Plasma glucose response to recreational diving in novice teenage divers with insulin-requiring diabetes mellitus.

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Pollock NW, Uguccioni DM, Dear GdeL, Bates S, Albushies TM, Prosterman SA. Plasma glucose response to recreational diving in novice teenage divers with insulin-requiring diabetes mellitus. Undersea Hyperb Med 2006; 33(2):125-133. A growing number of individuals with insulin-requiring diabetes mellitus (IRDM) dive, but data on plasma glucose (PG) response to diving are limited, particularly for adolescents. We report on seven 16-17 year old novice divers with IRDM participating in a tropical diving camp who had recent at least moderate PG control (HbA_{1c} 7.3±1.1%) (mean ± SD). PG was measured at 60, 30 and 10 min pre-dive and immediately following 42 dives. Maximum depth (17±6 msw) and total underwater times (44±14 min) were not extreme. Pre-dive PG exceeded 16.7 $mmol{\cdot}L^{-1}$ (300 $mg{\cdot}dL^{-1}$) in 22% of dives. Males had significantly higher pre-dive levels (15.4±5.6 $mmol{\cdot}L^{-1}$ [277±100 $mg{\cdot}dL^{-1}$] vs. 12.8±2.9 $mmol{\cdot}L^{-1}$ [230±52 $mg{\cdot}dL^{-1}$], respectively) and greater pre-post-dive changes (-4.3±4.4 $mmol{\cdot}L^{-1}$ [-78±79 $mg{\cdot}dL^{-1}$] vs. -0.5±4.3 $mmol{\cdot}L^{-1}$ [-9±77 $mg{\cdot}dL^{-1}$], respectively). Post-dive PG was <4.4 $mmol{\cdot}L^{-1}$ [<80 $mg{\cdot}dL^{-1}$] in two dives by two different males (3.4 and 3.9 $mmol{\cdot}L^{-1}$ [61 and 70 $mg{\cdot}dL^{-1}$]). No symptoms or complications of hypoglycemia were reported. These data show that in a closely monitored situation, and with benign diving conditions, some diabetic adolescents with good control and no secondary complications may be able to dive safely. The impact of purposeful elevation of PG to protect against hypoglycemia during diving remains to be determined.

INTRODUCTION

Diabetes is a disease in which the body produces too little or is relatively insensitive to insulin. Diabetic individuals are at risk of altered consciousness and long term secondary complications if plasma glucose is not carefully maintained. Insulin-requiring diabetes mellitus (IRDM) was once almost universally viewed as an absolute contraindication for scuba diving. This position has softened within the last 15 years. Divers with diabetes- non-insulin-requiring (NIRDM) or IRDM - have been allowed to participate in regular British Sub-Aqua Club (BSAC), Sub-Aqua Association (SAA) and the Scottish Sub-Aqua Club (SSAC) activity since 1991 (1). Retrospective data describing 8,760 dives over an 11 year period by 323 BSAC/SSA/SSAC divers was recently presented (2). Seventy-five percent of participants had IRDM (34±11 years of age [mean ± standard deviation) and 25 percent had NIRDM (47±8 years of age). The dives were conducted across a wide range of environments and across all seasons. Only one case of symptomatic hypoglycemia was reported to have occurred underwater in a diver with IRDM. Data on plasma glucose values were not available.

We recently reported on an observational study of plasma glucose responses in adult divers with diabetes (3). The study included 40 certified divers with IRDM, completing a total of 555 dives. Participants were 45±8 [30-62] years of age. The diving was conducted in tropical or subtropical waters from a variety of dive platforms under generally modest conditions. Plasma glucose was recorded at 60, 30 and 10 min pre-dive and immediately post-dive. Divers regulated their own diving activities, bound by a requirement to maintain plasma glucose above 4.4 $mmol \cdot L^{-1}$ (80 $mg \cdot dL^{-1}$; 1 $mmol \cdot L^{-1}$ = 17.99 $mg \cdot dL^{-1}$) before entering the water. They also needed stable or rising values in the three pre-dive measures. Hypoglycemia (defined as plasma glucose <3.9 $mmol \cdot L^{-1}$ [<70 $mg \cdot dL^{-1}$]) was observed post-dive in 7% of cases. No episodes of symptomatic hypoglycemia were noted during diving. Pre-dive hyperglycemia (defined as plasma glucose >16.7 $mmol \cdot L^{-1}$ [>300 $mg \cdot dL^{-1}$]) was noted in 12% of dives.

The studies described above provide important documentation of safe diving by adults with diabetes. Diving, however, is not limited to the adult population. Several certification agencies have developed programs to lower the age of entry into the sport, and it can be expected that younger individuals with diabetes will also wish to participate. Data from adult subjects may not represent the experience of adolescents fairly, especially since hormonal changes may contribute to a greater variability in plasma glucose levels in adolescents with diabetes (4). Because this could put them at greater risk, it is important to collect specific data to evaluate diving safety in younger diabetics. The present study was undertaken to monitor plasma glucose response to recreational diving in a group of teenage novice divers with IRDM.

METHODS

Seven divers participated in the study. After receiving medical clearance, candidates completed basic dive training in New York and then in July, 2004 traveled to St. John, U.S. Virgin Islands to participate in a scuba camp organized by the Barton Center for Diabetes Education. The program was proposed by Colleen McCarthy LaPierre and funded by Bayer HealthCare through the Ascensia 2003 Dream Fund contest. The Institutional Review Board of Duke University Medical Center approved the research and all subjects and caregivers/parents provided written informed consent prior to participation.

Study eligibility required a demonstrated understanding of the relationship between plasma glucose and exercise, no secondary complications (including neuropathy, cardiovascular, renal or coronary artery disease, proliferative retinopathy or peripheral vascular disease), no history of severe insulin reactions (loss of consciousness or seizures) within the previous 12 months, a recent history of at least moderate diabetes control documented by a measured glycosylated hemoglobin (HbA_{1c}) of ≤9%, and approval of personal physicians and parents.

Divers checked for urine ketones first thing in the morning and one hour prior to each planned dive (urine ketone reagent strips, Becton Dickinson, Franklin Lakes, NJ). Divers measured plasma glucose levels via finger stick at planned times of 60, 30 and 10 min pre-dive and immediately post-dive. This type of repetitive monitoring schedule was first described by Winsett et al. (5). Additional samples were taken if dives were delayed. The value reported as the 10 minute pre-dive sample is the final pre-dive sample, but the pre-dive samples at 60 and 30 minute will not represent accurate times if the start of the dive was delayed. Plasma glucose was required to be greater than 6.7 mmol·L^{-1} (120 mg·dL^{-1}) and rising on successive tests prior to the dive. Plasma glucose levels below this level on the pre-dive measurement, or falling levels, were to be treated with oral glucose gel self-administered by the diver. Dives would then be delayed until samples tested at 10-15 minute intervals confirmed that the desired effect was achieved. A hypoglycemic episode was defined as: 1) plasma glucose level 4.4 mmol·L^{-1} (80 mg·dL^{-1}) or below, or 2) symptoms of hypoglycemia during or after diving. If hypoglycemia was suspected during a dive, buddy pairs were instructed to surface slowly, inflate their buoyancy compensators, the diver with diabetes to ingest glucose, and the dive ended. Glucose was carried at all times by all divers.

Bayer Ascensia® Contour™ portable glucometers (Tarrytown, NY) were used for the plasma glucose analysis. These automatically-calibrating glucometers required approximately 0.6 µL of blood per test and 15 s to analyze a sample.

Data loggers (Sensus Pro, ReefNet, Mississauga, Ontario, Canada) that recorded ambient pressure at 10 second intervals were attached to the diver's equipment for the duration of the study. The loggers were unobtrusive (approximately 2 cm x 3 cm x 5 cm) and had no display screen visible to the diver. For this study, a dive was defined as the in-water period bracketed by pre- and post-dive plasma glucose measures. Some dives included multiple descent-ascent cycles. Total underwater times reflect the combined underwater time for the series bracketed by plasma glucose measures. This practice was maintained even if the surface intervals exceeded the 10 minute duration normally used to define underwater excursions as repetitive dives.

Divers recorded carbohydrate ingestion throughout the day. They also provided subjective reports after each dive. Questions included: decompression stop status ('none,' 'safety stop' or 'required stop'), type of protective suit worn, thermal comfort ('warm,' 'pleasant,' 'cold' or 'very cold'), perceived work rate during the dive and post-dive ('none,' light,' 'moderate,' 'severe' or 'exhausting'), and whether any problems occurred or symptoms developed.

Results are described as mean ± standard deviation with ranges as appropriate. Statistical comparisons of plasma glucose at different sample points and pre- to post-dive changes in plasma glucose were made with analysis of variance tests (SPSS, version 10.0.5, Chicago, IL) and post hoc least significant difference tests, where appropriate. Significance of all statistical tests was accepted at $p<0.05$.

RESULTS

Descriptive characteristics of participants are displayed in Table 1. Computerized dive profile data and plasma glucose measures were available for a total of 42 dives. Each diver completed six dives. Three divers completed a maximum of one dive per

Table 1. Descriptive characteristics (mean ± standard deviation with range)

Subjects	Age (y)	Weight (kg)	Height (m)	BMI[1] (kg·m^{-2})	Pre-Study HbA_{1c} (%)	Max Depth (msw)	Total UWT[2] (min)
Female (4)	16.0±0.0 (16)	56.8±1.9 (54.5-59.1)	1.65±0.05 (1.57-1.69)	20.8±0.9 (19.9-22.0)	7.3±1.4 (5.3-8.4)	16±6 (6-24)	43±14 (9-58)
Male (3)	16.3±0.6 (16-17)	81.1±13.9 (65.9-93.2)	1.80±0.09 (1.75-1.91)	24.8±3.0 (21.5-27.4)	7.4±1.1 (6.4-8.5)	18±6 (10-34)	45±13 (4-57)

[1] BMI = body mass index (weight in kg divided by the square of height in m)
[2] UWT = underwater time

day, three completed two dives per day on one day and one diver completed two dives per day on two days. Twenty of the dives (48%) included multiple descent-ascent cycles. The intra-dive surface interval duration (up to a maximum of four) was 10.1±9.0 (0.5-30) minutes. Five very shallow dives (≤ 2 meters) were recorded. Four of those dives (by four divers) occurred on the second day of diving (mean total underwater time of 8±4 minutes). The five shallow dives were excluded from summary computations of maximum dive depth and total underwater time.

Diving conditions throughout the camp week were calm seas, little to no current (mild current noted on one), visibility of 18 to 24 m (60-80 feet), and water temperature around 28°C (82°F). There was good vertical mixing and minimal temperature stratification. All divers wore wet suits on every dive. Divers rated their thermal status as 'warm' or 'pleasant' for all dives. Physical effort underwater was described as 'light' (70%), 'moderate' (16%) or 'resting' (14%). Post-dive exercise intensity was described as 'light' (66%) or 'none' (32%). Problems were rare – middle ear equalization in four cases, and single buoyancy and single regluator complaints.

In the morning pre-dive samples, urinary ketones were not detected in any of the subjects during the camp week. Plasma glucose levels at the four standard sample points are given in Table 2 and Figure 1. Pre-dive plasma glucose in the hypoglycemic range was observed in only one case (female, 4.3 mmol·L^{-1} [78 mg·dL^{-1}] at 30 min pre-dive, rising to 9.3 mmol·L^{-1} [168 mg·dL^{-1}] immediately pre-dive).

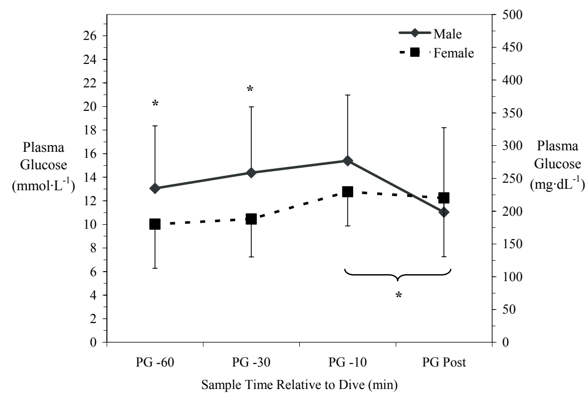

Fig. 1. Plasma glucose values at four standard sampling points (mean ± SD; *p<0.05)

Post-dive plasma glucose <4.4 mmol·L^{-1} was observed in two cases, both in male subjects (3.4 and 3.9 mmol·L^{-1} [61 and 70 mg·dL^{-1}]). Both post-dive hypoglycemia cases involved substantial pre-dive to post-dive

Table 2. Plasma Glucose Responses to All Dives[1]

Time Reference	Female		Male	
	(mmol·L^{-1})	(mg·dL^{-1})	(mmol·L^{-1})	(mg·dL^{-1})
60 min before	10.0±3.7 (4.7-18.3)	180±67* (84-329)	13.1±5.3 (4.9-22.5)	235±95* (88-405)
30 min before	10.5±3.2 (4.3-17.1)	188±58* (78-308)	14.4±5.6 (6.6-25.2)	259±101* (119-454)
10 min before	12.8±2.9 (8.1-19.1)	230±52 (145-344)	15.4±5.6 (8.1-26.3)	277±100 (145-473)
Post-Dive	12.2±5.0 (6.3-21.1)	220±90 (113-379)	11.1±7.2 (3.4-31.1)	199±129 (61-559)
Delta PG[2]	-0.5±4.3 (-5.8 to +8.3)	-9±77* (-105 to +150)	-4.3±4.4 (-10.0 to +4.9)	-78±79* (-179 to +88)

[1] Values are mean ± SD (range).
[2] Delta PG is the difference between plasma glucose approximately 10 min before and immediately post-dive, negative values indicate a fall in plasma glucose.
* denotes significant contrasts (p<0.05) between genders.

declines in plasma glucose (-6.2 and -10.0 mmol·L^{-1} [-112 and -179 mg·dL^{-1}], respectively). The pre-dive to post-dive change in plasma glucose was significantly greater for males than females. There were no reported symptoms or complications related to hypoglycemia.

Subjects reported taking carbohydrate supplements before 32 of 42 dives (76%). Pre-dive plasma glucose levels in females exceeded 13.9 mmol·L^{-1} (250 mg·dL^{-1}) in 26% of cases and exceeded 16.7 mmol·L^{-1} (300 mg·dL^{-1}) in 13% of cases. Pre-dive plasma glucose levels were significantly higher in males at the -60 and -30 min sample points. Male values exceeded 13.9 mmol·L^{-1} (250 mg·dL^{-1}) in 50% of cases and exceeded 16.7 mmol·L^{-1} (300 mg·dL^{-1}) in 33% of cases.

The final pre-dive plasma glucose values are presented by gender for each day of the dive series in Figure 2. There were no significant differences in female values through the series. Values in males varied much more; first day values were highest, significantly higher than all but the fourth day of the series. Fourth day values were significantly higher than third and fifth day values.

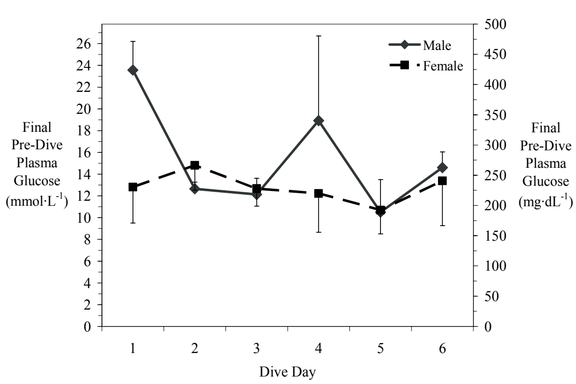

Fig. 2. Final pre-dive plasma glucose values by gender and dive day

The highest post-dive plasma glucose value (31.1 mmol·L^{-1} [559 mg·dL^{-1}] in a male subject) was 10.0 mmol·L^{-1} (180 mg·dL^{-1}) higher than the second highest post-dive value (21.1 mmol·L^{-1} [379 mg·dL^{-1}]). The maximum value was observed following the first dive. The plasma glucose patterns for this individual were much less extreme on subsequent dives (Figure 3).

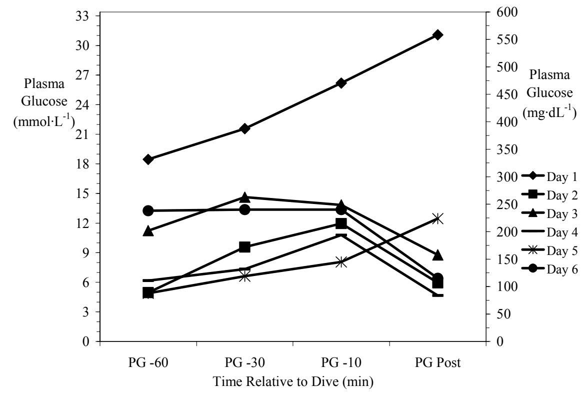

Fig. 3. Plasma glucose values at four standard sampling points for the male subject having the most extreme first dive values.

Of note, the 10 min pre-dive glucose measurement is lower than the 30 min pre-dive measurement on Day 3 for the values in Figure 3. As described in the methods, the 10 min pre-dive values shown are the final measurements preceding the start of diving. Multiple '10 min' plasma glucose measures preceded 23 of 42 (55%) of the dives. In this case, a fall in plasma glucose noted at the scheduled 10 min pre-dive sample point required a delay, corrective action, and reassessment prior to diving. The value shown in Figure 3 as the final pre-dive measure was higher than the previous measure (not shown; 13.2 mmol·L^{-1} [238 mg·dL^{-1}]) and the diver was cleared to dive.

DISCUSSION

The prohibition of diving by individuals with IRDM has not been universally agreed upon for many years. The decision to allow individuals with diabetes to dive made by the BSAC/SAA/SSAC in 1991 represents the clearest shift towards acceptance. While the South Pacific Undersea Medical Society

(SPUMS) released a position statement in 1992 supporting continued prohibition (6), this position has been questioned in subsequent years (7,8). Some recent reviews actively discourage diving by individuals with diabetes (9,10), some are relatively non-committal or ambiguous (11-13), and others favor a medical clearance for responsible individuals with IRDM (14-17).

Justification for the prohibition has weakened as data have accumulated documenting a low incidence of problems. This does not imply that a diver with IRDM has the same risk as the diver who does not have IRDM; simply that the risks can be managed effectively by well-trained, knowledgeable individuals. The opportunity to participate in activities like diving may also motivate an individual to take additional care to protect or improve long term health. Case-by-case evaluations should be able to identify good candidates for participation and, equally important, individuals who should not participate.

The question of whether adolescents with IRDM should be allowed to dive involves special issues. Observations that hormonal changes can make plasma glucose levels in adolescents more variable is a concern (4). The potential for distraction in the young person is another consideration. Youthful inexperience could translate into a reduced ability to anticipate or recognize developing problems.

Dembert and Keith (18) wrote an early review on the medical evaluation of the pediatric diver. They took the position that the risks associated with acute hypoglycemia in a diving environment were unacceptable and advocated complete prohibition. An exception to this position was taken in a letter response (19). These authors felt that unilateral disqualification was as inappropriate as a previously proposed prohibition on competitive athletics for children with IRDM.

Appropriate training can address most of the issues faced by the diver, adult or adolescent. Both physical skills and awareness can be learned and demonstrated by competent individuals. And contrary to the most commonly illustrated situations, the diving does not have to be strenuous. Good neutral buoyancy and water skills reduce the effort required on any dive. The exceptional demands of fighting currents, rough seas, or assisting/rescuing a buddy in trouble can usually be avoided by diving in good conditions and well within skill limits. The demands of entries, exits, and surface swimming are typically short-lived in most cases. Thermal stress can be avoided by a variety of protective suits. While it is easy to envision life threatening scenarios and feel compelled to be conservative, it is important to maintain a realistic perspective. Diving can be fairly benign with proper training, preparation, and sound decision-making. The combination of a solid foundation with appropriate supervision can make diving experiences successful for adolescents.

The subjects in the current study represent good physical candidates for diving. Body mass index measures (Table 1) were likely superior to the typical diver. While few published data are available, a recent survey evaluating dive club members in Australia provides some perspective. Body mass index measures were available for 328 of 346 respondents in a postal survey (only one respondent reported having IRDM). Almost half had body mass index values in excess of normal: 36% were classed as overweight (25-29.9 $kg \cdot m^{-2}$), 11% obese (30-34.9 $kg \cdot m^{-2}$), and 2.4% morbidly obese (≥ 35 $kg \cdot m^{-2}$) (20).

The risk of hypoglycemia is a major concern for divers with diabetes. There is no doubt that an event occurring underwater is a greater threat than comparable events on dry land. The impact of the diving environment, however, may not be that difficult to manage. A recent study demonstrated that hyperbaric pressure *per se* does not seem to influence plasma glucose levels (21). Compensating for exercise intensity and thermal stress are not novel challenges for diabetics, particularly those who are physically active.

A variety of guidelines have been offered to help divers with diabetes minimize the risk of hypoglycemia during diving. Advocates have called for pre-dive plasma glucose to be maintained at levels 'slightly higher' than normal (1); greater than 4.2 $mmol \cdot L^{-1}$ (75 $mg \cdot dL^{-1}$) (22); greater than 8.3 $mmol \cdot L^{-1}$ (150 $mg \cdot dL^{-1}$) (23); greater than 8.9 $mmol \cdot L^{-1}$ (160 $mg \cdot dL^{-1}$) (24); and greater than 7.8 $mmol \cdot L^{-1}$ (140 $mg \cdot dL^{-1}$) or higher if rising or 10.0 $mmol \cdot L^{-1}$ (180 $mg \cdot dL^{-1}$) if constant (25).

We recently noted an absence of reports of symptomatic hypoglycemia in divers with diabetes despite several instances of plasma glucose readings in the 2.2-2.8 $mmol \cdot L^{-1}$ (40-50 $mg \cdot dL^{-1}$) range (3). There are not yet sufficient data to determine if the distractions of diving make it easier to miss the early signs of hypoglycemia. It is clear, however, that conservative practices such as planned glucose ingestion during the dive could be implemented to reduce the hazard. Rules for prophylactic ingestion of glucose if a monitoring schedule cannot be maintained have been deemed acceptable to support special issuance third-class (non-commercial) medical certificates for U.S. pilots with IRDM (26,27).

Hypoglycemia was not common in this study with minimal thermal stress and modest physical effort during the dives. This finding is consistent with recent reports on adults divers with diabetes (2,3). The disproportionately large pre-to-post-dive drops seen in the males in the current study do raise concerns. The tendency for marked decline was observed on all dive days. There was no obvious correlation to the perceived work rate or thermal stress during the dives. It can only be speculated that an unrecognized but greater degree of physical activity during the dive or possibly less concern regarding plasma glucose management contributed to the greater drops seen in males. A series of closely monitored dives in a swimming pool (17) or a relatively controlled open water environment would be useful to begin to optimize individual insulin dosage adjustments.

Generally speaking, the utility of modern sampling devices, the relative ease of in-water management, and awareness by the divers, all help to reduce the frequency of hypoglycemic events. For in-water management, home-made strategies for glucose supplementation (28,29) have largely been supplanted by convenient and easy to use commercially-packaged forms. A greater practical concern may be hyperglycemia if efforts to protect against hypoglycemia get out of control. It is common for individuals to increase plasma glucose levels intentionally before physical activity to reduce the risk of hypoglycemia and/or the need to interrupt the activity. This must be done judiciously, however. Vigorous exercise by persons with IRDM and plasma glucose levels exceeding 250 $mg \cdot dL^{-1}$ can promote dehydration and ketoacidosis. Current guidelines from the American Diabetes Association recommend avoidance of physical activity if fasting plasma glucose levels exceed 250 $mg \cdot dL^{-1}$ and urine ketones are present and caution if plasma glucose levels exceed 300 $mg \cdot dL^{-1}$ even when urine ketones are absent (4).

There has been relatively little focus on hyperglycemia as an issue related to diving. Advocates have called for a maximum pre-dive plasma glucose levels of 12.2 $mmol \cdot L^{-1}$ (220 $mg \cdot dL^{-1}$) (24); 13.3 $mmol \cdot L^{-1}$ (240 $mg \cdot dL^{-1}$) (22; Burghen, 1996 pers. com.); 13.9 $mmol \cdot L^{-1}$ (250 $mg \cdot dL^{-1}$) (10,30); and, most recently, 16.7 $mmol \cdot L^{-1}$ (300 $mg \cdot dL^{-1}$) (31). Relatively high glucose values, however, have sometimes been ignored in discussion (24).

The pre-dive plasma glucose profiles

observed in the current study were higher than optimal. Pre-dive values exceeded 16.7 mmol·L^{-1} (300 mg·dL^{-1}) in 22 percent of the dives. This was markedly higher than the 12 percent incidence observed in our recent study of adult divers with IRDM (3). The pattern of final pre-dive measures was actually very consistent for females (12.8±2.9 and 12.4± 3.9 mmol·L^{-1} [230±52 and 223±71 mg·dL^{-1}], respectively). Mean values for males were much higher in the current study (15.4±5.69 vs. 10.8± 3.6 mmol·L^{-1} [277±100 vs. 194±65 mg·dL^{-1}], respectively), primarily due to erratic daily patterns (Figure 2). The current results must be interpreted cautiously given the small sample size. It is possible that the high values reflect differences in experience. The novice youths probably focused on avoiding hypoglycemia as a chief priority when they were unsure of the effects of the diving and the often protracted dives. This likely explains the peak values on Day 1. The deepest dives for six out of seven divers were conducted on Day 4. It is possible that the males prepared for this with a more aggressive glucose loading. If so, the females made better choices in keeping their values both moderate and stable.

The rapid stabilization of plasma glucose patterns seen from the first to subsequent days of diving in the subject with the highest values demonstrates that novices can quickly learn to compensate for the demands of tropical recreational diving. Winsett *et al.* (5) presented a description of the monitoring guidelines developed for Camp DAVI (Diabetes Association of the Virgin Islands), a dive camp for young adults with IRDM. The approach is to evaluate plasma glucose levels over time before the dive to get a clearer understanding of individual status. Specifically, plasma glucose was to be between 4.4-13.9 mmol·L^{-1} (80-250 mg·dL^{-1}) one hour before diving; greater than the previous value and between 6.7-13.9 mmol·L^{-1} (120-250 mg·dL^{-1}) 30 min prior to diving; and greater than the previous level and between 8.3-13.9 mmol·L^{-1} (150-250 mg·dL^{-1}) immediately prior to diving. Refinements of this standard can be found. For example, the YMCA diabetic diver protocol allows plasma glucose levels of 6.7-12.8 mmol·L^{-1} (120-230 mg·dL^{-1}) with negative urine ketone tests in the hour period prior to diving (30). Specific targets can be adjusted as appropriate. The important point is that adherence to this type of monitoring schedule (including post-dive monitoring) can assist individuals with diabetes to optimize plasma glucose management in conjunction with diving.

CONCLUSIONS

We followed the plasma glucose response in seven novice adolescent divers with diabetes performing one to two dives per day in benign tropical waters. Hypoglycemia was a relatively rare event in this group. Hyperglycemia was much more common, particularly for males. Our data demonstrate that some adolescents with IRDM who have the cognitive and physical capabilities to learn the required information and with none of the secondary complications of diabetes, and who adhere to monitoring and safety protocols, can effectively manage their plasma glucose in relation to diving under benign conditions. Rapid improvements in glucose management during diving activities are possible with appropriate guidance. The importance of avoiding both hypoglycemia and hyperglycemia must be reinforced. Further studies on divers with diabetes are needed to increase the data on adolescents, evaluate plasma glucose response to a wide range of conditions and demands, as well as evaluate different insulin therapy strategies, the impact of voluntary acute elevation of plasma glucose on dehydration and decompression safety and long-term health, and whether the distractions of diving create a specific influence on selfawareness of hypoglycemic state.

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