

The 5th International Sport Science Symposium on “Sport Sciences for the Promotion of Active Life”
Symposium: Role of exercise in the prevention of obesity: does physiological compensatory response
link behavioural compensatory response?

Sport Sciences, 8, 188-196, 2011

Accepted for publication: 6 September 2011

Exercise and appetite regulation: appetite responses to acute exercise

David J Stensel

School of Sport, Exercise and Health Sciences, Loughborough University, UK

The effect of exercise on appetite has obvious implications for the role exercise plays in weight control. If exercise stimulates an overconsumption of food this could lead to weight gain rather than weight maintenance or weight loss. Indeed a recent article in *Time* magazine entitled ‘Why Exercise Won’t Make You Thin’ began with the following words ‘Whether because exercise makes us hungry or because we want to reward ourselves, many people eat more – and eat more junk food, like doughnuts – after going to the gym’ (<http://www.time.com/time/health/article/0,8599,1914857,00.html> Sunday 9 August 2009).

In contrast to the statement from *Time*, most research in this area does not support a role for exercise in causing overeating and weight gain. Although there are limitations to assessing appetite and food intake responses to exercise in a laboratory environment, research of this nature suggests that for most people neither appetite nor food intake are elevated beyond control

(non-exercising conditions) in the hours immediately after exercise. These findings are supported by data which show that an acute bout of exercise does not elevate plasma concentrations of the hunger stimulating hormone ghrelin but does increase plasma concentrations of the hunger suppressing hormone peptide YY. These hormonal responses to exercise may explain the lack of a compensatory increase in food intake in the hours after exercise.

This presentation will focus on appetite, energy intake, ghrelin and peptide YY responses to acute bouts of exercise. The presentation will examine the influence of different types of exercise on appetite as well as addressing the effects of exercising in different environmental conditions (i.e. heat, cold, and high altitude) on appetite. The implications of this research for the role of exercise in preventing obesity will be discussed in keeping with the symposium theme: Role of exercise in the prevention of obesity.

The interaction between exercise and appetite: hedonic and homeostatic compensatory responses

Neil King

School of Human Movement studies, Institute of Health and Biomedical Innovation,
Queensland University of Technology

Does exercise promote weight loss? The role of exercise in weight management is usually associated with its direct impact on energy expenditure and its potential to induce weight loss. However, exercise also influences body weight indirectly by exerting some influence on appetite and food intake.

Exercise could alter various components of appetite control and eating behaviour via changes in nutrient and taste preferences, meal size and frequency, and the drive to eat. This presentation will present data on the effects of exercise on appetite and eating behaviour and answer the question: “do people who exercise compensate for the increase in energy expenditure via compensatory increases in hunger and food intake?” Evidence will also be presented to demonstrate that exercise has the

capacity to alter the sensitivity of the appetite regulatory system.

One limitation with studies that assess the efficacy of exercise as a method of weight control is that only mean data are presented – the individual variability tends to be overlooked. Recent evidence highlights the importance of characterising the individual variability by demonstrating exercise-induced changes in appetite. Individuals who experience lower than theoretically predicted reductions in body weight can be characterised by hedonic (e.g. pleasure) and homeostatic (e.g., hunger) features.

In summary, the evidence presented will support that people vary in their responses to exercise, and that by characterising this variability, we will be better informed to tailor weight loss strategies to suit individuals.

**Exercise and hormonal regulation of appetite:
Sex differences and implications for body weight control**

Todd Hagobian

California Polytechnic State University, USA

Evidence from the national weight control registry shows the critical importance of regular aerobic exercise in maintaining lost body weight. On the basis of a strong body of data, the Institute of Medicine indicated that preventing body fat gain over time probably requires 60 min of physical activity per day. When previously sedentary individuals begin exercise training programs, however, fat loss is neither inevitable nor consistent across the sexes. In general, men lose body fat when they undertake structured exercise training programs with ad libitum eating. In contrast, women do not lose body fat in identical protocols. These data suggest that in response to exercise training, men do not sufficiently increase their energy intake to

balance their new higher energy expenditure. In contrast, women more precisely match their energy intake to expenditure, and therefore do not lose body weight.

This presentation will focus on whether sex differences in body weight loss with aerobic exercise training could be related to changes in appetite-regulating hormones (e.g. acylated ghrelin, insulin, leptin, etc.) and perceptions of hunger and satiety that mediate energy balance. The potential sex difference in the regulation of energy balance has implications both for our understanding of basic human biology (e.g., defending body fat for reproductive success in women) and in terms of exercise and dietary recommendations for the lay public.

Students Symposium

Heart-capturing (Delight) scene in watching sport

Daichi Oshimi¹, Harada Munehiko²

¹Graduate School of Sport Sciences, Waseda University,

²Faculty of Sport Sciences, Waseda University

Previous research has found that watching sports is a delightful and exciting experience (Bernhardt, Dabbs, Fielden, & Lutter, 1998; Yoshida & James, 2010). However, there are few studies focusing on the kinds of scenes actually enjoyed by sport spectators. We empirically developed a scale to measure the delightful experience while watching sport. Moreover, we verified the kinds of emotions aroused before and after watching sports, and investigated how they fluctuate while watching sports.

Consequently, eight aspects of heart-capturing (Delight) scenes scale were developed and it was found that sympathy/togetherness, dramatic scenes, outstanding play, and strenuous figures influenced spectators' satisfaction (Oshimi & Harada, 2010). Moreover, it was verified that watching games in which the favored team won aroused positive emotions such as liveliness and pride, surprise, excitement and enthusiasm, energy, and motivation (Oshimi & Harada, 2011).

Presently, we examined the relationships between some variables (gender, age, frequency of attendance, and loyalty to favorite team) and delight scenes to verify the characteristics of delight in more detail. The survey involved three games: a Japan Basketball League match and two Japanese professional soccer league matches, and the participants were 1434 spectators.

As a result, it was found that the scores of delight scenes in females were significantly higher than those in males were in almost every scene ($p < .05$). Regarding the other three variables (age, frequency of attendance, and loyalty to favorite team), loyalty to the team and delight scenes were moderately correlated ($r = .319-.464$, $p < .01$) and frequency of attendance and delight scenes were weakly correlated ($r = .226-.360$, $p < .01$). Moreover, it was verified that four aspects of exciting scenes (sympathy/togetherness, dramatic scenes, strenuous figures, and success in overcoming barriers) positively influenced loyalty to the favorite team; in particular, sympathy/togetherness and dramatic scenes significantly influenced loyalty in all three games.

Our findings indicate that there were moderate (weak) positive correlation among the frequency of attendance, loyalty to the favorite team, and delight experience except for spectating stadium. Moreover, from the perspective of sport management, sports teams should develop some strategies for spectators to feel sympathy / togetherness at a stadium and sport leagues should apply these to balance the strength of each team and make games more exciting.

The role of physical activity in the prevention of Atherosclerotic cardiovascular disease in older adults

Jong-Hwan Park¹, Masashi Miyashita², Masaki Takahashi^{1,3}, Noriaki Kawanishi^{1,3},
Katsuhiko Suzuki², Yoshio Nakamura²

¹Graduate School of Sport Sciences, Waseda University, ²Faculty of Sport Sciences,
Waseda University, ³Research Fellow of the Japan Society for the Promotion of Science

Although oxidised low-density lipoprotein (LDL), a risk marker for cardiovascular disease, increases with age, regular physical activity ameliorates oxidative stress and prevents the accumulation of lipids. However, it remains unclear the role of physical activity on oxidised LDL in older adults. Here we report the findings from two studies which examine 1) the relationship between the moderate to vigorous physical activity (MVPA) and oxidised LDL concentrations in older adults (Study 1), 2) the effects of supervised walking programme on oxidised LDL concentrations in older adults (Study 2). A total of 27 older adults (aged 69.9 ± 4.3 years, mean \pm SD; 16 females and 11 males) were analysed in the cross-sectional design (Study 1). Prior to the blood collection, participants were asked to wear an uniaxial accelerometer for 4 consecutive weeks to determine the physical activity status. We demonstrated that fasting plasma oxidised LDL and fasting plasma monocyte chemoattractant protein-1 (MCP-1) concentrations are negatively correlated with the MVPA levels in older adults (Park et al., *J AtherosclerThromb*, 2011;18:568-573). Twenty-eight older (≥ 60 years) participants were recruited (Study 2). Fourteen older adults were assigned to a 12-week supervised walking

exercise intervention group (low intensity walking (i.e. ratings of perceived exertion = 9-11), 30-60 min/session on 2 days/week) and fourteen older adults were assigned to a control group (participants were advised to maintain their normal lifestyle during the study). Blood samples were collected at baseline and immediately after 12 weeks. The results of this study showed that there are no significant changes in oxidised LDL concentrations, MCP-1 concentrations, and CD36 expression in leukocyte in both groups. Circulating concentrations of reactive oxygen metabolites (a marker of oxidative stress) were significantly decreased only in the exercise group after 12 weeks compared with the baseline values. Conversely, circulating concentrations of biological antioxidant potential (a marker of antioxidant capacity) were significantly increased only in the exercise group after 12 weeks compared with the baseline values.

These data demonstrate that: 1) regular physical activity may play a protective role in the oxidation of LDL in older adults. 2) a low-intensity physical activity programme lasting for 12 weeks, at least in our study, did not downregulate oxidised LDL and its receptor expression (i.e. a scavenger receptor). We are

currently conducting the Study 2 with a 6-month follow-up period (i.e. monitoring physical activity in both groups). Thus, it would be

interesting to assess whether increased or decreased physical activity during a follow-up period influences these parameters.

Mitochondrial DNA and exercise performance

Eri Mikami^{1,2,3}, Noriyuki Fuku³, Hideyuki Takahashi⁴, Nao Ohiwa⁴, Yannis P. Pitsiladis⁵,
Mitsuru Higuchi⁶, Takashi Kawahara⁴, Masashi Tanaka³

¹Graduate School of Sport Sciences, Waseda University, ²Research fellow of the Japan Society for the Promotion of Science, ³Department of Genomics for Longevity and Health, Tokyo Metropolitan Institute of Gerontology, ⁴Japan Institute of Sports Sciences, ⁵Institute of Cardiovascular and Medical Sciences, University of Glasgow, ⁶Faculty of Sport Sciences, Waseda University,

Elite athletes possess exceptional physical qualities, thus enabling outstanding sporting performances. A number of familial and twin studies suggest that genetics can account for 40-50% of the variability in physical performance (Frederiksen et al., *Scand J Med Sci Sports*, 2003). The identification of the genetic component to physical performance could greatly improve the development of training methods.

Aerobic ATP generation by oxidative phosphorylation (OXPHOS) in the mitochondrial respiratory chain is a prerequisite for physical exercise. Thirteen subunits essential to OXPHOS are encoded by mitochondrial DNA (mtDNA), which is a 16569-bp maternally inherited genome. Interestingly, aerobic capacity has been observed to have stronger maternal inheritance than paternal (Lesage et al., *Hum Hered*, 1985), and patients with mtDNA mutations commonly present with exercise intolerance. Therefore, mtDNA is a promising candidate to contain variants influencing exercise performance.

We have examined the association between mitochondrial haplogroups, which are a set of tightly linked mtDNA polymorphisms, and physical performance in elite Japanese athletes.

Mitochondrial haplogroups G1 and F, derived from the analysis of haplogroup-specific polymorphisms in the mtDNA control region (hypervariable sequence I), were found to be associated with elite Japanese athlete status (Mikami et al., *Br J Sports Med*, 2010).

The mtDNA control region contains various non-haplogroup-specific polymorphisms that have previously been found to associate with trainability in VO₂max, metabolic syndrome and type 2 diabetes; all of which are closely related with mitochondrial function. Thus, we examined the influences of polymorphisms in the control region on elite Japanese athlete status. Three polymorphisms: m.152T>C, m.514CA repeat and poly-C stretch at m.568-573, were associated with elite endurance/middle-power athlete status, whereas 2 polymorphisms: m.16278C>T and m.204T>C, were associated with elite sprint/power athlete status.

Our findings imply that mtDNA polymorphisms/haplogroups may influence physical performance: potentially due to differences in the mitochondrial function. Further sequence analyses of entire mtDNA of elite athletes are underway to elucidate the role of mtDNA variations in physical performance.

Increased daily-activity alters thermal perception and behavioral thermoregulation in mice: exercise may induce neuropsychological adaptation to heat

Cheng-Hsien Lin¹, Ken Tokizawa¹, Mayumi Nakamura², Yuki Uchida², Hisae Mori²,
Kei Nagashima^{1,2,3}

¹Graduate School of Sport Sciences, Waseda University, ²Faculty of Human Sciences, Waseda University, ³Institute of Applied Brain Sciences, Waseda University

Physical activity is associated with improvement of autonomic-thermoregulation in the heat, i.e. increase in sweat rate. However, exercise could be a factor increasing incidence of heat stroke. The main reason would be that exercising people have many chances exposed to heat and caused dehydration. In the present study, we tested the hypothesis that physical activity improves behavior thermoregulation during heat exposure in a dehydrated condition.

Male ICR mice (2-4 mo, age) were divided into two groups: one group had free access to running wheel for 8 weeks (WR, n=20) and the other had no access (NWR, n=20). After subcutaneous injection (1 ml/100 g of body weight) of either isotonic (154 mM, IS) or hypertonic saline (2,500 mM, HS), each mouse was placed in a behavior box with 5 peltier boards at the bottom, where a) thermal mosaic (temperature of each board was randomly chosen among set at 15 °C, 22 °C, 28 °C, 35 °C, or 39 °C; mice could select preferable position while the temperature setting was changed each 6 min) or b) operant behavior available (the temperature of each board was set at 39 °C; the right-end board was changed to 20°C within 1 min of a mouse moving on the left-end two boards).

As compared with NWR group treated with IS or HS, the WR group treated with IS or HS,

respectively had significantly lower thermal preference of board temperature (33.3 °C vs 34.7 °C for IS; 32.8 °C vs 34.8 °C for HS). In contrast in the heat (39 °C) without operant behavior, the WR group had significantly higher body core temperature elevation in the heat (39 °C for 90 min) than those of the NWR group treated with IS (2.0 °C vs 0.7 °C) or HS (3.1 °C vs 1.0 °C), suggesting that WR group had lesser heat tolerance than those of the NWR group. In the heat (39 °C) with operant system available condition, NWR group received HS higher body core temperature than those of IS controls (1.5 °C vs -0.1 °C). Heat-induced increased body core temperature in the operant behavioral trials was significantly reduced by WR (1.5 °C vs 0.2 °C). As compared to those of IS controls, the NWR group treated with HS had significantly lower heat-escape cold-seeking behavior counts (20 vs 10 counts for 90 min).

Our results indicate that physical activity may improve behavioral thermoregulation in dehydrated mice in the heat. In particular, physical activity lowers the thermal temperature of preference. In other words, physical activity or exercise training may improve heat-escape/cold-seeking behavior in mice in the heat during osmotic stimulus.

The kinematics of hand and fingers to determine the spin rate of baseball fastball

Tomoyuki Nagami^{1,2}, Takatoshi Higuchi¹, Toshimasa Yanai³, Kazuyuki Kanosue³

¹Graduate School of Sport Sciences, Waseda University, ²Research Fellow of the Japan Society for the Promotion of Science, ³Faculty of Sport Sciences, Waseda University

Fastball is the most common pitch in baseball. It travels with a backspin which gives the ball a lift force, and decreases its fall due to gravity. The spin parameter defined as $\pi \cdot d \cdot \omega / v$, where d is diameter of the ball, ω is the ball spin rate, and v is the free-stream velocity, has a major effect on the lift force. Actually, an elite collegiate pitcher, whose fastball spins faster than similar speed fastballs thrown by others, could get a lot of strikeouts in his league. So in this study, we analyzed the motions of the ball and fingers during the ball release to investigate how baseball pitchers create the spin on fastball.

Five professional and three collegiate baseball pitchers threw three four-seam fastballs from a pitching mound to a catcher. Three high-speed video cameras operating at a rate of 1000 frames per second were used to record the motion of the ball, hand and fingers. The angles of metacarpophalangeal (MP), proximal interphalangeal (PIP), and distal interphalangeal

(DIP) joints of index and middle fingers were calculated. Ball spin rate immediately after ball release was calculated from the number of video frames for one rotation of the ball. We defined “back spin angle” as the ball’s angular displacement in the backspin direction that occurred immediately before release. This angle was assumed to be indicative of the movement range through which the fingers could do a positive work on the ball to generate backspin.

A significant correlation was found between the “back spin angle” and the spin rate ($r = 0.895$, $p < 0.01$). Another significant correlation was found between the extension angle of PIP joint of both fingers and the ball spin rate (index finger; $r = 0.776$, $p < 0.05$, middle finger; $r = 0.912$, $p < 0.01$, respectively). These results demonstrate that spin rate of fastball pitched by baseballpitchers is determined by the hand and fingers motion before ball release.