

THE STUDY OF JUDGMATIC METHOD OF FUZZY EVALUATION OF ANAEROBIC THRESHOLD(AT) ABOUT EXERCISE LOAD TEST OF CARDIO-PULMONARY FUNCTION

Zhu Bao-yu

Department of Internal Medicine of the General Hospital, Tianjin Medical University, Tianjin, China

ABSTRACT

In this paper, we make use of the method of Truth-Valued-Flow Inference(TVFI) and Fussy random falling shadow to carry on affirmation of anaerobic threshold(AT) for every factor index. Final we establish the AT with the method of multifactoral evaluation base on judgement criterions of AT. The result of clinical analysis is in keeping with actual practice. It is a actual value of clinical practice.

Keyword: Fuzzy Mathematics Lung Function Exercise Load Test

1. preface

The exercise test of cardio-pulmonary function is a diagnosis method. It is applying to cosmo-medicine, exercise medicine and clinical medicine. By the method of exercise test we can check and measure function of the circulation system and breath system of human body. For a certain disease it can assist us to investigate the patho-physiologic mechanism, to know the developing degree and to judge the healing effect and prediction. By exercise test we can be serve as a guardian for variety of cardio-pulmonary function of human body in order to find physical abnormal variation early and to carry on the prevention and treatment. Therefore, it is a good method which is clinical diagnosis of disease and divided degree of cardio-pulmonary function.

The Anaerobic threshold(AT) refers the level absorbed oxygen when reaching the exercise load. If the exercise load surpasses the level absorbed oxygen there will be the Anaerobic energy supply. The AT is the intensity of exercise load when the anaerobe anabolism has been replaced the aerobic anabolism in exercise load added increasingly or when the lactic acid enhances suddenly in the blood of human body.

The test of AT can predict the ability and achievement of exercise, therefor it is not only applying to the exercise medicine but also to clinical medicine. It is important and complex problem that we judge the AT in researching of exercise load of cardio-pulmonary function. When reached the AT, it is a difficult foras to judge the AT by artificial method because the variety of each index is ununity and because the sensitiveness, exactness and reliableness of each index are also different in the AT judgment. We make use of the method of Truth-Valued-Flow Inference(TVFI) and Fuzzy random falling shadow as well as the method of multifactoral evaluation to carry on affirmation of

anaerobic threshold(AT).The result is a good. It is a practical value.

2.Math Model is Formed

Based on the principle of Truth- Valued- Flow Inference(TVFI) we can affirm whether the X should conform concept P or not about X of certain object. Let the $P(x)$ express the "x is P" of thesis. When the X is changing, the concept P can express Common or Fuzzy set in set X. The truth value of thesis is equal to membership degree of set.

$$T(p(x)) = \mu p(x)$$

The form of inference is IF... THEN... . In same target(factor index) there is $P(x) \rightarrow Q(x)$. Before reaching AT the some targets, such as ventilative volume and consumption of oxygen etc, they increase at a certain rate. After reaching AT they add increasingly at a greater rate in order to adapt to necessity of human body, but the consumption of oxygen decreases gradually because the volume of necessity of oxygen of the body increases and oxygen is not enough, when reaching the AT. Due to the variety of the rate we can get another result, that is $P(y) \rightarrow Q(y)$.

If $X=a$, the factor index X_{ab} increases and decreases at certain rate. We can get a channel of inference. It is shown by $P(a) \rightarrow Q(a)$. Therefor we can get a line A which is the oblique rate of aa . If $x=b$, the factor index X_{ab} increases and decreases at another rate. We can get another channel of inference. It is shown by $P_1(b) \rightarrow Q_1(b)$. Then we can get a line B which is the oblique rate of bb . The line A and B cross at the point ab . The point $ab(x_1, y_1)$ refers to AT of the factor index X_{ab} .

In the same way, we can get $AT(X_n, Y_n)$ of other factor index. Based on the principle of fuzzy projective .Let $f \rightarrow \mu(x)$. that the AT of every factor index falls on the time axes forms the time set of AT. Then we can affirm the time of AT by fuzzy multifactorial evaluation. Therefor we shall get the value of AT of every facor.

3.Application

based on the judgment standard of AT, in incremental exercise load test after reaching certain work (1) the AT is a turn point of which the VE goes up suddenly. (2) the AT is a tuen point of which the VE/V_{O_2} rises keenly but the VE/V_{CO_2} doesn't go up. (3) the AT is a turn point of which the $FeO_2\%$ increases markedly. (4) the AT is a turn point of which the V_{CO_2} goes up suddenly. (5) the AT is a point of which V_{O_2} and V_{CO_2} cross. (6) the AT is a turn point of which the R rises keenly.

About the VE, before reaching the AT the value of VE increases at 0.5-1.0L/min. After reaching the AT the value of VE increases at 3-4L/min. Then we can get the point ATV which two lines cross. The two lines which are different oblique rate in front and backe of the AT cross the point $ATV(14, 22.5)$ which falls on atl of the time axes. The

point at1 is the time of AT of the VE(see table and fig).

Table The Result of Exercise Test of Patient Yang

TIME	MV	BF	FO2	FCO2	RQ	HR	VO2	VCO2
0.5	15.2	25	2.72	2.43	0.86	110	0.35	0.30
...
11.0	21.8	28	2.87	2.99	0.92	113	0.51	0.43
11.5	22.6	29	2.91	3.09	0.94	114	0.53	0.46
12.0	21.4	28	2.86	3.06	0.94	113	0.49	0.44
12.5	21.9	26	2.93	3.07	0.95	112	0.52	0.45
13.0	21.8	28	2.85	3.10	0.95	114	0.50	0.48
13.5	21.2	27	2.85	3.01	0.96	116	0.49	0.48
14.0	22.5	28	2.90	3.04	0.98	114	0.53	0.51
14.5	23.7	30	2.88	3.05	0.99	117	0.55	0.55
15.0	25.3	29	3.05	3.17	1.04	116	0.63	0.66
15.5	26.4	30	3.13	3.26	1.04	116	0.67	0.71
16.0	27.7	30	3.14	3.31	1.06	116	0.70	0.75
16.5	29.9	33	3.07	3.23	1.06	120	0.74	0.79
17.0	32.1	31	3.05	3.23	1.06	121	0.79	0.85
17.5	33.4	31	3.17	3.44	1.10	122	0.85	0.94
18.0	35.8	32	3.18	3.40	1.08	124	0.92	1.00
19.5	37.5	35	3.19	3.63	1.18	133	0.95	1.12

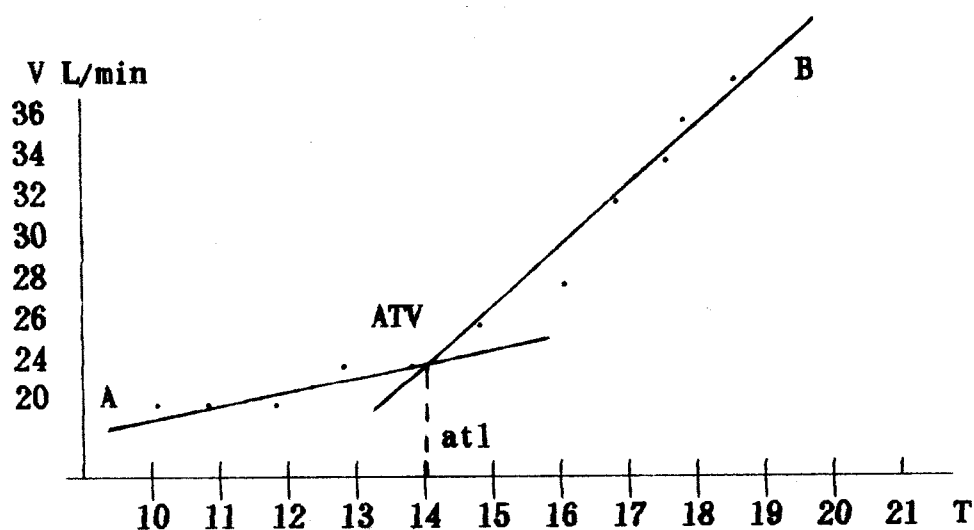


Fig. The Judgment of AT about factor VC

Based on the same reason, some factors such as FO_2 , VE/VO_2 , R , ..., VCO_2 etc, we can get the AT of every other factor. They are respectively $at_2=(15, 3.05)$, $at_3=(14.5, 43)$, $at_4=(15, 1.04)$, $at_5=(15, 0.63)$, $at_6=(14.5, 0.55)$. The time of AT of every factor is respectively 14min, 15min, 14.5min, 15min, 15min, 14.5min. The range of time is between 14min and 15min. We can get the evaluation set $V=(v_1, v_2, v_3)=(14min, 14.5min, 15min)$, but what is the time of precise AT? Now we affirm it by the method of fuzzy

multifactorial evaluation as follow.

(1). We establish the relation matrix R.

$$R = \begin{matrix} & \begin{matrix} V1 & V2 & V3 \end{matrix} \\ \begin{matrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{matrix} & \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \end{matrix}$$

(2). Distribution of number of weighted for all the factor is respectively $A=(a_1, a_2, \dots, a_6)=(0.15, 0.15, 0.15, 0.2, 0.2, 0.15)$.

Based on the formula $B = A \circ R$ we can get the evaluation vector B.

$$B = A \circ R = (0.15, 0.30, 0.45)$$

We know that the time of AT is at 15 min after exercise by the principle of maximum membership degree. Therefore we can get the values of every other factor, such as $VE=25.3, BF=29, FO_2\%=3.05, Fco_2\%=3.17, R=1.04, HR=116, Vo_2=0.63, Vco_2=0.66$, when reaching the AT.

4. Conclusion

In incremental exercise load test the AT is corresponding intensity of exercise load when the body reaches anaerobic anabolism. Exercise time and intensity are among them too when reaching the anaerobic anabolism. Based on judgment standard of the AT and the principle of Truth-Valued-Flow Inference (TVFI) as well as the principle of fuzzy projective, let the variation of every factor space of the AT unify in range of time. Then we can affirm the time of AT by fuzzy multifactorial evaluation. At the same time we can get the value of AT of every factor. The result conforms to an objective reality by analysing. The method is good. It is an actual value of clinical medicine.

5. Reference

1. Wasserman K, et al. *Excercise physiology in health and disease. Am rew Respir Dis.* 1975, 112: 219
2. Mu kui-jing and Lin you-hua, *Measurement Principle and Clinical Applying of Lung Function.* (1992), P. 33 - 216.
3. Wang Pei-zhuang, *Introduction to Fussy Mathematics, Mathematics Inprectice and theory,* (1980), P. 55 - 110.
4. Zhu Bao-yu, *Fussy Pattern for Early Diagnosis of Cor Pulmonale, Fussy Systems and Knowledge Engineering,* 1987, No, 7.