Bulletin of the Faculty of Education, Hiroshima University, Vol. 31, Part 2, March 20, 1983.

On the Regulative Effects of Metabolism in the Educational Physiology

— Effect of Swim Training and Ingestion on the Human Obesity —

Akira Mito and Shigenobu Matsuoka
(Received: Oct. 1, 1982)

Abstract

The behavior in plasma levels of insulin, glucose, free fatty acid, gycerol, norepinephrine and epinephrine in during swim training have been studied in humans. To assess the posible reguratory role of nutritional state in the control of these plasma fluctuations, the obese and lean women group were measured at intervals of 30, 60, 90, and 120 min in the swim training.

Continued swim training (60–120 min/day) and food restriction decreased body weight gain in both groups. Swim training plus food restriction in the obese women further depressed body weight gain such that it was similar to the gain of lean group in during swim training. Swiming periods in the 0–60 min range for glucose and insulin were consistently, however, progresive consumption to 60 min produced decreases in more irregularity and then were influenced in the plasma levels of free fatty acid, glycerol,and norepinephrine. These fluctuations were associated with changes in nutritional state. Plasma free fatty acid levels increased during the 60–120 min of swim training. It seems that it continued to rise for the exercise period and possible longer. The data presented that norepinephrine can elicit the mobilization of free fatty acid to the plasma in conscious swim training. The matabolites (free fatty acid and glycerol) are probably derived from adipose tissue (triglyceride). The data suggest an activation of the lipolytic enzyme system was stimulated by swim training (stimulation with norepinephrine).

Introduction

To say that nutritional indoctrination plays a comforming to what is rightful method in educational physiology, but is, nevertheless to the concept of education, is already to disadvantage at a very important character. Learning is generally defined as any change of behavior and the distinction has certain advantages for the science in educational physiology. Activities of educational physiology makes it possible to deal with scientific learning is an obserble phenomena (in phylosophy of Kant), which is important if the study of leaning is to remain a scientific inquiry. There are many conceptual problems and practical problems associated with the concept of basis in educational physiology.

A more promosing treatment for obesity may be to increase physical activity in addition to controlling energy intake. Oscal et al[1,2] reported that exercise training in the lean causes a preferential fat consumption during physical exercise, and results in the obese with less fat than sedentary control. And also, whereas food restriction alone tends to cause consumption of protein as well as adipose tissue, physical exercise seems to show a protein-sparing effect.[1–4]This study investigated the effects of physical exercise plus food restriction on the reguratory changes in the obese and lean women. This work have demonstrated that physical exercise (swim training) can influence on the body weight gain of obese and lean women. Although the continual swim training (120 min/day) induced an increase of the food intake and appetite in both groups, this phenomenon was not enough to compensate for the higher energy expended.

This study in view of educational physiology was designed to determine whether more intense forced swim training (60–120 min/day) plus food restriction could influence the developing of obesity in the obese.

Procedures

Female obese (average body weight, >60 kg) and lean (body weitht, 40–45 kg) women volunteered in this experiment. Subjects were divided into two groups (obese and lean group). Obese group (n=6) were divided into two groups (food restriction group, n=3 and food non-restriction group, n=3), and lean group (n=6) were divided into two groups (food restriction, n=3 and food non-restriction, n=3). Swim took place in pool filled with water (25–27 °C), starting at 10 AM every day. Food restriction were performed by each person.

Blood samples were collected into chilled, heparinized tubes, and were centrifuged at 4 °C, and the fresh plasma was analyzed for plasma glucose, free fatty acid, glycerol by Kit, respectively (WAKO KK). Separate aliquots of plasma were stored at 20 °C until assayed for plasma insulin with a immunoassay Kit (Mochida KK). Plasma samples for norepinephrine and epinephrine determinations were collected into chilled, heparinized tubes containing reduced glutathion and EGTA, and the plasma was stored at 60 °C until assayed for norepinephrine and epinephrine as described previously by THI method.

The connected experiment in the other obese determined for the effects of swimming time and food restriction on the plasma free fatty acid behaviors.

Results and Discussion

An anaysis of some of the concepts of health in educational physiology used in existing education from the power to see or think of things in their true relationship to each other and the true relationship of objects or even to one another. These concepts of health in educational physiology made more readily understandable, according to their use in education without a turning for help or protection to their programatic significance in educational science. Represents a first step toward establishing a bridge between educational physiology and human nutritional science.

Exercise (swim training) for 60–120 min resulted in significantly lighter body weights in both obese and lean women compared with their body weights before swim training and exercise (0–60 min) in exercise plus food restriction (Fig. 1). The exercise (90–120 min) induced stimulation of food intake was not suffient to allow maintenance of body wight of before swim training. It is not unexpected that obese group gained more weight than the lean group. Hence, in the obese group, swim training plus food restriction resulted in a body weight gain similar to that of lean group, swim training plus food restriction. Exercised obese (0–30 min) and food (over eating) also increased weight gain such that by the end of the 1st week of swim training their cumulative

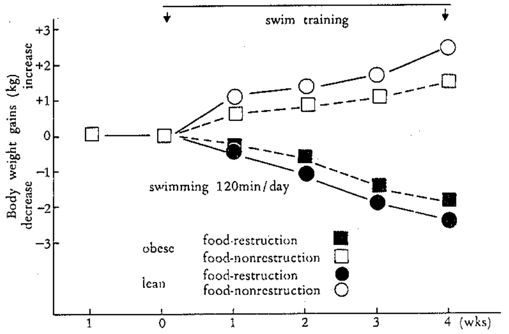

Fig 1. Effect of swim training on cumulative body weight gains in obese and lean women. Values are average cumulative body weight gains for each group. Obese group are significantly different from lean group for each week ($p < 0.05$).

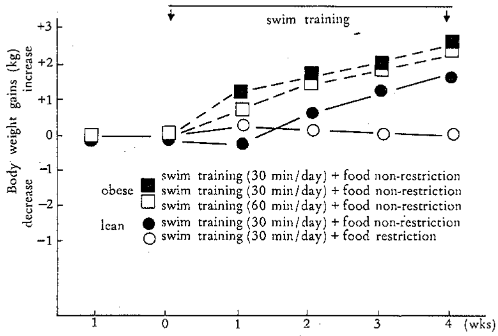

Fig 2. Effect of swim training on cumulative body weight gains in obese and lean women. The experiments were maintained swimming for 120 min/day through the end of the swim training period. Food non-restiction group are significantly different from food restriction group for each week ($p < 0.05$).

weight gain was greater than before swim training (Fig 2).

In summary, swim training (60–120 min/day) plus food restriction decreased body weight gain in lean women and more dramatically in obese woman. Swim training plus food restriction in the obese group further depressed total body weight gain such that it was similar to the gain of lean group during swim training. 2 weeks of food-take (ad libitum), body weights of the swim training (0–30 min) lean and obese women were distinguishable from the swim training (60–120 min) plus food restriction group. In the obese group (ad libitum), this was expected due to their transient increase in food intake. And also, in the obese, swim traing (0–30 min) plus food restriction increased body weight gain (Fig 2).

This study (Fig 1) has shown the effect of continual swim training (60–120 min/day) plus food restriction on the body weight gains in the obese and lean women. Our findings are in agreement with various studies[6,7,8] using rats have supported that forced swim training (60–120 min/day) plus food restriction have depressed body weight gain of obese and lean group. The data from these experiments are in agreement with the observations of animal experiments.[3,6,8]

In lean group, plasma insulin concentration was unaffected by swim training (30, 60, 90, 120 min/day). In comparison with lean group, obese group were significantly hyperinsulinemic and then moderatly lowered by continual swim training (60–120 min/day) plus food restriction (Fig. 3). The striking effect of continual swim training (60–120 min/day) plus food restriction on lowering plasma insulin level was not permanent, but all obese (contain overeating, genetic, etc.) have similar insulin levels, I think. Johnson et al[9,10] has shown a correlation between fat cell size and plasma insulin levels in sedentary rats. Continual swim training and food restriction in the obese get nearer to normal plasma insulin levels. Insulin levels would be expected to decrease due to the lower body weight seen in physical exercised the obese group. It is interesting to note that although the food restricted the obese women. There may be an improvement of insulin activity of the obese with continual swim training and food restriction. Mondon et al[11] have observed improvement of glucose tolerance, increases in insulin binding to cell receptors, and enhanced glucose uptake by perpherial tissue in exercised animals. Effect of continual swim training (60–120 min/day) and

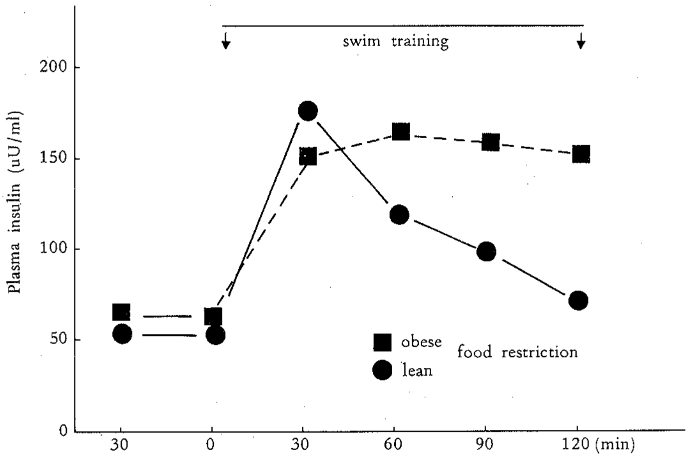

Fig 3. Effect of swim training on plasma insulin in obese and lean women. Values are average for each group. Obese group are significantly different from lean group ($p < 0.05$).

food restriction on the obese group was depression of high insulin level in plasma that may reflect improvement of insulin sensitivity.

Plasma epinephrine and norepinephrine were measured before and a process of swim training (30, 60, 90, and 120 min) in the obese and lean group (Fig. 4, 5). Plasma epinephrine reached to maximum at 5 min and then lowered immediately to normal state in the both group. Plasma norepinephrine in the obese group was lower than that of the lean group. Plasma norepinephrine increased significantly during of swim training (30, 60, 90, and 120 min) and continued to increase up to the end of swim training (120 min) and possible longer (Fig. 5).

The small increase of plasma free fatty acid observed at 30 60 min after swim training was significantly different from the increase induced by swim training (60--120 min) in the obese group (Fig. 6). Plasma free fatty acid level of lean group was higher than plasma free fatty acid level of the obese group during the swim training period (Fig. 5). This result seems to exclude the posibility that the plasma free fatty acid mobilization induced by swim training (30 -120 min) was due to a continuance of high level norepinephrine. The thought in also supported by the data

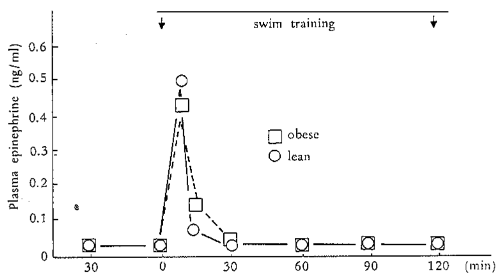

Fig 4. Effect of swim training on plasma epinephrinr in obese and lean women. Values are average for each group. Obese are significantly different from lean group ($p < 0.05$)

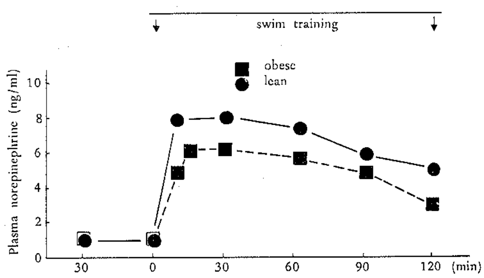

Fig 5. Effect of swim training on plasma norepinephrine in obese and lean women. Values are average for each group. Obese group are significantly different from lean group ($p < 0.05$)

that the plasma free fatty acid response actually increased when the secretion of norepinephrine was increased to 4–6 ng/ml.

Plasma glycerol levels also increased after level up to plasma norepinephrine (Fig. 7). When the small but statistically significant rise in plasma glycerol induced by swim training (30 min) was determined, the rise of 4 ng/ml level of norepinephrine concentration were effective in increasing plasma glycerol concentrations. Plasma glycerol level of lean group was significantly higher than that in the obese group at experimental intervals (Fig. 7). And at 60–120 min of swim training there were a tendency to higher values of plasma glycerol concentration in the obese and lean groups (with 4–6 ng/ml of plasma norepinephrine) and the differences in two groups were statistically significant. Although intravenous levels of 4–6 ng/ml of norepinephrine induced slight

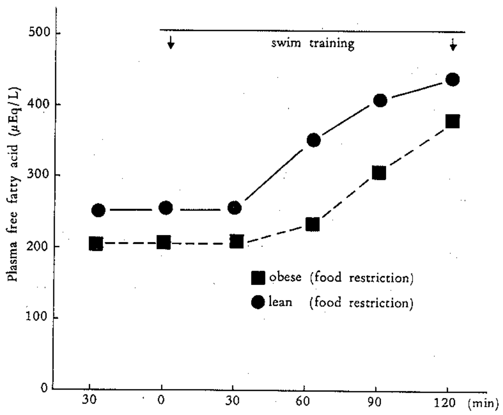

Fig 6–1. Effect of swim training on plasma free fatty acid in obese and lean women. Values are average for each group. Obese group are significantly different from lean group ($p < 0.05$)

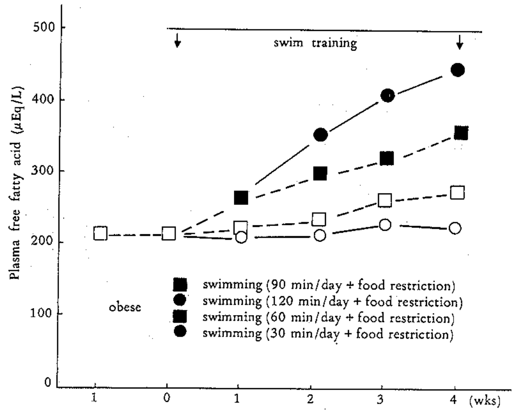

Fig 6–2. Effect of swim training plus food restriction on plasma free fatty acid levels at rest (after swimming, hungry time) in the obese group. Values are average for each group (n=3)

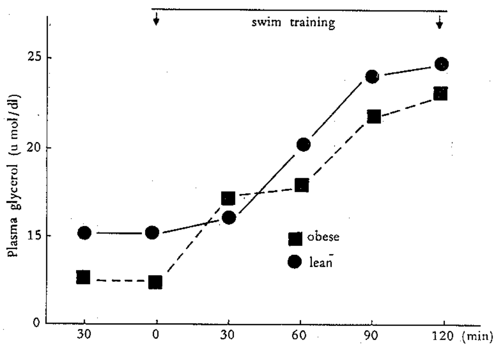

Fig 7. Effect of swim training on plasma glycerol in obese and lean women. Values are average for each group. Obese group are significantly different from lean group ($p < 0.05$)

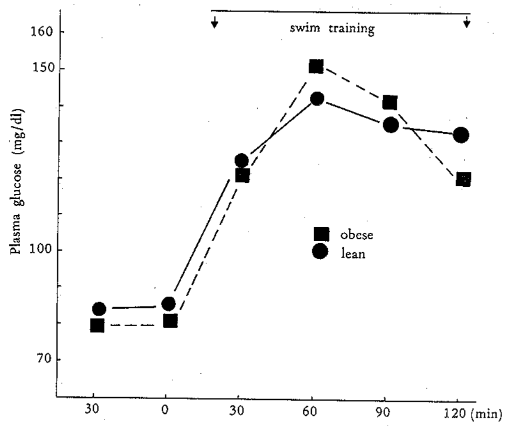

Fig 8. Effect of swim training on plasma glucose in obese and lean women. Values are average for each group. Obese group are significantly different from lean group ($p < 0.05$).

elevation in plasma free fatty acid and glycerol, their elevation of levels were different from those stimulated by the swim training plus food restriction. In contrat to its effects on plasma free fatty acid mobilization, swim training (60 min) in the obese group induced a marked increase in plasma glucose concentration that were higher than those induced by swim training (60 min) of the lean group (Fig. 8). As suggested by a comparison of Fig 5, Fig 6, Fig 7 and Fig 8, plasma free fatty acid response to norepinephrine was evidently rised by the swim training plus food restriction. Notwithstanding the decrease in the secretion of norepinephrine in the swim training (60–120 min), data in Fig. 5 showed clear that, plasma free fatty acid levels after the swim training (60–120 min) plus food restriction in the lean group were significantly different from those in the obese group treated with food restriction. Food non-restriction completely inhibited the plasma free fatty acid and glycerol increses induced by the norepinephrine.

The data indicated here show that norepinephrine can elicit the mobilization of free fatty acid to the plasma in conscious or unrestrained swim training (60–120 min) plus food restriction. Although the origin of the excess in plasma free fatty acid after the swim training (60–120 min) was established from these experiments, the metabolites (free fatty acid and glycerol) are probably derived from triglyceride of adipose tissue. Bicause plasma glycerol concentration was concomitantly raised by the swim training (60–120 min), the data indicated an activation of the lipolytic process by the swim training plus food restriction (stimulation with norepinephrine). The plasma free fatty acid increases maintained after the swim training (60–120 min) resulted from the direct stimulation of plasma catecholamin.

References

1) Oscal, L.B., S.P. Banirak, F.B. Dubach, J.A. McGarr, and C.N. Spirakis.: Exercise or food restriction: effect onadipose tissue cellularity. Am. J. Physiol., 227, 901--904, 1974.
2) Oscal, L.B., and J.O. Holloszy.: Effects of weight change produced by exercise, food restriction or overeating on body composition. J. Clin. Invest., 48, 2124--2128, 1969.
3) Katch, V., R. Martin, and J. Martin.: Effect of exercise intensity on food consumption in the male rat.
Am. J. Clin. Natur., 32, 1401–1407, 1979.
4) LeBlanc, J., A. Nadeau, M. Boulay, and S. Rousseau-Migneron.: Effects of physical training and adiposity on glucose metabolish and ^{125}I-insulin binding.
J. Appl. Physiol.: Respirat. Environ. Exercise Physiol., 46, 235–239, 1979.
5) 山村雄一監集：医化学実験法講座，第6巻A， 188 － 191，㈱中山書店 1972.
6) Oscal, L.B., P.A. Molé, and J.O. Hollozy.: Effects of exercise on cardiac weight and mitochondria in male and female rats.
Am. J. Physiol., 220, 1944–1948, 1971.
7) Zucker, L.M.: Efficiency of energy utilization by the Zucker hereditary obese rat "fatty".
Proc. Soc. Exp. Biol. Med., 148, 498–500, 1975.
8) Crews, E.L., K.W. Fuge, L.B. Oscal, J.O. Holloszy, and R.E. Shank.: Weight, food intake, and body composition : effects of excercise and of protein deficiency.
Am. J. Physiol., 216, 359–363, 1969.

9) Johnson, P.R., J.S. Stern, M.R.C. Greenwood, and J. Hirschen : Adipose tissue hyperplasia and hyperinsulinemia in Zucker obese female rats : a developmental study.
Metabolism, 27, 1941–1954, 1978.
10) Johnson, P.R., J.S. Stern, M.R.C. Greenwood, L.M. Zucker, and J. Hirsch : Effect of eary nutrition on adipose cellularity and pancreatic insulin release in the Zucker rat.
J. Nutr., 103, 738–743, 1973.
11) Mondon, C.E., C.B. Dolkas, and G.M. Reaver : Site of enhanced insulin sensitivity in exercise-training rats at rest.
Am. J. Physiol., 239 (endocrinol. Metab. 2) : E169–E177, 1980.