7. Ferrannini E. The theoretical bases of indirect calorimetry: a review. *Metabolism.* 1988; 37(3):287-301.
8. Reid CL, Carlson GL. Indirect calorimetry: a review of recent clinical applications. *Curr Opin Clin Nutr Metab Care.* 1998;1:281-6.
9. Lam YY, Ravussin E. Indirect calorimetry: an indispensable tool to understand and predict obesity. *Eur J Clin Nutr.* 2017;71(3):318-22.
10. Mtaweh H, Tuira L, Floh AA, Parshuram CS. Indirect calorimetry: history, technology, and application. *Front Pediatr.* 2018;6:257.
11. Delsoglio M, Achamrah N, Berger MM, Pichard C. Indirect calorimetry in clinical practice. *J Clin Med.* 2019;8:1387.
12. Brun JF, Halbeher C, Fédou C, Mercier J. What are the limits of normality of the LIPOXmax? can it be predict without exercise calorimetry? *Sci Sports*. 2011;26:166–9.
13. Emerenziani GP, Ferrari D, Marocco C, Greco EA, Migliaccio S, Lenzi A, *et al.* Relationship between individual ventilatory threshold and maximal fat oxidation (MFO) over different obesity classes in women. *PLoS One.* 2019;14:e0215307.
14. Jeukendrup AE, Wallis GA. Measurement of substrate oxidation during exercise by means of gas exchange measurements. *Int J Sports Med*. 2005;S28–37.
15. Hollmann W. 42 years ago-development of the concepts of ventilatory and lactate threshold. *Sports Med*. 2001;31:315–20.
16. Wasserman K, McIlroy MB. Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. *Am J Cardiol.* 1964;14:844-52.
17. Reinhardt U, Müller PH, Schmülling RM. Determination of Anaerobic Threshold by the Ventilation Equivalent in normal individuals. *Respiration*. 1979;38:36-42.
18. Ishihara K, Taniguchi H. Fat max as an index of aerobic exercise performance in mice during uphill running. *PLoS One.* 2018;23;13:e0193470.
19. Achten J, Gleeson M, Jeukendrup AE. Determination of exercise intensity that elicits maximal fat oxidation. *Med Sci Sports Exerc*. 2002;34:92–7.
20. Crisp NA, Guelfi KJ, Licari MK, Braham R, Fournier PA. Does exercise duration affect Fatmax in overweight boys? *Eur J Appl Physiol.* 2012;112:2557-64.
21. Amaro-Gahete FJ, Sanchez-Delgado G, Jurado-Fasoli L, De-la-O A, Castillo MJ, Helge JW, *et al.* Assessment of maximal fat oxidation during exercise: A systematic review. *Scand J Med Sci Sports.* 2019;29:910-21.
22. Purdom T, Kravitz L, Dokladny K, Mermier C. Understanding the factors that effect maximal fat oxidation. *J Int Soc Sports Nutr.* 2018;12:15:3.
23. Schwindling S, Kindermann W, Meyer T. Limited benefit of fatmax-test to derive training prescriptions. *Int J Sports Med*. 2014;35:280–5.
24. Lanzi S, Codecasa F, Cornacchia M, Maestrini S, Capodaglio P, Brunani A, *et al.* Short-term HIIT and Fat max training increase aerobic and metabolic fitness in men with class II and III obesity. *Obesity (Silver Spring).* 2015;23:1987-94.
25. Guio de Prada V, Ortega JF, Ramirez-Jimenez M, Morales-Palomo F, Pallares JG, Mora-Rodriguez R. Training intensity relative to ventilatory thresholds determines cardiorespiratory fitness improvements in sedentary adults with obesity. *Eur J Sport Sci.* 2019;19:549-56.

The usefulness of interval training to lose weight

We do exercise when we repeat structured movements specifically designed to improve our fitness, performance and/or health[1]. Although it cannot be outrightly stated that this alone can help reduce and/or maintain our weight without complementary strategies such as nutritional management or education in healthy habits[2,3], there is solid evidence on the benefits of continuous exercise in maintaining body composition, physical function and mental health[1,2,4-6], on the close relationship between these variables, and the importance their interactions have in achieving holistic health[1,3].

Understanding continuous exercise as uninterrupted exercise performed long enough to produce responses and, therefore, positive adaptations, the literature on the subject raises no doubts about its contribution to reducing obesity, medical conditions, chronic disease, mortality and morbimortality [1,3]. Nevertheless, the increasing application and effectiveness of interval-based methodologies means that it is necessary to review the effectiveness of programmes based on such sustained exertion, their substantiation, strategies and rules of prescription.

Substantiation

For obese people, continuous exercise is performed at intensities beneath or in the vicinity of the second ventilatory threshold (VT2)[1,7]: Light-intensity activity (1-3 METs), moderate-intensity activity (3-6 METs) and vigorous-intensity activity (>6 METs). The exertion is lengthened enough time to bring about improvements despite its low intensity, provided that this can be done safely and independently of previous fitness level[1]. Given that the use of accelerometers and other recent technologies offers conflicting evidence on the benefits of light physical activity[1,5], work with obese individuals should focus on intensities above 3 METs, where the evidence is solid[1,2,4-6,8].

The metabolic demand or mechanical load at these intensities may seem low compared to those of normal weight individuals (in absolute values), but is sufficiently demanding in terms of relative intensity and perceived exertion[1]. Among other things, it should be borne in mind that these individuals' likely rejection of physical exercise[3,8], usual lack of experience -or even bad experiences in the past[3]-, poor fitness level at the start of exercise programmes[3,9] and augmented perception of exertion[1,3] will mean that the demands, both perceived and real, will actually be high[1,3].

Although it is generally accepted that the benefits of exercise or the reduction of the risks attributed to exercise can be obtained within a range of 500 to 1.00 MET x minutes per week (equivalent to 150-300 minutes per week of moderate exercise or 75-150 minutes when working at twice the intensity)[1], there is strong evidence suggesting that this prescription is insufficient in the obese population, both when it comes to losing weight and when it comes to keeping it stable once lost[1,2,4,5,10]. Having observed the relationship between a longer physical activity time and reducing and maintaining body weight (dose-response)[1-5,10], if food intake remains unchanged, the time should exceed 150 min, with the objective of up to 7 hours per week[1,2,4,5,6,8,10].

From the review conducted by Donnelly *et al.*[4], it can be taken as a certainty that >150 min/week of moderate-to-vigorous-intensity activity can reduce weight by about 2-3 kg, but increasing this to 225-420 min/week leads to greater losses (5-7.5 kg). Similarly, 150-220 min/week (1,200-2,000 kcal per week) are sufficient to prevent weight gain of more than 3% (evidence statement I), but it is necessary to keep doing at least 200-300 min/week in order not to regain weight previously lost (regain; evidence statement IIa) [4]. These guidelines are reflected in subsequent health guides[1, 3, 6, 8, 10] but other widely referenced proposals are also worthy of note beside them, such as: Ross *et al.*[11] with a drop of 7.5 kg (7%) in men with BMI >27kg/m^2 after 12 weeks of exercise at a constant intensity <70% VO_2 until 700 kcal per day (about 60 minutes per day) without nutritional control; or Chiu *et al.*[12] with similar weight losses (6.72 kg, 7%) also after 12 weeks, but with three weekly training which lasted 60 min, progressing in intensity from 40 to 80% HRR.

So, it is advisable to start continuous exercise at very low relative intensities (40-50%) to increase gradually and shift the thresholds to within a range of 60-70%, and up to 80-90% for capable or more trained subjects[2,3,6,7,9,13]. The progression in intensity which both continuous exercise itself and interventions of greater longitudinal duration permit when compared to high-intensity exercise[1,6,9] ensures an enhanced oxidative capacity, preserving muscle mass and protecting joints[9,13], while technique and efficiency at higher intensities are also improved. This is important because many obese patients also present other medical conditions which can also benefit from moderate exercise and progressive loads[3,13]. Additionally, training every or almost every day of the week favours the habit and contributes to the stability of progress achieved in the long term[2,3,9], even in children[14].

As for the duration of the sessions, although continuous moderate exercise lasting more than 10 minutes is considered effective in normal weight subjects (e.g. 40-60% HR or VO_2 reserve)[1,6], in the obese population more than 30 minutes[3,15], even approaching 60 minutes[1-4,13,15], of moderate exercise are needed.

In any event, it is important to remember, as Arad *et al.*[15] state, that in the exercise-based treatment of the obese population, we find responders and non-responders [2,13]; there are inconsistencies in the research methodology; and individualised longitudinal monitoring is needed if we want to get the prescription (dose and type of exercise) right, regardless of the strategy prescribed.

Strategies

Each specific case can benefit from a specific strategy. Success lies in analysing the characteristics and needs of subjects in depth, choosing and specifying the goals well, hitting on the ideal prescription and monitoring it continuously to make adjustments. We are not only faced with responders and non-responders[2,13,15] ;human beings are complex systems[1] and even the best stimuli tend to stagnate and lose potential with time[16]. Consequently, although different strategies share certain points or can be combined within a single programme, some preliminary considerations would seem advisable, at least in 3 main areas:

Specifying objectives

Focussing on improving body composition in general is not the same as specifying weight loss and/or reducing the fat percentage, or even achieving an improvement in general health based on lowering body weight and fat mass when this is not the main goal pursued. Be that as it may, it is always possible to concomitantly (or not) seek to improve the physical function and/or fitness and/or quality of life and/or psychosocial well-being.

The parameters which determine the intensity at which we burn fat are not the same as those that condition our ability to work at VO_2max[15,16]. Moderate-to-high-intensity exercise is recommended to focus more on reducing fat[8,12,13,16] -particularly visceral fat and waist circumference[1,4,12]-, greater weight gain[4,8] or cardiorespiratory fitness -increased VO_2max[1,6,8]. It is also recommended when less time is available. Conversely, moderate continuous exercise is sufficient to reduce the risk of metabolic syndrome -body composition, insulin resistance and glycosylated haemoglobin[1,6,8,12]- or improve physical fitness, endothelial function, lipid profile, and blood glucose control[6,8], among other things, but affects weight and fat reduction and general body composition less[4,8,13].

Since some 11-12 kcal/kg per day are needed to maintain the changes in body composition after a weight loss intervention[2], it would seem that conservative strategies (moderate exercise) are more easily extended over time, minimise rejection from the obese population, generate good habits and lead to significant improvements in health, with good long-term results[2,3,6,8,13,14,17]. As already noted, they are also less traumatic than high-intensity-based strategies[1], avoiding the risks of increased pain and bone/ligament/muscle problems[2,13,16], and reducing anxiety and state changes[2,8]. They also avoid the reduction of calories in daily activities which can accompany strategies based on more intense exertion [2].

Focus and type of exercise in the programme

Both what is traditionally known as aerobic exercise[1,6,18] -large muscle mass mobilised in patterns of continuous exercise, with a cardiovascular and respiratory focus- and strength training involving loads or counter-resistance[1,6,18] have led to proven improvements in body composition in adults[1,4,10] and children[1,16,18]. It should be borne in mind that strength training can be given a metabolic focus by combining initially neuromuscular exercises and incorporating them in wide-ranging circuits to generate metabolic demands not dissimilar to aerobic exercise. Likewise, multicomponent training programmes, which work on several aspects at the same time, can be presented as a form of moderate-to-vigorous-intensity continuous exercise, with improvements in body composition, which has proved effective in both elderly adults with overweight[19,20] and children[14,16,21].

And so we differentiate between strategies with focuses which are distinctly metabolic (cardiovascular and respiratory), distinctly neuromuscular (related to strength and/or function) and combinations of these. Similarly, and regardless of the focus, we should select the main type of muscle contraction to stress: concentric, eccentric or, once again, a combination of the two.

For example, and although the evidence cannot yet be considered solid because it is still so new, it seems that eccentric work -such as backpedalling or braking forward-driven pedal movement- favours the use of greater muscle mass, with increased neural activation and mechanical production for lower absolute intensity, meaning that, once learned, it is ideal in programmes with obese subjects and allows them to exercise for longer [22-26]. If, in general, cycling and forms of exercise where the subject does not bear their own weight (swimming, exercise on elliptical trainers, rowing) are ideal because they eliminate the osteoarticular stress which can be demanding for this population, minimising pain and the risk of injury[13,26], continuous reverse exercise using these same methods would be a good alternative for doing long sets and consuming fat in obese populations. We will probably find out more about this kind of exercise in the next few years.

Dose format (one long session vs. several shorter sessions)

In brief, here we are talking about the way to administer the programme: if we are interested in one longer session on training days or doing the same amount of exercise but in numerous micro-sessions lasting less time.

More than 10 minutes is considered an effective amount of time for moderate-to-vigorous exercise and such sessions can be accumulated over the length of the day to meet the daily recommendations and provide obese individuals with the same benefits[1,3,6]. However, it seems that these benefits are influenced by the type of exercise performed, as well as by the parameters evaluated, even for the same volumes, at least in elderly overweight adults[19]. For example, with the oft-cited prescription of walking at least 10,000 steps per day, we find that there is no solid evidence to back walking in itself when distributed over the day without any programming or periodisation of rhythms[1,5]. It appears that dose distribution can affect body composition outcomes when less metabolically demanding tasks are performed[19].

Indication

No matter what strategy is used, it is essential to define the load properly, trying to individualise the parameters as much as possible. This individualisation needs to be dynamic in order to remain efficient as initial goals and changes are achieved. Individualising exercise is like tailoring a suit and, in the case of obesity, continuous adjustments need to be made to the size and seams of the suit as the programme progresses. More than a one-off, unchanging measure, exercise programmes and training in general should be seen as an individualised process dependent on the results achieved.

To complete a minimum of 7 hours of physical activity at the lower end of moderate activity, representing about 2,200 kcal/week extra for a subject weighing 100 kg (420 min at 3 METs; 1 MET = 0.0175 kcal/min/kg body weight), it is necessary to have a wide range of options and progress in all the parameters of training depending on the motivations and possibilities of the subject. It is better to raise first the volume of exercise than its intensity, progressing more slowly with older people[1]. Once this initial load has been assimilated (a couple of week could suffice), the different parameters can be adjusted, the recommendation being not to drop beneath 12 weeks (according to most of the literature). We are focussing only on the continuous exercise here, but, professionally, the recommendation would be to gradually include forms of interval training and greater intensities, as well as actual strength work, in the event of extending the intervention[6].

Intensity

With moderate exercise (3-6 METs), progress from relatively very low intensities (40-50%), in the vicinity of the first threshold, up to a range of 60-70%, seeking longer durations and the use of fat. With moderate-to-intense exercise (>6 METs), progress from these low intensities up to 75-80%, even 85-90% with more capable or trained subjects, in order to mobilise glucose and increase the metabolic rate and cardio-vascular demands. The METs of the most common types of activities can be consulted in the prescribing guidelines or on specialised websites (such as the *Compendium of Physical Activities,* extracted from: https://sites.google.com/site/compendiumofphysicalactivities/home)

Duration and frequency

These variables are necessarily linked to establish the total volume of exercise. Depending on the intensity and very much depending on the strategy/strategies selected, achieving at least 30 min/day, 5 days per week, or increasing this to 60 min, 3 days/week, can be set as an objective in the first stage to reach 150-220 min/week (1,200-2,000 kcal/week; ≥300 kcal/session). Remember that these volumes can be reduced in proportion to an increase in intensity, provided the subject does not fall beneath the target calories. In the next stages, the number of training days and/or the duration of the sessions can be gradually increased to more than 7 hours per week (225-420 min/week), or at least leaving no more than one day without training[8]. The first option would seem simpler in obese individuals [8]. When the strategy involves several short sessions per day, this is achieved by starting with micro-sessions lasting at least 10 minutes to accumulate 30 min/day and then increasing the length or intensity of the micro-sessions to complete 60 min/day or about 300 kcal/day. But remember that higher intensities are needed in each micro-session when this strategy is applied to obese individuals.

When the strategy is based on eccentric exercise, it is possible to exercise at lower intensities, as already noted, or increase the intensity as the individual masters the technique, achieving benefit at lower volumes, in order to accomplish the same overall metabolic expenditure objectives. In all events, the subject should start very low and get used to the type of muscle contraction beforehand.

Takeaways

- 150 min of moderate- or vigorous-intensity exercise can reduce weight by about 2-3 kg, but increasing this to 225-420 min per week leads to greater loss (between 5 and 7.5 kg).
- 150-220 min per week (1,200-2,000 kcal) are sufficient to prevent weight gain of more than 3% (evidence statement I), but it is necessary to keep doing at least 200-300 min per week in order not to regain weight previously lost (evidence statement IIa).
- It is advisable to start continuous exercise at very low relative intensities (40-50%) to increase gradually and shift the thresholds to within a range of 60-70%, and up to 80-90% for capable subjects.
- Both what is traditionally known as aerobic exercise (large muscle mass mobilised in patterns of continuous exercise) and strength training involving loads or counter-resistance (aimed at improving strength or functionality) have led to proven improvements in body composition.
- Mixed work in continuous protocols has less impact on reducing fat than aerobic exercise. However, people with metabolic syndrome or who are overweight with type II diabetes benefit from the combination of both focuses in a programme.

Bibliography

1. 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: U.S.: US Department of Health and Human Services; 2018.
2. Cox CE. Role of physical activity for weight loss and weight maintenance. *Diabetes Spectr.* 2017;30:157-60.
3. ACSM, Riebe D, Ehrman kJ, Liguori G, Magal M. Benefits and Risks Associated with Physical Activity. In: Medicine ACoS, editor. *ACSM's exercise testing and prescription.* 10 ed. Philadelphia, USA Lippincott Williams & Wilkins; 2017.
4. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc.* 2009;41:459-71.

5. Jakicic JM, Powell KE, Campbell WW, Dipietro L, Pate RR, Pescatello LS, *et al.* Physical activity and the prevention of weight gain in adults: a systematic review. *Med Sci Sports Exerc*. 2019;51:1262-9.
6. Reed JL, Pipe AL. Practical approaches to prescribing physical activity and monitoring exercise intensity. *Can J Cardiol.* 2016;32:514-22.
7. Sáez-Olivares S, Pino-Zúñiga J, Olivares-Gálvez M, Cancino-López J. Maximal fat oxidation by heart rate variability in physically active subjects. *Apunts. Educación Física y Deportes.* 2019;138:111-22.
8. American College of Sports Medicine and the American Diabetes Association: joint position statement. Exercise and type 2 diabetes. *Med Sci Sports Exerc*. 2010;42:2282-303.
9. Reed JL, Pipe AL. The talk test: a useful tool for prescribing and monitoring exercise intensity. *Curr Opin Cardiol.* 2014;29:475-80.
10. Garvey W, Mechanick J, Brett E. American College of Endocrinology comprehensive clinical practice guidelines for medical care of patients with obesity. *Endocr Pract.* 2016;22(Suppl 3):1-203.
11. Ross R, Dagnone D, Jones PJ, Smith H, Paddags A, Hudson R, *et al.* Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men: a randomized, controlled trial. *Ann Intern Med*. 2000;133:92-103.
12. Chiu C-H, Ko M-C, Wu L-S, Yeh D-P, Kan N-W, Lee P-F, *et al.* Benefits of different intensity of aerobic exercise in modulating body composition among obese young adults: a pilot randomized controlled trial. *Health quality of life outcomes.* 2017;15:168.
13. Barrow DR, Abbate LM, Paquette MR, Driban JB, Vincent HK, Newman C, *et al*. Exercise prescription for weight management in obese adults at risk for osteoarthritis: synthesis from a systematic review. *BMC Musculoskel Dis.* 2019;20:610.
14. Saavedra JM, García-Hermoso A, Escalante Y, Domínguez AM. Self-determined motivation, physical exercise and diet in obese children: A three-year follow-up study. *International Journal of Clinical Health Psychology Review.* 2014;14:195-201.
15. Arad AD, Basile AJ, Albu J, DiMenna FJ. No influence of overweight/obesity on exercise lipid oxidation: A Systematic Review. *Int J Mol Sci*. 2020;21:1614.
16. Kelley GA, Kelley KS, Pate RR. Exercise and adiposity in overweight and obese children and adolescents: a systematic review with network meta-analysis of randomised trials. *BMJ Open*. 2017;7:e019512.
17. Rezaeipour M. Investigation of Pool Workouts on Weight, Body Composition, Resting Energy Expenditure, and Quality of Life among Sedentary Obese Older Women. *Monten J Sports Sci Med.* 2020;9:67-72.
18. Del Valle Soto M, Marqueta PM, De Teresa Galván C, Bonafonte LF, Luengo E, Aurrekoetxea TG. Prescripción de ejercicio físico en la prevención y tratamiento de la hipertensión arterial. Documento de Consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE). *Arch Med Deporte*. 2015; 169:281-313.
19. Blasco-Lafarga C, Monteagudo P, Roldán A, Cordellat A, Pesce C. Strategies to change body composition in older adults: Do type of exercise and dose distribution matter? *J Sports Med Phys Fitness.* 2020;60:552-561.
20. Monteagudo P, Cordellat A, Roldán A, Gómez-Cabrera, Blasco-Lafarga C. Effects of multicomponent exercise on metabolic health parameters in elderly. *MOJ Sports Med*. 2019;3:70-4.
21. Alves ASR, Venancio TL, Honorio SAA, Martins JMC. Multicomponent training with different frequencies on body composition and physical fitness in obese children. *An Acad Bras Cienc.* 2019;91(4). e20181264.
22. Julian V, Thivel D, Costes F, Touron J, Boirie Y, Pereira B, *et al.* Eccentric training improves body composition by inducing mechanical and metabolic adaptations: A promising approach for overweight and obese individuals. *Front Physiol.* 2018;9:1013.
23. Paschalis V, Nikolaidis MG, Giakas G, Theodorou AA, Sakellariou G, Fatouros I, et al. Beneficial changes in energy expenditure and lipid profile after eccentric exercise in overweight and lean women. *Scand J Med Sci Spor.* 2010;20:e103-e11.
24. Penailillo L, Blazevich A, Nosaka K. Energy expenditure and substrate oxidation during and after eccentric cycling. *Eur J Appl Physiol.* 2014;114:805-14.
25. Julian V, Thivel D, Miguet M, Pereira B, Costes F, Coudeyre E, *et al.* Eccentric cycling is more efficient in reducing fat mass than concentric cycling in adolescents with obesity. *Scand J Med Sci Spor.* 2019;29:4-15.
26. Thivel D, Julian V, Miguet M, Pereira B, Beaulieu K, Finlayson G, *et al*. Introducing eccentric cycling during a multidisciplinary weight loss intervention might prevent adolescents with obesity from increasing their food intake: the TEXTOO study. *Physiology Behavior.* 2020;214:112744.

Usefulness of interval training to lose weight

Interval training comes from the world of sport. Gerschler-Reindell called it Interval Training in mid-1950. In 1960, the first scientific studies in which Åstrand, Christensen & Hedman concluded that the intervals which led to the greatest cardiorespiratory adaptations were those lasting 2-3 minutes appeared1. In sport, the aim of high-intensity interval training (HIIT or HIT) is to improve VO_2max, working on the basis that the total time of the work bouts in HIIT means it is possible to exercise longer than it is with continuous exercise at the same intensity until exhaustion. This work takes place at the stage known as metabolic instability, when the maximal lactate steady state or ventilatory threshold 2 has been passed, at about 80-90% VO_2max[2].

In recent years, great interest has been shown in HIIT in the exercise and health world, and its use with people with all kinds of medical conditions, obesity for instance. It should be borne very much in mind that to apply HIIT with such populations, most of the forms used will be adaptations of those applied in performance sports and, generally, will not comply with either the intensity or duration of the work intervals used in them. Untrained subjects (and even more so if they suffer medical conditions) will barely be able to withstand or even reach such high intensity loads or maintain the steady VO_2max plateau, which in most cases will coincide with their exhaustion peak, meaning they will only be able to exercise at these intensities for a very short period of time. HIIT in these populations involves lowering the intensity considerably, increasing its range and decreasing the length of the work intervals.

Substantiation

There is no universal definition of HIIT. We will use the one quoted by Campbell in 2019[3] which defines it as "episodic short bouts of high intensity exercise separated by short periods of recovery at a lower intensity" or complete rest, but understanding that "high intensity" can be as low as 65% VO_2max or as high as maximal exertion, and that the length of the work bouts can range from 30 seconds to 4 minutes, or even more. For it to be considered HIIT, there must be at least two exercise bouts[3].

The protocols of interval training are usually divided by intensity into 3:

- High Intensity Interval Training (HIIT). Approximately 80%-100% MHR, 65-100% VO_2max. This is also known as aerobic interval training and interval lengths are differentiated.
  - Short, up to 1 min, at approximately 90%-100% MHR, VO_2max.
  - Long, 1 to 4 min, at approximately 60-89% MHR, 65%-89% VO_2max (vigorous aerobic intensity), which can be within the individual's aerobic capacity. For most people, this can be equated with an intensity that, if done without rest, could be maintained for 5 to 10 min before fatigue.
- Sprint Interval Training (SIT).

Short exercise reps, 8 to 30 seconds at 100% VO_2max or more and recovery periods lasting between 1 and 4 min.

Repeated Sprint Training (RST), characteristic of team sports, is also distinguished from Speed Strength Training, for sprinters, in the world of sport[1]. Technically, SIT, RST and Speed Strength Training do not come under HIIT because the goal is not to improve VO_2max and their intensity is above 90% VO_2max.

Exercise beneath the intensities defined, 55-69% MHR, 40-59% VO_2max., is called Moderate-Intensity Continuous Training (MICT). " "Traditional" stable-state exercise for a set period of time (usually 20-60 min)[4].

Systematic reviews with meta-analysis[3-6] compare the effects of MICT with HIIT/SIT to measure their effectiveness in adults regarding the management of overweight and/or obesity. Although the adjustments are always specific to the training method used and the variables that define the load applied, they generally conclude that HIIT/SIT is more effective than MICT when it comes to losing weight and has two big advantages: a) up to 40% less time dedicated to training can yield the same benefits as a similar time commitment and/or similar energy expenditure. b) it leads to greater activation of all the factors needed to consume fat as an energy substrate during exercise (hormone secretion, transportation through the bloodstream and greater mitochondrial consumption) and after exercise (through excess post-exercise oxygen consumption - EPOC), favouring lipolysis.

The intensity of exercise plays an important role in regulating body composition and local fat consumption in obese people, who often suffer some kind of lipid metabolism disorder. If the exercise is not sufficiently intense, the effect of regulating insulin and improving exercise resistance is significantly weakened or may even disappear. Improving insulin sensitivity lies in muscle contraction and HIIT/SIT involves a larger proportion of muscle fibres than MICT. HIIT/SIT produces an oxidative increase in skeletal muscle, improving insulin sensitivity and glycaemic control, proving more effective than MICT[5,7].

Strategies

Epidemiological data show that most adults do not meet the recommended exercise guidelines to prevent weight gain[4], the main reason being a lack of time[8]. Some authors attribute the rapid acceptance of HIIT/SIT at sports centres to the shorter time spent in each session to achieve the same results[9].

General considerations

The application of HIIT as a way of reducing body fat is the primary objective of millions of people. Its actual effectiveness when it comes to solving a social problem in most cases caused by an inadequate diet is another question[2]. Exercise, be it MICT or HIIT/SIT, unless applied in very high volumes, does not by itself lead to significant changes in weight loss and should, therefore, be a component of a long-term obesity management programme[4,5,10]. The effects of exercise on blood lipid levels in overweight or obese individuals depend on their blood lipid levels prior to exercise, the intensity of the exercise, the duration of the exercise, body composition, caloric intake, metabolic rate and lifestyle, so all these factors must be taken into account.

Total energy consumption plays a more critical role in weight loss than exercise intensity[5], so effective body weight loss should be associated with caloric restriction and the other aspects mentioned10. These factors are generally poorly controlled or not controlled at all. In the review published by Keating et al. in 2017[4], which includes 31 studies with meta-analysis comparing MICT with HIIT (n=17) and SIT (n=14), only 26% took them into account.

An important aspect to bear in mind is the influence of exercise on intake habits. HIIT reduces energy intake and, because it involves higher energy expenditure during exercise, fosters a greater negative energy balance. HIIT has been shown to produce more beneficial changes in appetite regulation than MICT and SIT, has been found to suppress energy intake after exercise to a greater extent in overweight men and reduces perceptions of hunger and satiety after exercise significantly more than MICT. To date, there has been no long-term research into the impact of MICT and HIIT/SIT on changes in sedentary behaviour, usual levels of physical activity, diet or energy expenditure, examining the adoption of and long term compliance with HIIT/SIT and MICT protocols in real-world settings, or compliance with the intensities established[4].

Meanwhile, the variable that most affects daily energy consumption is Non-Exercise Activity Thermogenesis (NEAT), which spans all the activities of daily life not associated with programmed exercise. NEAT could account for between 15 and 50% of energy expenditure. Obesity is currently associated with decreased NEAT, mainly in the workplace, obese people being more prone to low NEAT and sedentary lifestyles. Therefore, regardless of the exercise intensity, obesity management programmes should be accompanied by increased NEAT. Adapting the workplace so that subjects can walk at a leisurely pace for 2.5 hours per day leads to a weight loss of 20 to 30 kg/year in obese individuals without inducing compensation or a decrease in activity or energy expenditure during non-working hours[11].

Adaptation and tolerance level

Is it appropriate and/or possible to do long-term high-intensity work with obese adult populations who are usually sedentary? SIT protocols are extremely difficult and are unlikely to be tolerated or enjoyed by previously inactive individuals or populations with obesity[4,12,13]. Non-athletes with obesity/overweight will have trouble tolerating HIIT/SIT without getting their bodies used to MICT beforehand. HIIT/SIT can cause not only musculoskeletal disorders (injuries), but also psychological disorders leading to the abandonment of such exercise[4]. However, some authors advocate training aerobic capacity from the outset via HIIT before MICT in individuals presenting low fitness levels, obesity, cardiovascular disease or metabolic disorders[2].

Motivation and adherence

The American College of Sports Medicine has published annual worldwide trends in fitness in *ACSM's Health & Fitness Journal* for the last 14 years. The instrument used is a survey covering 38 possible trends in order to establish and be able to compare the fitness trends in Europe, North and South America, and Asia. In its latest study[14], 56,746 surveys were sent electronically to professionals from the sector and 3,037 of these from more than 40 countries responded. HIIT has featured among the top 3 trends since 2014 and in the latest survey (2020), while it was not even in the top 20 in Asia, held first place in North America, second in Europe and seventh in South America. In the "exercise for weight loss" trend (involving diet and an exercise programme) for 2020, it held first place in South America and Asia, sixth in Europe and eleventh in North America. There can be little doubt that these data demonstrate the wide acceptance of HIIT and weight loss programmes for a population which exercises regularly. Are these trends just as motivating for the obese adult population?

As previously stated, there have been no long-term studies on HIIT in obese populations, with most lasting between 2 and 14 weeks[4], barely sufficient time to generate true adherence to exercise and not enough to produce stable adaptations in the body. The results speak of weight loss in the short term, but none of them talks about the long term. How long will the outcomes last when training is no longer continued? Weight loss maintenance is defined as losing at least 5% of body weight or reducing the body mass index by at least 1 unit and keeping weight below this minimum amount for at least 1 year[5].

How long can an obese individual keep up HIIT as a training method and lifelong habit? The willingness and ability of people to adhere to HIIT/SIT on a long-term basis is currently unknown. More research is needed into the scope of psychological responses to HIIT/SIT and MICT in obese populations compared to regular intensity-independent exercise[4].

It is important to note that failing to achieve the desired results is strongly associated with the stress generated by the need to lose weight, feelings of guilt and failure leading to non-attendance[15,16]. Considering that adherence to exercise is the key to long-term weight loss, it may be more appropriate to propose a long-term programme which is progressive in terms of intensity, thereby decreasing the likelihood of having to stop constantly due to musculoskeletal problems or psychological factors, relieving the stress produced by the need to lose weight in the short term and seeking to mobilise and activate the metabolism every day, increasing energy expenditure. The aim should be for the subject to switch from their initial extrinsic motivation (weight loss by prescription) to intrinsic motivation (enjoyment of the activity itself), key to adherence to and continuity with the programme. To this end, it is essential to take into account such important aspects as socialisation (group activities with the same objectives), positive feedback (directed by an empathetic monitor with motivational skills) and activities that, as far as possible, are pleasant for the subjects.

Indication

Safety

Individuals must pass a medical examination beforehand showing that they are fit to train at the intensities set for HIIT/SIT. Existing scientific evidence shows that HIIT is safe and effective for almost all types of populations and conditions[3-6]. The safety of SIT for clinical populations, including the obese, has not been established[4]. In the review published by Jelleyman *et al.*[17], only 34% of the studies report adverse events. Out of a total of 18 musculoskeletal injuries incurred in exercise, 14 occurred with HIIT.

Load variables

These must be established, but in a general manner, without being too strict and adapting to the specific needs of each type of population. Such a broad range of intensities can make it difficult for health professionals to plan suitable programmes in an optimal manner. Further research should be conducted into suitable, optimal doses for each type of population, because these have not been established[3].

The fundamental goal of HIIT in obese populations is to reduce the body fat percentage. The variables to determine for general application are:

- *Type of exercise:* dynamic, involving a large proportion of the muscle chains in the body. Activities like running, swimming, cycling, rowing, boxing and others based on running and multi-joint exercises and on multiple planes. With obese populations, assessment is required to determine the appropriacy of complex exercises (Olympic exercises and variants, burpees, jump training, suspended push-ups, etc.) and equipment (dumbbells, Olympic bars, high bars, thick ropes, etc .) that cause great stress to the joints and/or may result in injuries due to, for example, lack of strength and technique, speed of movement, eccentric work, etc..
- *Weekly frequency:* Reducing the physiological profile (intensity

and duration) of HIIT for obese populations makes more frequent sessions possible. The goal should be to exercise every day.
- *Intensity:* approximately 80-100% MHR, 65-100% VO_2max.
- *Volume:* the total working time in HIIT is usually between 4 and 20-30 min, plus 10 min of warm-up-activation and 5-10 min to cool down, making for a total time of between 24 and 50 min per session.
- *Work-to-rest ratio and rest between repetitions and/or sets:* Work-to-rest ratio of 1:4 to 2:1. Beginner 1: 2; Intermediate 1: 1; Advanced 2: 1. With obese populations, short intervals of up to 60 seconds are the most common, while those of 30 seconds are considered more acceptable because they are less stressful. When working with intervals of 30 seconds, progressively increase to 4 sets of 6 intervals with rest between intervals of 1:1 and between sets of 1 to 2 minutes. When working with intervals of up to 60 seconds, progressively increase up to 2 sets of 6 intervals with rest between intervals of 1:1 and between sets of 2 minutes. When working by intervals, sets are not necessary[2].
- *Intensity indicators and session assessment:* The new technology on the equipment at sports centres and/or the user's own devices can be used to programme and control exercise. The simplest way is probably by %MHR with submaximal HIIT. To minimise the HR error, the heart rate reserve or Karvonen formula should be used. Another simple way is to use the Borg rating of perceived exertion scale (RPE). Its ease of use makes it well suited for all protocols and it also takes into account psychophysical aspects such as rest and a number of subjective factors. The scale is specific for each type of exercise and, once the subject is familiar with how to use it, is highly valid and reliable. Values of 17-18 (6-20 scale) and 7-8 (1-10 scale) for obese populations are a good indication that HIIT has been carried out at the right intensity [2].

As for the time of day for HIIT, it should be borne in mind that this type of training greatly activates the sympathetic nervous system and causes a significant decrease in parasympathetic reactivation afterwards. It is, therefore, not recommended at the end of the day so that the subject can rest properly[1].

Takeaways

- Both long-term HIIT and MICT lead to clinically significant fat loss.
- Existing scientific evidence shows that HIIT is safe and effective for almost all types of populations and conditions.
- Dynamic exercises involving a large proportion of the muscle chains in the body should be performed.
- Start with intervals of 30 to 60 seconds and a 1:2 work-to-rest ratio.
- In order to be effective managing obesity, such exercise should be complemented with dietary intervention and the adoption of healthy habits, increasing total daily energy expenditure.

Bibliography

1. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. *Sports Medicine* (Auckland, NZ). 2013. 43:313–38.
2. López Chicharro J, Vicente Campos D. HIIT. *Entrenamiento interválico de alta intensidad. Bases fisiológicas y aplicaciones prácticas.* Ed. José López Chicharro; 2018.
3. Campbell WW, Krauss WE, Powell KE, Haskell WL, Jnz KF, Jakicic JM, *et al*. High-intensity interval training for cardiometabolic disease prevention. *Med Sci Sports Exerc.* 2019;51:1220-6.
4. Keating SE, Johnson NA, Mielke GI, Coombes JS. A systematic review and meta-analysis of interval training versus moderate-intensity continuous training on body adiposity. *Obes Rev.* 2017;18:943–64.
5. Su L, Fu J, Sun Si, Zhao G, Cheng W, Dou C, *et al.* Effects of HIIT and MICT on cardiovascular risk factors in adults with overweight and/or obesity: A meta-analysis. *PLoS One.* 2019;14: e0210644.
6. Wewege M, Van den Berg R, Ward RE, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. *Obes Rev*. 2017;18:635–46.
7. Boutcher SH. High-intensity intermittent exercise and fat loss. *J Obes*. 2011;2011:868305.
8. Bauman A, Owen N. Physical activity of adult Australians: epidemiological evidence and potential strategies for health gain. *J Sci Med Sport.* 1999;2:30– 41.
9. Gibala MJ, Little JP, Macdonald MJ, Hawley JA. Physiological adaptations to low-volume, high-intensity interval training in health and disease. *J Physiol.* 2012;590:1077–84.
10. Maillard F, Pereira B, Boisseau N. Effect of high-intensity interval training on total, abdominal and visceral fat mass: a meta-analysis. *Sports Med.* 2018;48:269–88.
11. Malaeb S, Perez-Leighton CE, Noble EE and Billington C. A "NEAT" approach to obesity prevention in the modern work environement. *Workplace Health Saf.* 2019;67:102-110.
12. Lunt H, Draper N, Marshall HC, Logan FJ, Hamlin MJ, Shearman JP, Cotter JD, *et al.* High intensity interval training in a real world setting: a randomized controlled feasibility study in overweight inactive adults, measuring change in maximal oxygen uptake. *PLoS One*. 2014; 9:e83256.
13. Decker ES, Ekkekakis P. More efficient, perhaps, but at what price? Pleasure and enjoyment responses to high-intensity interval exercise in low-active women with obesity. *Psychol Sport Exerc.* 2017; 28:1-10.
14. Thompson WR. Worldwide survey of fitness trends for 2020. *ACSMs Health Fit J.* 2019;23:10-8.
15. Carels RA, Cacciapaglia HM, Douglass OM, Rydin S, O'Brien WH. The early identification of poor treatment outcome in a women's weight loss program. *Eat Behav*. 2003;4: 265-82.
16. Brockmann, A.N., Ross, K.M. Bidirectional association between stress and physical activity in adults with overweight and obesity. *J Behav Med.* 2020;43:246–53.
17. Jelleyman C, Yates T, O'Donovan G, Gray LJ, King JA, Khunti K, Davies MJ. The effects of high-intensity interval training on glucose regulation and insulin resistance: a meta-analysis. *Obes Rev*. 2015;16(11):942–61.

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