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Ricerca

BG Continuous monitoring

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DIABET 171 1–7
ARTICLE IN PRESS
Available online at ScienceDirect www.sciencedirect.com
Elsevier Masson France EM|consulte www.em-consulte.com
Diabetes & Metabolism
ELSEVIER MASSON
Diabetes & Metabolism xxx (2009) xxx–xxx

Original article

Safety of recreational scuba diving in type 1 diabetic patients: The Deep Monitoring programme

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Received 2 January 2008; received in revised form 21 August 2008; accepted 24 August 2008

DAN Europe Diving Safety Laboratory

Special Project
Glycaemia continuous monitoring during the dive

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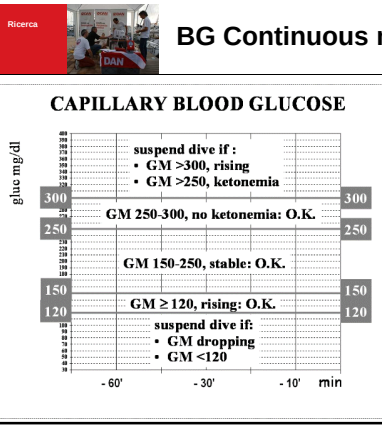
BG Continuous monitoring



A new protocol was developed to permit diabetic divers to know how & when it is safe to dive

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BG Continuous monitoring

A real-time underwater glycaemia monitoring during dives could by very useful to prevent worsening of hypoglycaemia and to permit safe dives for diabetic divers.
The scope of this work is implement continuous underwater BG monitoring using a dedicated real time monitor during diving whilst checking that the values recorded underwater are not influenced by the hyperbaric exposure.
Several test and data analysis were performed in order to verify the accuracy of hyperbaric data collected.

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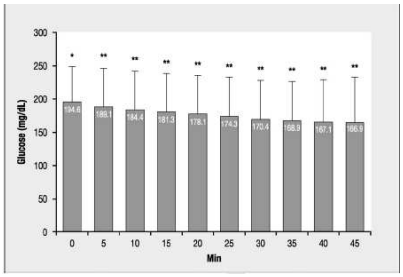
BG Continuos monitoring



Interstitial glucose values, as monitored continuously (CGMS) but not in real time and data was evaluated after diving with a Black Box

BG Continuous monitoring

In 2013 DAN Europe start a special project called :

A continuous real time monitoring and recording of glycaemia during scuba diving.

To prevent worsening of hypoglycaemia and to correctly interpret hypoglycaemia-like symptoms whilst diving, diabetic divers could benefit from real-time Blood Glucose (BG) monitoring during their dives.
The scope of this work is developing a continuous BG monitoring system using a dedicate real time monitor during diving.

BG Continuous monitoring

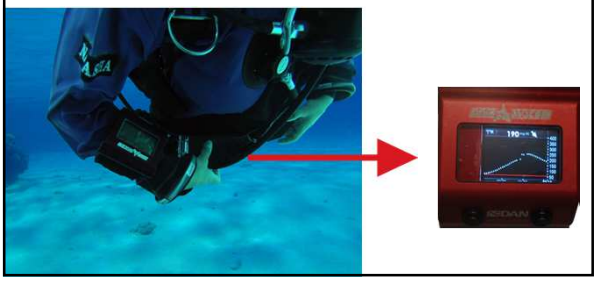
A specific device was assembled in order to be able to read the glycaemia value during dive.

BG Continuous monitoring

A device able to monitor in continuous the Glycaemia value (Dexcom G4)

BG Continuous monitoring

Limiting of data transmission requires to keep the device close to the sensor



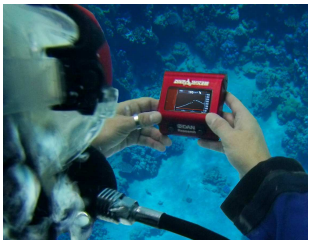
BG Continuous monitoring

Dive time in one day

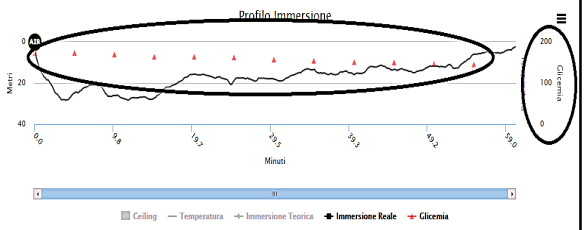
A specific software that record glycaemia value during the day for 7 days

BG Continuous monitoring

The BG data will update every five minutes on the display and the diver is able to check the data value and also the trend of them.



BG Continuous monitoring



The Glycaemia values will be saved on the diver's dive profile, a special DAN portal, called Diver Safety Guardian (DSG) was developped. It is able to save BG values

BG Continuous monitoring

Comparison between interstitial sensor and capillary BG value

BG Continuous monitoring

<u>Evaluation of CGM accuracy in hyperbaric chamber - "validation test"</u>

To assure the correct measurement of interstitial glycaemia values in a hyperbaric environment we had previously completed a comparison test between CBG with Verio IQ .

BG Continuous monitoring

Comparison between interstitial sensor and capillary BG value using the Clarke Grid error:

The grid breaks down a scatterplot of a reference glucose meter and an evaluated glucose meter into five regions:

Region A are those values within 20% of the reference sensor,
Region B contains points that are outside of 20% but would not lead to inappropriate treatment,
Region C are those points leading to unnecessary treatment,
Region D are those points indicating a potentially dangerous failure to detect hypoglycemia or Hyperglycaemia, and
Region E are those points that would confuse treatment of hypoglycemia for hyperglycemia and vice versa.

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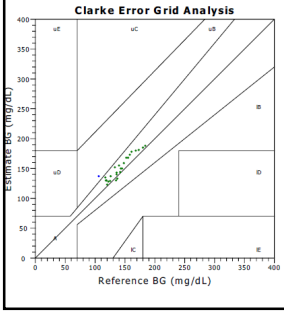
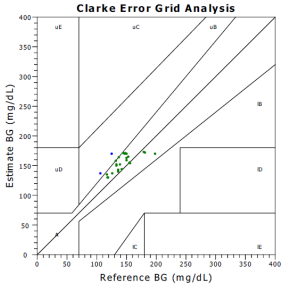
A simulate dive in hyperbaric chamber 40m

BG Continuous monitoring
Clarke grid error test

Normobaric



Hyperbaric



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Clarke grid error results

Normobaric %		Hyperbaric %	
A	96,1	A	92.4
B	3,9	B	7.6
C	0	C	0
D	0	D	0
E	0	E	0

The accuracy tests made in the hyperbaric chamber showed 2 out of 26 MRD glucose values (7.7%) exceeding the 5% difference allowed by ISO guideline 15197 as the maximum difference acceptable in at least 95% of the compared values.

BG Continuous monitoring

BG Continuous monitoring

UHM 2016,VOL. 43, NO. 3 - MONITORING GLYCEMIA DURING SCUBA DIVING: PILOT STUDY

Continuous real-time monitoring and recording of glycemia during scuba diving: pilot study

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[2] Caddy Project: Cognitive Autonomous Diving Buddy (FP7 Marie Curie, grant no. 611373)

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Funding
This study is part of the Cognitive Autonomous Diving Buddy – CADDY – Project (FP7 Marie Curie, EU grant no. 611373) and Green Bubbles Project (H2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 643712).

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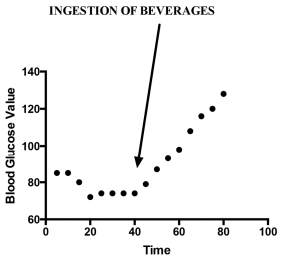
BG Continuous monitoring



p= 0.001

Continuous underwater real time monitoring system can be very important for diabetic divers, as it allows for continuous monitoring and if necessary adjustment of Blood Glucose Levels during diving.
Additionally our data (even if referred to only two subjects at the moment) are in agreement with the current literature and confirm that diving does not imply significant risks of hypoglycaemia.

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Results
Two diabetic subjects (one male and one female) R.D. (male, 36 years, weight 72 Kg, height 167 cm) and N.B. (female, 29 years, weight 53 Kg, height 157 cm) were investigated. Both of divers showed a gradually decreased in BG value during diving. (Table 1).

	Pre diving	During diving	Post diving	P=value	
RD	184 mg/dL (75-271)	140 mg/dL (70-264)	163 mg/dL (57-273)	Pre Vs. during Pre Vs. post During Vs. post	*** * Ns
NB	171 mg/dL (69-324)	152.5 mg/dL (70-329)	123.5 mg/dL (41-263)	Pre Vs. during Pre Vs. post During Vs. post	Ns *** ***

Table 1:
Behaviour of Blood glucose Value in the two divers during Diving a gradually decreased in BG value during diving;

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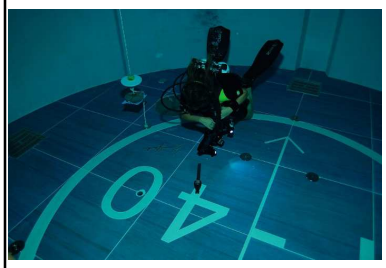
BG Continuous monitoring



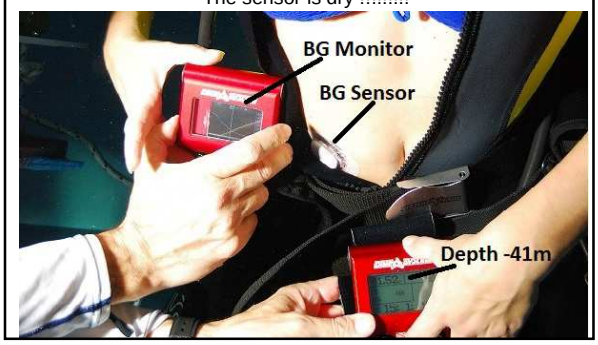
Other limitation of the first part of the study was that the sensor need to under a dry suit .
We have used the deepest pool in the world (Y-40) in order to test if the sensor was dry at 42 meter of deep .

Guinness World Record Hurghada 4-6 June 2015

The device was used to continuously monitor BG during 52 hours every 5 minutes

BG Continuous monitoring

The sensor is dry !!!!!!!!



Guinness World Record Hurghada 4-6 June 2015

The device was used to continuously monitor BG during 52 hours every 5 minutes

Guinness World Record Hurghada 4-6 June 2015

Number of values collected : 634

Minimum	42.00
25% Percentile	64.00
Median	70.00
75% Percentile	82.00
Maximum	124.0
Mean	73.50
Std. Deviation	14.29
Std. Error of Mean	0.5677

Guinness World Record Hurghada 4-6 June 2015

Details:

- Water temperature
  - Minimum 25°
  - Maximum 27°
- Time spent underwater
  - 51h 20m 40seconds
- Gas breathed
  - Air
- Dive equipment
  - Dry suit
  - Open circuit
  - Full Face Mask (used for 12h)

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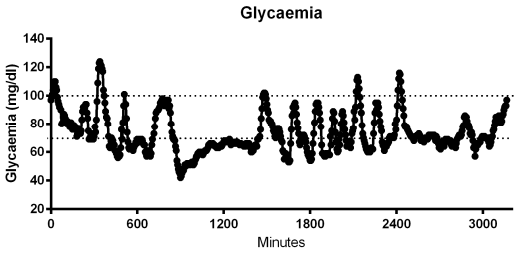
The diver has spent the majority of time in hypoglycemia condition



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Problems encountered during the long permanence in the water:

- **Cold**
  - Low body temperature reached

    Measurements :
    - Before starting the record dive: 36.7°
    - Immediately after the record dive: 34.8°

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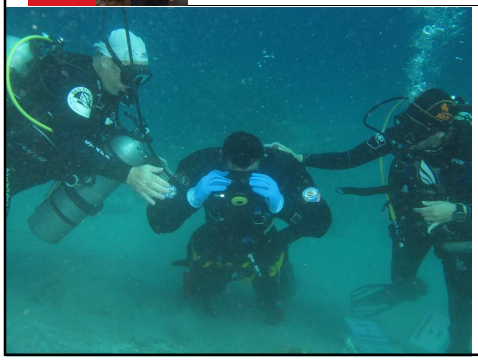

Guinness World Record Hurghada 4-6 June 2015

Problems encountered during the long permanence in the water:

- **Glycaemia values**
  - Low BG values reached
  - We were unable to reach a stable level of Glycaemia in a non-diabetic diver

Guinness World Record Hurghada 4-6 June 2015

Problems encountered during the long permanence in the water:

Glycaemia trend

- Unstable Glycaemia values
  - Observed for several hours
  - Low BG values reached

Actions :
- Sweets, chocolate, banana milk and honey
  - Peak of BG value no constant value reached
- Cognitive test
  - Peak of BG value

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