Applied Mathematics and Nonlinear Sciences

<https://www.sciendo.com>

The Model of Sugar Metabolism and Exercise Energy Expenditure Based on Fractional Linear Regression Equation

Jinchao Gao^{1,†}, Fahd S Alotaibi^{2,‡}, Ragab Ibrahim.Ismail^{3,§}¹ School of Sports Leisure, Beijing Normal University Zhuhai, Guangdong 519087, China² Information Systems, Faculty of Computing and Information Technology, Jeddah, Saudi Arabia³ Department of Accounting and Finance, Faculty of Administrative Sciences, Applied Science University, Al Eker, Kingdom of Bahrain

Submission Info

Communicated by Juan Luis García Guirao

Received April 12th 2021

Accepted July 7th 2021

Available online July 27th 2021

Abstract

Carbohydrate metabolism can provide energy for human exercise. However, different exercise intensities will consume different amounts of energy. For this reason, the paper uses a fractional linear regression equation to study the characteristics of carbohydrate metabolism and energy consumption of other groups of human beings with the same oxygen consumption during exercise. In addition, the thesis measures energy consumption during exercise and body recovery by analyzing gas metabolism methods. As a result, we found that the sugar, fat metabolism, and energy consumption of heavier volunteers under the same exercise intensity were lower than those of regular weight volunteers. Thus, the fractional linear regression method can help us analyze the relationship between glucose metabolism and exercise energy.

Keywords: Fractional linear regression equation; continuous exercise; intermittent exercise; energy expenditure; glucose metabolism
AMS 2010 codes: 62J05.

1 Introduction

Obesity has become a global social problem. Cardiovascular and cerebrovascular diseases and diabetes-related to obesity endanger human health. Prolonged aerobic exercise can reduce the risk of metabolic diseases, improve cardiorespiratory function and maintain weight. How to achieve rapid weight loss and health promotion by changing the intensity and method of exercise needs further research [1]. At present, some scholars have proposed that high-intensity interval exercise training (HIIT) can increase a person's maximum oxygen uptake level

[†]Corresponding author. Email address: cnkiw@vip.qq.com[‡]Email address: fsalotaibi@kau.edu.sa[§]Email address: ragab.ebrahim@asu.edu.bh

Table 1 Basic situation of research subjects.

Group	Age	Height (m)	Weight (kg)	BMI (kg/m ²)	VO2max (ml/min/kg)
Normal body reorganization	17.25±0.7	1.75±0.05	69.63±7.19	22.64±1.65	42.11±4.48
Obese body restructuring	17.27±0.6	1.76±0.04	106.8±10.34	32.0±2.51	32.63±4.78

and improve body fat distribution. The weight loss effect is significantly better than continuous exercise. To explore the characteristics of substrate metabolism and energy consumption of two different exercise methods under the same average oxygen consumption of different weights. In this study, two exercise methods, including 50% VO2max, 75% VO2max, and 100% VO2max, were used for obese and normal-weight people: continuous running and intermittent running. We compare and analyze the characteristics of its substrate metabolism and energy consumption to obtain the relationship between the optimal amount of exercise based on energy metabolism and the body's energy consumption and substrate metabolism characteristics during exercise [2]. Thus, we provide a scientific basis for formulating obese weight exercise and weight loss programs and guide the public to perform correct fitness and weight loss.

2 Materials and methods

2.1 Research object

We use random sampling to select 16 students from a particular university (voluntarily participate in this experiment). Among them, 8 were young men of average weight, and 8 were obese young men [3]. The inclusion criteria are as follows: 1) The consequence has been stable in the past three months. According to the Chinese adult BMI standard: average body weight BMI 18.5-23.9, obesity BMI ≥ 28 . 2) No history of motion sickness and no organic disease. Through incremental exercise load test and physical examination, and eliminate risk factors such as cardiovascular dysfunction. 3) I have not taken hormone drugs recently. 4) No bad habits such as smoking and drinking.

2.2 Research methods

All subjects performed 4 experiments. First, we obtain the respective maximum oxygen uptake based on the incremental load results. Second, we determine the treadmill speed of 50% VO2max, 75% VO2max, and 100% VO2max exercise intensity. Third, three exercise tests were carried out after 5 minutes of preparation for the experiment: (1) Volunteers continued to run for 30 minutes and recover for 30 minutes at an exercise intensity of 50% VO2max. (2) Volunteers run at 75% VO2max exercise intensity for 4 minutes and intermittently recover for 2 minutes as a group of intermittent exercises, perform 5 consecutive groups, and recover for 30 minutes after 5 groups exercises. (3) Volunteers run for 3 minutes at an exercise intensity of 100% VO2max and intermittently recover for 3 minutes as a group of intermittent exercises. Finally, the volunteers recovered for 30 minutes after performing 5 consecutive exercises [4]. Throughout the experiment, the MAX-II test system was used to measure the body's gas metabolism indicators.

This experiment uses complete rest during the intermittent period. We performed the statistics in the above table to prove that the body function did not return to a normal state after taking complete rest. Table 2 shows that after 75% VO2max and 100% VO2max are intermittent for 2 min and 3 min, the final heart rate (HR) is still 135 beats/min. This shows that the subjects have not fully recovered before the next exercise and ensure the primary conditions for intermittent exercise.

2.2.1 Maximum oxygen uptake test

During the maximal oxygen uptake test, the subjects were allowed to perform an incremental load experiment on the treadmill until exhaustion. The movement is completed within 12 minutes. We use an Italian

Table 2 Intermittent recovery of terminal heart rate during intermittent exercise.

Group	strength	Recovery interval	HR	RQ
Obesity group	75%VO ₂ max	2min	140.94±10.73	0.96±0.09
	100%VO ₂ max	3min	148.61±20.74	1.10±0.11
Normal body reorganization	75%VO ₂ max	2min	134.21±13.11	0.98±0.07
	100%VO ₂ max	3min	148.74±7.27	1.12±0.03

COSMEDT150 sports treadmill. The subjects used 7km/h as the initial speed, and the movement frequency was increased by 1km/2min, and the horizontal slope remained unchanged.

Discrimination criteria: HR≥180 times/min. Respiratory quotient ≥ 1.10. As the load increases, oxygen consumption remains in a straight line and enters a plateau [5]. The subject was unable to exercise continuously after being motivated. The experiment meets 3 or more of them can be considered to reach VO₂max.

2.2.2 Substrate metabolism and energy consumption calculation formula

The current international calculation formula is as follows:

Sugar Oxidation (g/min) = 4.585VCO₂(L/min) – 3.226VO₂(L/min);

Fat Oxidation (g/min) = 1.695VO₂(L/min) – 1.701VCO₂(L/min);

Total energy output (kcal/min) = [fat oxidation amount (g/min) × 9 + sugar oxidation amount (g/min) × 4].

2.3 Mathematical Statistics

We collect data through a gas analyzer and create a data table. We use Excle2010 and SPSS20.0 statistical software for data processing. The paper uses ±s to describe the statistical indicators, uses two-way analysis of variance and independent sample T-test to analyze the data and draw conclusions [6]. The difference was statistically significant when P<0.05.

During the development of the fractional calculus theory, many definitions of fractional calculus of middle function appeared, such as the definition of Grünwald-Letnikov fractional calculus, the definition of Riemann-Liouville fractional calculus, and the definition of Caputo. This section will introduce the fractional Caputo to define the differential operator and introduce the equivalent transformation relations and related functions used in this article:

(1) Definition of Caputo fractional differential

$$D_t^a f(t) = \frac{1}{\Gamma(1-a)} \int_0^t \frac{f^{m+1}(\tau)}{(t-\tau)^a} d\tau \quad (1)$$

Where: is an integer $\alpha = m + \gamma, 0 < \gamma < 1$.

(2) Integral transformation of Caputo fractional calculus

Laplace transform of the fractional differential of the function Caputo:

$$L_0 (D_t^a f(t)) = s^a f(s) - \sum_{k=0}^{m-1} s^{a-1-k} \left[\frac{d^k f(t)}{dt^k} \right]_{t=0} \quad (2)$$

Where: $m - 1 < a < m$.

(3) Mittag-Leffler function

The Mittag-Leffler function with two parameters in the paper is defined as follows:

$$E_{a,b}(t) = \sum_{k=0}^{\infty} \frac{t^k}{\Gamma(ak+b)}; a > 0, b > 0 \quad (3)$$

The Laplace transformation of the Mittag-Leffler process used in this article is:

$$L \left[t^{b-1} E_{a,b}(-a^0 t) \right] = \frac{s^{a-b}}{s^a + a} \quad (4)$$

Time fractional lossy transmission line equation analysis. Take the Laplace to transform defined by the Caputo fractional order of time t on both sides of equation (5), then:

$$u_{xx}(x, s) = RC \left[S^a u(x, s) - \sum_{k=0}^0 u^{(k)}(x, 0) s^{a-1-k} \right] = RC [S^a u(x, s) - u(x, 0) s^{a-1}] \quad (5)$$

Organize to get:

$$u(x, s) = \frac{1}{RCS^a} u_{xx} u_{xx}(x, s) + \frac{u(x, 0)}{s} \quad (6)$$

Assuming $u(x, s) = \sum_0^\infty u_n(x, s)$ then:

$$\sum_0^\infty u_n(x, s) = \frac{u(x, 0)}{s} + \frac{1}{RCS^a} u_{xx}(x, s) \quad (7)$$

The paper uses the Adomian decomposition method to decompose $u(x, s)$, and the initial condition is considered to be $u(x, s) = V_0 \cos x$, and the recurrence formula is obtained:

$$\begin{cases} u_0(x, s) = \frac{u(x, 0)}{s} = \frac{V_0 \cos x}{s} \\ u_{n+1}(x, t) = \frac{1}{RCS^a} u_{xx}(x, s) \end{cases} \quad (8)$$

We can use MATLAB software to get:

$$u(x, s) = \sum_0^\infty u_n(x, s) = \frac{V_0 \cos x}{s} \left(1 - \frac{1}{RCS^a} + \frac{1}{(RCS^a)^2} + \cdots + (-1)^n \frac{1}{(RCS^a)^n} + \cdots \right) = \frac{s^{a-1}}{s^a + 1/RC} V_0 \cos x \quad (9)$$

Finally, the inverse Laplace transformation of the Mittag-Leffler function can be used to obtain the voltage response:

$$u(x, s) = L^{-1} \left(u(x, s) = L^{-1} \left(\frac{s^{a-1}}{s^a + 1/RC} V_0 \cos x \right) = V_0 \cos x E_{a,1} \left(-\frac{t^a}{RC} \right) = V_0 \cos x \sum_{k=0}^0 \frac{(-t^a/RC)^k}{\Gamma(ak+1)} \right) \quad (10)$$

3 Results

3.1 The characteristics of substrate metabolism and energy expenditure during exercise in the obese group and the average body

Table 3 shows that the sugar oxidation amount, sugar oxidation energy supply ratio, fat oxidation amount, and oxidation energy supply ratio per kilogram bodyweight of the obese group are lower than average body weight under the same exercise intensity.

Exercise intensity and body weight are two factors that affect substrate metabolism and energy consumption [7]. Table 4 shows that the main effects of exercise intensity on substrate metabolism and energy consumption reached a significant level during exercise through the two-factor analysis of variance. Still, the main results of bodyweight-only on sugar and total energy consumption reached a considerable level. Therefore, there is only interaction between strength and body weight in the amount of sugar oxidation.

Table 3 Comparison of substrate metabolism and energy consumption during exercise period (30min) between obesity group and normal body recombination.

Group		Obesity group		
Exercise mode		50% VO2max continuous exercise	75% VO2max intermittent exercise	100% VO2max intermittent exercise
Sugar oxidation	10.96±1.49	17.96±2.06	25.91±4.48	25.91±4.48
Fat oxidation	4.37±0.31	4.35±1.25	2.33±0.96	2.33±0.96
Total energy consumption	84.27±6.88	111.00±11.70	124.59±10.42	124.59±10.42
Fat oxidation for energy	50.27±3.53	37.59±4.37	27.57±3.08	27.57±3.08
Sugar Oxidation Energy Supply Ratio	46.75±3.48	59.68±4.49	68.01±5.06	68.01±5.06
Group		Normal body reorganization		
Exercise mode		50% VO2max continuous exercise	75% VO2 max intermittent exercise	100% VO2 max intermittent exercise
Sugar oxidation	(mg/min/kg)	13.32±1.80	22.52±3.11	40.17±4.84
Fat oxidation	(mg/min/kg)	6.29±1.44	5.70±0.20	2.47±0.03
Total energy consumption	(cal/min/kg)	109.87±10.80	141.34±12.56	182.96±13.29
Fat oxidation for energy	Proportion (Fat%)	54.19±6.29	38.24±4.62	25.23±3.07
Sugar Oxidation Energy Supply Ratio	Example (CHO%)	42.66±4.34	58.73±6.68	72.25±8.03

Table 4 Two-factor analysis of variance results of the influence of exercise intensity and body weight on substrate metabolism and energy expenditure.

	Sugar oxidation	Fat oxidation	Total energy consumption	Fat%	CHO%
Exercise intensity	F=30.86 P=0.000	F=10.60 P=0.000	F=41.28 P=0.000	F=16.329 P=0.000	F=17.219 P=0.000
body weight	F=13.070 P=0.001	F=3.981 P=0.052	F=55.88 P=0.000	F=0.045 P=0.832	F=0.006 P=0.094
Strength*weight	F=3.98 P=0.026	F=0.83 P=0.44	F=4.34 P=0.19	F=0.26 P=0.773	F=0.45 P=0.637

Table 5 Comparison of substrate metabolism and energy consumption during the recovery period (30min) between the obese group and the average body with different exercise methods.

Group		Obesity group		
Exercise mode		50%VO2max	75%VO2max	100%VO2max
Sugar oxidation	mg/min/kg	3.72±0.90	3.08±0.31	2.24±0.33
Fat oxidation	mg/min/kg	1.21±0.53	1.30±0.71	2.15±0.97
Total energy consumption	cal/min/kg	25.8±3.12	24.03±2.62	28.28±3.23
Fat oxidation energy supply ratio	Fat%	44.29±5.51	50.82±3.20	64.42±4.98
Sugar oxidation energy supply ratio	CHO%	44.79±5.87	37.53±3.88	26.43±3.35
Group		Normal body reorganization		
Exercise mode		50%VO2max	75%VO2max	100%VO2max
Sugar oxidation	mg/min/kg	3.37±0.08	3.49±0.64	1.05±0.05
Fat oxidation	mg/min/kg	1.77±0.82	1.63±0.85	3.2±0.28**
Total energy consumption	cal/min/kg	29.4±3.95	28.59±4.41	32.99±3.57*
Fat oxidation energy supply ratio	Fat%	52.47±4.19	51.87±3.34	72.46±5.46
Sugar oxidation energy supply ratio	CHO%	32.56±3.84	34.53±4.29	16.58±2.98*

Table 6 Two-factor analysis of variance results of the effects of exercise intensity and body weight on substrate metabolism and energy expenditure during the recovery period after exercise.

Group	Sugar oxidation	Fat oxidation	Total energy consumption	Fat%	CHO%
Exercise intensity	F=9.62 P=0.000	F=20.96 P=0.000	F=4.162 P=0.022	F=0.624 P=0.000	F=8.359 P=0.01
body weight	F=0.982 P=0.327	F=13.77 P=0.001	F=11.66 P=0.001	F=2.254 P=0.14	F=5.13 P=0.028
Strength*weight	F=1.476 P=0.24	F=1.552 P=0.224	F=0.74 P=0.929	F=0.365 P=0.696	F=0.552 P=0.58

3.2 Characteristics of substrate metabolism and energy expenditure in the recovery period after exercise in the obese group and the average body

Table 5 shows that under the same exercise intensity, the obesity group only had higher sugar oxidation per kilogram body weight and oxidation energy supply ratio than average body weight. And the total energy consumption, fat oxidation amount, and oxidation energy supply ratio per kilogram weight were lower than the medium bodyweight group.

The results of the two-way analysis of variance are shown in Table 6. In the recovery period after exercise, the main effects of exercise intensity on substrate metabolism and energy consumption reached a significant level ($P<0.05$). In addition, the main products of body weight on fat oxidation, total energy consumption. And sugar oxidation energy supply ratio reached significant levels ($P<0.05$), but there was no significant effect on sugar oxidation and fat oxidation energy supply ratio [8]. Thus, there is no interaction between exercise intensity and body weight on substrate metabolism and energy consumption during the recovery period.

4 Discussion

4.1 Analysis of the characteristics of substrate metabolism and energy expenditure in the obesity group and the average body during the restructuring exercise period

Continuous exercise and intermittent exercise on substrate metabolism and energy consumption are all related to exercise intensity. With the increase of exercise intensity, the amount of sugar oxidation and the ratio of oxidative energy supply, and the total energy consumption gradually increase, the amount of fat oxidation and the percentage of oxidation energy supply decrease progressively [9]. These changes are related to output power. Thus, with the increase of exercise intensity, the body puts forward higher requirements for the energy supply rate.

In the primary effect analysis, it was found that body weight has a significant effect on sugar and total energy consumption but has no significant impact on the ratio of fat and substrate metabolism. The reason may be that different body fat levels, and body weight has a particular effect on exercise capacity. Among them, it has the most significant impact on lean body weight. The slender body mass is highly correlated with the aerobic and anaerobic capacity of the human body, and the lean body mass varies greatly between body weights [10]. Therefore, there is a significant difference between body weights when sugars are needed for rapid oxidation for energy. In addition, it may be because the absolute exercise intensity of normal-weight people is greater than that of obese people.

4.2 Analysis of the characteristics of substrate metabolism and energy expenditure during the recovery period of the obese group and the average body

Exercise weight loss mainly considers total energy expenditure. Therefore, for fat loss, the total energy consumption during exercise and recovery period is more important than the effect of energy consumption during exercise alone. This is also why some scholars have strongly advocated high-intensity interval training (HIIT) in recent years [11]. This study found that exercise intensity significantly impacts substrate metabolism and energy consumption during the recovery period after exercise. With the increase of exercise intensity, the amount of sugar oxidation and the ratio of energy supply for sugar metabolism gradually decrease after training, the amount of oxidation of fat, the proportion of energy supply for fat metabolism, and the total energy consumption increase progressively. This is mainly because endocrine hormones, body temperature, pulmonary ventilation, etc., remain at high levels after intensive exercise. Therefore, oxygen reserves need to be restored as soon as possible. The ATP-CP system needs to be quickly replenished, and lactic acid needs to be cleared as soon as possible. Currently, the primary energy supply mode has been changed from anaerobic energy supply to aerobic energy supply, and glycogen in the body has almost been exhausted during exercise. Therefore, the primary substance for aerobic energy is changed from sugar to fat. As a result, the free fatty acid level in the blood increased significantly after the training. Studies have proved that the energy supply ratio of fat after exercise is closely related to exercise intensity and exercise time. Exercise intensity affects the amount of excess oxygen consumption after exercise, and exercise time will prolong excessive oxygen consumption after exercise. In theory, high-intensity training to reduce fat is mainly in the excess oxygen consumption after exercise. The greater the exercise intensity, the higher the excess oxygen consumption after exercise.

There was no significant difference in comparing substrate metabolism and energy consumption during the recovery period between 50% $\text{VO}_{2\text{max}}$ and 75% $\text{VO}_{2\text{max}}$. It shows that when the intensity exceeds 50% $\text{VO}_{2\text{max}}$, excessive oxygen consumption and substrate metabolism changes are not apparent after exercise. Or at this time, the excessive oxygen consumption after exercise temporarily enters the plateau period. Exercise intensity as an independent factor can affect substrate metabolism and energy consumption after practice remains to be studied [12]. There is a significant difference in the ratio of substrate metabolism energy supply between interval and continuous exercise. The reasons may be as follows: during high-intensity intermittent exercise, the pituitary-adrenal axis reacts more intensely, which leads to increased hormone secretion and improves fat

oxidation energy supply ratio. It is also possible that intermittent exercise consists of the exercise period and the recovery period. The two periods continue to intersect, increasing the number of substrate mobilizations, producing numerous metabolites, increasing the amount of fat and the ratio of the oxidative energy supply after exercise.

4.3 Analysis of the characteristics of substrate metabolism and energy expenditure during the whole process of the obesity group and the average body during the exercise period and the post-exercise recovery period

Exercise intensity as the main effect significantly impacts the amount of sugar oxidation and total energy consumption. During the whole exercise process, with the increase of exercise intensity, the oxidation amount of sugar, the ratio of oxidation energy supply, and the total energy consumption gradually increase. In contrast, the oxidation amount of fat and the percentage of oxidation energy supply decrease progressively; there are significant differences in substrate metabolism and energy consumption characteristics during and after exercise. Still, the trends of the two are exactly opposite. This is because the body's regulation realizes the sugar oxidation energy supply ratio and the fat oxidation energy supply ratio.

The whole process of comprehensive exercise and recovery period found that moderate-intensity continuous training is better than an intermittent exercise in terms of the fat burning effect. The amount of fat oxidation and the ratio of oxidative energy supply in the constant movement are higher than that in intermittent exercise. Although the total energy consumption of intermittent exercise is higher than that of continuous practice, the energy is mainly provided by the burning of sugar. Keeping the hormone content at a high level after exercise also increases excessive oxygen consumption after exercise. Due to the short rest time during the recovery period after training in this study, the gas of excessive oxygen consumption after training was not fully collected, which resulted in the relative value of substrate metabolism, and the energy consumption is significantly lower than in other studies.

5 Conclusion

Under the exact condition of average oxygen consumption, the fat metabolism level of continuous exercise during exercise is higher than that of erratic movement. The story of glucose metabolism and the total energy consumption is lower than that of sporadic activity. During the recovery period, the fat metabolism level and total energy consumption of continuous exercise are lower than erratic movement. The glucose metabolism level is higher than that of sporadic activity. Under the same exercise intensity, the sugar, fat metabolism, and energy consumption per kilogram of body weight in the obese group were lower than average body weight.

References

- [1] Teimouri, R., Amini, S., Lotfi, M., & Alinaghian, M. Sustainable drilling process of 1045 steel plates regarding minimum energy consumption and desired work quality. *International Journal of Lightweight Materials and Manufacture*, 2019. 2(4): 397-406
- [2] Xie, T., Liu, R. & Wei, Z. Improvement of the Fast Clustering Algorithm Improved by K-Means in the Big Data. *Applied Mathematics and Nonlinear Sciences*, 2020. 5(1): 1-10
- [3] Zhou, P., Fan, Q. & Zhu, J. Empirical Analysis on Environmental Regulation Performance Measurement in Manufacturing Industry: A Case Study of Chongqing, China. *Applied Mathematics and Nonlinear Sciences*, 2020. 5(1): 25-34
- [4] Luan, X., Zhang, S., Chen, J., & Li, G. Energy modelling and energy saving strategy analysis of a machine tool during non-cutting status. *International Journal of Production Research*, 2019. 57(14): 4451-4467
- [5] Alvarado, R., Ortiz, C., Bravo, D., & Chamba, J. Urban concentration, non-renewable energy consumption, and output: do levels of economic development matter?. *Environmental Science and Pollution Research*, 2020. 27(3): 2760-2772
- [6] Adebayo, T. S., & Akinsola, G. D. Investigating the causal linkage among economic growth, energy consumption and CO2 emissions in Thailand: an application of the wavelet coherence approach. *Int J Renew Energy Dev*, 2021. 10(1):

17-26

- [7] Kahia, M., Jebli, M. B., & Belloumi, M. Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technologies and Environmental Policy*, 2019. 21(4): 871-885
- [8] Ahmad, N., Du, L., Tian, X. L., & Wang, J. Chinese growth and dilemmas: modelling energy consumption, CO 2 emissions and growth in China. *Quality & Quantity*, 2019. 53(1): 315-338
- [9] Wang, Z., Ahmed, Z., Zhang, B., & Wang, B. The nexus between urbanization, road infrastructure, and transport energy demand: empirical evidence from Pakistan. *Environmental Science and Pollution Research*, 2019. 26(34): 34884-34895
- [10] Gatarić, P., Širok, B., Hočevan, M., & Novak, L. Modeling of heat pump tumble dryer energy consumption and drying time. *Drying Technology*, 2019. 37(11): 1396-1404
- [11] Koengkan, M., Fuinhas, J. A., & Santiago, R. The relationship between CO2 emissions, renewable and non-renewable energy consumption, economic growth, and urbanisation in the Southern Common Market. *Journal of Environmental Economics and Policy*, 2020. 9(4): 383-401
- [12] YUKSEL, S., & Ubay, G. G. Identifying the influencing factors of renewable energy consumption in Turkey with MARS methodology. *Ekonomi İşletme ve Maliye Araştırmaları Dergisi*, 2020. 2(1): 1-14

This page is intentionally left blank