

CLINICAL STUDY

Somatotropic responses to soy protein alone and as part of a meal

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Abstract

Context: GH is an important regulator of growth and body composition. We previously showed that GH release can be promoted by oral ingestion of soy protein; it is not known, however, whether these somatotropic effects of soy protein are also present when soy protein is ingested as part of a complete meal.

Objective/design: We compared the effects of oral ingestion of soy protein alone with the effects of a meal containing the same amount of soy protein on GH secretion in six healthy women (body mass index 19–26 kg/m², 19–36 years), in a randomized crossover design. During the whole experiment, serum GH, insulin, and glucose were determined every 20 min.

Results: GH responses as determined by area under the curve (AUC) and peak values were lower after ingestion of the meal, in comparison with GH responses after the soy protein consumption alone ($P < 0.05$), and did not differ from the placebo. Glucose and insulin responses, both determined as AUC and peak values, were higher after ingestion of the meal, compared with those after ingestion of the protein drink or the placebo ($P < 0.05$).

Conclusion: The somatotropic effect of soy protein is reduced and delayed when soy protein is ingested as part of a complete meal. Dietary carbohydrates, by increasing serum levels of glucose and insulin concentration, as well as dietary fat, may have interfered with the somatotropic effects of soy protein.

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Introduction

Growth hormone (GH), a hormone originating from the anterior pituitary gland, is an important regulator of growth and body composition (1). GH exerts its growth-promoting effect (typically of fat-free mass) through stimulation of the secretion of insulin-like growth factor-I (IGF-I) from the target cells (1).

It has been shown by many authors that GH secretion can be promoted by i.v. or oral administration of various amino acids (2, 3). The stimulatory effect of amino acids on GH secretion is also present when ingested as proteins. Our previous study showed that GH secretion did not differ after ingestion of an amino acid mixture from that of soy protein, with comparable amino acid content (4).

It is not known whether the somatotropic effect of soy protein is still present when it is ingested as part of a complete meal. No study compared the effect of protein alone with a meal on GH secretion. Studies on the effects of meals in general on plasma GH have produced controversial results. It has been reported that after a high-protein meal, GH is increased, (5) and after a high-carbohydrate meal, GH is first decreased, but increased in late postprandial phases (6). However, no change in GH concentrations was found after 1 week of a

low-carbohydrate, high-fat, and high-protein diet (7). Another study found that high-carbohydrate diets suppress GH secretion, whereas high-fat and high-protein diets of similar caloric value have no measurable effect (8).

The reason for the inconsistency in the above-mentioned studies is unclear. It may be that either the protein content of the meal was insufficient to increase GH or that other meal components interfere with protein on GH concentrations. Therefore, this study aims to compare the effects of protein given alone or combined with carbohydrates and fat on GH secretion.

Methods**Subjects**

Subjects were recruited via advertisements at the University. Six healthy young females (age 24 ± 5.8 years, body mass index 22 ± 2.5 kg/m²) participated in the study. Each subject was in good health, non-smoker, using contraceptives, free of any other medication, and spent no more than 3 h a week on sport activities. The Medical Ethics Committee of Maastricht University approved the study protocol and all subjects gave their written informed consent before participating in the study.

Table 1 Composition of the test conditions, based on a subject of 70 kg.

	Soy protein drink	Meal	Placebo
Volume (g)	467	834	500
Soy protein (g)	42	42	–
Carbohydrates (g)	–	92.4	–
Fat (g)	–	14.92	–
Sugar-free syrup (ml)	–	–	40
Viscosity	Liquid	Semisolid	Liquid

Experimental design

A randomized crossover study design was applied. Subjects reported to the laboratory for consumption of three different test products (placebo, soy protein alone, or a meal containing soy protein; Table 1), at separate test days. Each time the subjects arrived at the laboratory in a fasted state in the morning. They were instructed to fast from 2200 h the night prior to the test day. A permanent cannula was inserted into a dorsal vein of the hand for venous blood sampling (9). Blood sampling began 60 min after the placement of the cannula. Blood was sampled every 20 min for the following 5 h. During blood sampling, the subjects remained awake and fasted, and were allowed to drink water *ad libitum*. Immediately after obtaining the first blood sample, the subjects received a test product. The composition of the test products is described in Table 1.

Blood analysis

Arterialized venous blood was collected in clot tubes (Becton Dickinson Vacutainer system; Becton Dickinson, Franklin Lakes, NJ, USA) and was allowed to clot for 30 min and was centrifuged at 3000 rpm, 4 °C, for 10 min to obtain serum. Serum was collected for determination of GH, insulin, and glucose concentrations. Each serum aliquot was frozen immediately in liquid nitrogen and stored at –80 °C, until analysis.

All samples from the same subjects were run in the same assay.

The GH concentrations were measured by an ultrasensitive GH chemiluminescence immunoassay (Beckman Coulter, Harbor Blvd. Fullerton, CA, USA).

Insulin concentrations were measured by an electrochemiluminescence immunoassay (Roche Diagnostica). Glucose concentrations were measured by enzymatic assay (G6-PDH) (Roche Diagnostica).

Statistical analysis

All data are expressed as median \pm S.E.M. Statview SE+ Graphics (1988; Abacus Concepts, Berkeley, CA, USA) was used for the analysis. GH, insulin, and glucose responses were calculated as area under the curve (AUC), peak values, and time to peak (TTP) values. Since the data were not normally distributed, Kruskal–Wallis tests (non-parametric) were performed. Mann–Whitney tests were performed to locate possible significant differences. Statistical significance was set at $P < 0.05$.

Results

GH responses as determined by AUC and peak values were increased after soy protein ingestion when compared with the placebo ($P < 0.05$). GH responses were significantly higher at $t = 260$ and 280 after ingestion of the meal compared with the placebo ($P < 0.05$). No differences in AUC and peak values were found in GH responses after ingestion of the meal compared with the placebo. GH responses (AUC and peak values) were lower after ingestion of the meal than after soy protein alone ($P < 0.05$). TTP concentration was later after ingestion of the meal than after ingestion of the protein drink and the placebo ($P < 0.05$), and TTP was later after the placebo than after the protein drink ($P < 0.05$) (Fig. 1; Table 2).

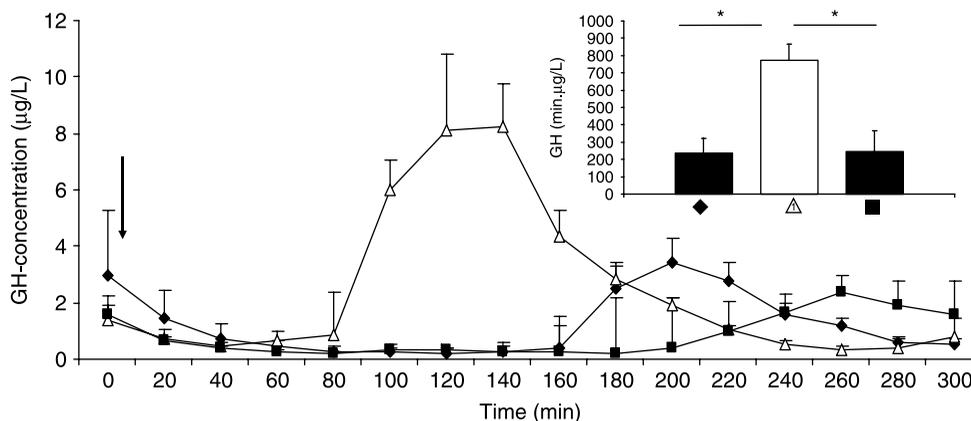


Figure 1 Growth hormone concentrations after ingestion of a placebo test drink (◆), soy protein drink (△), and meal (■) ($n = 6$). Data are presented as medians (\pm S.E.M.) and shown as lines and bars (AUC). \downarrow = ingestion of test drink. * $P < 0.05$.

Table 2 Blood parameters after ingestion of a placebo test drink, soy protein drink, and a meal ($n=6$), expressed as area under the curve (AUC), peak values, and time to peak, TTP.

	Placebo	Soy protein	Meal
AUC			
GH ($\mu\text{g/l min}$)	235 \pm 87	772 \pm 96*	245 \pm 122 [†]
Insulin (mU/l min)	1972 \pm 189	5185 \pm 753	11 910 \pm 5042* [†]
Glucose (mmol/l min)	50 \pm 31	37 \pm 26	231 \pm 32* [†]
Peak			
GH ($\mu\text{g/l}$)	4 \pm 2	10 \pm 5*	5 \pm 4 [†]
Insulin (mU/l)	–	49 \pm 6	105 \pm 116 [†]
TTP			
GH (min)	190 \pm 9	120 \pm 8*	260 \pm 19* [†]
Insulin (min)	–	40 \pm 8	50 \pm 15
Glucose (min)	–	–	40 \pm 4

Data are presented as means (\pm s.e.m.). * $P < 0.05$ compared with the placebo drink (repeated-measures ANOVA). [†] $P < 0.05$ compared with the soy protein drink (repeated-measures ANOVA).

The glucose and insulin concentrations, both determined as AUC and peak values, were higher after ingestion of the meal, compared with ingestion of the protein drink or the placebo ($P < 0.05$). Ingestion of the soy protein drink did not affect glucose or insulin responses (AUC and peak values), compared with the placebo. No difference between the conditions was found in TTP of glucose and insulin concentrations (Fig. 2; Table 2).

Discussion

It was shown that the somatotrophic effect of soy protein, as has been shown before, was reduced and delayed when soy protein is ingested as part of a complete meal. This may indicate that besides soy protein, carbohydrates and/or fat play an important modulating role in the postprandial secretion of GH after ingestion of a high-protein meal. Thus, either carbohydrates or fat, or

both carbohydrates and fat, are likely to have interfered with the GH-promoting effect of soy protein.

To the best of our knowledge, this is the only human study performed assessing the effects of soy protein alone and as part of a complete meal on GH secretion. Two previous studies compared the effects of intake of glucose, protein, and glucose plus protein on plasma GH concentrations. Pallotta & Kennedy showed a delayed increase in GH concentrations (5 h after ingestion) following glucose (100 g) and starch (700 g, equivalent to 100 g glucose) after the blood sugar has decreased, and an acute increase in GH concentrations (2 h after ingestion) following the protein intake (60 g). No effect was shown after ingestion of glucose plus protein (10). Also, Rabinowitz showed a delayed increase in GH after intake of glucose (100 g) and an acute increase in GH after intake of beef (64 g proteins, 3 g fat), but a blunted response after a mixed-substrate meal (glucose plus beef) (5). Based upon these studies, it is likely that carbohydrates may have contributed to the blunted GH response of soy protein ingestion after intake of a mixed meal, presumably through elevation of plasma glucose concentrations. Indeed, hyperglycemia is associated with a decrease in plasma GH (11), while hypoglycemia is a potent stimulator of plasma GH (12). The results from these studies, the two previous and the present study, are similar and point to carbohydrates suppressing a protein stimulated GH response.

With respect to the role of fat intake as part of a meal, increasing plasma concentrations of free fatty acids (FFAs), but not triglycerides, as a result of fat ingestion may also have been involved in the suppression of the GH-promoting effect of soy protein during meal ingestion, since FFAs have suggested to suppress GH secretion (13, 14).

Fineberg *et al.* showed that GH release by protein ingestion can be inhibited but not completely abolished by increases in postprandial FFA concentrations (14). These studies show that alterations in FFA concentrations also modified GH secretion. Together, all

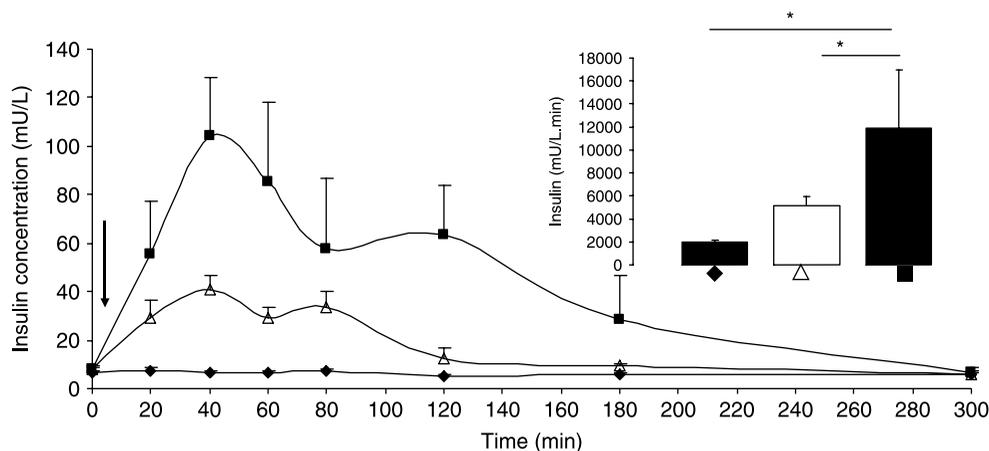


Figure 2 Insulin concentrations after ingestion of a placebo test drink (\blacklozenge), soy protein drink (\triangle), and meal (\blacksquare) ($n=6$). Data are presented as medians (\pm s.e.m.) and shown as lines and bars (AUC). \downarrow = ingestion of test drink. * $P < 0.05$.

previous mentioned studies show that both plasma glucose and plasma FFA concentrations influence GH secretion. Therefore, the question remains of which macronutrients are most responsible for interference with the protein-induced GH secretion. More research with studies that only add either carbohydrates or fat to the protein being assessed is necessary.

Some studies suggest an effect of gastric emptying on hormonal release (15, 16). In this study, it is unlikely that gastric emptying has an influence on the reduced and delayed GH secretion after ingestion of a meal, compared with the soy protein drink, since we showed in a previous study where we compared ingestion of an amino acid mixture with complete protein on GH secretion that the rate of the appearance of plasma amino acids is not related to GH responses (4).

This study confirms previous findings that ingestion of dietary protein regulates GH secretion in the short term. Moreover, it also shows that the physiological role of food intake on the regulation of GH secretion involves complex interactions between the different macronutrients. Also, in the long-term (after 7 days) low-carbohydrate/high-protein diets increased IGF-I concentrations and stimulated muscle protein synthesis and whole body proteolysis (7).

The clinical relevance of the results of this study, however, remains to be investigated. These results show that in normal healthy women, GH responses increase after oral ingestion of proteins, but not when proteins are combined with carbohydrates and fat. It is not known whether this effect also occurs in a GH-deficient population, such as in visceral obese subjects. In the visceral obese subjects, GH replacement therapy reduced weight and in particular decreased fat mass and increased lean body mass (17, 18); moreover it appeared that weight loss also restored GH concentrations to normal values (19). It may be useful to explore the possibility of adding only one other macronutrient to soy protein in order to be able to design a diet that could stimulate GH secretion in such a population.

In conclusion, the short-term somatotrophic effect of soy protein is reduced and delayed if soy protein is ingested as part of a complete meal. Dietary carbohydrates, by increasing levels of glucose and insulin concentration, as well as free fatty acids may have interfered with the somatotrophic effects of soy protein.

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