

Effect of alcohol on glucose, insulin, free fatty acid and triacylglycerol responses to a light meal in non-insulin-dependent diabetic subjects

BY CHRISTIAN CHRISTIANSEN^{1,2}, CLAUD THOMSEN¹, OLE RASMUSSEN³, CATRINE HAUERSLEV², METTE BALLE², CARSTEN HANSEN⁴ AND KJELD HERMANSEN^{2*}

¹Institute of Clinical Experimental Research, Aarhus University, ²Medical Department III and ³Medical Department M (Departments of Diabetes and Endocrinology), Aarhus University Hospital, Tage Hansensgade 2, DK-8000, Aarhus C, Denmark, ⁴Department of Forensic Toxicology, Aarhus University, Denmark

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Alcohol accounts for 4–6% of the average energy intake in most Western countries. Alcohol-induced hypoglycaemia is a well-known and feared complication in insulin-dependent diabetic subjects, but little attention has been paid to the impact of alcohol on carbohydrate metabolism in non-insulin-dependent diabetes. The aim of the present study was to investigate in non-insulin-dependent diabetic subjects the acute metabolic effects of a moderate amount of alcohol taken with a light meal, conditions chosen to mimic an everyday situation. The patients received 500 ml non-alcoholic beer with an alcohol content (ml/l) of 0 (treatment A) and 54 (treatment B) together with a light meal, implying identity of the contents of ingredients except for alcohol. We found similar serum glucose, insulin, free fatty acid and triacylglycerol responses irrespective of addition of a moderate amount of alcohol. In conclusion, a moderate amount of alcohol can be taken with a meal without eliciting hypoglycaemia in non-insulin-dependent diabetic subjects.

Non-insulin-dependent diabetes mellitus: Blood biochemistry: Alcohol: Man

Alcohol consumption plays a significant role in the social life of different societies and constitutes a normal part of meals in many regions. It accounts for 4–6% of the total energy intake in most Western countries (Bebb *et al.* 1971; Windham *et al.* 1983; Block *et al.* 1985; Thomson *et al.* 1988), which makes it relevant to study the metabolic consequences in diabetes mellitus. It is well known that long-term intake of large amounts of alcohol has adverse effects, e.g. weight gain, hypertriacylglycerolaemia and hepatic cirrhosis. The risk of acute hypoglycaemia after alcohol intake is well established in subjects suffering from insulin-dependent diabetes mellitus (IDDM; Freinkel *et al.* 1965; Walsh & O'Sullivan, 1974; Nikkilä & Taskinen, 1975; Connor & Marks, 1985), while little is known about the influence of alcohol on metabolism in non-insulin-dependent diabetes mellitus (NIDDM; Friedenber *et al.* 1971; Walsh & O'Sullivan, 1974; McMonagle & Felig, 1975; Gin *et al.* 1992). Consequently, the recommendations provided about alcohol intake in NIDDM subjects is often rather vague and based on dogma rather than on scientific results. Previously we have demonstrated in NIDDM that alcohol taken without a meal

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stimulates insulin secretion dose-dependently without suppressing blood glucose levels (Christiansen *et al.* 1993), the results corroborating those of Walsh & O'Sullivan (1974). Others have found slightly diminished blood glucose concentrations (McMonagle & Felig, 1975; Gin *et al.* 1992).

The aim of the present study was to evaluate the acute metabolic effects of alcohol taken with a light meal in NIDDM subjects.

SUBJECTS AND METHODS

Subjects

The study included ten NIDDM patients (five women, five men) fully informed of the experimental nature of the investigation which had approval from the local Ethics Committee. Their clinical characteristics are given in Table 1. None of the subjects had diabetic complications except for background retinopathy. Three patients were treated with diet alone, while three also took sulphonylurea, one took metformin and three took a combination of the two agents. No one experienced flushing during the experiments. All participants had endogenous insulin production with postprandial serum C-peptide levels above 1100 pmol/l. None of the participants had a history of liver disease or alcohol abuse.

Experimental protocol

The subjects participated in random order in the two treatments A and B. After an overnight fast the participants consumed 100 g white bread (50 g carbohydrate), 20 g low-fat margarine, 40 g ham and 500 ml non-alcoholic-beer (NAB; Wiibroe Breweries, Elsinore, Denmark) containing 1900 kJ. In treatment B ethanol was added to the NAB to attain an alcohol content of 54 ml/l, i.e. 24 g alcohol having an energy content of 700 kJ. The patients took their prescribed medicine at 08.00 hours and consumed the meal within 10 min.

Blood samples for glucose, serum insulin, free fatty acid (FFA), triacylglycerol and ethanol analyses were collected from a cubital vein every 15 min from 07.30 to 08.30 hours and every 30 min from 08.30 until 12.00 hours. The samples were stored at -20° until required for analysis. Urine was collected from 08.00 to 12.00 hours to determine the urinary glucose excretion.

Analytical methods

Plasma and urinary glucose concentrations were measured by a glucose oxidase (*EC* 1.1.3.4) method and serum insulin levels by a specific radioimmunoassay (Ørskov *et al.* 1968). HbA_{1c} was measured by ion-exchange chromatography (Bio-Rad, Richmond, CA, USA); normal range 3.5–5.5%. FFA and triacylglycerols were determined using standard enzymic colorimetric commercial assay kits (Wako Chemicals, Germany and Boehringer Mannheim, Germany). Serum ethanol was determined by gas-liquid chromatography using a head-space technique (Machata, 1975).

Statistical methods

The blood glucose and serum insulin responses are expressed as the incremental area above the fasting concentration (AUC). The concentrations of serum FFA and triacylglycerols are given as mean values for the entire study period. Serum ethanol is expressed as peak concentration values. The fasting concentrations were the mean values between 07.30 and

Table 1. *Clinical data for the ten non-insulin-dependent diabetic subjects*
(Mean values with their standard errors for five male and five female subjects)

Duration of diabetes (years)		Age (years)		BMI (kg/m ²)		HbA _{1c} (%)		Fasting blood glucose (mmol/l)			
								Treatment A		Treatment B	
Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
6	2	55	3	29.0	1.2	7.0	0.4	9.0	1.0	9.5	1.1

BMI, body mass index (weight/height²); HbA_{1c}, glycosylated haemoglobin A_{1c}.

Table 2. *Metabolic responses in ten non-insulin-dependent diabetic subjects receiving 500 ml non-alcoholic beer with an alcohol content of 0 (treatment A) or 54 (treatment B) ml/l**

(Glucose and insulin values are given as incremental area under curve (AUC), triacylglycerols and free fatty acids (FFA) as average concentrations, ethanol as maximum value and urinary glucose as total amount in a 240 min time-period following eating. Values are means with their standard errors)

Treatment ...	A		B		Statistical significance of difference: <i>P</i>
	Mean	SE	Mean	SE	
Glucose (mmol/l)	554	69	574	89	NS
Insulin (pmol/l)	6716	884	8252	1193	NS
Triacylglycerols (mmol/l)	1.74	0.23	1.79	0.23	NS
FFA (μmol/l)	518	50	423	37	NS
Peak ethanol (mmol/l)	0.00	0.00	9.1	0.7	< 0.01
Urinary glucose (mmol)	13.5	6.7	20.8	9.7	NS

NS, not significant.

* For details of subjects and procedures, see Table 1 and pp. 450–451.

08.00 hours. The results are expressed as means with their standard errors. A two sample *t* test was used for statistical analysis, and *P* = 0.05 was considered significant.

RESULTS

All subjects had both treatments (A and B) adhered well to the timing, and consumed the meals completely. There were no significant differences in fasting concentrations of serum glucose, insulin, triacylglycerols or FFA. There were no traceable amounts of ethanol in the fasting blood samples.

The effects of treatments A and B on metabolic responses are shown in Table 2. As illustrated in Fig. 1, blood glucose responses were superimposable. The alcohol-containing meal was associated with a slight increase in insulin concentrations compared with the

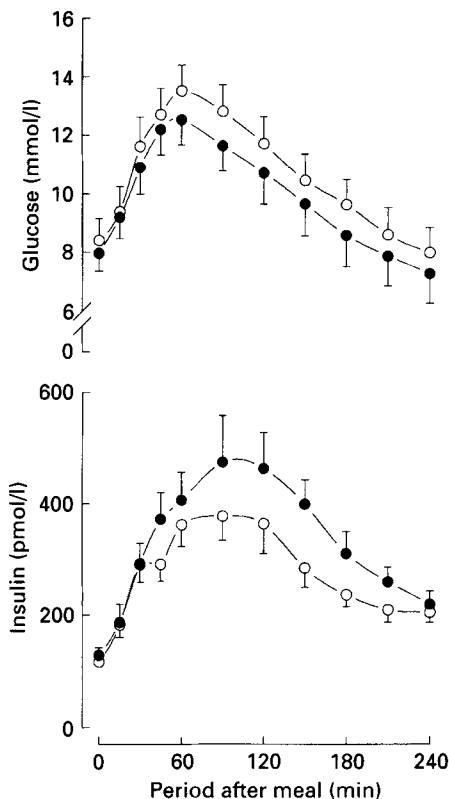


Fig. 1. Effects of 500 ml beer containing 0 (O—O) and 54 (●—●) ml ethanol/l taken with a light meal on blood glucose and serum insulin responses in ten non-insulin-dependent diabetic subjects. Values are means with their standard errors represented by vertical bars. For details of subjects and procedures, see Table 1 and pp. 450–451.

alcohol-free meal; however, this was not significant. Concentrations of serum triacylglycerols and FFA were similar after the two treatments (Fig. 2). Urinary glucose excretion was similar with the two treatments. Fig. 3 illustrates differences in serum ethanol levels.

DISCUSSION

Alcohol possesses the ability to induce hypoglycaemia in normal and insulin-dependent diabetic subjects (Freinkel *et al.* 1965; Walsh & O'Sullivan, 1974; Nikkilä & Taskinen, 1975; Connor & Marks, 1985), mainly because it effectively inhibits gluconeogenesis in the liver (Yki Järvinen *et al.* 1988). This effect is more pronounced when the liver is depleted of glycogen, for example in chronic alcoholism and fasting (Freinkel *et al.* 1965).

In short-term studies moderate doses of ethanol have been found either to diminish slightly (McMonagle & Felig, 1975; Gin *et al.* 1992) or not affect blood glucose responses in NIDDM subjects (Walsh & O'Sullivan, 1974; Christiansen *et al.* 1993).

The design of the present study implied that the patients received identical amounts of dietary carbohydrate in the two treatments, whereas the total energy load was increased by the added ethanol. The amount of food was chosen to mimic an everyday normal light meal.

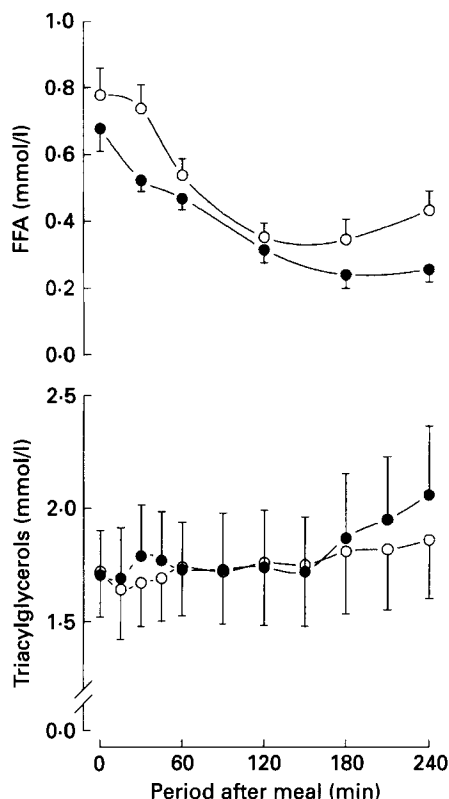


Fig. 2. Changes in serum free fatty acids and triacylglycerols in ten non-insulin-dependent diabetic subjects after intake of 500 ml beer containing 0 (○—○) and 54 (●—●) ml ethanol/l ingested with a light meal. Values are means with their standard errors represented by vertical bars. For details of subjects and procedures, see Table 1 and pp. 450–451.

Our findings indicate that the postprandial blood glucose response is unaffected by moderate amounts of alcohol consumed with a light meal. Some have reported similar results (Walsh & O'Sullivan, 1974), while others found slightly diminished serum glucose concentrations when comparable amounts of alcohol had been taken with a meal (McMonagle & Felig, 1975; Gin *et al.* 1992). Even though hypoglycaemia is a well-known complication in sulphonylurea-treated NIDDM, there is, to our knowledge, no report of hypoglycaemia in NIDDM associated with intake of moderate doses of alcohol either with or without simultaneous food intake.

Recently we demonstrated that 500 ml non-alcoholic beer containing 0, 27 and 54 ml alcohol/l caused a dose-dependent stimulation of insulin secretion in NIDDM subjects (Christiansen *et al.* 1993). In the present study it appears that a light meal extensively dilutes or eliminates the insulinogenic effect of moderate alcohol intake in NIDDM. Furthermore, no difference in FFA and triacylglycerol concentrations was seen.

The present results indicate that a moderate amount of alcohol does not acutely reduce the glycaemic control in NIDDM and it seems safe for NIDDM patients to consume moderate amounts of alcohol with a meal without risking hypoglycaemia. In the long term, however, one must bear in mind the energy content of beer and alcohol, i.e. consider the potential of alcohol to increase body weight, especially in overweight and obese NIDDM subjects.

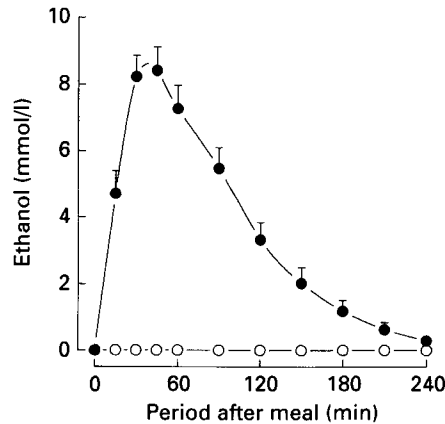


Fig. 3. Serum ethanol levels in response to intake of a light meal and 500 ml beer containing 0 (○—○) and 54 (●—●) ml ethanol/l in ten non-insulin-dependent diabetic subjects. Values are means with their standard errors represented by vertical bars. For details of subjects and procedures, see Table 1 and pp. 443–451.

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