Respuestas del polipéptido pancreático y péptido YY a fórmulas líquidas con grasas de diferente grado de insaturación (aceite de oliva y Girasol) en humanos

Pancreatic Polypeptide and Peptide YY Responses to Liquid Formulas Containing Dietary Fats of Different Degrees of Unsaturation (Olive and Sunflower Oil) in Human.

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RESUMEN

Los perfiles en plasma del polipéptido pancreático y el péptido YY tras la administración oral de dos soluciones que diferían únicamente en el tipo de grasa fueron investigados en humanos. Los resultados apoyan el uso de fórmulas líquidas que contengan aceite de oliva en la terapia nutricional de varias enfermedades gastrointestinales.

PALABRAS CLAVES: Grasa de la dieta, polipéptidos gastrointestinales, humanos, aceite de oliva, aceite de girasol, enfermedades gastrointestinales.

ABSTRACT

The plasma profiles of pancreatic polypeptide and peptide YY after the oral administration of two feeding solutions that only differed in the type of dietary fat were examined in humans. The results support the use of liquid formulas containing olive oil as the source of fat in the nutritional therapy of several gastrointestinal diseases.

KEY WORDS: Dietary fat and gastrointestinal peptides, human, olive oil, sunflower oil, gastrointestinal diseases.

INTRODUCTION

Oleic acid has been shown to be one of the most effective stimuli for the release of pancreatic polypeptide (PP) and peptide YY (PYY). The purpose of this study was to examine whether the type of dietary fat affects the plasma pattern of the above peptides in response to the ingestion of food. Olive oil, a dietary fat with the highest oleic acid content, was compared to sunflower oil, rich in polyunsaturated fatty acids.

Methods: The study was conducted in cholecystectomized subjects who, during the 30-day period immediately before surgery had been consuming diets containing olive (group O) or sunflower (group S) oils as the source of fat. During the experiments, the participants received 200 mL of oleic acid- (group O) or linoleic acid-enriched (group S) liquid formulas. Radioimmunoassay techniques were used

to measure the hormone concentrations before and after feeding.

Results: Food induced significant (p<.05) increases in plasma PP, both in group O and S, but the PP concentration was significantly (p<.05) greater in group O during the entire postprandial period. No significant changes in plasma PYY were found in response to the liquid test meals in either group, which could be associated with the low concentration of bile acids in the intestine of our participants. Nevertheless, both at fasting (p<.05) and during the digestive period, the plasma PYY levels were higher in group O than in group S.

Conclusions: The type of dietary fat seems to exert some influence upon the plasma concentrations of PP and PYY in humans. Our results suggest that the use of liquid formulas containing olive oil may be very helpful in the nutritional therapy of several gastrointestinal illnesses.

The gastrointestinal function depends on a complex interplay between nerves and hormones. Among the latter, pancreatic polypeptide (PP) and peptide YY (PYY) seem to exert important regulatory actions at multiple levels. Thus, those of PYY include inhibition of exocrine pancreatic[1,2] and gastric acid secretion[3,4], and inhibition of gastric emptying and intestinal transit[5,6]. Concerning the physiological role of PP, there is evidence that it inhibits exocrine pancreatic secretion and biliary tract motility[7-11].

It has been shown that plasma PP and PYY concentrations increase in response to the ingestion of a mixed meal[12,13] and intraduodenal fatty acids[14,15], oleic acid being one of the most effective nutrients in releasing both peptides[14-17]. The marked differences in the overall pattern of pancreatic response to food that we found in a previous study[18] conducted in two groups of dogs adapted for 8 months to diets containing olive or sunflower oil, suggest that the type of dietary fat may affect the release of those gastrointestinal hormones that control pancreatic secretion, such that PP and PYY.

In the current study, we questioned whether the postprandial release of the above inhibitory peptides is, in humans, affected by the type of dietary fat. Olive oil, the most common source of fat in the conventional Mediterranean diet, rich in monounsaturated fatty acids, was compared to sunflower oil as a dietary fat rich in polyunsaturated fatty acids. The liquid test meals assayed during the experimental period were similar to some tube feeding solutions commercially available and, given the broad spectrum of actions exerted by PP and PYY, the information obtained by us may be of use in deciding the most appropiate nutritional therapy for patients recovering from different gastrointestinal illnesses.

MATERIALS AND METHODS

Subjects

Eighteen nonsmoking, nonalcoholic patients with gallstones in the gallbladder, showing current clinical signs or symptoms, and awaiting surgery (cholecystectomy), were selected. None of them had undergone pancreatic, gastric or biliary tract surgery before. Choledocolithiasis and asymptomatic cholelithiasis cases were excluded from the study. The subjects had no history of systemic (arterial hypertension, atherosclerosis, diabetes mellitus), gastric (hiatal hernia, gastric or duodenal ulcer) or gastrointestinal disease of any other etiology (acute or chronic pancreatitis). None of them were receiving any medication known to influence gastrointestinal secretions (or motility) or postprandial hormonal responses. These subjects were chosen because of the large number available,

the possibility of strictly controlling the participants according the experimental protocol, and, finally, the applicability of this ailment to our research. The experimental protocol was approved by the local ethical committee, and all subjects gave written consent after being fully informed of the nature and procedures of the study. The patients were divided into two experimental groups, the olive oil group (group O) and the sunflowerseed oil group (group S), according to their dietetic habits, particularly the type of dietary fat habitually consumed before the study (information gained from a dietary history interview at the beginning of the study). Each group contained nine patients, with a mean (± SEM) age of 54.4 ± 4.04 and 41.7 ± 3.85 years for group O and group S, respectively.

Experimental protocol and diets

During the 30 day period immediately before surgery, the subjects from both groups were asked to consume their habitual diets (at home), except for the two following points: a) the only source of dietary fat used to prepare their meals had to be olive oil (group O) or sunflower oil (group S); b) they had to avoid eating food items high in saturated fat (butter, all types of sausage, etc.). Four 7 day dietary records were completed to establish the energy intake and the composition of the diets, the subjects recording all foods and beverages ingested each day. Careful instruction was given not only regarding the methods for recording amounts of food and drinks but also regarding the need to record all addition to foods as well as cooking methods. These records were collected at every visit to the hospital, the data quantified and the energy and nutrient intakes evaluated by the computer program Nutrition and Health (General Asde, Valencia, Spain), which we developed in the Institute of Nutrition of the University of Granada. The data base used was «Spanish Food Composition Tables», which we published[19]. The results were validated by using the package Nutritionist IV (First Data Bank, San Bruno, CA), after entering the composition of the necessary food items into the data base, also taken from the aforementioned food composition tables. As shown in Table I, the two dietary groups differed primarily in relation to polyunsaturated and monounsaturated fat intake, whereas the composition of the remaining part of the diet was similar. Thus, although this preparation period can not be strictly considered as an adaptation period to the diet, as in the animal studies, these previous diets do reflect, to a great extent, the fat composition of the meals tested during the experimental period, which was our intention.

The experiments were performed 48 hours after surgery. At that time, it was confirmed that the subjects had recovered normality of digestive function and could tolerate oral feeding. The liquid formulas (pH 6.33; 294 mOsmol/L), contained 1 kcal/mL, and were composed of 17 % of energy as protein, 30 % as fat, 53 % as carbohydrates, vitamins and minerals. They were prepared by adequately mixing the separate components according to protein (lactalbumin), carbohydrate (maltodextrins) and vitamin-mineral mixture modules (Eda Modular, Ibys Nutrición, Madrid, Spain). Table II shows the composition of the carbohydrate module, and Table III gives the detailed composition of the vitamin-mineral module, which was added to the liquid meals at a concentration of 12.5 g/L. As the source of dietary fat, olive oil was used in the meal given to group O and sunflower oil in the meal given to group S. The fatty acid composition of the liquid meals was determined. After direct transesterification according to Lepage and Roy[20], methylated esters were analysed by GLC on a Hewlett Packard chromatograph (Model 3396, Hewlett Packard, Palo Alto, CA) equipped with an automatic injector (Hewlett Packard,

Table I. Calculated energy and nutrient intakes during the 30 day period before surgery

	group S	group O
Energy (kcal)	1485.5 ± 297.9	1623.5 ± 153.3
Protein (% energy)	18.2 ±2.1	18.6 ± 1.7
Carbohydrate (% energy)	38.8 ± 3.9	39.4 ± 2.5
Fat (% energy)	42.6 ± 3.3	41.6 ± 2.5
Monounsaturated fat (g)	26.2 ± 2.9	40.1 ± 2.6
Polyunsaturated fat (g)	19.8 ± 2.5	8.3 ± 0.8
Saturated fat (g)	18.8 ± 3.2	20.6 ± 3.8

group S: sunflower oil group; group O: olive oil group
Mean ± SD of four 7-day dietary records per subject (9 subjects per group).

Model 7673) and a silica column (SP^{TM} - 2330, Supelco, Inc., Bellefonte, PA; 60 m, 0.32 mm ID, 0.20 mm particle size). The two liquid meals were isoenergetic and isonitrogenous, thus differing only in their fatty acid composition (Table IV).

Table II. Composition (g per 100 g) of the carbohydrate module* employed to prepare the formulas

Glucose	2.59	Maltose	12.50
Maltotrioses	17.60	Maltotetroses	12.12
Maltopentoses	13.10	Maltohexoses	16.67
Maltoheptoses	11.28	Maltooctoses	6.23
Maltononaoses	2.29	Other	0.61

* Eda Modular, Ibys Nutrición, Madrid, Spain

Table III. Composition (mg per 100 g) of the vitamin-mineral module* employed to prepare the formulas

Minerals		Vitamins	
Sodium[†]	5.65	Vitamin A	5.00
Potassium[†]	15.70	Vitamin D	45.00
Chlorine[†]	13.60	Vitamin E	50.00
Calcium[†]	4.90	Vitamin C	290.00
Phosphorus[†]	4.35	Thiamin	7.00
Magnesium[†]	1.44	Riboflavin	8.00
Iron	70.00	Pyridoxin	10.00
Zinc	68.00	Vitamin B_{12}	15.00
Iodine	0.60	Niacin	90.00
Copper	15.00	Folic acid	2.00
Manganese	20.00	Vitamin K	700.00
Fluorine	16.00	Biotin	1.00
Chromium	0.80	Pantothenic acid	35.00
Selenium	0.80		
Molybdenum	2.00		

* Eda Modular, Ibys Nutrición, Madrid, Spain.
[†] Expressed as g per 100 g of product.

Table IV. Fatty acid composition (g per 100 g of total fatty acids) of the liquid formulas*

	group S	group O
Oleic (C18:1 n-9)	29.03 ± 0.66[†]	61.89 ± 2.00
Linoleic (C18:2 n-6)	42.16 ± 1.70[†]	5.06 ± 0.12
Monounsaturated	29.67 ± 0.66[†]	63.08 ± 1.95
Polyunsaturated	44.62 ± 1.55[†]	8.19 ± 0.14
Saturated	25.93 ± 1.93	29.03 ± 1.86
U/S	2.99 ± 0.30	2.51 ± 0.23

group S: sunflower oil group; group O: olive oil group; U/S: ratio of unsaturated to saturated fat
*Mean ± SEM, n=6.
[†] Significanrt differences ($p<.05$) between the two study formulas

Each subject was studied on two consecutive days and after at least an 8 hour fasting. The participants were intubated with a radio-opaque two-lumen nasoduodenal tube, enabling separate aspiration of gastric and duodenal contents. The latter were collected at the distal aspiration site, placed in the third or fourth duodenal segment. Adequate positioning of the tube was checked frequently during the investigation by radiological control.

Peripheral-vein blood and duodenal samples were taken before, and at 30, 60, 120 and 180 minutes after beginning the slow ingestion of the correspondent liquid test meal (200 mL ingested over 30 minutes). The complete feeding and sampling procedure was repeated on the second experimental day, each individual receiving the same formula than the day before. Blood samples were collected in heparinized tubes containing aprotinin (Sigma Chemicals, St. Louis, MO) to obtain a concentration of 360 KIU/mL blood. The tubes were placed immediately on ice and, at the end of each experiment, plasma was separated by a refrigerated centrifugation and stored as aliquots at-80 °C until radioimmunoassay (RIA) of PP and PYY. The duodenal samples were slow and manually collected by aspiration with an adequately adapted syringe, avoiding the entry of air, and thereafter frozen at-80 °C for the later analysis of bile acids.

Radioimmunoassays

For assay purposes, antiserum against pure bovine PP (Eurodiagnostica, Malmö, Sweden) was used in a final dilution of 1:20 000. The labeled peptide (synthetic human PP, iodinated by the chloramine-T method and purified by HPLC), was also purchased from Eurodiagnostica. Highly purified (99 % HPLC purity) synthetic human PP (Sigma Chemicals) was used as standard after serial dilution (from 15 to 480 pmol/L) in assay buffer. This was a sodium barbital buffer (0.02 mol/L), pH 8.60, containing   bovine serum albumin (2 g/L), and sodium azide (0.0077 mol/L). The following reagents were added to a polystyrene tube (11 per 55 mm): 100 mL of plasma specimens and standards, 500 mL of diluted PP antiserum, and either 100 mL of assay buffer (unknown) or 100 mL of PP-free plasma (standard), the latter obtained by processing fresh plasma through a Sep-Pak C18 cartridge (Millipore Corporation, Mildford, MA). After incubation for

72 hours at 4 °C, 100 mL of labeled PP (about 5 000 cpm) were added and the tubes incubated for an additional 24 hours. The free and bound peptides were separated by the addition of 50 mL of diluted normal rabbit serum (Eurodiagnostica) and 500 mL of goat antirabbit-IgG antiserum (Eurodiagnostica), previously diluted with assay buffer containing polyethyleneglycol 6 000 (75 g/L). The mixture was incubated at 20-25 °C for 45 minutes and then centrifuged at 1 700 x g for 15 minutes at 4 °C. Finally, the pellet radioactivity was counted. The detection limit of the radioimmunoassay, defined as the quantity of standard PP required to produce a 2 SD decrease in the initial binding of the tracer to the antiserum, was 3 pmol/L. The antiserum chosen was free (0.03 %) of cross-reactivity with tetragastrin, human gastrin-17 and -34, porcine gastric inhibitory peptide, CCK-39, secretin, pancreatic glucagon, insulin and adrenocorticotrophic hormone 1-39, showing a cross reaction equal to 120 % with bovine PP. The intra- and inter-assay coefficients of variation were 5.6 % and 5.7 %, respectively.

Immunoreactive PYY in plasma was measured by a dextran-coated charcoal radioimmunoassay. The labeled peptide (synthetic, iodinated by the chloramine-T method and purified by HPLC) and the antiserum (raised in rabbits against porcine-sequence PYY) were purchased from Eurodiagnostica. The radioimmunoassay procedure was based in that   described by Ekman et al[21]. Briefly, assays were set up in polystyrene tubes (11 per 55 mm). One hundred mL of either plasma sample or standard PYY (synthetic porcine, 98 % HPLC purity, purchased from Sigma and prepared to obtain a concentration varying from 18.5 to 1180 pmol/L) in sodium phosphate buffer (0.05 mol/L), pH 7.50, containing human serum albumin (2.5 g/L), disodium ethylenediaminetetraacetate (0.0067 mol/L), sodium azide (0.0077 mol/L) and 500 000 KIU/L of aprotinin, were incubated with 200 mL of antiserum (final dilution 1:5 000) for 24 hours at 4 °C. Then, 200 mL of iodinated PYY (about 10 000 cpm) were added and the incubation continued for another 24 hours. Antibody-bound tracer was separated from free tracer by the adition of 500 mL of charcoal (5 g/L) in the assay buffer without aprotinin, containing dextran T-70 (0.5 g/L). After 25 minutes at 4 °C, the tubes were centrifuged at 1 700 x g for 15 minutes at 4 °C. The radioactivity of the supernatants was counted to calculate the percentage of PYY bound to the antibody in each assay tube. The assay had a detection limit of 3

pmol/L, calculated as mentioned for the PP assay. The intra- and inter-assay coefficients of variation were 2.6 and 6.3 %, respectively. The antiserum registered a cross-reactivity lower than 0.01 % with human, bovine and aviar PP, porcine neuropeptide Y, human vasoactive intestinal peptide, peptide histidine-methionine and porcine secretin.

Analytical methods for bile acids ·

After removing protein and pigments according to the method of Levin et al[22], total bile acid concentration was determined in the duodenal samples by the enzymatic 3a-hydroxysteroid dehydrogenase procedure[23].

Calculations

Plasma hormone and duodenal bile acid concentrations are expressed as the mean ± SEM for two experiments per patient, nine patients per group. For comparisons between postprandial values to basal values for each group, analysis of variance was made (Oneway Procedure, SPSS PC Statistical Package v. 6.1; SPSS Inc., Chicago, IL), utilizing the multiple-comparison Duncan test. Differences in the hormone and duodenal measurements between the two groups at the same points in time, as well as between the two liquid meals (fatty acid composition) were analyzed by unpaired Student´s t test (T-Test Groups Procedure, SPSS PC Statistical Package v. 6.1). Differences with a p value $<.05$ were considered significant.

RESULTS

Hormones

Fasting values for plasma PP concentration were similar in the two dietary groups, slightly but not significantly higher in the group O subjects (141.9 ± 18.2 pmol/L, group O; 97.9 ± 13.8 pmol/L, group S). Liquid food ingestion induced significant ($p<.05$) increases in plasma PP concentration in both groups. The peak was reached 30 minutes after starting the meal. In group O, plasma PP remained significantly ($p<.05$) higher, compared with the fasting values, until the end of the experimental period, whereas a decrease was observed in group S from the second postprandial hour onwards. At any point during the postprandial period, plasma PP concentration was significantly ($p<.05$) higher in group O than in group S (Fig. 1). During fasting, the plasma PYY concentration was significantly ($p<.05$) higher in group O (96.9 ± 7.4 pmol/L) than in group S (69.0 ± 9.6 pmol/L). Food ingestion did not result in significant changes in plasma PYY concentration

in either group (Fig. 2), although postprandial values tended to increase, slowly and progressively, during this period. Nevertheless, the PYY concentration in the subjects given the meal containing olive oil (group O) remained higher than in those whose meal contained sunflower oil (group S).

Bile acids

In the basal situation, the concentration of bile acids in duodenal contents was significantly ($p<.05$) greater in group S than in group O. In the latter, no further changes were observed throughout the experiment, whereas a decrease was recorded in group S, this being statistically significant ($p<.05$), when compared with baseline, from 60 minutes postprandially onwards. However, no significant differences were revealed between the two groups in relation to this parameter during the digestive period (Fig. 3).

DISCUSSION

The characteristically food-mediated PP release consists of a sharp rise, with an early peak

response, followed by a prolonged second release period, with PP concentrations exceeding fasting
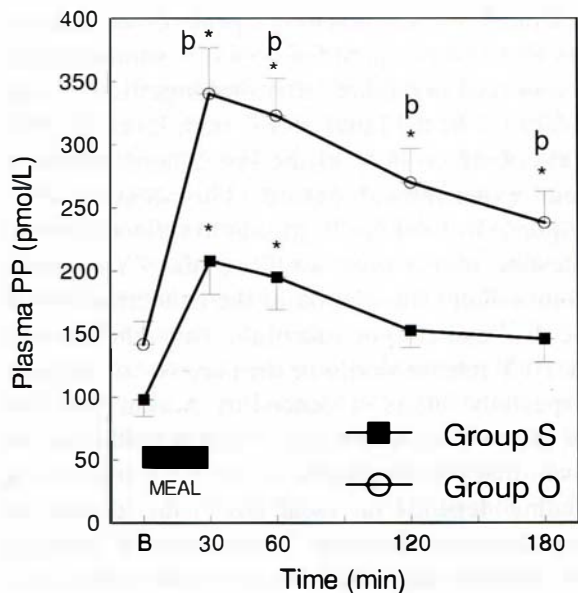
FIG. 1. Plasma PP concentrations after the administration of oleic (group O) or linoleic acid-enriched liquid formulas (group S) to two groups of subjects that had been consuming olive (group O) or sunflower oil-enriched diets (group S) during the 30-day period before the experiments. B denotes the fasting values. Values are means ± SEM of two experiments per subject, nine subjects per group. * Mean values for each dietary group were significantly ($p <$ .05) different from the fasting ones. þ Mean values for the two dietary groups were significantly ($p < .05$) different at the same points in time.
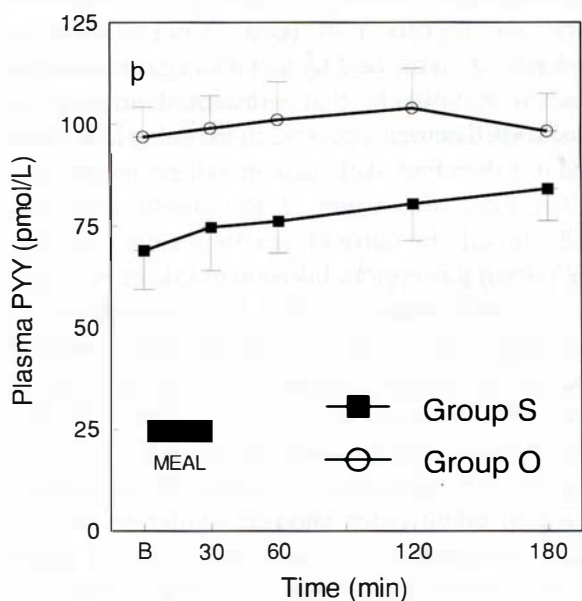

FIG. 2. Plasma PYY concentrations after the administration of oleic (group O) or linoleic acid-enriched liquid formulas (group S) to two groups of subjects that had been consuming olive (group O) or sunflower oil-enriched diets (group S) during the 30-day period before the experiments. B denotes the fasting values. Values are means ± SEM of two experiments per subject, nine subjects per group. þ Mean values for the two dietary groups were significantly ($p < .05$) different at the same points in time.
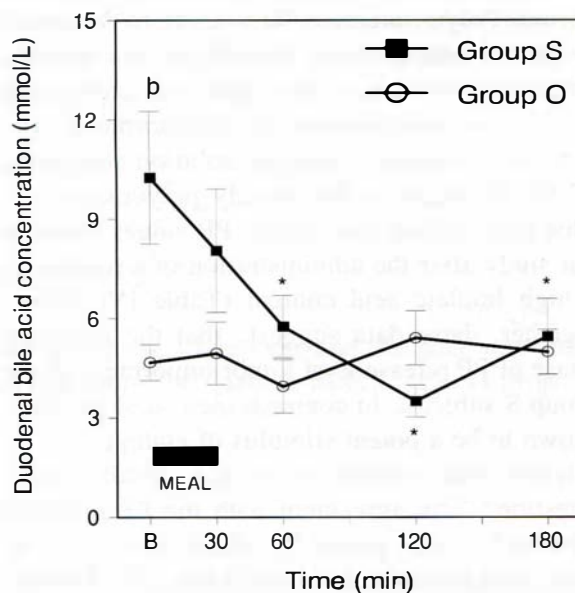

FIG. 3. Duodenal bile acid concentrations after the administration of oleic (group O) or linoleic acid-enriched liquid formulas (group S) to two groups of subjects that had been consuming olive (group O) or sunflower oil-enriched diets (group S) during the 30-day period before the experiments. B denotes the fasting values. Values are means ± SEM of two experiments per subject, nine subjects per group. * Mean values for each dietary group were significantly ($p < .05$) different from the fasting ones. þ Mean values for the two dietary groups were significantly ($p < .05$) different at the same points in time.

values for several hours[12,13,24]. Cephalic[25], gastric[26], and intestinal[14] phases of PP release have been described. The early rise observed by us may result from the additive responses mediated by cephalic-neural and small intestinal mechanisms. Under our experimental conditions, after oral ingestion of a small-volume liquid meal, the contribution of the gastric phase was probably not great, given that it has been reported[14] that this phase has more impact when a solid meal is ingested, due to the greater gastric distension and/or the more prolonged contact of nutrient stimuli with the gastric mucosa.

The PP response to meal ingestion was similar in both groups, although certain quantitative and qualitative differences emerged. Thus, in group O, plasma PP concentrations increased significantly and remained higher than fasting values during the remainder of the postprandial period, in contrast with the decline observed in the group S after the first postprandial hour. Moreover, plasma PP concentration in group S was significantly lower than in group O throughout the entire postprandial period. Polyunsaturated fatty acids have proved to be a weak stimulus for PP release. In fact, Pffeifer et al[27] found no significant changes in the plasma concentration of this hormone after jejunal infusion of a nutrient solution containing 27 % of energy as fat, mainly polyunsaturated. This may explain the smaller PP values found in our study after the administration of a meal with a high linoleic acid content (Table IV). Taken together, these data suggest that the intestinal phase of PP release is of minor importance in the group S subjects. In contrast, oleic acid has been shown to be a potent stimulus of endogenous PP release after perfusion of the middle small intestine[14,16], in agreement with the PP response observed in our group O, which was given an oleic acid-enriched formula (Table IV). Finally, our study provides an additional information, which is related to the fact that the PP response to the liquid meals was in our patients (regardless of the group) similar to that observed in healthy and non-operated subjects[12,13,24]. Indeed, it has been shown that cholecystectomy does not affect food-mediated PP release on a long-term bases[28]. Our results confirm that the same occurs within a short time after surgery.

Liquid-food ingestion caused no significant increase in the plasma concentration of PYY in any of the experimental groups. Taylor[29] has reported that the plasma PYY concentration increases progressively in dogs after the intragastric instillation of a meal, without reaching a peak response during the first two postprandial hours. A similar pattern is observed in humans after oral ingestion of solid meals[13,30]. In the latter study, high levels of PYY were observed only in the last 2 hours of the 4-hour experimental period. This delayed PYY response to food has been said to reflect the small intestine transit time, resulting the PYY release from a direct stimulation of the endocrine cells in the ileal and colonic mucosa[13]. Thus, the stimulus for PYY release would be the presence of nutrients (especially fat, as evidenced by Adrian et al[13]) in the distal gut. According to this hypothesis, and given that the magnitude of the PYY response to feeding depends on meal size[13], the absence of any significant increase in plasma PYY levels in the current study could be associated to the small volume and the slow administration rate of the liquid formula, which may have lead to a little amount of nutrient stimuli in contact with the distal-intestine mucosa. It should be noted, however, that the exact mechanism by which PYY is released after the ingestion of food is not completely understood. In the healthy and intact gastrointestinal tract it is unlikely that substantial amounts of unabsorbed nutrients ever reach the colon in humans, and it is therefore likely that an indirect mechanism, rather than stimulation of the enteric endocrine cells directly by nutrients, exists for the release of PYY from this region. Infusion of bile or bile acids in the distal ileum or colon has demonstrated to increase venous PYY concentration in several species, including humans[31-33]. Moreover, in the latter, the intracolonic infusion of oleic acid plus deoxycholate has no more effect on PYY release than the bile salt alone [32]. Studies in the isolated perfused rabbit colon showed similar results[34]. It has been reported[35] a reduced total bile acid output in cholecystectomized subjects compared with those with an intact gallbladder. In keeping with these findings, the total bile acid concentration in the duodenal contents of the participants in our study was quite low, regardless of the group. These low concentrations, even in the most proximal segments of intestine, could explain the lack of significant increases in the PYY levels after the ingestion of the liquid formulas, once considered the aforementioned bile salt dependent mechanism for the release of this peptide.

It is noteworthy that, after the ingestion of food, the plasma PYY concentration was slightly, though consistently, higher in group O than in group S. This is not surprising, since there is

considerable evidence to indicate that intraduodenal oleic acid, the major fatty acid in olive oil, is one of the most potent stimuli for this peptide[15,17]. Accordingly, we have recently found that postprandial plasma PYY levels were significantly greater in dogs submitted to a 6 month adaptation period to diets containing olive oil as the source of fat than in those animals given sunflower oil (unpublished observations). If we take into account the well known inhibitory action of PYY on exocrine pancreatic secretion[1,2], the above findings, both in humans and dogs, are consistent with previous data obtained by us in dogs adapted for 8 months to diets containing the same two dietary fats, i.e., olive and sunflower oils[18]. In that study, feeding was followed by a marked rise in pancreatic flow rate and electrolyte and protein outputs in the dogs given the sunflower oil diet, whereas there was a lack of response to food (as determined by the same parameters) in the animals fed the olive oil diet. Finally, the fact that the type of dietary fat can affect the circulating levels of PYY does not exclude bile salts as mediators in the release mechanism. Thus, the presence in the intestinal lumen of oleic acid, one of the most potent releasers of CCK[36], would lead to a great stimulation of the endocrine PYY cells in the distal intestine through a gallbladder contraction effect[37], and an increased bile salt concentration in these areas. Both the significantly greater plasma CCK concentration in the group O subjects throughout the postprandial period as compared to those in the group S ones[38], and the findings of Riber et al[39] in humans given trioleate or fish oil, are in keeping with the former idea. Thus, it is likely that the differences between our experimental groups concerning plasma PYY levels are much greater in subjects with an intact gallbladder, similar to our findings in dogs (unpublished observations).

In summary, our results demonstrate the existence of different PP and PYY release patterns in response to liquid diets that only differed in the type of dietary fat. The subjects given the olive oil formula (group O) showed greater values of the plasma concentration of both peptides, which indicates that feeding solutions containing this dietary fat may be very useful in the nutritional therapy of those gastrointestinal diseases requiring a limitation of acid secretion[3,4] or gastrointestinal transit[5,6], as well as a reduced pancreatic secretoy rate [1,2,7,8,10,11] such that pancreatitis.

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