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Anorexia Nervosa: A Discriminant Function Analysis

By W. S. WRIGHT, M. K. C. MANWELL and J. D. MERRETT

Introduction

The diagnosis of anorexia nervosa is not always straightforward. Bliss and Branch (1960) regard all non-organic conditions causing anorexia as anorexia nervosa. However, more recent authors like Dally and Sargant (1960), King (1963), Crisp (1965*b*) and Bruch (1965) limit the use of the diagnostic label anorexia nervosa to a highly specific entity. Many patients who present with loss of weight and/or loss of appetite fit easily into this classical anorexia nervosa category, whilst many others are equally easily excluded.

Bruch (1965) has suggested that the frequency of anorexia nervosa in clinical practice is increasing. This may in part be due to the referral of cases which are milder, and in these the diagnosis may prove more difficult. It has also been the authors' experience that diagnosis in a minority of cases is only reached after considerable in-patient observation.

Accepting that some patients can readily be categorized as suffering from anorexia nervosa whilst others display anorexia and weight loss of non-organic origin, it was decided to examine the clinical features which might discriminate most clearly between the two groups, referred to hereafter as the "anorexic" and "control" groups respectively, by means of the linear discriminant function method of Fisher (1938).

Material

From 1 February 1958 to 31 December 1965 486 patients who had been classified as having disturbance of food intake and/or disturbance of weight, or any combination of these items, were seen in the University Department of Mental Health, Belfast City Hospital. Clinical information about all patients attending the department is coded on an eighty-column I.C.L. punch card. After a search of the relevant literature, it was decided to include twenty-four variables which were thought to be important in distinguishing between the two groups (see Appendix I). An item was scored only if specific mention was made of it in the patients' notes. Where an item was not mentioned, that patient was excluded from the study (see below), since non-mention is not necessarily synonymous with absence.

It was impossible to include several clinical features, e.g. disturbance of body image, autistic behaviour, details of attitude to food, for the above reason.

It was decided to exclude from the original sample:

(a) male patients,

(b) patients for whom complete information on the twenty-four variables was not available,

(c) patients who were overweight or those who over-ate, and

(d) patients in whom diminished food intake or weight loss or thinness were regarded as "non-significant". "Significance" was ascribed when the feature was a presenting complaint in the initial history as given by the patient or her relative, and is not to be confused with statistical significance defined later.

For these reasons, 359 patients in the original sample were omitted. Of the remaining 127 patients, 104 were classified as control and twenty-three as anorexic. In this latter group the diagnosis was that of the consultant psychiatrists using the criteria generally accepted as essential features of the condition—amenorrhoea, aversion from food, loss of weight, motor restlessness, the latter, however, not being regarded as an essential feature.

Method of Analysis

The aim was to discriminate between anorexic and control patients, using clinical data as

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variables for linear discriminant functions derived by Fisher's (1938) method. This analysis yields a formula of the form

$$Y = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

where Y is the discriminant score (predicted value of variable y) for given values of X_1, X_2, ... X_n; the values of a, b_1, b_2, ... b_n are derived from the data and the b's are known as regression coefficients.

For both groups combined the mean discriminant score is Y = 0, so that an individual would be allotted to a group depending on whether substitution of his X values in the formula results in his value of Y being greater or less than zero.

All computations were performed on the I.C.L. 1905 computer at the Department of Applied Mathematics at the Queen's University of Belfast, using a multiple regression program (XDS 2).

Data

Twenty-four variables and assessments of them (Appendix I) were used to discriminate between the anorexics and the controls. Several of these assessments were qualitative and were scored conjointly by the clinicians (Appendix I) before application of Fisher's linear discriminant function technique. Information for these variables was available for twenty-three anorexic and 104 control patients.

In the present analysis the value $y = 0{\cdot}8189$ was allotted to each member of the anorexic group and the value $y = -0{\cdot}1811$ to each of the control group (using the formula of Fisher, 1938).

In subsequent discussion individual variables are denoted by the variable number in brackets.

Results

Of the twenty-four variables included, only four contribute significantly (at $p<{\cdot}05$ used throughout) to the discrimination, and the omission of the other twenty does not produce a significant loss in discrimination ($F = 0{\cdot}78$, $n_1 = 20$, $n_2 = 102$, $p>0{\cdot}20$).

The four significant variables are:

Amenorrhoea (7)
Pulse rate (10)
Lanugo (12)
Denial of illness (13).

Significant discrimination is obtained using only these four variables ($F = 440{\cdot}28$, $n_1 = 4$, $n_2 = 122$, $p<0{\cdot}001$); the multiple correlation coefficient (R) is high, 0·967. Furthermore, the regression coefficient (b) of each of these four variables is significantly different from zero, suggesting that each variable makes a significant contribution to the discrimination.

The function is:

$$Y = 0{\cdot}630\,X_7 - 0{\cdot}001\,X_{10} + 0{\cdot}238\,X_{12} + 0{\cdot}153\,X_{13} - 0{\cdot}077$$

and has a theoretical misclassification rate of less than 1 per cent.

The average discriminant score of the anorexic group was 0·7658, and that of the control group −0·1694. Substituting the observed values of the four variables for a given member (of either group) results in an estimate of Y which if greater than zero classifies that member as anorexic, and if less than zero classifies him as control. For example, the discriminant score of a patient presenting with the clinical features of amenorrhoea (score 1), lanugo (score 1), a pulse rate of seventy beats/minute, and denying the presence of illness (score 1) is calculated as follows:

$$Y = 0{\cdot}630\times1 - 0{\cdot}001\times70 + 0{\cdot}238\times1 + 0{\cdot}153\times1 - 0{\cdot}077 = 0{\cdot}874$$

Calculation of each member's discriminant score (Y) resulted in none of the anorexic group being classified as control, and two (1·9 per cent) of the control group being classified as anorexic; thus classification of 125 (98·4 per cent) of the 127 members was in agreement with the clinical classification. The results agree reasonably with the theoretical expectation of the percentage correctly classified (i.e. >99 per cent).

The discriminant scores were found to be normally distributed in the anorexic group ($g_1 = -0{\cdot}69\pm0{\cdot}48$, $0{\cdot}20>p>0{\cdot}10$; $g_2 = 0{\cdot}95\pm0{\cdot}93$, $0{\cdot}40>p>0{\cdot}30$) but not in the control group ($g_1 = 5{\cdot}58\pm0{\cdot}24$, $p<0{\cdot}001$; $g_2 = 3{\cdot}46\pm0{\cdot}47$, $p<0{\cdot}001$).

Check sample

A check sample was obtained to see how well the function discriminated on another set of data. Seventeen cases of anorexia nervosa were obtained by searching the records of an adjoin-

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ing teaching hospital. The diagnosis in these cases was made by the consultant physician in charge of the endocrinology unit. Thirty-one control patients were obtained from cases rejected previously because of incomplete data on the twenty-four variables, but with information on the four relevant factors. The discriminant score for each member was calculated, with the result that the discriminant classification of each member agreed with the clinical diagnosis.

Discussion

Several theoretical conditions must be fulfilled for a valid derivation of a discriminant by Fisher's (1938) method. Firstly, the variables used should be normally distributed; secondly, the elements of the "sums of squares and products" matrix for the anorexic group should be similar to corresponding elements of the matrix for the control group; and thirdly, the discriminant scores should be normally distributed within each group. Unfortunately, the present data do not satisfy each of these criteria completely. Theoretically, the use of a quadratic function may be more valid, but the difficulties in the practical application of such a function are obvious.

The derived function favours different combinations of the following variables as most suggestive of a classification of anorexic: the presence of amenorrhoea, a low pulse rate, the presence of lanugo, and the denial of illness. In contrast, the function suggests that a classification of control is the more probable when various combinations of the following are observed: the absence of amenorrhoea, a high pulse rate, the absence of lanugo, and the admission of illness by the patient.

Perhaps the best justification of the practical application of any discriminant function, in spite of the theoretical deficiencies of the data, is a low misclassification rate. In the present data the misclassification rate was only 1·6 per cent. However, the crucial test of the practical value of any discriminant function is to see how well it discriminates with data which have not been used to derive the function.

The data of forty-eight patients (seventeen anorexics and thirty-one controls) were used for this purpose; in no instance did the discriminant classification disagree with the clinical diagnosis.

The finding that amenorrhoea is a useful discriminator between anorexics and controls is hardly surprising, since most recent authors, e.g. King (1963), Nemiah (1950) and Crisp (1965*b*), regard it as one of the important diagnostic criteria.

The importance of the presence of lanugo appears to be a finding of particular usefulness, since it is rarely found in other conditions.

Denial of illness has long been recognized as an important feature of anorexia nervosa (Gull 1874; Lasègue, 1873), and this view is supported by the present analysis. Undue optimism and cheerfulness are usually described in association with denial, but this association has not been found. Mood disturbances appear to be similar to those in other psychiatric conditions.

Gull (1874) described bradycardia in anorexia nervosa, and King (1963) found that pulse rate differentiated between his primary and secondary group of anorexia nervosa. This finding has been confirmed.

Poor sexual adjustment, with symbolization of food and fatness, has received extensive attention in the literature to the point where some authors regard it as a *sine qua non* for the diagnosis of anorexia nervosa. Crisp (1965*b*) has made the point that all of his patients had been subjected to sexual trauma, real or imagined. Sexual adjustment, as defined, does not emerge as significantly different in patients with anorexia nervosa and a control group of psychiatric patients. Crisp (1965*a*) has also pointed out that the age of menarche is younger in patients with anorexia nervosa. Again, this factor has been shown to have no discriminatory power.

Nemiah (1950) found a high incidence of overtly protective parents, with patient dependence, while King (1963) found the combination of a dominant restrictive mother and a passive father most significant. Using instead the concept of disturbed–not disturbed (Appendix I) no difference was found in parent–patient relationships between anorexic and control groups.

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Many disturbances of food intake have been regarded as characteristic of anorexia nervosa (Appendix I). King (1963) found that only bulimia and constipation were useful clinically but these have not been shown to differentiate.

The obsessional personality traits described by Kay and Leigh (1954) and by King (1963) are not apparent, and are not useful discriminators.

Whilst it is appreciated that the final four variables could have been recognized either by inspection or by the use of simpler statistical techniques, these methods could not have been used to omit the other twenty variables, as neither can take into account the possible interactions between some of them. The fact that some twenty variables have been omitted is of significance only in so far as they do not serve to discriminate between anorexia nervosa patients and others. It does not mean that the variables are unimportant in the condition, but rather that their frequent occurrence in the control group greatly diminishes their differential diagnostic value in patients referred to a psychiatric clinic with anorexia and weight loss. Thus it would seem that the clinician has to rely much more on physical factors than on psychopathology in arriving at a diagnosis. If this is so, then early diagnosis is indeed difficult to achieve with a high degree of certainty, as it is usually not until the condition is well established that obvious physical features emerge. The results of this inquiry tend to suggest that a further search for useful discriminators in a prospective study might assist in early diagnosis.

Summary

Data were available for twenty-four clinical variables relating to twenty-three anorexic and 104 control patients and a linear discriminant function in four variables was derived to distinguish between the two groups, with a resulting misclassification rate of 1·6 per cent. These variables were: amenorrhoea, pulse rate, lanugo, and denial of illness. These four were used in a check sample of seventeen anorexics and thirty-one controls, and the discriminant score confirmed the clinical diagnosis in each case.

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Appendix I

Variables used in discrimination function analysis

Variable	Description
X_1	Age at time of referral in years.
X_2	Age at onset of present illness in years.
X_3	Sexual adjustment. Score 0: Good: Enjoying petting with boy-friend or, if younger, enjoying the company of boys, dating, etc.; in marriage enjoyment of sexual relations. Score 1: Fair: Having boy-friend and tolerating kissing; in marriage toleration of sexual intercourse without enjoyment. Score 2: Poor: Having had no boy-friends, or no interest in the opposite sex: in marriage, revulsion with frigidity and/or dyspareunia.
X_4	Obsessional traits. Score 0: Absent: No checking. Score 1: Present to a slight degree; mild checking; orderly. Score 2: Present to a marked degree; extreme and repeated checking; perfectionism.

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Variable	Description
X_5	Relationship with father. Score 0: Not disturbed—minor hostilities, e.g. over hair styles, clothes. Score 1: Disturbed: death or absence of one or both parents before age of 15. Over-dependent, requiring parent(s) to decide on everything; "homesickness"; history of anxiety on separation; never leaving parents. Hostile—reported continual rows between patient and parent(s); patient reporting being picked on; verbal attacks on parents to doctor.
X_6	Relationship with mother. Score 0: Not disturbed. Score 1: Disturbed—as defined above.
X_7	Amenorrhoea. Score 0: Absent: If menstruating, or if amenorrhoea due to pregnancy, hysterectomy; if patient menopausal age range (40–50), or if premenstrual. Score 1: Present: Missing at least one period and no other obvious cause.
X_8	Systolic blood pressure in mm. Hg.
X_9	Diastolic blood pressure in mm. Hg.
X_{10}	Pulse rate—measured during physical examination.
X_{11}	Peripheral cyanosis. Score 0: Absent. Score 1: Present.
X_{12}	Lanugo. Score 0: Absent: no abnormality of body hair distribution, or if hirsutism of face, chest, abdomen and distal extremities. Score 1: Present: Fine downy growth of hair on back, shoulders and upper arms.
X_{13}	Denial of illness. Score 0: Absent: Admission of illness either physical or psychiatric, or concern over symptoms. Score 1: Present: Persistent claims to well-being and health.
X_{14}	Anorexia. Score 0: Absent. Score 1: Present.
X_{15}	Vomiting. Score 0: Absent. Score 1: Present.
X_{16}	Bulimia. Score 0: Absent. Score 1: Present.
X_{17}	Discomfort after meals. Score 0: Absent. Score 1: Present.
X_{18}	Poor intake of food. Score 0: Absent. Score 1: Present.
X_{19}	Constipation. Score 0: Absent. Score 1: Present.
X_{20}	Age of menarche in years.
X_{21}	Father's age at birth of patient.
X_{22}	Mother's age at birth of patient.
X_{23}	Religion. Score 0: Inactive. Score 1: Active.
X_{24}	Mood. Score 0: Depressed—depression, sadness, anxiety, tension, worry. Score 1: Normal—no marked deviation. Score 2: Cheerful—patient is bright, chatty, flippant.

Appendix II

Distribution of each variable which contributed significantly to the discrimination

	Anorexic		Control	
	No.	%	No.	%
7. Amenorrhoea				
Absent	—	—	102	98·1
Present	23	100·0	2	1·9
10. Pulse rate (beats/min.)				
<60	5	21·7	2	1·9
60–	10	43·5	4	3·8
70–	4	17·4	14	13·5
80–	3	13·0	44	42·3
90–	1	4·3	16	15·4
100–	—	—	12	11·5
110+	—	—	14	13·5
Mean	65·4	—	87·6	—
12. Lanugo				
Absent	6	26·1	104	100·0
Present	17	73·9	—	—
13. Denial of illness				
Absent	5	21·7	99	95·2
Present	18	78·3	5	4·8
Total	23	100	104	100

W. S. Wright, M.B., B.Ch., B.A.O., D.P.M., *Medical Director, Welfare and Guidance Clinics, Queensland Health Department, Queensland, Australia; formerly Tutor Registrar, Department of Mental Health, Queen's University, Belfast 7*

Morna K. C. Manwell, M.B., B.Ch., B.A.O., D.P.M., *Registrar, Department of Child Psychiatry, Belfast City Hospital, Lisburn Road, Belfast 9; formerly Senior House Officer, Department of Mental Health, Queen's University, Belfast 7*

J. D. Merrett, B.Sc., Ph.D., *Senior Lecturer in Medical Statistics, Department of Medical Statistics, Queen's University, Belfast 7*

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