HOSTED BY
ELSEVIER

Check for updates

Available online at www.sciencedirect.com
ScienceDirect

Journal of Sport and Health Science 7 (2018) 429–432

Sport Health Science
www.jshs.org.cn

Opinion

Battle of the sexes: Which is better for you, high- or low-intensity exercise?

Christian Cobbold

School of Science, Australian Catholic University, Banyo, QLD 4014, Australia

Received 4 April 2018; revised 19 April 2018; accepted 27 April 2018
Available online 1 June 2018

1. Introduction

Cardiovascular disease (CVD) accounts for more than 17 million deaths per year;[1] however, morbidity statistics alone underestimate the scale of the problem because a significant proportion of the population live with CVD. Obesity and type 2 diabetes mellitus (T2DM) have significant influence on CVD initiation and progression, and obesity is independently associated with CVD, particularly among women.[2] Obesity levels are rising rapidly in adults, but of particular concern is its swift rise in children and adolescents,[3] who are at risk of remaining overweight into adult life[4] in which long-term health consequences are most likely to manifest.[5] In its simplest form, obesity arises because of an imbalance between energy intake and energy expenditure, with excess triglycerides being stored in adipocytes, which can increase in both size and number.[6] Obesity results in numerous potential adverse effects such as sleep apnea, increased incidence of osteoarthritis,[7] and psychological impact,[8] but adipocytes also act as an endocrine organ secreting hormones and cytokines such as retinol-binding protein 4 (RBP-4) and adiponectin. In obesity, adiponectin levels decrease and RBP-4 levels increase, the effects of which enhance insulin resistance, thus increasing T2DM risk.[9] Individuals with T2DM have a several-fold increased risk of CVD, and many of the risk factors for obesity, T2DM, and CVD overlap highlighting the interlinking complexity of these pathologic processes: poor diet, age, gender, ethnicity, smoking, dyslipidemia, hypertension, and physical inactivity, to name a few.[10–12]

2. Physical inactivity

Physical activity (PA) is an effective way of managing weight, and public health guidelines suggest individuals perform 150 min of moderate-intensity aerobic exercise per week or 75 min at a vigorous level to lose weight, reduce blood pressure, and decrease cholesterol levels (i.e., sufficiently active);[13] for greater health benefits, the World Health Organization now recommends 300 min of moderate-intensity exercise per week or 150 min at a vigorous level.[14]

Globally, physical inactivity was approximately 23% in 2010, and this physical inactivity is seen in both genders to different degrees. It is well known that females do not exercise as much as males, and this is reflected in the 2010 global inactivity levels, which reported that in the UK, 32% of males and 42% of females do not exercise to the recommended levels.[14] Similar gender differences are observed throughout the world; for example, the United States (male *vs.* female: 25% *vs.* 39%); Australia (male *vs.* female: 20% *vs.* 28%); and Saudi Arabia (male *vs.* female: 53% *vs.* 69%).[14] It is therefore clear that compliance with current recommendations is poor, particularly in women; the reasons are varied, but common explanations include limited available time and motivation.[15,16] Recommendations for PA levels are currently the same for both males and females, which overlooks any potential requirement for different levels based on gender, particularly because males have lower overall health levels than females[14] (e.g., hypertension and CVD), males have higher incidences of hypertension and CVD compared to females. Health status is clearly based on more than just PA levels and includes other modifiable risk factors such as diet and stress and nonmodifiable factors such as being male, which confers additional risk in itself. Despite this, exercise is still a key player in overall health and decreased disease risk.

3. High-intensity interval training (HIIT)

The high-time and low-motivation reasons for a lack of exercise has driven research into the use of HIIT as a possible PA regime that provides rapid positive benefits in health risk factors, such as blood pressure, cholesterol levels, and insulin sensitivity, and also takes up little time.[16–18] In fact, some studies have shown that health benefits can be gained by undertaking 2 weeks of supervised HIIT comprising just 15 min of total exercise,[15] whereas other studies have shown benefits in slightly longer 4- to 6-week programs.[19] HIIT is defined as repeated short-duration exercises at a high-intensity level interspersed with recovery periods and is thus a time-efficient method of exercising. Because HIIT offers an impact on

Peer review under responsibility of Shanghai University of Sport.
E-mail address: christian.cobbold@acu.edu.au

https://doi.org/10.1016/j.jshs.2018.05.004

physical health and assists with compliance issues, it is an exciting prospect for use in the treatment, management, and prevention of chronic diseases, which are currently pose significant concern to the global population.

4. Gender responses to exercise

It is well documented that exercise has considerable physiological and psychological health benefits for both men and women; however, it is less clear if there are differing levels of health benefits between the sexes or if different modes of exercise are more beneficial to one gender than the other. Fuel metabolism during exercise places a varying degree of importance on fuel substrate utilization between the sexes. During long-distance exercise at approximately 65% maximal oxygen consumption (VO_{2max}), women metabolize more lipids, and correspondingly less carbohydrates and proteins, than equally trained and nourished men.[20] In part, this may be a result of increased adrenaline levels observed in men, which is a powerful mobilizer of muscle and liver glycogen. Muscle glycogen is an important fuel during exercise, and carbohydrate loading for 4 days in athletes revealed that although male muscle glycogen levels increased by 41%, there was no significant increase in female levels.[21] Performance was subsequently analyzed in a submaximal endurance cycle at 75% VO_{2max}; again, males showed a significant increase in performance that females did not, and as previously noted, females metabolized significantly more lipid than males, who metabolized more protein and glycogen during exercise.[21] Interestingly, it is possible that the lower glycogen usage in females, and thus reduced glycogen depletion, may result in a significant increase in performance time in women, particularly when working in the 75%−85% VO_{2max} range.[22] This is backed up by the observation that females had significantly lower mid and terminal exercise respiratory quotient values, indicating a later occurrence of muscle glycogen depletion.[22]

Body size, body composition, and muscle characteristics have also been implicated as potential reasons for gender-based differences in response to exercise.[23,24] Females tend to have a greater proportion of body fat than men, which is stored in the gluteal-femoral region in women compared with the visceral area in men.[25] Total cross-sectional muscle area is 60%−85% lower in women than in men, and greater muscle mass activation requires increased need to replenish stores and increased glycogen breakdown turnover.[15] The degree of fitness has been implicated in accounting for gender-based differences in performance; prior training triggers muscular adaptations to improve fuel utilization and therefore more efficient functioning during exercise.[26] PA levels should therefore be matched between the sexes when studying the effects of exercise on performance between the sexes.

The significant health benefits that exercise provides are well understood, and it is therefore often prescribed to aid in the prevention and management of chronic disorders.[16] Our lab has previously highlighted the heterogeneous responses individuals have to exercise, with some participants showing positive responses to a variety of health markers, whereas others have no change or show potentially adverse responses.[18] For example, we showed that positive responders had significant improvements in systolic and diastolic blood pressures and VO_{2max}.[18] Not all individuals show positive responses to exercise; many show no significant change, and others may show an adverse response (e.g., systolic pressure may increase (get worse) or insulin sensitivity decrease).[17]

There is a wealth of knowledge on how male and female physiology responds differently to exercise; this includes lipid, protein, and carbohydrate metabolism and hormonal changes (e.g., adrenaline during exercise or estrogen during the menstrual cycle[21,27]); however, a key question remains whether there are different health benefits following exercise. One of the best current markers of overall morbidity and mortality is VO_{2max},[28] which, put simply, is a measure of how effective the body is at using oxygen; it is thus a marker of overall respiratory and cardiovascular (heart and blood vessels) function. Our preliminary data indicates that, following a 6-week HIIT program in healthy 20- to 24-year-old participants, males showed an average increase in VO_{2max} of 11% ($p = 0.037$), whereas the change in female VO_{2max} was not significant (unpublished data). As discussed previously, there are significant differences in body composition between the sexes; males have greater skeletal muscle mass,[29] and women have more body fat.[25] There is also an overall increased left ventricular end-diastolic volume in males compared with that found in females.[30] All of these factors could potentially influence the increased VO_{2max} we observed in males compared with females. Previous work has demonstrated that both sexes gain significant health benefits when moving from the sedentary state to low levels of exercise[31] however, when intensity further increases to vigorous levels, as observed in our HIIT program, males gain greater health benefits than females.[32] Women appear to benefit from increased duration of low to moderate intensity[33] with limited benefits following higher-intensity exercise.[34] Despite this, females have increased health benefits and protection from T2DM and CVD than their male counterparts when undertaking low to moderate aerobic exercise (e.g., brisk walking, cycling, or jogging where a conversation can still be held).[33]

There have been several studies looking into the effects of exercise on cancer. For example, reports have suggested that lung cancer risk is not altered following PA in non-smokers but does reduce risk in smokers, and that risk for colon, breast, and endometrial cancers is reduced in those who undertake regular PA.[35] In males, prostate cancer risk may be reduced with PA, particularly if activity levels are high.[35]

Exercise is well known to improve health, energy levels, and mood, for example, through the production of endorphins and the so-called runner's high, which energizes individuals, leading to sharper focus, and through increased cardiovascular health, which improves endurance. Research consistently shows that exercise reduces the incidence of insomnia, resulting in better sleep as well as improved mood.[36] Furthermore, the incidence of depression is lower in those who exercise regularly, which is thought to be through increased release of neurotrophic factors that cause new nerve connections to form, thus improving brain functionality and potentially reducing depressive tendencies.[37] It is interesting to note that men seem to gain more antidepressant value from vigorous PA, whereas women gain it from lower levels of activity, such as walking, which may enable greater social interaction and bonding.[38] This appears consistent with other studies comparing exercise modalities and health between the genders.

5. Conclusion

Low levels of PA and cardiorespiratory fitness are associated with increased risk of CVD, and a large proportion of the population does not meet these recommended levels. There is thus considerable heterogeneity in an individual's ability to improve cardiorespiratory health and metabolic disorder risk such as diabetes mellitus in response to exercise, with responses varied depending on sex, genetics, and the environment. Evidence suggests that females and males respond differently to the type of PA they undertake: females appear to gain greater benefit from low to moderate aerobic exercise, whereas males may acquire greater health status through more intense activity. There are significant differences in the structure and function of males and females: the cardiovascular system of males enables them to perform more vigorous exercise, and therefore males tend to have higher VO_{2max} values, higher red blood cell counts, lower heart rates, and greater lung function[39,40] females use more lipids compared with males, who use greater proportions of carbohydrates and proteins as energy sources.

All of these differences lead us to the conclusion that one size does *not* fit all and that exercise prescription should be targeted and not generalized. Although females may not currently undertake as much PA as their male counterparts, perhaps they do not need to; perhaps lower level activity, and a little bit more of it, preferably with friends, will allow them to gain significant health benefits. Males, however, may want to take part in higher-intensity exercise, such as HIIT, in which their cardiovascular system is pushed to adapt and improve while gaining overall health benefits. Of course, we should also be thinking about exercise and health across the life span; just as males and females appear to differ in their requirements, so will the young and the old, the young female and young male, and the old male and old female. So although increasing PA levels is a clear benefit to individuals, it must be done smartly.

Competing interests

The author declares that he has no competing interests.

References

1. World Health Organization. *Cardiovascular diseases*. Available at: http://www.afro.who.int/health-topics/cardiovascular-diseases; 2018. [accessed 22.05.2018].
2. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation* 1983;**67**:968–77.
3. Wang Y, Monteiro C, Popkin BM. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *Am J Clin Nutr* 2002;**75**:971–7.
4. Nader PR, O'Brien M, Houts R, Bradley R, Belsky J, Crosnoe R, et al. Identifying risk for obesity in early childhood. *Pediatrics* 2006;**118**:e594–601.
5. Stice E, Presnell K, Shaw H, Rohde P. Psychological and behavioral risk factors for obesity onset in adolescent girls: a prospective study. *J Consult Clin Psychol* 2005;**73**:195–202.
6. Bray GA. Medical consequences of obesity. *J Clin Endocrinol Metab* 2004;**89**:2583–9.
7. Bray GA. Pathophysiology of obesity. *Am J Clin Nutr* 1992;**55**:488S–94S.
8. Puhl RM, Heuer CA. The stigma of obesity: a review and update. *Obesity (Silver Spring)* 2009;**17**:941–64.
9. Phillips A, Cobbold C. A comparison of the effects of aerobic and intense exercise on the type 2 diabetes mellitus risk marker adipokines, adiponectin and retinol binding protein-4. *Int J Chronic Dis* 2014;**2014**: 358058. doi:10.1155/2014/358058.
10. Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *The Lancet* 2004;**364**:937–52.
11. Burns DM. Epidemiology of smoking-induced cardiovascular disease. *Prog Cardiovasc Dis* 2003;**46**:11–29.
12. Howard BV, Van Horn L, Hsia J, Manson JE, Stefanick ML, Wassertheil-Smoller S, et al. Low-fat dietary pattern and risk of cardiovascular disease: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. *JAMA* 2006;**295**:655–66.
13. Bassuk SS, Manson JE. Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *J Appl Physiol* 2005;**99**:1193–204.
14. World Health Organization. *Global strategy on diet, physical activity and health*. Geneva: World Health Organization; 2018.
15. Babraj JA, Vollaard NB, Keast C, Guppy FM, Cottrell G, Timmons JA. Extremely short duration high intensity interval training substantially improves insulin action in young healthy males. *BMC Endocr Disord* 2009;**9**:3. doi:10.1186/1472-6823-9-3.
16. Talanian JL, Galloway SD, Heigenhauser GJ, Bonen A, Spriet LL. Two weeks of high-intensity aerobic interval training increases the capacity for fat oxidation during exercise in women. *J Appl Physiol* 2007;**102**:1439–47.
17. Bouchard C, Blair SN, Church TS, Earnest CP, Hagberg JM, Hakkinen K, et al. Adverse metabolic response to regular exercise: is it a rare or common occurrence. *PloS One* 2012;**7**:e37887. doi:10.1371/journal.pone.0037887.
18. Higgins TP, Baker MD, Evans SA, Adams RA, Cobbold C. Heterogeneous responses of personalised high intensity interval training on type 2 diabetes mellitus and cardiovascular disease risk in young healthy adults. *Clin Hemorheol Microcirc* 2015;**59**:365–77.
19. Søgaard D, Lund MT, Scheuer CM, Dehlbaek MS, Dideriksen SG, Abildskov CV, et al. High-intensity interval training improves insulin sensitivity in older individuals. *Acta Physiol (Oxf)* 2018;**222**(4)e13009. doi:10.1111/apha.13009.
20. Tarnopolsky LJ, MacDougall JD, Atkinson SA, Tarnopolsky MA, Sutton JR. Gender differences in substrate for endurance exercise. *J Appl Physiol* 1990;**68**:302–8.
21. Tarnopolsky MA, Atkinson SA, Phillips SM, MacDougall JD. Carbohydrate loading and metabolism during exercise in men and women. *J Appl Physiol* 1995;**78**:1360–8.
22. Froberg K, Pedersen PK. Sex differences in endurance capacity and metabolic response to prolonged, heavy exercise. *Eur J Appl Physiol Occup Physiol* 1984;**52**:446–50.
23. Marliss EB, Kreisman SH, Manzon A, Halter JB, Vranic M, Nessim SJ. Gender differences in glucoregulatory responses to intense exercise. *J Appl Physiol* 2000;**88**:457–66.
24. Toth MJ, Goran MI, Ades PA, Howard DB, Poehlman ET. Examination of data normalization procedures for expressing peak VO_2 data. *J Appl Physiol* 1993;**75**:2288–92.
25. Blaak E. Gender differences in fat metabolism. *Curr Opin Clin Nutr Metab Care* 2001;**4**:499–502.

26. Brooks GA, Mercier J. Balance of carbohydrate and lipid utilization during exercise: the "crossover" concept. *J Appl Physiol (1985)* 1994;**76**:2253–61.
27. Scheuer J, Malhotra A, Schaible TF, Capasso J. Effects of gonadectomy and hormonal replacement on rat hearts. *Circ Res* 1987;**61**:12–9.
28. Timmons JA. Variability in training-induced skeletal muscle adaptation. *J Appl Physiol* 2011;**110**:846–53.
29. Janssen I, Heymsfield SB, Wang ZM, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. *J Appl Physiol* 2000;**89**:81–8.
30. Sandstede J, Lipke C, Beer M, Hofmann S, Pabst T, Kenn W, et al. Age- and gender-specific differences in left and right ventricular cardiac function and mass determined by cine magnetic resonance imaging. *Eur Radiol* 2000;**10**:438–42.
31. Wen CP, Wai JP, Tsai MK, Yang YC, Cheng TY, Lee MC, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. *The Lancet* 2011;**378**:1244–53.
32. Tanasescu M, Leitzmann MF, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Exercise type and intensity in relation to coronary heart disease in men. *JAMA* 2002;**288**:1994–2000.
33. Sattelmair J, Pertman J, Ding EL, Kohl HW, Haskell W, Lee IM. Dose response between physical activity and risk of coronary heart disease: a meta-analysis. *Circulation* 2011;**124**:789–95.
34. Carlsson S, Andersson T, Wolk A, Ahlbom A. Low physical activity and mortality in women: baseline lifestyle and health as alternative explanations. *Scand J Public Health* 2006;**34**:480–7.
35. Friedenreich CM, Neilson HK, Lynch BM. State of the epidemiological evidence on physical activity and cancer prevention. *Eur J Cancer* 2010;**46**:2593–604.
36. Hartescu I, Morgan K, Stevinson CD. Increased physical activity improves sleep and mood outcomes in inactive people with insomnia: a randomized controlled trial. *J Sleep Res* 2015;**24**:526–34.
37. Matta Mello Portugal E, Cevada T, Sobral Monteiro-Junior R, Teixeira Guimarães T, da Cruz Rubini E, Lattari E, et al. Neuroscience of exercise: from neurobiology mechanisms to mental health. *Neuropsychobiology* 2013;**68**:1–14.
38. Asztalos M, De Bourdeaudhuij I, Cardon G. The relationship between physical activity and mental health varies across activity intensity levels and dimensions of mental health among women and men. *Public Health Nutr* 2010;**13**:1207–14.
39. Harms CA. Does gender affect pulmonary function and exercise capacity. *Respir Physiol Neurobiol* 2006;**151**:124–31.
40. Armstrong N, Tomkinson G, Ekelund U. Aerobic fitness and its relationship to sport, exercise training and habitual physical activity during youth. *Br J Sports Med* 2011;**45**:849–58.