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Effects of fasting or a vegetarian diet on subjective ratings of appetite and mood during strenuous physical activity

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ABSTRACT

Thirty-four subjects participating in "fasting marches" at a health spa were studied during three days of hiking 14-27 km daily and the combined effects of either fasting (n=10) or a hypocaloric lactovegetarian diet (n=20). Hunger, satiety, tiredness, irritability and contentedness, assessed by visual analogue scales, and the energy intake (fasting fixed to 1.1 MJ, 253 kcal/day, lactovegetarians mean 4.8 MJ, 1147 kcal/day) assessed by dietary recall were analysed. Lactovegetarians on their hypocaloric diet experienced more hunger before meals than fasters but a similar degree of tiredness. The combination of exercise and a hypocaloric diet, probably resulting in varying degrees of ketonaemia, seems to lead to responses which can be explained by a combination of psychological and physiological reactions. Fasters, although less hungry than lactovegetarians, complied equally well with the endurance program, but displayed lower mood.

Key words: Appetite, exercise, fasting, hunger, mood

Introduction

For many individuals, fasting is part of a particular lifestyle. There is a belief that fasting cleanses the body from waste or toxic products and many individuals become euphoric if refraining from food intake for some time (1). The objective and physiological effects of starvation have been studied by *Cahill* who documented the effects of ensuing negative protein balance and the development of ketonaemia after only a few days of starvation. *Cahill* notes that during starvation, intellectual functions may be unaffected, but that subjects may react with either inactivity as well as hyperactivity, when the body readjusts fat metabolism and increases use of ketones as a metabolic fuel.

In the short or intermediate term, the effects of physical activity on subsequent food intake are not tightly linked as shown by *King* et al. (2). A good deal of evidence demonstrates that there is a weak coupling between energy expenditure and energy intake in their short-term studies. The evidence suggests that activity-induced energy expenditure does not constitute a major drive for energy intake. It is a common clinical experience in the obesity clinic that some patients argue that physical activity may reduce hunger sensations, whereas others believe that exercise makes them hungry. Such divergent information clearly has implications for the proper design of weight reducing treatment programmes.

In a study comparing a sedentary three week period with a physically active period of the same duration in obese individuals, *Woo* et al. (3) found that energy intake was similar during both periods, but that there was a large variation between subjects over the days of the study. A difference between normal weight and obese women was later found in that obese women did not adjust energy intake at all in response to a high level of physical activity, whereas normal weight women made a partial compensatory increase (4). However, in response to exercise some individuals relax their deliberate control over food intake (5).

For exercise to induce a negative energy balance, compliance over two forms of behaviour must take place. Firstly, adherence to the exercise regime itself, and secondly, compliance to maintain a judicious pattern of eating (e.g. self-reward by food) and to prevent passive overconsumption (e.g. high-fat foods) (6,7).

Reger et al. (8) and *King* et al. (9) have demonstrated that hunger was temporarily suppressed by short term physical activity of up to 60 minutes. This suppression is short-lived, hence it has little or no effect on food intake. Studies demonstrating that exercise has inhibitory effects on food intake in humans are scarce, according to *Pi-Sunyer* (10).

Even if moderately intense physical activity does stimulate appetite, the reverse may occur when the intensity of the activity is increased. Exhausting activity may affect food intake dramatically, affecting both eating and drinking (11). *Strauzenberg* et al. (12) even suggested an inverse relationship between energy expenditure and food intake. This occurs with prolonged strenuous activity (13).

Ketosis is a normal consequence of fasting and exercise (14,15). A combination of these two conditions might result in faster development of ketosis, which in turn may affect mood, hunger and appetite. Exercise seems to result in both increased hepatic ketogenesis and increased muscular extraction of ketones, maintaining the level in a catabolic situation stable to allow the ketone bodies to be preferentially used by the brain (14). Although clinical anecdotes suggest that patients undergoing semistarvation or very low calorie diet (VLCD) treatment develop a certain degree of euphoria within days as they become ketotic, no systematic information on the relationship between ketosis and mood is currently available and short duration exposure demonstrates only minimal effects on neurobehaviour (16).

At the Svanstein Health Spa in the northernmost part of Sweden on the Finnish border, so-called "fasting marches" have been arranged for a couple of years. These group-organised long-endurance exercise programmes attract fit, interested and highly motivated individuals to take part in a programme lasting one week, which include cross-country walking of 20-26 kilometres per day. The programme is not aimed at top athletes, but is sufficiently demanding to attract modera-

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Table 1. Mean (SD) macronutrient intakes for fasting and lactovegetarian participants on day 1.

	Fasting			Lactovegetarian		
	kcal	kJ	ED (%)	kcal	kJ	ED (%)
Protein	4.5	18.8	7	40 (7)	167 (29)	13 (1)
Fat	2.1	8.8	7	27 (13)	113 (55)	18 (8)
Carbohydrate	53.2	222.6	85	215 (50)	878 (209)	69 (7)
Total energy	253	1059	100	1272 (262)	5322 (1100)	100

ED=Energy distribution

tely physically fit subjects, who are concerned about their health and fitness. Some but not all participants fast during this week in addition to the strenuous exercise. The Svanstein Spa has a vegan and a vegetarian dietary profile. We decided to take the unique opportunity of an on-going Svanstein fasting march to study the effects of this exercise programme on food intake, mood and various aspects of hunger and satiety.

Method

Subjects

The participants were all healthy men and women, who had paid for a week at the spa, where the "fasting marches" occupied a major part of their time. Some selected to fast, others to eat the standard vegetarian or vegan diet during the week. 34 subjects (10 males) completed the programme. The mean age was 52.2 years (SD = 11.0 yrs), the mean weight 74.3 kg (SD = 12.4 kg), height 171 cm (SD = 8 cm) and BMI 25.4 kg/m^2 (SD = 3.2 kg/m^2). No subjects were smokers, 4 were on continuous medication for hypertension, asthma and post-operative breast cancer respectively. One female keen to participate was found later to be an insulin dependent diabetic and was excluded from the data analysis. 10 subjects fasted, 3 selected a vegan diet and 20 a vegetarian diet.

The Spa programme

All subjects arrived on a Saturday at noon, after which only the individually selected spa diet was available. Upon arrival, all participants were interviewed by a trained nurse and a simple health check was carried out, blood pressure was measured and basic blood tests were drawn. All participants were carefully informed about the characteristics of the diet at the spa and selected the type of food they would consume during the programme.

The exercise programme was also described in great detail. The following day a short test march of 14 kilometres on paths in the surrounding woods was performed. Generally, the subjects marched for about 50 minutes with a 10 minutes break for rest and water replenishment. From the third day at the spa (corresponding to measurement Day 1), the daily marching distance ranged from 20 to 26 kilometres with breaks for drinking during the morning and afternoon as well as a 60 minute lunch break, during which the individually selected type of meal was served. During the week of the study the temperature was high for Swedish summer conditions, ranging from +24°C to +30°C during the marching hours.

The research programme

The purpose of the study was carefully described to all participants, and all but five were willing to participate. All tests protocols were brought along during the marches. A standard dietary recall protocol from the Obesity Unit was administered, in which all food eaten and the time for these meals were recorded. A questionnaire with visual analogue scales was distributed and subjects were instructed to register their feelings of hunger, satiety, tiredness, irritability and the urge to eat (17) ten times a day: Immediately before and after breakfast, lunch and dinner; twice at equal intervals during the hours between breakfast and lunch as well as between lunch and dinner. Throughout the march, during breaks for drinks and rest, all subjects were reminded that these scales should be filled out. Likewise all subjects performed a global rating of their feelings towards the end of the day (17) which assessed anxiousness, urges to eat, thirst, content, hunger and fullness.

Because of the weather and exercise conditions, the extensive water consumption could not possibly be accurately recorded. Body weight was measured only upon arrival and not systematically monitored throughout the week. The study was granted ethical by the Ethical Committee of the Karolinska Institute.

Data computation and statistical methods

The data were collected after each day and coded immediately. Complete data were collected for Days 1, 2 and 3 (about 26 km march, about 5 hours exercise duration), but several subjects also provided additional information about Day 4 and 5. The food diaries were analysed at the Obesity Unit by the standard method, using the computer program MATMats based on the food sheets from Swedish Food Agency. For cooked meals, recipes were obtained from the Svanstein Spa kitchen when necessary. Only non-caloric fluids were consumed during the study.

Energy and macronutrient intakes

Energy and macronutrient intakes for the lactovegetarians were analysed by analysis of variance with one within subjects factor (day of study). Intake for the fasting subjects (a fixed daily amount of a herbal fruit drink) had standard deviations of zero and therefore, could not be analysed statistically.

Visual Analogue Scales (VAS)

VAS were analysed by analysis of variance with two within subjects factors (Day and Time) and one between subjects factor (Diet). Further ANOVA's were also performed for each day of study and two way ANOVA's with one within subjects factor (Day) and one between subjects factor (Diet) were used to analyse the end of day questionnaire. All analyses were performed using SPSS for Windows (version 6.1).

Results

Only data for fasting and lactovegetarians will be reported here due to the low number of subjects who selected a vegan diet.

Energy intake

For the fasting subjects the mean daily energy intake from the 3 fixed size herbal and fruit drinks consumed was 1.1 MJ (253 kcal) every day. The mean energy intake in lactovegetarians was 4.8 MJ (1147 kcal/day). Energy intake was by definition constant across all three study days for fasting subjects and did not vary significantly across the three study days for subjects consuming a lactovegetarian diet (F^2_{18}=1.2235, ns). Table 1 summarises macronutrient intake for Day 1.

However, the macronutrient composition of the lactovegetarian diet did vary slightly over the three study days. Percentage of energy intake from protein and from fat did not differ on Days 1 and 2 but was slightly higher on Day 3 (F^2_{18}=13.56, p=0.000 and F^2_{18}=9.75, p=0.001 respectively). The percentage of energy from carbohydrate was lowest on Day 3 (F^2_{18} = 12.92, p=0.000).

Subjective ratings of hunger motivation

A significant main effect of time was found for *hunger ratings* on each of the three study days (F^9_{14}=7.35, p = 0.001; F^9_{16}

$=9.71, p=0.000; F^{9}_{10}=4.84, p=0.01$ respectively) (Figure 1).

On each day, the effect size (eta^2) was of the order of 0.8. Over the course of the day, there are three peaks in ratings of hunger, each prior to meals. This effect was consistent over all three days and ratings of hunger did not vary by day of study ($F^{2}_{12}=2.68$, ns).

The main effect of Diet across the three study days was not significant ($F^{1}_{13}=1.45$, $p=0.25$). However, separate analyses for each day revealed a highly significant main effect of Diet on Day 1 ($F^{1}_{22}=10.55$, $p=0.004$) and no effect on Day 2 ($F^{1}_{24}=2.9$, $p=0.1$) or Day 3 ($F^{1}_{18}=0.18$, $p=0.679$).

The main source of these differences between fasters and those consuming a lactovegetarian diet was the enhanced ratings of hunger prior to each meal in the lactovegetarian subjects. The Diet by Time interaction was significant only on Day 1 ($F^{9}_{14}=4.93$, $p=0.004$).

Satiety ratings varied inversely to hunger and increased after consumption. A clear temporal profile of satiety occurred in relation to consumption of meals or drinks in all subjects. The main effect of time was highly significant on Days 1 and 2 ($F^{9}_{14}=7.27$, $p=0.001$; $F^{9}_{17}=4.9$, $p= 0.002$) and approached significance on Day 3 ($F^{9}_{10}=2.69$, $p=0.07$) with effect sizes of the order of 0.7 on each day.

Fasting subjects reported higher levels of satiety at all time points compared to lactovegetarian subjects who consumed significantly more energy (Main effect of Group: $F^{1}_{13}=9.09$, $p=0.01$). Effects were consistent over all three days (Figure 2).

Urges to eat ratings showed main effects of Time on each day of the study ($F^{9}_{15}=8.24$, $p=0.000$; $F^{9}_{16}=11.62$, $p=0.000$; $F^{9}_{10}= 3.44$, $p=0.034$ respectively) with effect sizes of the order of 0.8. The profile of urges to eat follows a similar temporal pattern to ratings of hunger peaking prior to each mealtime (Figure 3). The pre-lunch peak was highest on Day 2 and lowest on Day 1 and the pre-dinner peak was lowest on Day 3 and highest on Day 1, accounting for the significant Day by Time interaction ($F^{18}_{216}=2.69$, $p=0.000$).

For fasting subjects on Day 1, reports of urges to eat were lower in the morning than on Days 2 and 3 but were similar in the afternoon on all study days.

Ratings of urges to eat were similar on Days 1 and 2 but declined on Day 3, producing a significant main effect of Day ($F^{2}_{11}=7.61$, $p=0.008$). This effect is qualified by a significant Diet by Day interaction ($F^{2}_{11}=5.95$, $p=0.018$) in which lactovegetarian subjects report stronger urges to eat than fasting subjects on Days 1 and 2 but not Day 3.

A main effect of time on ratings of

Figure 1. Mean hunger ratings (SD) over Day 1 for fasting and lactovegetarian subjects. Key to time (x axis). 1: pre breakfast, 2: post breakfast, 3: early am, 4: mid am, 5: pre lunch, 6: post lunch, 7: early pm, 8: mid pm, 9: pre dinner, 10: post dinner.

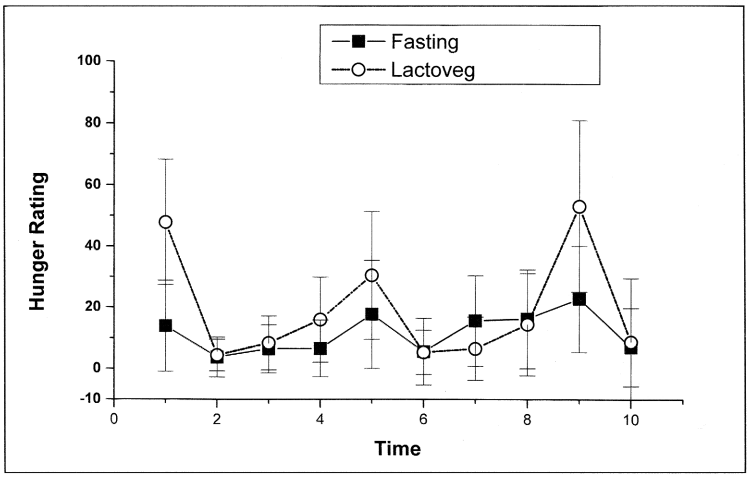


Figure 2. Mean Satiety ratings (SD) over the three study days for fasting and lactovegetarian subjects. Main effects of diet and time are significant (values are mean of three days). Key to time (x axis) see Figure 1.

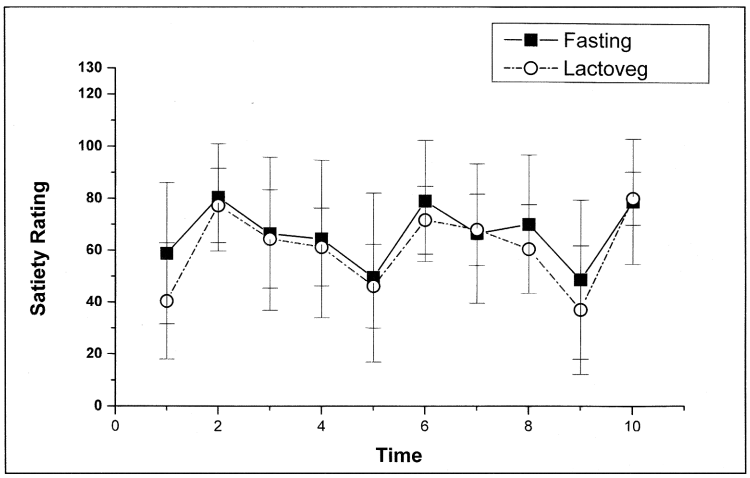
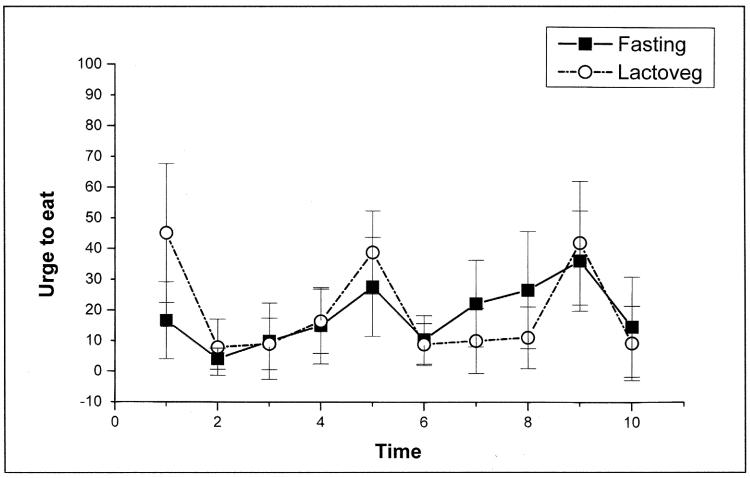


Figure 3. Mean Urge to eat ratings (SD) over the day for fasting and lactovegetarian subjects. Main effect of time is significant on each of the three study days (values are mean of three days). Key to time (x axis) see Figure 1.



tiredness was found for each day of the study. This was significant on Days 1 and 2 (F^{9}_{14}=8.6, p=0.000 and F^{9}_{17}=2.62, p =0.042 respectively), but failed to reach conventional significance level on Day 3 (F^{9}_{11} =2.55, p=0.073). Profiles of tiredness show two peaks during the day, one just prior to lunch (Time 5) and one prior to dinner (Time 9) with generally raised levels of tiredness reported throughout the afternoon period.

The Day by Time interaction was however, significant (F^{18}_{234}=2.12, p=0.006). Although levels of tiredness were similar and have a similar temporal profile on Days 1 and 2, levels were much lower on Day 3.

There was also a significant Diet by Day interaction (F^{2}_{12}=5.06, p=0.026). Both dietary groups showed similar levels of tiredness overall on Day 1 but fasters reported substantially less tiredness than lactovegetarians on Day 2. On Day 3, both groups reports decreased to a similar level which was lower than that of Day 1 i.e. Fasters decreased in tiredness from Day 1 to 2, but not from Day 2 to 3. Lactovegetarians increased from Day 1 to Day 2 and decreased from Day 2 to Day 3. This variation accounts for the significant main effect of Day also observed (F^{2}_{12} = 6.69, p =0.011). No significant effects were found for ratings of irritability with levels of reporting remaining very low throughout the study.

Discussion

In this short term study of well-motivated, healthy subjects protocol compliance was high and those who agreed to participate were all included in the analysis with exception of one insulin dependent diabetic woman, who was excluded.

The natural setting limited the scope of this study; for practical reasons no blood samples could be obtained during marches, with which to correlate physiological changes and psychological data. However, the analysis of the data show several significant effects of the food intake/endurance exercise on eating related psychological variables. It is reasonable to assume that these findings constitute a combination of psychological and physiological responses to the catabolic situation.

The physiological effects of a negative short term energy balance on mood are not well known. In clinical practice with VLCDs most clinicians would agree that obese patients report less hunger feelings and even a certain degree of euphoria, once ketonaemia has developed. However, depending on the nutritional status before a diet and exercise program, the storage of glycogen and the extent of the negative energy balance, it may take a few days until urinary ketonaemia is established (18). Furthermore, the relationship between the degree of ketonaemia and the effects on the central nervous system are highly variable. Whereas some individuals spontaneously report well-being in this metabolic state, others cannot comply with a VLCD program due to headache, concentration difficulties and unbearable hunger.

Figure 1 demonstrates that over the day, hunger ratings are increased before each meal, as expected. An interesting finding is that the lactovegetarian subjects experience more hunger before each meal than those fasting. After each meal, the hunger ratings are very similar in both groups. Since it was not feasible to randomly allocate the subjects to any of the diet alternatives, it is possible that lactovegetarian subjects are experiencing normal physiological response before each meal, whereas the fasting subjects were already psychologically prepared to fast. The satiety ratings and the urge to eat, described in Figures 2 and 3, in principal mirror the hunger ratings, underscoring the robustness of these data.

The fasters and the lactovegetarian subjects report similar levels of tiredness over the day. As expected, all subjects were more tired immediately before each main break. However, the fasters did not report any higher degree of tiredness in spite of their more catabolic situation. Subject self selection and psychological preparedness may help to explain these findings. In both groups, a lower degree of tiredness on Day 3 probably reflects a combination of a training effect as well as habituation to both the exercise and the dietary regime of the program. Similarly, the slightly surprising finding that irritability ratings were very low, remained so throughout the study and did not vary between groups can be explained by motivation and subject self selection.

Although the subjects who chose to fast varied only a little in their eating related ratings from those who consumed the lactovegetarian diet, there was a significant difference in that the fasters systematically reported less contentedness on all three days. Thus it is possible that the fasters' decision to refrain from almost all food during this period and the fact that they manage to comply with the fasting, is paradoxically resulting in low mood. Such an interpretation of the results would suggest that psychological rather than physiological mechanisms explain the mental state of the fasting subjects since by Day 3 after almost complete starvation and 60-70 kilometers of exercise walking pronounced ketonaemia must have developed in all these normal weight subjects (18).

In conclusion, fasting subjects experienced lower hunger, more satiety and weaker urges to eat across the day. Fasters were also less tired but reported themselves to be less contented, although not more irritated. Under conditions of considerable energy expenditure (approx. 5-6 MJ, 1200-1500 kcal/day) the availability of food prompts hunger and urges to eat, and eating itself causes a modulation of feelings of satiety. Under conditions of fasting, hunger and urges to eat remain at a lower level. Consequently, in total fasting even accompanied by heavy physical activity (low intensity), subjects are not unduly troubled by uncomfortable hunger or urges to eat. However, overall mood appears to be lower than if food is eaten; subjects report feeling less content.

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