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Special Topic

COMPUTER-ASSISTED INSTRUCTION FOR DIABETICS
An original project developed at the University of Liège, Belgium [1].

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Summary :

An experiment conducted at the University of Liège, Belgium in the computer-assisted teaching of juvenile-type insulin-dependent diabetics is reported. The course was designed to individualize teaching in order to give a minimum of basic information to a maximum of patients. The original computer-assisted instruction system DOCEO II is described; methods and programming techniques are summarized. The course was evaluated on fifty patients who attended the first four lessons. The improvement in knowledge was impressive : scores corrected for guessing were 9.59 ± 4.43 out of 20 before the course and 17.04 ± 2.26 out of 20 after the course (paired *t* test : $p < 0.001$). The system was enthusiastically accepted by the patients and is now routinely used in our Institution. Long-term studies are in progress to determine whether increased knowledge leads to better self-care, improved control and, ultimately, reduced incidence of diabetic complications.

Key words : Computer. Computer-assisted instruction. Diabetes. Diabetics. Evaluation. Teaching Process.

Résumé :

Enseignement assisté par ordinateur destiné aux diabétiques. Un système développé à l'Université de Liège.

On relate une expérience menée à l'Université de Liège (Belgique) portant sur l'utilisation des techniques d'enseignement assisté par ordinateur (EAO) au service de l'éducation de diabétiques insulinodépendants. On a conféré au cours un caractère préceptoral dans le but d'offrir à un maximum de patients un minimum d'informations élémentaires. Le lecteur trouvera une description du système original d'EAO DOCEO II ainsi qu'un résumé des méthodes et techniques de programmation. L'évaluation du cours a porté sur cinquante patients qui ont suivi les quatre premières leçons. Le gain cognitif a été important : les scores corrigés pour divination sont passés de 9,59 ± 4,43/20 à 17,04 ± 2,26/20 (test *t* de Student : $p < 0{,}001$). Le système a été accepté avec enthousiasme par les patients et est maintenant institué en routine dans notre établissement. Des études à long terme sont en cours, qui devraient indiquer si un gain cognitif entraîne une amélioration de l'autonomie des patients et du contrôle de leur maladie, et par conséquent réduit l'incidence des complications du diabète.

Mots clés : Ordinateur. Enseignement assisté par ordinateur. Diabète. Diabétiques. Evaluation. Processus didactique.

It is now universally accepted that patients with diabetes mellitus should actively participate in their own treatment and, consequently, receive appropriate instruction (1-3). Traditional ways to reach this goal usually include private discussions with the various professionals involved in the management of diabetes (nurses, dieticians, physicians, podiatrists, etc.), collective lessons and seminars, activities of patients associations (including books, journals and magazines), audiovisual aids, etc. (4, 5). In some Institutions, these various media are concentrated in special *Teaching Units* or *Teaching Centers* (5, 6). Unfortunately, one of the limiting factors in the development of teaching methods for diabetics is the great amount of time required from qualified individuals. Attempts to circumvent this difficulty have been made easier by the development of modern educational techniques such as teaching machines (4, 7, 8). In this perspective, a programmed course has been written on the basis of an original audiovisual Computer-Assisted Instruction (CAI) system (9).

1. Rapport présenté à la réunion de l'ALFEDIAM des 13 et 14 mars 1981 à Lille.

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The latter has been designed at the University of Liège (Belgium) and will be described hereafter.

In its present state, the program consists of seven lessons dealing with various aspects of insulin-dependent diabetes. A detailed assessment program (also computerized) has been conducted in order to collect data on patient's knowledge of diabetes self-care before and after completing the computer-assisted teaching program (and so, to determine the improvement of his score).

The aim of this paper is to describe briefly : [1] the initial conditions and objectives ; [2] the methodology adopted ; [3] the characteristics of the CAI system ; [4] its experimental use ; [5] its evaluation and [6] its acceptance by patients.

1. INITIAL CONDITIONS AND OBJECTIVES

Insulin-dependent diabetics were initially selected to participate in this educational program because a major part of their successful management involves the greatest degree of knowledge and therapeutic initiative from the patients themselves. Other factors relevant to good care include intellectual ability, age and sociocultural level (1, 2, 5, 7). The course was designed to *individualize* teaching in order to give a minimum of basic information to a maximum of patients. The only prerequisites were the ability to read fluently, knowledge of the common language and absence of serious mental deficiency.

The main objective in this CAI program has been to supply the patient with *knowledge* and to arouse his desire and increase his ability to put his knowledge into *practice*. In this perspective, we assumed that the patient would be able not only to repeat something memorized, as a result of a Skinnerian conditioning, but also to use his knowledge to solve most of the problems encountered in his daily life as a diabetic.

The content of the program has been defined in view of its integration into a broader educational context. For this purpose, we have selected questions which spring from the theoretical aspects and solicit inductive and deductive skills rather than mere memorization. Topics of the lessons developed so far are : [1] Carbohydrate metabolism ; [2] Pathophysiology of insulin-dependent diabetes ; [3] Insulin : aspects, packaging and use ; [4] Types of insulin and principles for adapting doses to standard daily situations ; [5] Hypoglycaemia ; [6] Dietary basic principles ; [7] Testing urine for glucose and ketone bodies.

2. METHODOLOGY

The target population being rather heterogeneous, we have adopted a tutorial approach, in which the learner's rhythm and abilities, as they appear in the conversational process, are taken into account. Functionally, the general structure of the CAI system-learner relationship can be described as shown in *Fig. 1*.

The part played by the system consists in giving the learner information, and checking the efficiency of the reception of the message by displaying a question (a). Each answer is stored (b) and formally analyzed in contrast with

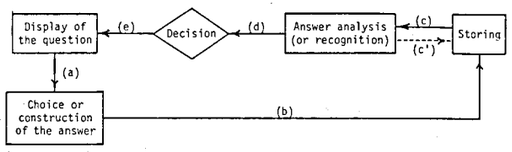

FIG. 1. — *General structure of the CAI system — learner relationship.*

stereotypes (c). The result of this analysis is memorized (c') and applied in the decision process (d). The nature and the content of the program feedback, *i.e.* comment, remedial sequence and/or selection of the next question (e), is determined either on the basis of the last answer or, in a more sophisticated and adaptive way, by referring to the content of the computer memory. Further details will be found in the description of the software (see 3.c.).

In this teaching method, it appears that making an error is considered, just as in daily life, as a natural occurrence, provided it is immediately recognized as such by the learner (10).

In the same way, the lessons arouse the subject's observation and reasoning as much as possible, in order to enable him, after a certain time, to reconstruct mentally vanishing notions and to increase his transfer of learning aptitudes, which the process of solving problems inevitably entails.

The matter has been thoroughly analyzed : with the help of relational matrices, it has been possible to bring out its various aspects and their relationship.

Most items make use of the multiple choice technique, which is easier for the patients than the constructed response, and turns out to be satisfactory as far as the diagnosis of mistakes and the determination of the appropriate remedial sequences are concerned.

The flexibility we intented to reach led us to adopt a great variety of programming structures. Yet, in the process of writing lessons, a certain number of standard algorithms emerged and, owing to their efficiency, have been repeatedly used in the course.

An example is given in *Fig. 2* in which the diagram shows the structure of one of the last sequences of the first lesson devoted to the role of insulin.

After a theoretical teaching sequence, the patient is asked to answer the following question :

Insulin produces : a rise in blood glucose 1
an increase of glucose penetration into cells 2
a reduction of glucose penetration into cells 3
a reduction of blood glucose 4
I don't know 5

From the beginning, the patient had been told that the correct answer was included in the list of the proposed answers and also that it could consist of one or several of the propositions (*e.g.* 1 ; or 1 and 3 ; or 1, 2 and 4, etc.).

The diagram shows how specifically the system reacts according, not only to the answer given, but also to information gathered during the lesson about the "pupil's" performances since the beginning of the lesson.

For practical reasons, the wording of the comments and other messages in the flow-diagram depicted in *Fig. 2* has

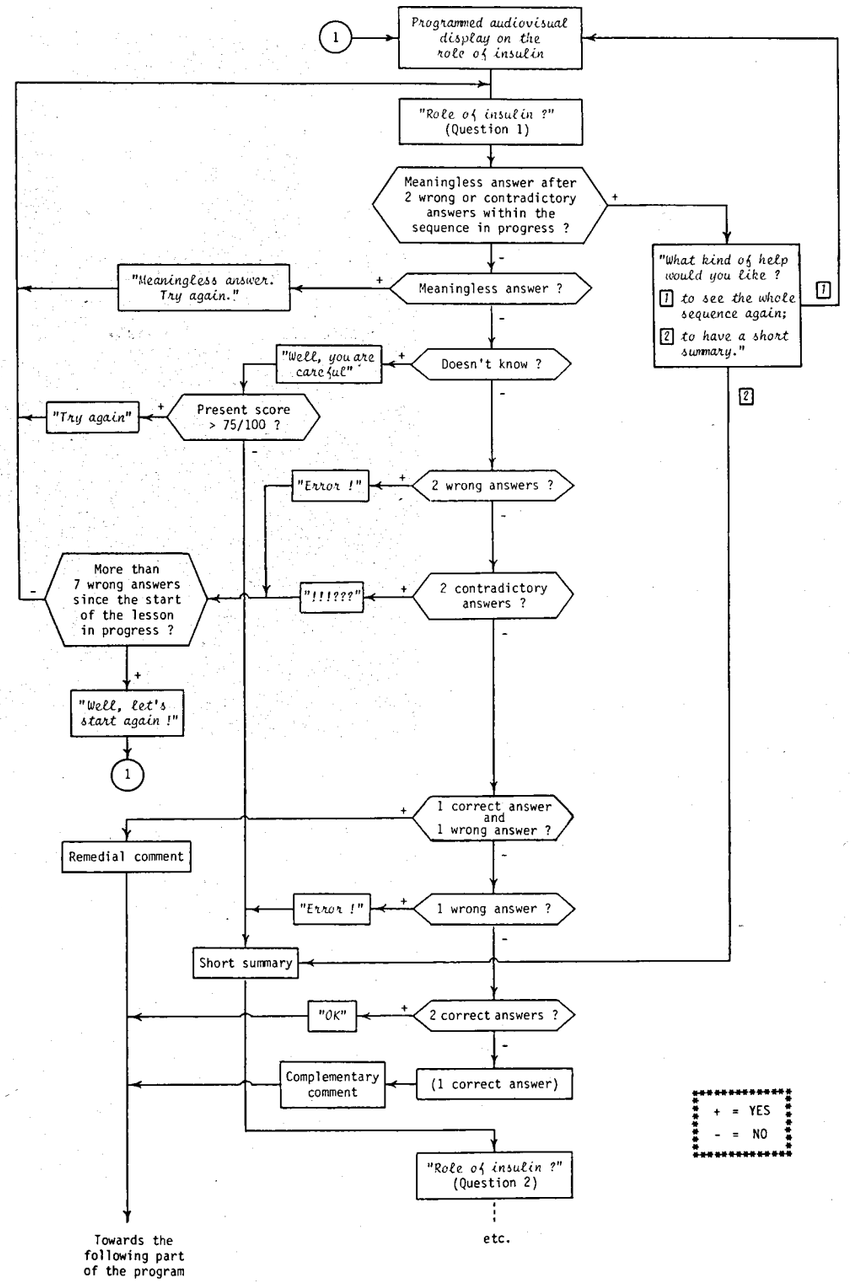

FIG. 2. — *Flow-diagram of a sequence about the role of insulin.*

been considerably condensed : it is actually far more explicit and occasionally rests on illustrations (*Fig. 3*).

Question 2 is the same as question 1 except for the last answer (I don't know) which has been withdrawn. The treatment of the answers is also similar but, if the patient, in spite of the help he has received, is still unable to provide the right answers (in this example, answers 2 and 4), the system gives them to him as explicitly as possible.

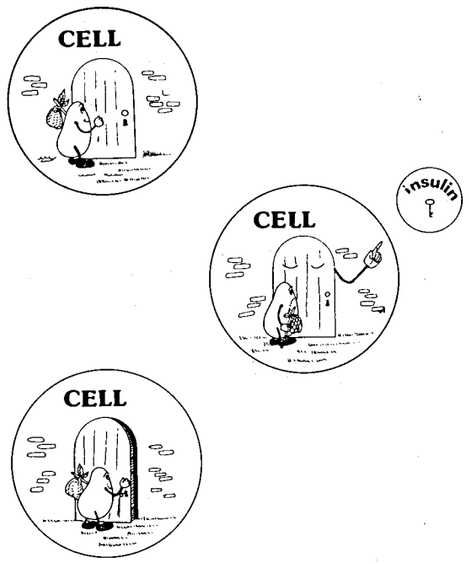

FIG. 3. — *Illustration used to explain that insulin plays the role of a key allowing glucose to enter the cell.*

3. FEATURES OF THE SYSTEM

The system has been named SIAM-DOCEO II : SIAM for « Système Informatique d'Anamnèse Multilingue », DOCEO from the latin *doceo*, I teach, and II since the system presently used is derived from the original DOCEO I system developed in 1965-1966 by one of us (11).

It consists of a central unit and a series of terminals for the hardware, and of a specially designed software.

a. The central unit

The central unit consists of a DEC PDP-8E mini-computer[2] with a 32K (12 bits-words) core memory, 2 disks of 32K, 3 disks of 1600K and 2 DECtapes (196K each). This configuration is capable of managing up to 10 terminals in time-sharing.

b. The terminals

Each specially designed terminal (*Fig. 4*) includes : an alphanumerical cathode-ray tube with an associated alphanumerical keyboard, a random-access Kodak ® slide projector with a rear projection screen, a Uher ® tape-recorder modified for selecting randomly audio-items from a hybrid (analog-digital) tape, earphones, and interface circuits.

FIG. 4. — *Audio-visual terminal of the DOCEO II-system.*

c. The software

A special purpose software has been elaborated which does not require a large central memory but allows great flexibility in programming lessons.

One of the main functions of the operating system, called RTS-LPC (Real-Time-Sharing in Language for Programming Conversational processes), is the interpretation of author's programs (A.P. *i.e.* courseware) written in a symbolic language, the LPC. To avoid the description necessary to account for all the possibilities of this language, we shall merely point out its main functional features. Users' answers can be chosen *or* constructed. In the first case, the user responds to a series of items by selecting one or more of the proposed answers, or by rejecting all of them. If, on the other hand, the answer is contructed, the technique of keywords is applied : as a matter of fact, the program is able to test their presence or their absence, the order in which they appear in the given answer, their number and their associations. Common misspellings are detected by simple algorithms.

At each step of the dialogue, the system may be programmed to modify its responses according to various criteria : whole or part of the previous pathway (including prior sessions), psycho-pedagogical profile of the user, latency of his answers, and so on. All these criteria may be combined in Boolean expressions. A number of routine control operations are automatically executed by means of permanent instructions included in the monitor program. The capacity of the system is considerably increased thanks to the availability of a set of auxiliary programs (written in Assembler), which may be activated from the A.P. Each lesson concludes with the storage of the different files (for the purpose of subsequent statistical analysis), and, if requested, with the printing of detailed reports for the users (patients, educational nurse, physician, etc.).

2. The transfer of our system onto a DEC PDP-11/44 is currently in progress (February 1981). For further technical information, please contact M. Bartholomé and M.-O. Houziaux, Co-directors of the Project (SMATI, Bât. B19, Université de Liège au Sart-Tilman, B - 4000 Liège, Belgium).

4. EXPERIMENTATION

So far, 117 patients have participated in the experiment which was supervised by two nurses specialized in teaching diabetics. Most patients were in-patients. All were individually informed about the twofold aim of the course : [1] to give them the opportunity to become more knowledgeable about their disease and, [2] to improve the efficiency of the methods and the lessons designed for them.

Our first program-trials soon revealed a number of methodological short-comings which we immediately corrected. For example, we soon realized that, in one of the sequences, we had failed to respect one of the principles we had decided to adopt when defining the methodology : patients should not be considered as pupils, in the usual sense (*i.e.* their self-respect should not be affected) ; it was, therefore, decided to forgo a rule which is generally followed in programmed instruction or computer-assisted instruction : learners should not be allowed to progress until they have mastered the notions taught so far. When really needed (*e.g.* to prevent a patient from becoming disheartened), the correct answer with an appropriate and explicit comment is provided.

5. EVALUATION

Rather than comparing results gathered in very dissimilar conditions, it was decided, at this stage of the experiment, to limit the evaluation to the elements of the experiment which were sufficiently homogeneous to be statistically analyzed. The present evaluation, therefore, deals only with the first four lessons attended by 50 in-patients during a period of 1 or 2 weeks.

TABLE I. — *Results of testing before and after the first four lessons*

	WA	OM	RA	SS ± S.D.	SG ± S.D.
Pre-test	194	236	520	10.95 ± 3.95	9.59 ± 4.43
Post-test	92	18	840	17.68 ± 1.76	17.04 ± 2.26

WA : wrong answers
OM : omissions
RA : right answers
SS : mean of simple scores (out of 20)
SG : mean of scores corrected for guessing (out of 20)
S.D. : standard deviation

All were insulin-dependent diabetics and were hospitalized either for initiation of insulin therapy or for changing insulin regimen. All were mentally alert, not confined to bed, and aware of the diagnosis of diabetes. There were 26 males and 24 females. The mean age (± S.D.) was 36 ± 15 years (range 13-74).

The efficiency of the teaching program was evaluated by submitting the patients to a 19-item questionnaire before (pre-test) and after (post-test) completing the first four lessons. The content was the same in the pre- and post-tests, but the formulation of the questions was not identical.

The pre-test was performed immediately before the first lesson and the post-test 24-48 hours after completion of the fourth lesson.

As shown in *Table I*, the mean ± S.D. of the simple scores (SS) was 10.95 ± 3.95 before the

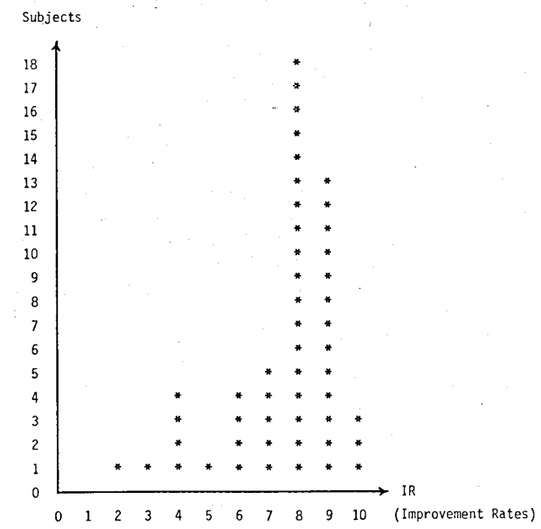

FIG. 5. — *Distribution of improvement rates in 50 patients after the first four lessons of the course. (From M.-O. Houziaux,* et al. *(6), with ccourtesy of Scientia Paedagogica Experimentalis.)*

TABLE II. — *Patients' opinions on the CAI course*

Subjects	Lesson 1 %	Lesson 2 %	Lesson 3 %	Lesson 4 %	Mean %
Totally negative opinion	12	6	—	2	5
Totally positive opinion	88	94	100	98	95
SPECIFIC OPINIONS[1]					
Respect of personal learning rhythm	38	32	46	64	45
Good understanding	38	42	64	70	53.5
Relaxed atmosphere	52	52	58	64	56.5
Alertness maintained	60	84	80	84	77
Too rapid a rhythm	2	2	—	2	1.5
Difficult comprehension	8	2	—	—	2.5
Difficult handling	—	2	—	—	0.5
Weariness	—	2	—	2	1

1. For interpretation of these percentages, see page below, par. 6.

course (pre-test) and 17.68 ± 1.76 after the course (post-test). When the scores were corrected for guessing (SG), they were 9.59 ± 4.43 and 17.04 ± 2.26 respectively (paired *t* test : $p < 0.001$). Those figures indicate not only that the average score has improved markedly, but also that the dispersion of the individual scores has been considerably reduced, as shown by the values of the standard deviations.

Fig. 5 shows an analysis of the distribution of the learners' improvement rate. The generally recommended formula for tabulating relative gain (absolute gain/possible gain) did not satisfy us since, with this formula, apparently equal relative gain might have very different meanings[3]. That is the reason why we adopted the formula established by P. Lambert (IR, Improvement Rate) to eliminate this effect of homogenization by taking into account relative gain *and* absolute gain[4]. The figure clearly shows a bimodality in the distribution of the improvement rates. The gain was quite impressive (IR = 6 to 10) as for the 43 patients whose improvement rates in score corrected for guessing constitute the main peak on the right of the figure. The smaller group of seven individuals whose IR ranged from 2 to 5 corresponds to patients whose scores were either high in the pre-test (14.7, 15.1, 15.8 and 17.2) and moderately increased in the post-test (respectively 17.5, 16.1, 17.8 and 18.6), or mediocre but above the mean in the pre-test (10.9, 11.6 and 13.3), with relatively little improvement in the post-test (respectively 13.3, 14.4 and 15.8).

3. For example, the relative gain will be of 100 % in these 2 cases :
1) pre-test score : 10/20 ; post-test score : 20/20 ;
2) pre-test score : 18/20 ; post-test score : 20/20.
4. The mathematics involved are too complex to be detailed here. For further information, consult M.-O. Houziaux *et al.* (9).

Fig. 6 shows the cumulative frequency curves of the scores corrected for guessing in the pre- and post-tests. One is favourably impressed by the greatly reduced dispersion of the scores on the right of the mean in the post-test. So the initial aim of giving a minimum of knowledge to a maximum of patients was attained : the scores (corrected for guessing) were 20/20 for 8 patients out of 50 (16 %), 18.5/20 for 13 patients (26 %) and 17-17.5/20 for 12 patients (24 %). It should also be noted that the three lowest post-test scores (11.5/20) were higher than the mean score of all patients in the pre-test (9.6/20).

6. ACCEPTANCE BY THE PATIENTS

Because of the flexibility of the teaching procedure in the present system, the time spent by the patients for a given lesson varied greatly from individual to individual. A mean of 30 minutes was needed for each of the first, second and fourth lessons with a range of 18 to 43 minutes. The third lesson lasted an average of 19 minutes (range 12-25 min.).

Each lesson ended with a multiple choice question allowing the patient to give his opinion on the method and the content of the lesson. *Table II* illustrates the answers given. A totally positive opinion was given by the vast majority of patients (from 88 to 100 % of the opinions) ; we cannot exclude the possibility that this high percentage of positive opinions may have been inspired by the wish to please. With regard to the specific opinions, only the presence of a comment (positive or negative) was to be considered, since patients were quite free to answer the questions or not. So, omitting « good understanding » does not mean « difficult understanding ». As evidenced in *Table II,* the first lesson has been found « difficult » by 8 % of the patients ; its

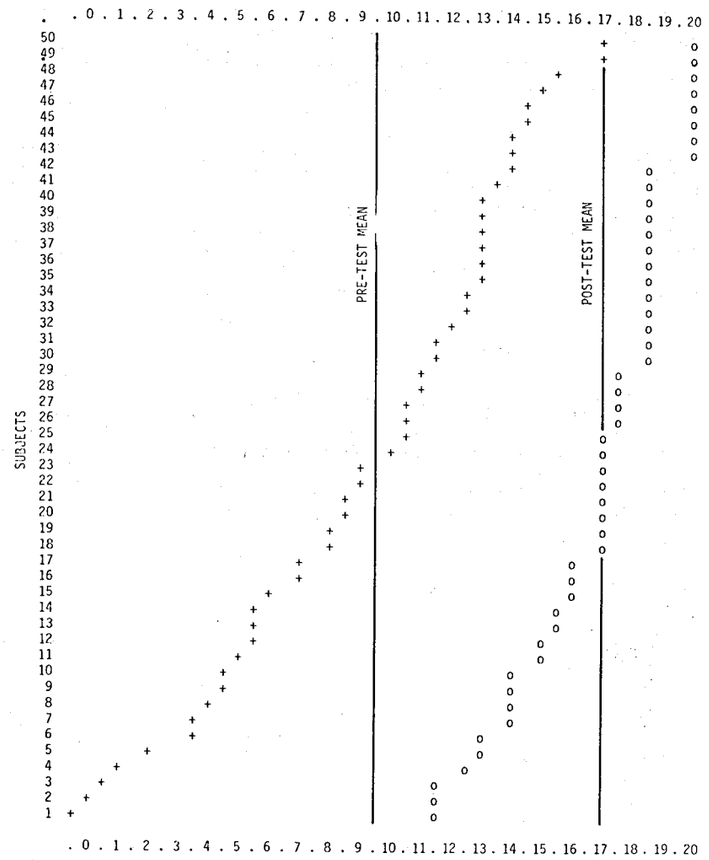

FIG. 6. — *Cumulative frequency curves for the pre- and the post-tests. (From M.-O. Houziaux,* et al. *(6), with courtesy of Scientia Paedagogica Experimentalis.)*

presentation will be slightly modified in accordance. Many patients expressed their opinion orally and emphasized the usefulness of the lessons, their interest in such a modern way of teaching and, often, their gratitude for what had been specially planned for them.

7. CONCLUSIONS AND PROSPECTIVE

Convinced that teaching diabetics is a cornerstone in their management and faced with the difficulties of providing every diabetic with the individualized education he/she may require, we have attempted to develop an original computer-assisted instruction course. This course has been designed to provide individualized teaching and to give a minimum of basic information to a maximum of patients. Our opinion is that such methods do not replace other more conventional ways of teaching (*e.g.* discussions with qualified professionnals, formal lectures or seminars, publications, movies, etc.) but should rather be incorporated into a general multimedia teaching policy which, of course, will vary from place to place, depending on the human, technical and financial possibilities available.

The evaluation of our system in fifty insulin-requiring diabetics having completed the first four lessons of the course is rather promising considering the impressive gain in knowledge and the 88 to 100 % enthusiastic acceptance by the patients. At the time of writing, a total of 117 patients have been involved and the method is used routinely in our Institution. Evaluation have been performed on the basis of a pre- and post-test paired comparison. Given the positive results obtained and the positive impact on our population of insulin-dependent diabetics, we have decided to pursue the experiment.

Further long-term studies are in progress to determine whether increased knowledge leads to better selfcare (12), improved control and, ultimately, reduced incidence of diabetic complications.

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Mise au point

IMPUISSANCE SEXUELLE ET TROUBLES DU MÉTABOLISME GLUCIDIQUE

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Résumé :

L'impuissance sexuelle érective constitue une des complications les plus fréquentes du diabète ; exceptionnellement elle peut être le symptôme de cette affection : bien qu'elle ne mette pas directement la vie du malade en danger, elle est parfois ressentie de façon dramatique et peut, dans certains cas exceptionnels, aboutir à un suicide.

Il importe donc de bien en connaître les différents mécanismes d'une part *psychogènes* plus importants qu'on ne le pense habituellement chez le patient diabétique, d'autre part *organiques* particulièrement vasculaires et neuropathiques, rarement endocriniens.

En dehors des cas de diabète franc, on trouve une proportion anormalement élevée de courbes d'intolérance au glucose chez les patients souffrant d'impuissance érective dite « psychogène ». Chez ces patients, le trouble glucidique pourrait être soit le reflet neuro-endocrinien d'une perturbation neuropsychologique, cause ou conséquence de l'impuissance, soit à la base de troubles neuropathiques débutants, origine de l'impuissance.

La bonne compréhension des mécanismes complexes liant les perturbations du métabolisme glucidique et l'impuissance sexuelle demande donc une exploration et une concertation pluridisciplinaires : c'est à ce prix que pourra être établi et conduit un traitement comprenant à des degrés divers la psychologie, la sexologie, l'endocrinologie, voire la chirurgie urologique et vasculaire. L'efficacité de ce traitement sera directement fonction de la qualité de l'approche étiopathogénique réalisée individuellement pour chaque malade.

Mots clés : Diabète. Intolérance au glucose. Impuissance sexuelle. Gonadotrophine. Testostérone.

Summary :

Sexual dysfunction and disordered carbohydrate metabolism

Sexual impotence with inability to produce erection is a frequent accompaniment of diabetes. Only exceptionally however is impotence complained of as a symptom. Though in no direct sense a danger to the patient's life, impotence is sometimes a source of major distress and, in a few exceptional cases, may lead to suicide. It is therefore important to distinguish the different mechanisms underlying impotence, and in particular to differentiate psychogenic mechanisms, far more relevant than formerly thought in diabetic patients, from organic mechanisms, in particular neuropathic and vascular, uncommonly, endocrine.

Besides cases of unequivocal diabetes, there is an abnormally high proportion of patients suffering from « psychogenic » impotence affecting erection who have impaired glucose tolerance. In such patients the disordered metabolism could reflect at neuroendocrine level the existence of neuro-psychological dysfunction, either a cause or a consequence of the impotence. A second possibility is that the metabolic disorder directly impairs neurological function, resulting in neuropathic impotence.

Clearer understanding of the complex mechanisms relating disturbance of carbohydrate metabolism to sexual impotence requires multidisciplinary approaches. Such arrangements are necessary for the planning and conduct of schemes of treatment involving to varying extents the special approaches of psychology, sexology, endocrinology, urology and vascular surgery. The success of such treatment will depend largely upon the quality of the diagnostic and therapeutic approach which requires individualised planning.

Key words : Diabetes. Glucose Intolerance. Gonadotropine. Testosterone.

Depuis plusieurs décennies, il est connu que l'impuissance sexuelle frappe une proportion importante de patients diabétiques (de 30 à 60 % selon les statistiques) (revue dans [1]) ; cette incidence va en croissant parallèlement à l'espérance de vie du diabétique. Le diabétologue sera donc de plus en plus souvent confronté avec le problème du traitement de l'impuissance sexuelle chez des patients parfois jeunes. Mais l'impuissance sexuelle chez des patients parfois jeunes peut également constituer le signe d'appel permettant de découvrir un diabète

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