The BASES Expert Statement on the Effect of Aerobic Exercise on Body Mass Regulation: Individual Variability and Compensatory Responses

Produced on behalf of the British Association of Sport and Exercise Sciences by Dr Mark Hopkins, Dr David Broom FBASES, Dr David Stensel, Prof Neil King and Prof John Blundell.

Introduction

Despite being a heavily promoted public health approach to combat obesity, the role of exercise in weight management has been questioned by the popular press and scientific community. Furthermore, it is commonly perceived that exercise is less effective for weight management in women. This (incorrect) portrayal of exercise undermines the important role that exercise should play in weight management. Therefore, this statement briefly summarises the scientific literature examining the effect of aerobic exercise on body mass (BM), and examines how individual variability and compensation to exercise influence exercise-induced reductions in BM.

The effect of aerobic exercise on body mass

The effect of aerobic exercise (as distinct from physical activity associated with daily living) without dietary restriction on BM has been extensively reviewed, with modest reductions (1.5-3.0 kg) typically reported over 3-18 months (Shaw *et al.,* 2006). However, study design varies markedly and exercise is often unsupervised and adherence either not measured or self-reported. Furthermore, the total exercise-induced energy expenditure (ExEE) is typically low and not measured objectively. In contrast, greater BM losses occur under controlled (often laboratory) conditions when the ExEE is larger (>2,000 kcal/week), or when exercise is combined with dietary restriction (Ross *et al.,* 2000). These findings underline the importance of distinguishing between efficacy (the ability to bring about intended change under ideal conditions) and effectiveness (the extent to which the intended change is achieved under 'real world' conditions). Regular aerobic exercise may be efficacious for weight loss under controlled conditions, but it may not be effective in the real world (as adherence is typically poor). While strategies that maximise effectiveness are clearly needed, two salient features also mediate the efficacy of exercise-induced BM losses; exercise-induced compensation and associated inter-individual variability.

Individual variability in response to exercise

One reason why exercise alone is often portrayed as being ineffective for weight loss is that studies typically focus on the mean response. However, individuals differ markedly in response to standardised exercise training, with inter-individual variability seen in cardiovascular fitness, insulin sensitivity and blood pressure (King *et al.,* 2010). Exercise-induced changes in body composition are also characterised by similar heterogeneity. For example, King *et al*. (2008) reported a mean (± SD) fat mass loss of 3.7 ± 2.6 kg following 12 weeks of supervised aerobic exercise. However, individual responses ranged from -9.5 to +2.6 kg, despite individuals performing the same objectively verified ExEE (see Figure 1). This heterogeneity is rarely acknowledged, with a 'one size fits all' approach typically adopted in exercise prescription and weight management. This variability reflects random/measurement error and biological variability, with biological variability determined in part by physiological and/or behavioural compensatory responses and genetic factors (not discussed here).

The concept of inter-individual variability raises the question of how we characterise the level of 'responsiveness' in individuals. Studies have termed individuals as 'responders' or 'non-responders' based on the changes seen in a single phenotype (see Mann *et al.,* 2014 for a review). This approach may help identify individuals or 'sub-groups' that benefit from an intervention (despite no apparent mean improvement). However, no consensus exists regarding the criteria used to categorise individuals. Furthermore, labelling individuals as 'non-responders' based on the change in a single

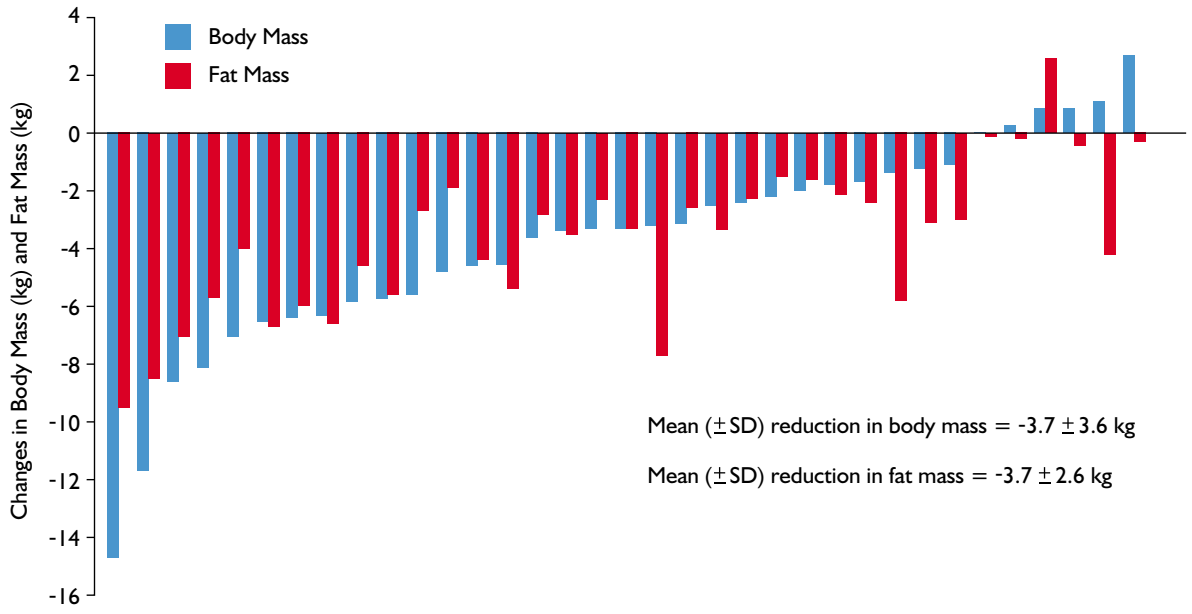

Figure 1. Individual changes in body and fat mass following 12 weeks of supervised aerobic exercise in overweight and obese individuals (adapted from King *et al.,* 2008).

variable can be misleading, as exercise training produces numerous concurrent physiological adaptations. It also needs to be established whether 'poor responsiveness' is evident across a range of phenotypes, reproducible or amenable to change, particularly in light of reports of adverse exercise responses in some (Mann *et al.,* 2014).

Compensation to exercise-induced body mass loss

There are a number of different approaches that can be taken when examining the underlying causes of inter-individual variability, with the HERITAGE study suggesting that heritability plays an important role in exercise responsiveness (Mann *et al.,* 2014). Variability in exercise-induced BM losses can also be examined in relation to energy balance regulation. The 'classic' depiction of energy balance, in which increased energy expenditure or decreased energy intake automatically leads to weight loss, is simplistic because it ignores the potential for adaptation to restore energy balance. Indeed, perturbations to energy balance may elicit biological and/or behavioural compensation that offset the prescribed energy deficit and minimises subsequent BM losses. Compensatory increases in hunger and food intake are commonly perceived as reasons why exercise alone produces modest BM losses (below that theoretically expected based on the ExEE). However, acute exercise does not stimulate an automatic increase in energy intake to restore energy balance. When exercise is performed over 7-14 days, partial compensation in energy intake equal to approximately 30% of the ExEE is seen, and these findings are consistent with longer-term interventions in which exercise-induced compensatory eating can mediate BM losses in susceptible individuals (see Hopkins *et al.,* 2010 for a review). Exercise-induced compensation could potentially also occur in components of total daily energy expenditure, e.g., resting metabolic rate, non-exercise activity thermogenesis (NEAT) or sedentary behaviour. However, at present there is little evidence to suggest that compensatory changes in energy expenditure play a key role in mediating susceptibility to exercise-induced weight loss, with a recent systematic review concluding that increased physical activity does not result in compensatory reductions in non-exercise physical activity in healthy adults (Washburn *et al.,* 2013).

Sex differences in exercise-induced body mass losses

It is commonly perceived that exercise is less effective for reducing BM in women than men. However, there are few randomised studies specifically examining sex differences in exercise-induced BM losses. Importantly, a recent systematic review demonstrated that no sex differences exist when the ExEE is equal between men and women (which is often not the case) (Caudwell *et al.,* 2014). While on average, women will need to exercise for longer and/or at a higher intensity during weight and non-weight bearing exercise to achieve the same energy expenditure (in part due to a lower lean BM), these findings challenge the prevailing view that women lose less BM than men following regular aerobic exercise. Therefore, exercise should be promoted equally to men and women for weight management. However, it is important for people to know that women will expend less energy for a given duration and intensity of exercise, compared with men.

Independent health benefits of exercise

While BM is typically used as the primary marker of success in weight management interventions, exercise can produce clinically meaningful improvements in health independent of changes in BM. For example, improvements in body composition (and distribution of tissue), blood pressure, insulin sensitivity and blood lipid profiles have been seen following regular exercise independent of BM changes (King *et al.,* 2010). Furthermore, individuals with a higher cardiovascular fitness may be at lower risk than those with low cardiovascular fitness, independent of BM (Blair *et al.,* 1995). Therefore, resistance to exercise-induced BM losses should not be portrayed as a rationale against the promotion of regular exercise.

From a public health standpoint, the independent health benefits of exercise should be promoted, while the emphasis reduced on BM as the only outcome in weight management.

Summary

Exercise-induced BM losses may vary markedly between individuals, with behavioural and/or biological compensation interacting with genetic factors to shape BM responses. For some, aerobic exercise is an effective means of reducing BM, while others experience more modest, or indeed, no reductions. Recognition that individual differences exist may help to promote a better understanding of BM regulation, and the mechanisms that mediate susceptibility to exercise-induced reductions in BM. Identifying predictors of exercise responsiveness, and strategies that enhance efficacy in poor-responders, will help develop more effective and personalised approaches to weight management. Importantly, clinically meaningful improvements in health still occur independent of changes in BM, while evidence suggests that exercise should be promoted equally to men and women for weight management (either alone or combined with dietary restriction). ■

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