Occupational exposure to urban pollutants and plasma insulin

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ABSTRACT

Objectives: The aim of this study was to investigate whether traffic police of a big city who are exposed to urban pollutants are at risk to alterations in plasma insulin concentrations compared with controls.

Methods: The class of workers examined in this study were employees of the municipal police in Rome, Italy. The study was carried out during the period March - April 2001. Traffic police were matched with a control group, where gender, age, working life and drinking habit were noted. A total of 246 traffic police (128 men and 118 women) with outdoor activity and exposure to urban pollutants and 242 subjects (128 men and 114 women) with indoor activity were included in the study.

Results: The levels of plasma insulin were significantly lower in traffic police compared to the control group of both gender.

Conclusion: Plasma insulin level was altered in traffic police who are exposed to chemical and physical stressors.

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Studies on animals and a few human subjects have hypothesized that chemical agents, present in urban air, may decrease the normal synthesis, secretion or action of insulin. These agents are cadmium,[1-7] chromium,[8] manganese,[9] nickel,[10] lead,[11-13] benzene,[14,15] sulfur dioxide[16] and carbon monoxide.[17-20] Aside from these, physical agents such as noise[21] also modify insulin levels.

The class of workers examined in this study were employees of the municipal police in Rome, Italy. The environmental and biological levels of some urban pollutants have already been reported in our previous work.[22-25] Exposure dosage to benzene was (mean 7 hours) an average of 10.7 $\mu g/m^3$ for the group of traffic policemen, which was 3 times lower than (3.6 $\mu g/m^3$) the control group.[22,23]

Due to the unleaded petrol that had been introduced, a mixed regime existed in Italy at the time of this study (use of leaded and unleaded petrol). Moreover, it is probable that anti-detonation additives containing manganese and nickel are also present in fuels. The use of green petrol is considered to be the cause for the increase of benzene in urban atmosphere. Our current research has shown an increase in blood nickel in subjects chronically exposed to urban pollution compared with a control population. The aim of the present study was to evaluate whether traffic police exposed to urban pollutants are at risk to alterations in plasma insulin levels compared with the control group.

Methods. During the period March - April 2001 the municipality of Rome monitored concentrations of particulate matter 10 micrometers

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Table 1 - Characteristics of the population studied and plasma levels of insulin.

Characteristics	Traffic Police		Control	
	Men n = 128	Women n = 118	Men n = 128	Women n = 114
Age in years mean ± SD (min - max)	47 ± 7.3 (33 - 65)	40.7 ± 5.9 (30 - 60)	47.5 ± 6.8 (33 - 63)	40.8 ± 5.7 (31-57)
Working life mean ± SD (min - max)	8.6 ± 5.4 (1 - 33)	8.8 ± 4 (1 - 24)	7.7 ± 5.2 (1 - 33)	8 ± 4.2 (1-24)
Plasma insulin values (μU/ml) mean ± SD (min - max)	8.2 ± 4.1 (1.8 - 20)	6.8 ± 3.3 (0.4 - 22)	11.1 ± 8.2* (2 - 62)	8.4 ± 4.5** (1.5 - 29)

*p=0.000 with respect to control workers
**p=0.002 with respect to control workers
SD - standard deviation, min - minimum, max - maximum

in diameter and smaller in fixed stations located in districts with different intensities of vehicle traffic. An average monthly values of 60 μg/m^3, 45 μg/m^3 and 30 μg/m^3, registered in a Municipal park (http://www.comune.roma.it). The study was carried out on a working population of 981 municipal police employees. Two groups were studied: 1) traffic police who worked in shifts on parking, patrols, keeping passage-ways free, controlling traffic at crossing and on roads with intense flow of traffic; and 2) subjects who carry out indoor activities of administrative and bureaucratic nature, not exposed to urban pollutants, at lesser level of exposure were used as controls. Traffic police and control group worked for 7 hours a day for at least 5 days a week. For inclusion in the study, all the workers were asked to fill out a questionnaire covering: age, working life, duties performed, weight, height, recent use of medicines (6 months previous to the taking of blood samples) , drinking habits (number of glasses of wine, beer or spirit drink per day), non-occupational exposure to paints, solvents, and pesticides, positive anamnesis for diabetes and clinical symptoms. Excluded from the study were workers who answered affirmatively to items related to the following: body mass index (BMI = Kg/m^2) above 30,[26,27] current assumption of β-blocker drugs,[28,29] consumption of wine or beer above 2 glasses per day or habitual consumption of spirits,[30,31] use of paints, pesticides and solvents[32,33] and positive anamnesis for diabetes. All the subjects included or excluded from the study were asymptomatic. All subjects underwent dosage of blood glucose, before they had eaten. Moreover, subjects with blood glucose normal values of 70 - 110 mg/dl and was presented outside our laboratory's were excluded from the study.

Traffic police were matched with the control group by gender, age, working life and drinking habit (below 2 glasses of wine or beer per day). The study included 246 traffic police (128 men and 118 women) with outdoor activities and are exposed to urban pollutants and 242 subjects (128 men and 114 women) with indoor activities (**Table 1**). All of the subjects consented to their personal details being available, declaring that they had been made aware that this data is ranked as "sensitive information". They consented that data arising from the research protocol should be treated in an anonymous and collective way, with scientific methods and for scientific purposes in accordance with the principles of the Declaration of Helsinki. A 10 ml sample of venous blood was taken from each worker between 8 and 10 in the morning, before they had eaten. Samples were kept in the workplace in a refrigerator at –4 °C until they were transferred (by means of a container at the same temperature) to the laboratory, where they were immediately centrifuged. The serum was separated and stored at –20°C until analysis (within 3 days). The laboratory measured the insulin concentration of the venous blood samples using radio-immunoassay (RIA) through which standard insulin and the one present in the samples, is recognized by a monoclonal antibody (mAb) 1 tied to the internal surface of a polystyrene tube. The successive addition of a mAb 2, directed against a diverse epitope of the molecule and marked with I125, provokes the formation of a complex sandwich tied to the solid phase: mAb 1 – insulin - mAb 2 - I125. At the end of incubation the quota of mAb 2 not tied to the solid phase is eliminated through aspiration and washing. Since the formation of the complex takes place only in the presence of insulin, the radioactivity tied to the solid phase is directly proportional to the concentration of insulin present in the sample. A standard curve, set up together with the samples to be analyzed, allows the determination of insulin present in them through interpolation. The normal values of the test were the ones applied in our laboratory were 3 and 25 μU/ml for both sexes. The laboratory did not know, which samples came from the group of traffic police and which was from the control group, although both the physicians in charge and the technicians knew a study was in progress.

Statistical analysis of the data was based on the calculation of the mean, standard deviation (SD), distribution, range and frequency according to the nature of the single variables.

The differences between the means were compared using Student's t-test for unpaired data. The frequencies of the single variables were compared using the chi-square test with Yates' correction setting up a 4-way contingency table and Fisher's exact test, setting up a 4-way contingency table. The differences were considered significant

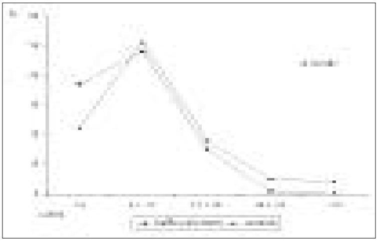

Figure 1 - Distribution of plasma insulin values (μU/ml) in male traffic police and control subjects (%).

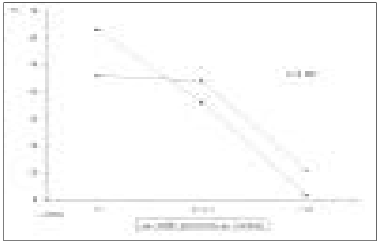

Figure 2 - Distribution of plasma insulin values (μU/ml) in female traffic police and control subjects (%).

when the *p* values were <0.05. The statistical analysis was carried out using the statistical program called Solo Biomedical Computer Program™ Statistical Software.

Results. In male traffic police mean plasma insulin levels were significantly lower compared with controls (p=0.000) (**Table 1**). The number of male traffic police with insulin values outside the lower normal limit of our laboratory was not significant compared to controls (3 traffic police and 3 controls). The number of male traffic police with insulin values outside the higher normal limit of our laboratory was not significant compared to control subjects (0 traffic police and 5 controls). The distribution of the insulin values in male traffic police and control subjects is shown in **Figure 1**.

In female traffic police, the mean plasma insulin levels were significantly lower compared with controls (p=0.002) (**Table 1**). The number of female traffic police with insulin values outside the lower normal limit of our laboratory was not significant compared to controls (5 traffic police and 3 controls). The number of female traffic police with insulin values outside the higher normal limit of our laboratory was not significant compared to controls (0 traffic police and 1 control). The distribution of the insulin values in female traffic police and controls is shown in **Figure 2**.

Discussion. Considering that the subjects with the principal confounding factors were excluded from the study, and that the subjects investigated were matched by gender, age and working life, the data suggested the possibility that occupational exposure to urban pollutants in traffic police may have an influence on plasma insulin concentrations. The fact that the differences between the means for traffic police and controls are significant suggests that these differences may have clinical validity, even if the levels are contained within laboratory limits and the deviation is not as wide as often seen in medical pathology. In fact, all the subjects included in the study were asymptomatic. The action mechanisms of chemical and physical agents present also as urban pollutants and able to modify insulin levels, are still uncertain. Studies on laboratory animals and few human subjects have led to the hypothesis that exposure to chemical and physical agents (such as noise) could decrease or increase insulin levels probably in relation to the doses, modality and time of exposure. From studies carried out in laboratory animals, it is possible to suppose that cadmium and chrome are able to reduce plasma levels of insulin.[1-6,8] Murata et al[7] in subjects affected by "Itai-Itai disease" and chronically exposed to cadmium has revealed a reduction of the pancreatic function. In rats exposed to manganese, plasma insulin level was reduced probably through the accumulation of the metal at the cellular membrane level of pancreas β cells.[9]

In mice injected with nickel, a decrease of plasma insulin levels was provoke, probably by the action of the metal at central level.[10] In studies with laboratory animals, lead has showed a reduction in plasma levels of insulin.[11,12] In worker chronically exposed to high concentrations of lead, a decrease in plasma levels of insulin has been shown. The mechanisms with which the lead acts at the pancreas level are not yet known, but a direct action at pancreatic level with inhibition of β cells' functionality has been hypothesised.[13] Benzene is able to integrate with the immunity system in various ways, determining even the apparition of auto-antibodies[14] and this may be one of the mechanisms implicated in the insurgence of insulin-dependent diabetes in predisposed subjects.[15]

It is well known that personal exposure to benzene, toluene and other aromatic hydrocarbons from direct exposure to traffic fumes, as experienced by some categories of outdoor workers, such as traffic police, may be considerably higher than personal exposure of indoor workers.[34] For this reason in our previous work we have studied exposure dosage to benzene, toluene and other aromatic hydrocarbons in the municipal police employees of the city in question. Time weighted average exposure to benzene (mean 10.7 $\mu g/m^3$ and 3.6 $\mu g/m^3$) and to toluene (mean 40.7 $\mu g/m^3$ and 13.5 $\mu g/m^3$) was significantly higher among traffic police than among indoor workers.[22-25] Sulphur dioxide is able to reduce plasma insulin concentration through an action mechanism that has not yet been explained.[16]

Studies on animals exposed to high concentrations of carbon monoxide have revealed a reduction in plasma insulin levels. One can assume that the reduction in plasma levels of insulin may be due to the liberation of catecholamine induced by exposure to this gas.[17-20] Our previous researches revealed that exposure of approximately 15 minutes to noise of intensity between 105 and 108 dbA, with maximum intensity of frequencies between 2000 and 4000 Hz is able to provoke a significant increase in plasma levels of insulin compared with values measured before and after acoustic stimulation.[21]

In conclusion, the present study suggests that the specific working activity of traffic police of both gender exposed to chemical and physical agents present in the city in question may alter plasma insulin levels, according to plasma insulin modifications found by other authors in study on animals and human subjects. These data suggest that there is a cumulative effect which is able to alter plasma insulin levels in traffic police exposed to urban pollutants present in the city in question. Therefore, this effect can be used as early risk factor for diabetes or for reduced glucose tolerance in workers exposed to urban pollutants.

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