

Scuba diving with Diabetes Mellitus – the UK experience 1991-2001

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Edge CJ, St. Leger Dowse M, Bryson P. Scuba diving with Diabetes Mellitus – the UK experience 1991-2001. *Undersea Hyperb Med* 2005; 32(1):27-37. Objectives: To survey the outcomes and practises of divers with diabetes mellitus. Methods: Diabetic persons wishing to learn to scuba-dive or established divers who have diabetes mellitus in the UK are requested to fill in a detailed questionnaire annually. Divers are asked to provide basic epidemiological information and general diving history. Data provided by the diver's diabetic physician provided independent evidence of the diver's medical status. These data are recorded and analysed. Results: Data have been gathered from 323 diabetic divers (269 male, 54 female) and 8,760 dives have been recorded over 11 years. Two fatalities were reported, both in non-insulin dependent divers. One incident of hypoglycaemia underwater in an insulin dependent diabetic diver has been reported. Conclusions: This survey showed that in the group of well-controlled diabetic divers studied, there were no serious problems due to hypoglycaemia when they dived. Long-term complications of diabetes must be excluded before a diabetic diver may be permitted to dive.

INTRODUCTION

Our understanding of the effects of scuba diving on diabetes mellitus (DM) or the effect of DM on a diver's ability to dive safely is limited. Most diving authorities worldwide consider insulin-dependent diabetes mellitus (IDDM) to be a contraindication to scuba diving (1, 2). Divers taking oral hypoglycaemic agents (e.g. sulphonamides, meglitinides) are considered to be at risk of hypoglycaemia in the water (3), while those controlled using non-hypoglycaemic agents (biguanides, thiazolidinediones, alpha-glucosidase inhibitors), or diet alone are thought by some authorities to be safe to dive. Evidence exists that there are divers with DM who dive safely, and have done so for many years (4, 5), either using insulin or hypoglycemic tablets.

The aim of this survey is to observe, over a period of time, the ordinary diving habits and histories of recreational divers, as opposed to the "monitored" and controlled diving of recreational divers with DM in some

studies (6-8). It also examines the rates at which divers with DM and divers without DM cease to dive and whether any significant differences exist between them. Preliminary results have been reported elsewhere (9-11). Data are presented from the first 11 years of this survey (1991-2001).

METHODS

Divers with DM who wished to dive or to learn to dive as members of the British Sub-Aqua Club (BSAC), the Sub-Aqua Association (SAA) or the Scottish Sub-Aqua Club (SSAC) from late 1991 onwards (12) have completed a questionnaire (see Appendix 1) on an annual basis in order to be considered fit to dive. Data collected include basic epidemiological and diving information. The physician responsible for the respondent's diabetic welfare and medication provided independent evidence of the medical status. The completed questionnaire was reviewed by the investigators, and the respondent's suitability to dive was assessed based on

the parameters set by the medical guidelines; diabetics may be allowed to dive provided that they are able to pass the standard medical examination and in addition, satisfy the following criteria:

1. The diabetic has not experienced any hypoglycaemic attack within the last year.
2. The diabetic has not been hospitalized for any reason connected with diabetes in the last year.
3. The physician in charge of the diabetic at the diabetic clinic must consider the level of control to be satisfactory. A guide to this may be obtained from the HbA_{1c} or fructosamine level. The physician must state that he/she considers the potential diabetic diver to be mentally and physically fit to undertake the sport of scuba diving.
4. There must be no microalbuminuria present. Any degree of retinopathy beyond background retinopathy is not allowed. There must be no evidence of neuropathy (sensory, motor or autonomic), nor of vascular or microvascular disease beyond background retinopathy in the eye.

Once a diabetic diver has been accepted as fit to dive, he/she is issued annually with a set of guidelines to assist him/her to dive safely.

Data were entered into the database by trained operators. Respondents were contacted on a regular basis, and reasons for ceasing to dive established. Quality assessment took place over all the data.

The databases of diving incidents maintained by the diving organizations and UK hyperbaric chambers are examined on an annual basis for the identities of respondents within our database. Additionally, a search is conducted for other diabetic divers who have not registered with our diabetic diver database by contacting individuals at dive shows and by publicizing the database through presentations at dive meetings and articles in the popular press.

While the basic information gathered by the survey has remained constant over the period of the project, the questionnaire and the database were updated in 1997 to obtain further information about the ways in which individual diabetic divers coped with their diabetes.

Statistical Analysis

Statistical analysis was conducted on the data using parametric methods for data that were normally distributed and non-parametric analysis on the remaining data. A p-value of less than 0.05 was regarded as significant. All calculations were carried out using Stata version 8 (StataCorp, College Station, Texas, USA).

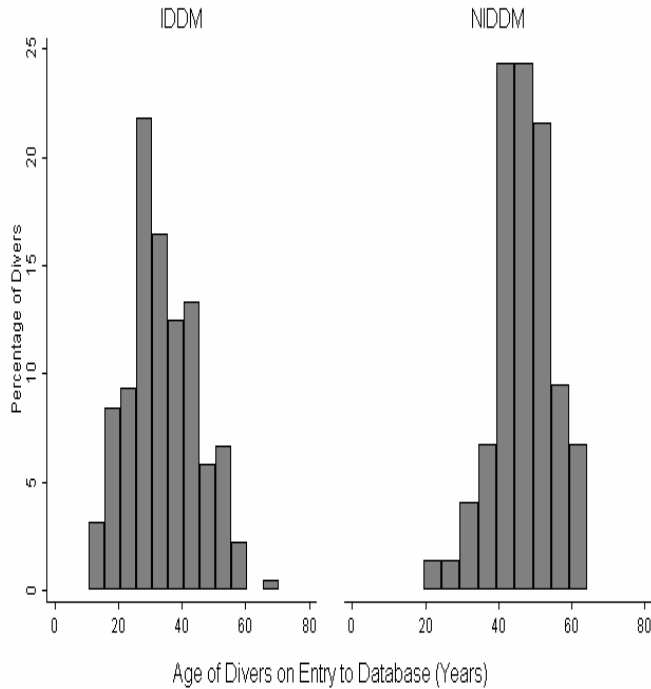
RESULTS

Epidemiology

At the end of 2001, 323 diabetic divers had been, or were, currently registered with the database. There were 269 males and 54 females; 211 (65%) diabetic divers were still diving, 55 (17%) had ceased diving, 13 (4%) had been refused medical certification to dive and 2 divers (1%) had died while diving. Of the 42 (13%) respondents lost to follow up, it was not possible to ascertain if they had ceased diving, or were still diving without formal medical certification. Eighty-six percent of diabetic divers had registered or were still registered with the BSAC/SAA/SSAC; the other 14% were affiliated to PADI or expressed no club affiliation.

Of the diabetic divers who carried out at least one dive while registered with the database, 241 (75%) were insulin-controlled when they started diving and 82 (25%) were controlled with diet alone or diet and tablets. The age range for the IDDM divers and non-insulin dependent diabetes mellitus (NIDDM) divers is compared in Figure 1. The mean age (\pm S.D.) in the IDDM group was 34 (11) while that of the NIDDM group was 47 (8).

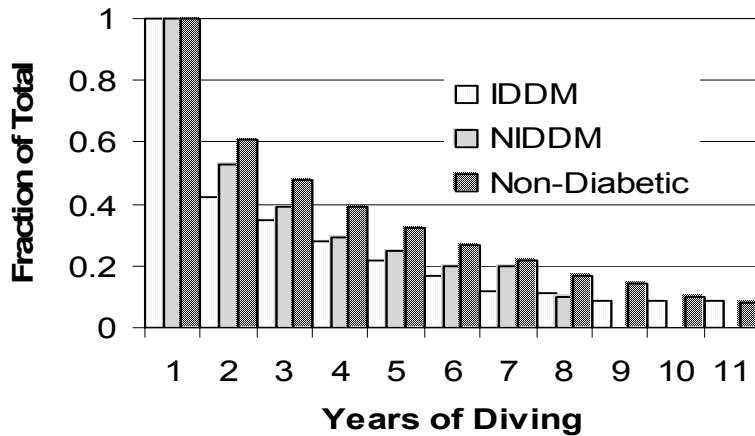
Fig. 1. Histograms showing the numbers of divers in each age range for both IDDM and NIDDM divers.



Chi-squared analysis showed that there was no significant difference between divers in a club organisation (BSAC, SAA, SSAC) and those who are not (primarily PADI members) as to whether they dive with the same buddy or not.

Comparing the divers in our survey over the period 1991-2000 and the cohort of divers who became members of the BSAC in 1991 shows a larger decrease in the number of divers with diabetes after one year compared to the decrease seen after one year in the non-diabetic divers (Figure 2). This difference declines over the following years with the database.

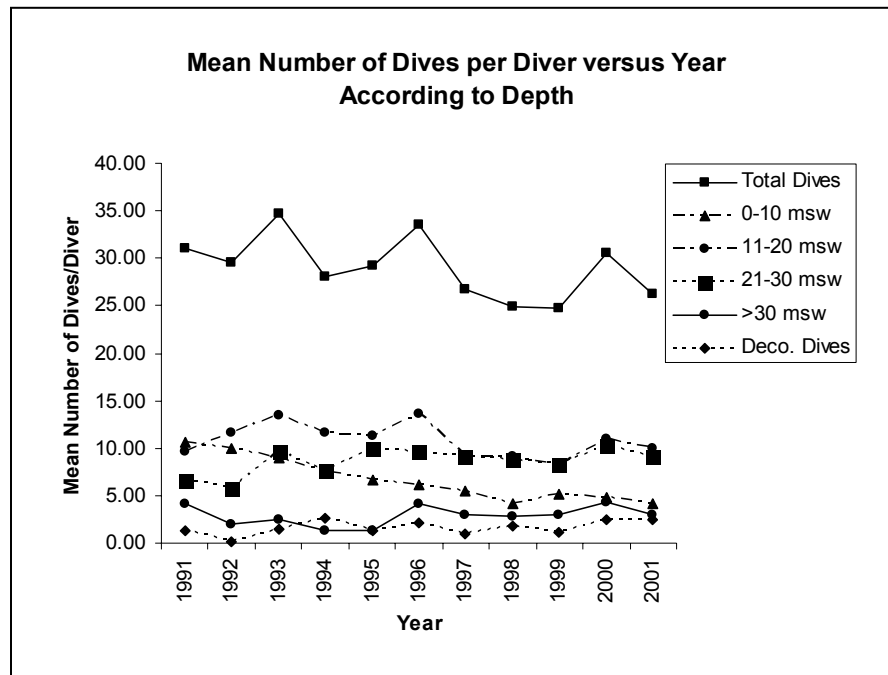
Fig. 2. Graph of Kaplan-Meier survival estimates for the length of time that IDDM and NIDDM divers participate in the survey and that divers with the BSAC remain members of the club.



Diving

Respondents reported 8,760 dives while enrolled with the survey. There were 7,714 male dives and 1,046 female dives. Figure 3 shows the mean number of dives per diver reported each year in the depth categories 0-10 m, 11-20 m, 21-30 m and greater than 30 meters. In addition, the mean number of dives per diver reported to require planned decompression stops is shown.

Fig. 3. Graph of mean number of open water dives per diver undertaken by all diabetic divers while participating in the survey.



Since 1997, of the divers who responded, 72% said that they dived all year round, with 9% saying that they only dived abroad (i.e. not in UK waters) and 19% diving in the summer only, both in the UK and abroad. 91% of the respondents said they have an annual check-up at the diabetic clinic involving eyes, nervous system, kidneys and measurement of the lysosylated haemoglobin or fructosamine level.

Table 1 presents the responses to three questions (questions 10, 18 and 20 from the questionnaire in Appendix 1) that have been asked of diabetic divers since 1997. Responses were categorized and presented as “Always”/“Sometimes”/“Never”.

Table 1. Table showing the percentage of diabetic divers grouped as shown and their responses to the three questions shown. The replies are in the form a/b/c with a being the percentage replying “Always” to the question, b being the percentage replying “Sometimes” and c the percentage replying “Never”.

	IDDM divers	NIDDM divers taking hypo-glycaemic agents	NIDDM divers taking non-hypo-glycaemic agents
Test blood glucose pre-dive?	80/19/1	50/30/20	20/32/48
Carry glucose paste underwater?	98/2/0	76/0/24	16/5/79
Carry glucose kit on board the boat?	77/23/0	66/34/0	14/86/0

Eating and drinking with appropriate fluids before a dive was reported by 82% of respondents. A person in the dive party who would be able to administer glucose tablets and/or an intramuscular glucagon injection was reported by 59% of respondents, but only 32% said that they knew how to use glucose

paste underwater.

Two fatalities were reported during the course of the survey, both in NIDDM divers. One IDDM diver has reported having a hypoglycaemic attack underwater, successfully treated using glucose paste. Three divers have reported problems with their diving equipment

while underwater. No other diving related problems have been reported.

DISCUSSION

Several studies on diabetic divers have been reported (6-8, 13). These studies have either been conducted in a hyperbaric chamber (13), or under carefully controlled and monitored conditions in tropical open water (6-8). In the open water studies, the deepest dive was to 30 msw with no planned decompression stops. Such studies are valuable as they permit measurement of the blood glucose and other hormonal profiles of divers during a typical diving period in tropical or semi-tropical waters.

These studies suggest that diabetic people may be able to dive safely, provided certain conditions are met. However, the study observations could be open to debate because the diabetic divers were closely monitored and their blood glucose levels controlled throughout the studies. In contrast, this survey provides a unique insight into the unmonitored everyday diving habits of DM divers. However, the problems associated with data collection over a long period of time in this field survey are numerous. Firstly, a proportion of diabetic divers had changed names and/or addresses one or more times during the course of the survey. Secondly, this type of survey is dependent upon persuading the divers to fill in their medical forms annually, and being truthful when replying. Thirdly, diabetic divers may cease diving because they have had problems underwater or on the surface and not reported these to the investigators.

Though every attempt was made to contact the diabetic divers registered with the database who had then ceased diving to ascertain the reason(s) for their cessation of diving, 13% could not be traced. However, none of the untraced group has appeared on the treatment databases of the hyperbaric

chambers in the United Kingdom, or in the records of diving accidents kept by the diving agencies. Additionally, data from the 17% of diabetic divers who are no longer diving but who were traceable, have shown that the reasons for ceasing to dive are mainly socio-economic with lack of time, money, and family commitments frequently cited. Although the attrition rate in this survey is high, figure 2 demonstrates that the rate is no greater than in a representative sample of the UK diving population.

Where diabetic divers have remained active in the sport but failed to return medical information to the survey, various reasons have been cited, including the concern that if their diabetic condition becomes public knowledge, they will be forced to cease diving. Despite extensive publicity of the survey, it is known that not all diabetic divers are enrolled with the database. Unfortunately, it is impossible to obtain reliable estimates of the number of such divers. The challenge this survey faces in the future, therefore, is to convince those divers who see the survey as a threat to change their views and join the database.

While the limitations of the data are acknowledged, including the important issues of under- and false reporting endemic to this type of survey, the survey differs from the work reviewed in this paper in several important aspects. It was conducted on diabetic divers diving in both tropical and cold waters at all times of year and has tracked diabetic divers over their diving careers, which may comprise only one season of diving, but often of two or more seasons' diving (figure 2). The respondents were diving in group situations (i.e. as part of a diving club organised trip) and/or as individual pairs. Both IDDM and NIDDM (diet and tablet controlled) divers were included in the survey. Diet controlled NIDDM divers were included because some will go on to become tablet or insulin controlled; conversely, a few tablet

controlled NIDDM divers may become diet controlled. Additionally, diet controlled NIDDM divers suffer long-term complications of diabetes comparable to tablet-controlled NIDDM divers.

An additional problem with the data is the lack of a control group of non-diabetic divers in the strict sense. However, data concerning the number of years that divers are diving for was obtained from a large cohort of divers who started diving in 1991. This was used to compare with similar data from the diabetic divers. The two distributions are very similar and, although the numbers of diabetic divers are small, it would suggest that scuba diving does not have a major adverse effect on divers with diabetes after they have been diving for several years.

The diving experience of the respondents ranged from novice through to experienced diving instructor. Taken overall, the divers in this survey averaged slightly fewer dives per year than the estimated number of dives per year undertaken by the non-diabetic diving population in the UK, with females averaging less per year than males (14). These data are approximate as a few divers “round” the numbers of dives they undertake during a particular a year, while others may not log all their dives. The dive profiles of the divers with diabetes are probably not be the same as those of an age and experience matched group without diabetes, as the guidelines issued to each diver with diabetes strongly advise against diving to depths greater than 30 msw. However, dives to over 30 msw and dives conducted with decompression stops have been reported by the respondents; the divers with diabetes are asked about such dives in order to further understanding of the diving taking place. (The guidelines are available on application to the authors). While not condoning these practices, in the future these data may prove valuable in furthering the case that divers with diabetes may dive safely. With over 50% of

respondents diving all the year round these data imply that many dives are being undertaken in cold water with poor visibility and, for some dives, strenuous conditions.

Since 1997 the high percentage of IDDM divers indicating that they “always” measure their blood sugar pre-dive, carry glucose in some form underwater and have recourse to an emergency glucose kit on the surface, demonstrates a responsible attitude to diving with diabetes. However, the correspondingly lower figures for those NIDDM divers taking oral hypoglycaemic agents is a cause for concern and this indicates that further education of diabetic divers is important.

During the survey, there were two fatalities, both in NIDDM divers. The first (male) suffered a myocardial infarction underwater and was dead on arrival at the surface. A coroner’s report showed that hypoglycaemia was not a factor in the death of the diver, but a contributing factor was severe narrowing of all the coronary arteries. Details of the second death of a female are unknown.

Forty-five divers admitted to having hypoglycaemic attacks during the period when they were registered with the database. Thorough investigation of these records by the reviewers including telephoning each of the divers, established that 41 of the hypoglycaemic attacks were not in any way diving related. They occurred when the diver had not been diving for at least 24 hours. Of the remaining 4 reports, 3 were diving incidents and no hypoglycaemic attack was actually recorded as the diver had not responded to the questionnaire correctly. The remaining problem was a hypoglycaemic attack underwater which was successfully dealt with using glucose paste underwater. This diver admitted that valuable lessons had been learnt from the experience.

This survey has shown that in the group of well-controlled diabetic divers studied, there were no serious adverse events

when they dived. Long-term complications of diabetes must be excluded before a diabetic diver may be permitted to dive. Education of divers about their condition and the way it may affect their diving is essential. However, some relaxation in the blanket ban on divers with diabetes may be reasonable.

ACKNOWLEDGEMENTS

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APPENDIX 1

QUESTIONNAIRE

GENERAL INFORMATION: name and address details IN CAPITAL LETTERS PLEASE

Name of diabetic	
Address of diabetic	
Home phone/fax number	
Work phone/fax number	
Email address	

Medical personnel: name and address details IN CAPITAL LETTERS PLEASE

Name of physician in charge	
Address of physician in charge	
Phone/fax of physician in charge	
Name of general practitioner	
Address of general practitioner	
Phone/fax of general practitioner	
Name of medical referee	
Address of medical referee	
Phone/fax of medical referee	

GENERAL INFORMATION cont. *Please circle or tick each answer as appropriate*

Gender M F	Height (cm)	Affiliation BSAC SAA SSA Other
Date of birth DD / MM / YY	Weight (kg)	Membership Number & branch
Are you new to the sport Yes No If yes go to question 5		Please circle "a" (<i>all the year round</i>) or "b" (<i>only in the summer</i>) for the response below as appropriate: Do you dive: UK a b Abroad ab

DIVING INFORMATION

1. Year of first dive	4b. If you have been an active diver in the last 12 months please tell us how many dives at each depth range 0 - 10 metres 11 - 20 metres 21 - 30 metres More than 30 metres: Number of dives with a compulsory deco stop:	4c. What bottom mix gas do you mainly use? (circle as appropriate) Air Nitrox Trimix
2. How many dives have you made in your diving career		
3. Date of last dive/...../..... DD MM YY		
4. How many dives have you made in the last 12 months		
4a. What is the maximum depth you have dived in the last 12 months metres		

HEALTH INFORMATION - *Please circle or tick each answer as appropriate*

5. Have you been admitted to hospital for a diabetic condition in the last 12 months? If yes, please tell us about it on page 5	Yes	No
6. Have you experienced any episodes of hypoglycaemia in the last 12 months and in what circumstances did these occur. If yes please tell us about it on page 5	Yes	No
7. Have you had an annual checkup at the diabetic clinic involving eyes, nervous system, kidneys and glycosylated haemoglobin or fructosamine level	Yes	No
8. What portable glucometer do you use and how often do you calibrate it	Name/Make	Calibration
9. Who undertakes the majority of your diabetic care	Hospital <input type="checkbox"/>	GP <input type="checkbox"/>
10. Do you check blood glucose pre and post dive	Always <input type="checkbox"/>	Sometimes <input type="checkbox"/>
	Never <input type="checkbox"/>	
11. Do you eat or drink as appropriate pre dive	Yes	No
12. Have you had any incidents due to low blood sugar in the last year If yes please explain the circumstances and the outcome on page 5	Yes	No
13. Please give the year when was diabetes first diagnosed and under what circumstance, you can give details on page 5		
14. Do you smoke cigarettes	Yes	No
14a If yes please indicate how many a day	How many	
15. Do you regularly consume alcohol	Yes	No
15a If yes please indicate you average weekly consumption <i>One unit = half pint of beer, lager or cider, or one measure of spirits or vermouth, or one glass of wine or sherry</i>	How much	
16. Women only to answer this question. Does the control of your diabetes differ in relation to your menstrual cycle? If yes please tell us how on page 5	Yes	No

17. Do you take fluids before you dive	Yes	No
<p>We recommend you carry the following in your dive kit <i>a. Oral glucose tablets or a tube of glucose paste</i> <i>b. Emergency intramuscular injection of glucagon</i> <i>c. Glucose oxidise sticks together with the necessary glucometer kit and CLEAR instructions for the use of such a kit</i></p>		
18. Do you carry all or any of the above with you to the dive site or on the boat, please indicate by putting a circle round your answer	Always	a b c
	Sometimes	a b c
	Never	a b c
19. Is there always someone in the dive party who is able to use and administer the glucose tablets and intramuscular injection of glucagon, should this be required	Yes	No
20. What do you carry in the form of glucose underwater - please define (eg. Mars Bar, Hypostop)		
21. Do you know how to use glucose paste underwater	Yes	No
21a If yes when did you last practice	In the last 6 months	<input type="checkbox"/>
	6 to 12 months ago	<input type="checkbox"/>
	More than 12 months ago	<input type="checkbox"/>
21b If you have practiced using glucose paste underwater, how successful was the exercise	Successful	<input type="checkbox"/>
	Not successful	<input type="checkbox"/>
22. Have you or your buddy experienced any problems of any nature during the course of the diving in the last 12 months? If yes please give us details on page 5	Yes	No
23. Do you consider that your diabetes has had any adverse effect on you or your buddy's diving during the last 12 months? If yes please give details on page 5	Yes	No
24. Do you dive with the same buddy all the time	Yes	No
25. How well informed is your buddy (regular or otherwise) about your condition	Very well	<input type="checkbox"/>
	Adequately	<input type="checkbox"/>
	Not well	<input type="checkbox"/>
26. How well informed is your club about your condition	Very well	<input type="checkbox"/>
	Adequately	<input type="checkbox"/>
	Not well	<input type="checkbox"/>
26a. When did you last give a lecture to your club on diabetes	In the last 6 months	<input type="checkbox"/>
	6 to 12 months ago	<input type="checkbox"/>
	More than 12 months ago	<input type="checkbox"/>

Section B. To be completed by the Physician-in-charge

LONG-TERM DIABETIC CONTROL - Please circle or tick each answer as appropriate

1. What is the diabetic's medication regime																			
2. When was the medication last changed	In the last 6 months <input type="checkbox"/> 6 to 12 months ago <input type="checkbox"/> More than 12 months ago <input type="checkbox"/>																		
3. Have any episodes of hypoglycaemia occurred in the last year and in what circumstances did these occur? If yes please indicate when, and tell us about it on page 5	Yes No In the last 6 months <input type="checkbox"/> 6 to 12 months ago <input type="checkbox"/>																		
4. Has the diabetic been hospitalized within the last year for any condition relating to diabetes? If yes please indicate the date and tell us about it on a separate piece of paper	Yes No In the last 6 months <input type="checkbox"/> 6 to 12 months ago <input type="checkbox"/>																		
5. What is the current %HbA _{1c} or fructosmine level and please give the normal range for your readings. 5a. When was the test performed	<table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">%</td> <td style="text-align: center;">Normal</td> <td style="text-align: center;">%</td> </tr> <tr> <td colspan="3"> </td> </tr> <tr> <td>In the last 6 months</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> <tr> <td>6 to 12 months ago</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> <tr> <td>More than 12 months ago</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> </table>	%	Normal	%				In the last 6 months	<input type="checkbox"/>		6 to 12 months ago	<input type="checkbox"/>		More than 12 months ago	<input type="checkbox"/>				
%	Normal	%																	
In the last 6 months	<input type="checkbox"/>																		
6 to 12 months ago	<input type="checkbox"/>																		
More than 12 months ago	<input type="checkbox"/>																		
6. Is microalbuminuria present 6a. When was the test performed.	Yes No In the last 6 months <input type="checkbox"/> 6 to 12 months ago <input type="checkbox"/> More than 12 months ago <input type="checkbox"/>																		
7. What degree of retinopathy is present 7a. When was this last checked 7b. Has this person ever had laser treatment to the eyes	<table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">None</td> <td style="text-align: center;">Mild background</td> <td style="text-align: center;">Proliferative</td> </tr> <tr> <td colspan="3"> </td> </tr> <tr> <td>In the last 6 months</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> <tr> <td>6 to 12 months ago</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> <tr> <td>More than 12 months ago</td> <td style="text-align: center;"><input type="checkbox"/></td> <td></td> </tr> <tr> <td>Yes</td> <td style="text-align: center;">No</td> <td></td> </tr> </table>	None	Mild background	Proliferative				In the last 6 months	<input type="checkbox"/>		6 to 12 months ago	<input type="checkbox"/>		More than 12 months ago	<input type="checkbox"/>		Yes	No	
None	Mild background	Proliferative																	
In the last 6 months	<input type="checkbox"/>																		
6 to 12 months ago	<input type="checkbox"/>																		
More than 12 months ago	<input type="checkbox"/>																		
Yes	No																		
8. Is any degree of sensory or autonomic neuropathy present (a check for the latter may be made by looking for R-R variation in the ECG as a Valsalva manoeuvre is performed; if there is no variation then a degree of autonomic neuropathy may be present. 8a. When was this last checked	Yes No In the last 6 months <input type="checkbox"/> 6 to 12 months ago <input type="checkbox"/> More than 12 months ago <input type="checkbox"/>																		
9. Is any degree of coronary, vascular or microvascular disease present	Yes No																		
10. Do you consider this person's level of diabetic control to be satisfactory	Yes No																		
11. Do you consider that this person is mentally and physically fit to undertake a sport that involves a degree of stress and exertion	Yes No																		