Influencing factors of infant adiposity rebound age and the age to onset of childhood in 1102 cases

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Abstract: To investigate infant adiposity rebound (AR) age and the age to onset of childhood (ACO), learn the growth and development characteristics, and explore its impact of growth and development. The longitudinal growth and development data of 1102 children were conducted by a spot check, ACO was estimated using infant-child-puberty (ICP) growth model, and influence factor of AR age and ACO was analyzed by regression analysis. The AR age of infant was 60 months, and the body mass index (BMI) reached the lowest at 60 months, males and females were 15.21±1.28 months and 14.97±1.16 months, respectively. The ACO of males and females was 10.9±2.92 months and 10.2±2.70 months (P<0.05), respectively; all the gender, height and BMI of 6 months, birth season had influence on ACO. Prevention of obesity and other accompanied diseases should be paid attention in preschool children, adolescents and adulthood.

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Key words: adiposity rebound age; age to onset of childhood; infant-child-puberty; obesity.

1. Introduction

Growth and development are unique physiological processes of children, they are also the two most important stages in the whole life,they have a great impact on final height(FH). Within 9 to 12 months after birth, the body mass index (BMI) of children is increased rapidly and then gradually decreased, it reached the lowest between 3-8 years old, followed by secondary growth of BMI, which is known as adiposity rebound (AR)(Brisbois et al.,2011; Campbell et al.,2011; Malenfant 2009)). It is a special manifestation of physical growth in childhood, and it can reflect the change of BMI from downward trend to increase status. The earlier AR occurred, the more influence on occurrence of obesity later, so AR is one of the prediction index about obesity in adulthood(Chivers et al.,2010; Freedman et al., 2005;WILLIAMS S,Dickson et al.,2002) . Age to onset (ACO) is mean the beginning of growth hormone axis regulation(Al-Musharaf et al.,2012; Albertsson-Wikland et al.,2011), it is an important milestone in growth and development, but it can also quantify the FH as an independent factor(Hochberg et al., 2011). Usually, ACO is between the age of 6 months to 12 months, and the ACO delay could cause the lower FH(Darelid et al.,2010).

At present, the average growth level of healthy children has exceeded the standard of WHO in part cities of China, meanwhile, the growth level of children from suburban also reach the standard. In recent two decades, the physical development of children has also showed an increasing trend in Guangzhou area, however, there are few reports about the growth and development of children in Guangzhou area. In our study, we investigate the physical development characteristics, AR age and ACO in Guangzhou area, and explore its impact for growth and development of childhood, which provides the basis for the prevention of obesity in childhood and the short stature in adulthood.

2. Materials and Methods

2.1 Clinical data

The retrospective medical information of 1102 children iwas randomly selected from six kindergartens of Guangzhou, including 570 male and 532 female.

2.2 Research methods

2.2.1 Items of survey

1) Physical measure index: height (cm), weight(kg), head circumference (HC,cm,under 3 years old), BMI (kg/m^2).
2) AR age: The AR age is the age of BMI reaching the lowest. The BMI trend curve was draw, and the time point of lowest BMI was analyzed.
3) ACO: The time point of rate sudden increase in decreasing tendency of growth rate was ACO.

2.3 Measuring methods

Acquisition time of the physical examination data point: from 0 to 6 month, measuring was performed every month; from 6 to 18 month, measuring was performed once every 3 months; from 18 to 36 month, measuring was performed once every 6 months; from 36 to 72 month, measuring was performed once every year. Newborns were measured with baby scales, from 1 to 6 month, measuring body weight with scales; for children who were less than 3 years old, measuring supine length; for children who were more than 3 years old, measuring children's standing height; head

circumference was measured with soft tape.

2.4 Evaluation criteria of physical development

1) The weight, height and head circumference of all time points were converted into height standard deviation score (HtSDS), weight standard deviation score (WtSDS) and head circumference standard deviation scores (HcSDS) respectively. They were corrected according to age and gender.Z score=measured value-mean/standard deviation. The reference standard was the research standards of physical development of children who were under seven years old in nine cities of China in 2005.
2) Evaluation criteria of obesity: That the ratio of height to weight was more than 20% of WHO/NCHS with the same sex was defined as obesity.
3) Evaluation of lower body weight: the weight was less than -2SDS of normal value with the same age and sex.

2.5 Evaluation criteria of ACO

ACO is the time point of rate sudden increase in decreasing tendency of growth rate. The growth curve and rate curve of each child were draw by computer, the growth trend of each child was observed with visual method, the ACO is the sudden increase point of growth rate with months as the unit.

2.6 Statistics analysis

Data in normal distribution were described with mean ± standard deviation ($\overline{X}$ ±s); independent two binary data were compared using Chi-square test, the relationship between multiple independent variables and the dependent variable was analyzed with multiple regression analysis. A $P<0.05$ was considered as significant difference. All the statistical data were analyzed by SPSS 16.0 software.

3. Results

3.1 The AR age

The overall situation of physical development in 1102 cases was shown in Table I. The BMI increased gradually after birth, and reached the highest at the sixth month, the BMI of male and female reached the highest at the 17.66±1.48 and 17.22±1.46 months, respectively; it reached the lowest at 60 months, the value was 15.21±1.28 months in male and 14.97±1.16 months in female [Fig. 1]. Therefore, the AR age of both male and female children was 60 months.

Table I. Investigation results of physical development in 1102 children in Guangzhou area

Age group	cases	male								cases	female							
		height（cm）		Weight (kg)		HC (cm)		BMI(kg/m^2)			height（cm）		Weight kg)		HC（cm）		BMI(kg/m^2)	
		mean	SD	mean	SD	mean	SD	mean	SD		mean	SD	mean	SD	mean	SD	mean	SD
0~3d	570	49.38	1.23	3.17	0.45	34.12	1.27	13.01	1.15	532	48.89	1.37	3.06	0.32	33.55	1.19	12.98	1.14
1M~	570	55.37	2.39	4.63	0.60	37.65	1.25	15.02	1.23	532	54.31	1.24	4.14	0.52	36.86	1.38	14.65	1.23
2M~	570	59.14	2.62	5.77	0.73	39.23	1.30	16.42	1.43	532	57.91	1.78	5.36	0.66	38.46	1.52	15.91	1.24
3M~	570	62.43	2.66	6.70	0.79	40.73	1.412	17.12	1.41	532	61.03	2.46	6.11	0.74	40.00	1.73	16.59	1.33
4M~	570	64.80	2.78	7.36	0.88	41.89	1.47	17.46	1.43	532	63.45	2.29	6.82	0.83	40.83.	1.76	16.84	1.41
5M~	570	66.85	2.89	7.92	0.95	42.85	1.53	17.61	1.75	532	65.26	2.66	7.33	0.89	41.57	1.82	17.13	1.45
6M~	570	68.68	3.02	8.37	1.00	43.57	1.60	17.66	1.48	532	67.02	3.33	7.78	0.96	42.75	1.56	17.22	1.46
9M~	570	73.12	3.27	9.29	1.08	45.37	1.65	17.21	1.36	532	71.51	3.42	8.70	1.07	44.41	1.69	16.73	1.33
12M~	570	76.70	3.54	10.02	1.16	46.45	1.62	16.95	1.26	532	75.44	3.69	9.47	1.12	45.23	1.71	16.46	1.31
15M~	570	80.03	3.79	10.79	1.60	47.19	1.47	16.47	1.41	532	78.43	3.78	9.97	1.28	45.91	1.55	16.03	1.04
18M~	570	82.86	3.86	11.34	1.37	47.82	1.66	16.34	1.36	532	81.56	4.04	10.70	1.29	46.59	1.73	15.75	1.34
24M~	570	89.70	4.09	12.44	1.47	48.68	1.30	15.69	1.24	532	87.93	4.17	11.93	1.51	47.54	1.45	15.48	1.33
30M~	570	93.75	4.53	13.44	1.83	49.19	1.48	15.42	1.90	532	93.13	4.63	13.14	1.72	48.25	1.60	15.23	1.25
36M~	570	97.36	4.73	14.48	2.06	49.74	1.52	15.31	1.40	532	96.41	4.85	14.34	2.13	48.72	1.48	15.20	1.33
48M~	570	104.61	4.63	16.54	2.17			15.25	1.49	532	103.87	4.93	16.54	2.32			15.03	1.17
60M~	570	111.79	4.86	18.99	2.24			15.03	1.43	532	110.07	4.96	18.37	2.38			14.97	1.16
72M~	570	118.64	4.88	21.28	2.72			15.21	1.28	532	117.52	4.98	20.17	2.48			15.15	1.19

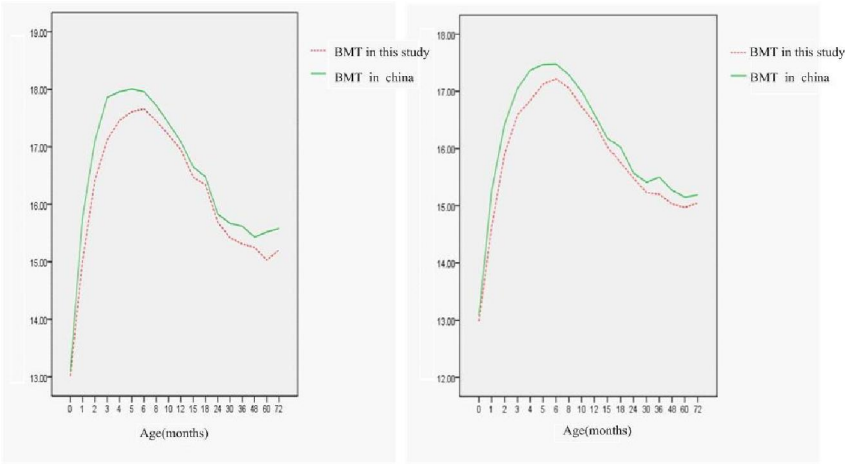

Figure 1. The BMI of male and female children compared with the BMI of the national average.

3.2 ACO distribution

The proportion of ACO at nineth month was 44.7% in male and 44.4% in female respectively, there was significant difference between the distribution of ACO in our study and that of 1980s in Shanghai (P<0.0001), but there was no significant difference between the ACO of male and that of female in the 1102 cases (P>0.05) (Table II). The ACO was non-normal distribution, which was converted into normal distribution through natural logarithm, and the ACO was 10.8±2.92 months in male and 10.2±2.70 months in female. It was earlier than the that of Shanghai, where the ACO was 11.2 months in male and 10.7 months in female (P<0.05) [Fig.2].

Table II. The ACO distribution in Guangzhou and Shanghai

ACO	cases				Percentage (%)				Cumulative percentage (%)			
	Guangzhou		Shanghai		Guangzhou		Shanghai		Guangzhou		Shanghai	
	male	female	male	female	male	female	male	female	male	female	male	female
6.0m~	97	98	54	45	17.0	18.4	6.4	5.8	17.0	18.4	6.4	5.8
9.0m~	255	236	314	338	44.7	44.4	37.0	43.7	61.7	62.8	43.3	49.4
12.0m~	106	116	371	333	18.6	21.8	43.7	43.0	80.3	84.6	87.0	92.5
15.0m~	87	66	74	50	15.3	12.4	8.7	6.5	95.6	97	95.8	99.0
≥18.0m	25	16	36	8	4.4	3.0	4.2	1.0	100	100	100	100
Total	570	532	894	774	100	100	100	100	—	—	—	—

Comparing the ACO of the same sex children in Guangzhou and Shanghai, male: X^2=118.3, female: X^2=106.3, P<0.0001; comparing the ACO of male and female, X^2=4.744, P＝0.315.

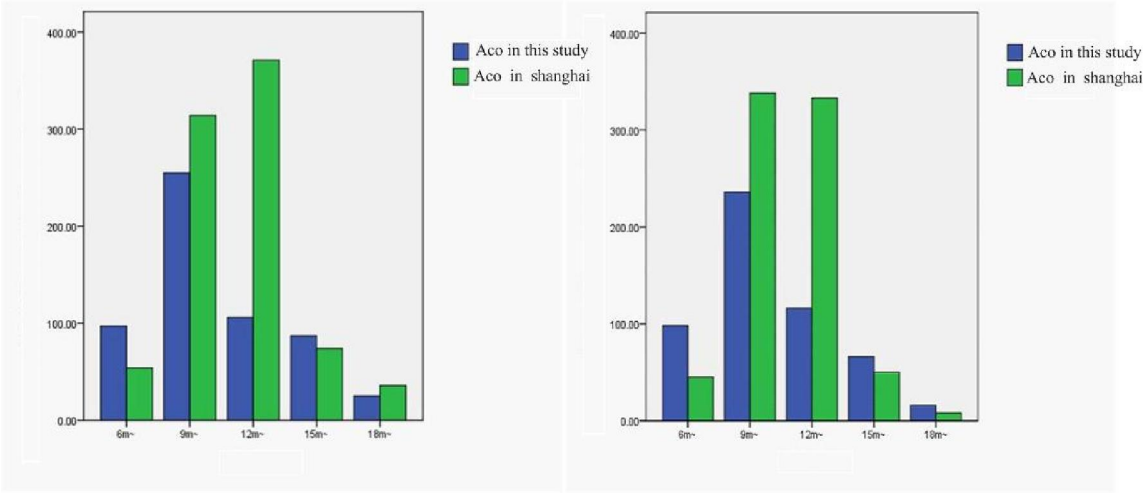

Figure 2. The ACO distribution of male (left) and female (right) in Guangzhou compared with that of Shanghai.

3.3 The influence factors of ACO

The influence factors of ACO were analyzed using multiple regression analysis in 1102 cases, the results showed that the height and BMI of 6 months and birth season had influence on ACO (P<0.05) (Table III).

Table III. The multiple regression analysis results of ACO (R^2=0.46)

Items	Beta	T	P
Gender	-0.102	-2.011	0.042
Height of 6 months	0.212	3.122	0.002
BMI of 6 months	-0.094	-1.954	0.048
1-3 months after birth	0.007	0.134	0.894
4-6 months after birth	0.022	0.439	0.661
7-9 months after birth	-0.108	-2.017	0.044

Gender: boys=1, girls=2; the time of birth reference 10-12 months, the time of birth influencing ACO was analyzed.

4. Discussion

BMI is the most widely indicator of age-related changes, which is used usually to measure weight. After birth, BMI go through a series of changes, because the fat tissue development and height growth rate are different: from birth to one year old, BMI shows an increasing status and reaches the peak time at about one year; BMI decrease gradually after one year old, and reaches the lowest at some time between 3 to 8 years old, that is the AR age, then BMI curve has the secondary growth phenomenon. The AR phenomenon does not only reflect that the weight growth is faster than height growth, but also suggest that the net weight is fat tissue, not lean body mass. A large number of studies have proved that the higher percentile and upper shift percentile of BMI were associated with earlier AR, at the same time, the lower percentile and downward shift percentile of BMI were associated with later AR. The children who had higher percentile and upper shift percentile of BMI had higher risk of obesity(Gupta et al.,2012; Musi et al.,2011). It was reported that the average increase of fat tissue in 5-year-old AR group was 3 times than that in 7-year-old group; the average BMI of early adulthood was 4-5 units (kg/m^2) higher than that of later adulthood; the risk of overweight, obesity and related chronic diseases in adolescence was 3.3 times of adult(Gilsanz et al.,2011). In our study, our results showed that BMI was low at birth, it had an increasing trend from 0 to 6 month after birth and reached the highest at 6^{th} month in 1102 cases in Guangzhou; the AR age was 60 months in both boys and girls, which was earlier than previous studies. Our results suggested the children might be a potential to be obesity, it needs to pay attention to prevent obesity and other accompanied diseases from pre-school children, adolescents and adults. Therefore, it needs to take measures to prevent and control obesity, such as, arranging outdoor activities, increasing sleep time and avoiding watching TV for a long time(Kwon et al.,2011), at the same time, it needs to strengthen management in AR age to control obesity earlier.

Linear growth of the human can be divided into infancy-child-puberty(Darelid et al.,2010; Javaid et al.,2011). Babyhood began in mid-gestation, showing a high-speed growth in intrauterine and a sharp drop of growth after birth, and reached the lowest at $6\text{-}8^{th}$ month after birth, and then a growth acceleration, that is ACO. The height was the superposition of infanthood and childhood after ACO, and the overall growth rate showed a sudden increasing. It was believed that ACO was between 6 to 12^{th} month, but the recent data of larger sample have shown ACO could be enlarged to 15 months(Tomova et al.,2010). ACO was delayed one month, the FH was reduced 0.09 SDS; when the ACO was more than 12 months, the FH was reduced 6 cm; when the ACO was more than 15 months, the FH could not be compensated by delayed development(Hochberg 2009). It has been proved that ACO was negatively correlated with the height of parents, that is, the higher the height of parents, the earlier ACO(Albertsson-Wikland et al.,2011). In this study, the influence factors of ACO were analyzed with multiple regression analysis, the results showed that the height and BMI of 6^{th} month and birth season were associated with ACO. The influence factors of ACO have been confirmed: gender(Javaid et al.,2011), socio-economic factors(Hochberg 2009), growth-related diseases (van Dommelen et al.,2009), growth rate before ACO(Javaid et al.,2011) and insulin-like growth factor-1 (Bernstein 2010).

In our study, it was the first time to analyze the physical development of children in Guangzhou by ICP growth model, the results showed that the average ACO of male was 10.8 and 10.2 months in male and female,respectively. The ACO was 0.4 and 0.5 month in advance compared to that of male and female in Shanghai ($P<0.05$). The ACO of female was 0.6 month in advance compared to male, which was consistent with the reports in Shanghai and Sweden. The reason might be that the population of Shanghai was born in 1980s, and economic conditions, social environment, health conditions and education have been improved in the last 20 years, so the ACO was earlier than that of 1980s, so was the FAH.

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