Research Paper : School Health Fundamentals

Variability of Blood Constituents in University Students: Correlations over a Three-Year Period, and Estimations of Annual Incidences and Continual Proportions of Abnormality

Yasuo Shiraishi[*], Wakana Usui[**], Akira Uchiyama[***], Takeo Nakagawa[***] and Toyoho Tanaka[***]

[*]Tokyo University of Science
500 Shimokiyoku, Kuki, Saitama 346-8512 Japan
yasuo@ms.kuki.tus.ac.jp
[**]Trident Sport and Health Science Specialty School (Then)
1-5-31 Imaike, Chikusa-ku, Nagoya 464-8611 Japan
[***]Chukyo University
101 Tokodachi, Kaizu-cho Toyota, Aichi-ken 470-0393 Japan
[Received February 19, 2010 ; Accepted December 7, 2010]

Objectives. To estimate the annual abnormality incidence proportions and annual continual abnormality proportions of blood constituents in order to examine the variability of blood characteristics during young adulthood.
Methods. We estimated the annual abnormality incidence proportions and annual continual abnormality proportions of blood constituents from 4th-year abnormality proportions of 1st-year abnormal subjects and from 4th-year abnormality proportions of 1st-year normal subjects. The estimation was performed only on items having 30 or more 1st-year abnormal subjects, using two calculation models.
Results. Model l, which assumed the coming and going of abnormal subjects, was more suited for the estimation than Model 2, which ignored coming and going. The blood constituents of university students had the following characteristics: i) 4th-year abnormality proportions were higher than 1st-year abnormality proportions for many items; however, except for serum protein and NF, the differences were not significant; ii) 4th-year abnormality proportions of 1st-year abnormal subjects, compared to 4th-year abnormality proportions of 1st-year normal subjects, were twice as high for low items and over 10 times as high for high items.
Conclusions The abnormality incidence proportions of blood constituents in university students were estimated to be 0.01-0.08, and the continual abnormality proportions were estimated to be approximately 0.5-0.8.

Keywords: university student, blood test, tracking, abnormality incidence proportion, continual abnormality proportion

[School Health Vol.6, 31-41, 2010]

1. Introduction

As blood tests are not required in regular health examinations for university students, they are seldom performed. However, even in university students, abnormalities such as impaired liver function, serum lipid abnormalities and high serum uric acid are not uncommon, and anemia is a relatively common health problem for young women. In addition, the preliminary conditions of lifestyle diseases have been shown to begin in childhood [Berenson at al, 1998; Hemmingsson et al, 2006; Komatsu et al, 1996; McMahan et al, 2006; Wamala et al, 2001], and serum lipid abnormalities, etc. of adolescence, etc. are risk factors of arteriosclerosis in adulthood [Daviglus et al, 2004; Kronmal et al, 1993; Stamler et al, 2000]

To examine the value of blood tests in health examinations of university students, it is important to know not only the relationships between blood characteristics and health problems, but also the

dynamic states of blood characteristics in adolescence [Usui et al, 2001; Yasui et al, 2004]. Therefore, using data from 1st-year and 4th-year blood tests in university students performed over a 3-year period, we attempted to examine relationships between 1st-year and 4th-year values and estimate the probability of subjects who are abnormal in one year being abnormal one year later as well as the probability of subjects who are normal in one year becoming abnormal one year later.

2. Methods

2.1. Definition of terminology

In this paper some terms are defined and abbreviated as follows:

(1) 1st -year -4th-year correlation; correlation coefficient between 1st-year and 4th-year blood test;
(2) 1st-year abnormality proportion; abnormality prevalence proportion of blood test at school entry;
(3) 4th-year abnormality proportion; abnormality prevalence proportion of blood test at the beginning of the 4th year;
(4) abnormality-abnormality proportion; abnormality prevalence proportion of blood test in the 4th year among subjects with 1st-year abnormality;
(5) normality-abnormality proportion; abnormality prevalence proportion of blood test in the 4th year among subjects with 1st-year normality;
(6) continual abnormality proportion; abnormality prevalence proportion of blood test after one year among subjects with abnormality;
(7) abnormality incidence proportion; abnormality prevalence proportion of blood test after one year among subjects with normality.

2.2. Correlation Coefficient

We examined relationships between 1st- and 4th-year values by simple correlation coefficients. In the calculations, linearity between the values was observed by scatter diagrams.

2.3. Analytical model

2.3.1. Analytical model 1

The continual abnormality proportion is designated as α, the abnormality incidence proportion is designated as β, and α and β are assumed to be the same ratio every year, respectively. If 1st-year abnormality proportion is designated as p and 1st-year normality proportion is designated as q, then in the whole population of subjects who were abnormal at the time of university entrance, the abnormality proportion after 1 year is pα, the normality proportion

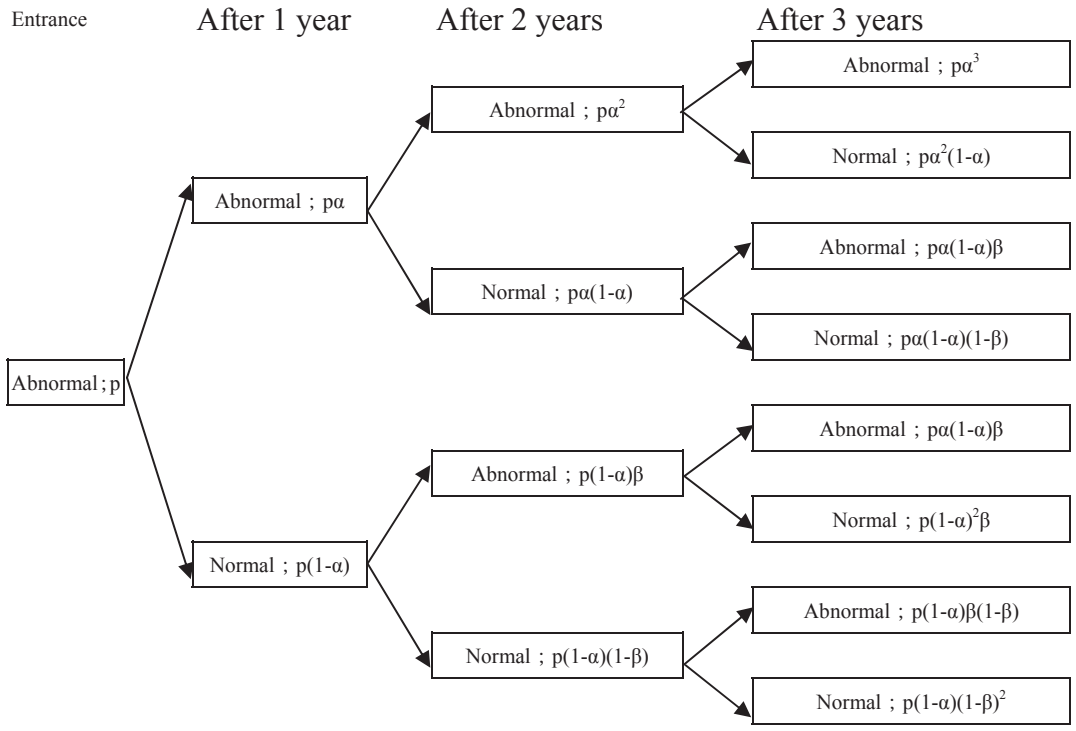

Figure 1 Divergence of abnormal subjects at school entry in following years

after 1 year is p(1-α), and the normal and abnormal diverge after 2 and 3 years as shown in **Figure 1**. Subjects who were normal at the time of university entrance showed the same divergence.

From the above relationship, if the abnormality-abnormality proportion is designated as r and the normality-abnormality proportion is designated s, then α, β, r, and s are expressed by the following relational expressions:

$$f(\alpha,\beta)=\alpha^3+\alpha(1-\alpha)\beta+\alpha(1-\alpha)\beta+(1-\alpha)\beta(1-\beta)=r \quad (1)$$

$$g(\alpha,\beta)=\alpha^2\beta+(1-\alpha)\beta^2+\alpha\beta(1-\beta)+\beta(1-\beta)^2=s \quad (2)$$

$$;0\leq\alpha,\beta\leq1,0\leq r,s\leq1$$

Since r and s are given as observed values, α and β can be calculated by solving the simultaneous equation (1) and (2). Solutions obtained from calculation software Mathematica were plural. However, since there was only one real value satisfying $0 \leq \alpha$ and $\beta \leq 1$ in all of the items, the desired estimated value was obtained for all items.

2.3.2. Analytical model 2

Since abnormal and normal subjects come and go every year in analytical Model 1, calculation is somewhat cumbersome. Therefore, we performed estimations by Model 2, which ignored the annual coming and going of abnormal subjects and was, therefore, simple; and we compared the results with those of Model 1.

If 1st-year abnormal subjects are assumed to be abnormal the following year at the same ratio every year, then the following relationships hold true:

$$Ab_1\times\dot{\alpha}\times\dot{\alpha}\times\dot{\alpha}=Ab_{14}$$

$$\dot{\alpha}^3=Ab_{14}/Ab_1=r$$

$$\dot{\alpha}=\sqrt[3]{r} \quad (3)$$

; Ab_1 = 1st-year abnormal subjects,

Ab_{14} = 4th-year abnormal subjects among 1st-year abnormal subjects

If 1st-year normal subjects are assumed to become abnormal at the same ratio every year and continue to be abnormal during the following years, the following relationships are obtained:

$$No_1\times\dot{\beta}+(No_1-No_1\times\dot{\beta})\times\dot{\beta}+(No_1-No_1\times\dot{\beta}-(No_1-No_1\times\dot{\beta})\times\dot{\beta})\dot{\beta}=NoAb_{14}$$

$$No_1\times\dot{\beta}\times3-No_1\times\dot{\beta}^2\times3+No_1\times\dot{\beta}^3=NoAb_{14}$$

Here, since the value of $\dot{\beta}$ is small, approximately the following relations hold true:

$$No_1\times\dot{\beta}\times3\approx NoAb_{14}$$

$$\dot{\beta}\approx (NoAb_{14}/No_1)/3=s/3$$

; No_1 = 1st-year normal subjects, (4)

$NoAb_{14}$ = 4th-year abnormal subjects among 1st-year normal subjects

$\dot{\alpha}$ is estimated from formula (3) and $\dot{\beta}$ is estimated from formula (4)

2.4. Data

The data used were blood test results from 2461 students (1607 males and 854 females) who entered School T of University C from 1995 to 1997.

Eighteen blood test items were analyzed, including total protein (TP), albumin (Alb), albumin/globulin ratio (A/G ratio), aspartate transaminase (AST), alanine aminotransferase (ALT), γ-glutamyltransferase (γ-GTP), urea nitrogen (UN), creatinine (Cr), uric acid (UA), total cholesterol (TC), high-density lipoprotein cholesterol (HDLC), neutral fat (NF), leukocytes (WBC), erythrocytes (RBC), hemoglobin (Hb), hematocrit (Ht), platelets (PLT) and serum iron (Fe).

The estimations were performed only for items having 30 or more 1st-year abnormal subjects each of males and females.

Blood tests were performed by LIAC, Ltd. Abnormal values were determined using standard values published by the same company, and the results were described as low-TC, high-TC, etc. Data analyses were performed using statistical software SPSS14.0 for Windows.

3. Results

3.1. Correlations between 1st-Year and 4th-Year Values

The 1st-year -4th-year correlations are shown in **Table 1**. The correlation coefficients of all items showed significant differences at $p<0.01$. Items with high correlations were UA (males), TC (males) and PLT (males and females) ($0.7 \leq$); and γ-GTP (males), Cr (females), TC (females) and RBC (males and females) ($0.6 \leq, < 0.7$). Items with low correlations were AST (males), ALT (males and females) and Fe (males and females) (< 0.3). Items with large differences between males and females were AST, γ-GTP and UA.

3.2. 1st-Year and 4th-Year Abnormality Proportions

The 1st-year and 4th-year abnormality proportions of blood tests are shown in **Table 2**. The 1st-year abnormality proportions were 0.02 or higher for all items. Items showing the proportions of 0.1 or higher were low-TC (male and female), low-HDLC (males), high-NF (males), low-NF (females) and low-Fe (females).

The 4th-year abnormality proportions were 0.02 or higher for all items. High-A/G (males), high-TC (females), low-TC (males), low-HDLC (males), high-NF (males) and low-Fe (females) had 0.1 or higher proportions.

The 4th-year abnormality proportions showed higher values than the 1st-year abnormality proportions for two-thirds of all items. Items that revealed a large difference between 1st-year and 4th-year proportions were high-TP (1st year > 4th year), high-A/G ratio (4th year > 1st year) and low-NF (female) (1st year > 4th year).

3.3. The 4th-Year Abnormality Proportions According to the Status in the 1st Year.

Table 3 shows the abnormality-abnormality proportions (r) and normality-abnormality proportions (s).

The highest abnormality-abnormality proportion (r) was high-TC (males) at 0.5526, while the lowest was low-NF (males) at 0.0748. Items that had the proportions of 0.4 or more were high-ALT (males), high-TC, low-TC (males and females), low-HDLC (males) and high-NF (males).

Among the normality-abnormality proportions (s), high-NF (males) was the highest, followed by low-Fe (females), high-A/G (males), and low-HDLC (males),

Table 1 Correlation coefficients between 1st-year values and 4th-year values

Item	Males (N=1607)	Females (N=854)
TP	0.48 **	0.48 **
Alb	0.40 **	0.40 **
A/G ratio	0.43 **	0.50 **
AST	0.10 **	0.36 **
ALT	0.22 **	0.19 **
γ-GTP	0.65 **	0.38 **
UN	0.46 **	0.42 **
Cr	0.55 **	0.63 **
UA	0.71 **	0.59 **
TC	0.74 **	0.62 **
HDLC	0.57 **	0.55 **
NF	0.36 **	0.35 **
WBC	0.40 **	0.45 **
RBC	0.67 **	0.66 **
Hb	0.57 **	0.57 **
Ht	0.53 **	0.54 **
PLT	0.73 **	0.74 **
Fe	0.14 **	0.17 **

**: P<0.01

Table 2 1st–year abnormality proportions and 4th–year abnormality proportions

Item· Abnormality· Sex			1st–year Abnormality Proportion	4th–year Abnormality Proportion	Risk Ratio
TP	High	M	0.0784 (126)	0.0386 (62)	0.4923
		F	0.0761 (65)	0.0363 (31)	0.4770
A/G Ratio	High	M	0.0205 (33)	0.1400 (225)	6.8293
AST	High	M	0.0268 (43)	0.0243 (39)	0.9067
ALT	High	M	0.0423 (68)	0.0660 (106)	1.5603
UN	Low	F	0.0386 (33)	0.0667 (57)	1.7280
UA	High	M	0.0255 (41)	0.0299 (48)	1.1725
TC	High	M	0.0473 (76)	0.0635 (102)	1.3425
		F	0.0843 (72)	0.1042 (89)	1.2361
	Low	M	0.2757 (443)	0.2016 (324)	0.7312
		F	0.1183 (101)	0.1101 (94)	0.9307
HDLC	High	F	0.0562 (48)	0.0597 (51)	1.0623
	Low	M	0.1220 (196)	0.1406 (226)	1.1525
NF	High	M	0.1070 (172)	0.1792 (288)	1.6748
		F	0.0480 (41)	0.0679 (58)	1.4146
	Low	M	0.0666 (107)	0.0212 (34)	0.3183
		F	0.1206 (103)	0.0429 (69)	0.3557
WBC	High	M	0.0243 (39)	0.0249 (40)	1.0247
	Low	M	0.0299 (48)	0.0398 (64)	1.3311
RBC	High	M	0.0454 (73)	0.0361 (58)	0.7952
Fe	High	M	0.0672 (108)	0.0790 (127)	1.1756
	Low	M	0.0716 (115)	0.0784 (126)	1.0950
		F	0.1557 (133)	0.1838 (157)	1.1805

Note) The estimations were performed for items having 30 or more abnormal subjects in the 1st year for males and females, respectively.
Number in parentheses: Number of abnormal subjects
Risk Ratio: 4th–year Abnormality Proportion/1st–year Abnormality Proportion

each at values of 0.1 or higher. The lowest proportion was low-NF (males).

For all items, the abnormality-abnormality proportions(r) were higher than the normality-abnormality proportions (s). Risk ratios (r/s) were particularly high for high-RBC (males), high-UA (males), high-TC (males), high-ALT (males), etc. The ratios were low for Fe.

3.4. Estimation of Continual Abnormality Proportions ($\sqrt[3]{r}$, α) and Abnormality Incidence Proportions (s/3, β)

The results of estimation are shown in **Table 4**. Except for low-NF (males), high-Fe (males) and low-Fe (males) by Model 1 (α), and except for low-NF (males) by Model 2 ($\sqrt[3]{r}$), all continual abnormality proportions were 0.5 or higher. Items that showed continual abnormality proportions of 0.7 or more by Model 1 were high-ALT (males), low-TC, high-TC, low-HDLC (males), high-NF (males) and high-RBC (males). Items that showed continual abnormality proportions of 0.7 or more by Model 2 were high-A/G ratio (males), high-ALT (males), high-TC, low-TC, low-HDLC (males), high-NF (males), high-RBC (males) and low-Fe (females). Continual abnormality proportions of Fe were lower than other items; however, the low values of females were approximately 0.7. Estimated values were higher by Model 2 than by Model 1 for all items. However, except for low-Fe (males), ratios of estimates ($\sqrt[3]{r}/\alpha$) were less than 1.1.

Abnormality incidence proportions were less than 0.1 for both Model 1 (β) and Model 2 (s/3). The estimates, unlike those of the continual abnormality proportions, were greater by Model 1 than by Model

Table 3 Abnormality proportions after 3 years according to the 1st-year states

Item· Abnormality· Sex			1st-Year States		r/s
			Abnormal(r)	Normal(s)	
TP	High	M	0.2143(27/126)	0.0236(35/1480)	9.0805
		F	0.1846 (12/65)	0.0241 (19/788)	7.6598
A/G Ratio	High	M	0.3636 (12/33)	0.1348(212/1573)	2.6973
AST	High	M	0.1628 (7/43)	0.0205(32/1560)	7.9415
ALT	High	M	0.5000 (34/68)	0.0462(69/1493)	10.8225
UN	Low	F	0.2727 (9/33)	0.0579 (47/812)	4.7098
UA	High	M	0.2683 (11/41)	0.0239(37/1547)	11.2259
TC	High	M	0.5526 (42/76)	0.0551(60/1088)	10.0290
		F	0.4861 (35/72)	0.0778 (53/681)	6.2481
	Low	M	0.5102(226/443)	0.0901(98/1088)	5.6626
		F	0.4752(48/101)	0.0675 (46/681)	7.04
HDLC	High	F	0.3125 (15/48)	0.0457 (36/787)	6.8381
	Low	M	0.4133(81/196)	0.1049(145/1382)	3.9399
NF	High	M	0.4070(70/172)	0.1581(210/1328)	2.5743
		F	0.2439 (10/41)	0.0676 (48/710)	3.6080
	Low	M	0.0748 (8/107)	0.0181(24/1328)	4.1326
		F	0.2039(21/103)	0.0662 (47/710)	3.0801
WBC	High	M	0.1538 (6/39)	0.0224(34/1520)	6.8661
	Low	M	0.2500 (12/48)	0.0342 (52/1520	7.3099
RBC	High	M	0.3562 (26/73)	0.0209(32/1531)	17.0431
Fe	High	M	0.1481(16/108)	0.0744(103/1384)	1.9906
	Low	M	0.1652(19/115)	0.0715(99/1384)	2.3105
		F	0.3459(46/133)	0.1546(107/692)	2.2374

Note) Abnormal(r): Abnormality-abnormality proportion
Normal(s): Normality-abnormality proportion

2 for all items, and the differences between the values estimated by both models were greater for the abnormality incidence proportions than for the continual abnormality proportions. Items that showed comparatively high values by Model 1 were high-A/G ratio (males), high-NF (males), low-Fe (females), etc. Items that showed small differences between Model 1 and Model 2 were TC, HDLC, etc., and an item with large differences between the models was Fe. However, even for high-TC (males) that showed a

Table 4 Estimates of continual abnormality proportions (α,$\sqrt[3]{r}$) and abnormality incidence proportions (β,s/3)

Item·Abnormality·Sex			α	β	$\sqrt[3]{r}$	s/3	$\sqrt[3]{r}$/α	s/3/β	α/β
TP	High	M	0.5880	0.0124	0.5984	0.0079	1.0177	0.6371	47.42
		F	0.5566	0.0131	0.5694	0.0080	1.0230	0.6107	42.49
A/G Ratio	High	M	0.6795	0.0670	0.7137	0.0449	1.0503	0.6701	10.14
AST	High	M	0.5335	0.0114	0.5460	0.0068	1.0234	0.5965	46.80
ALT	High	M	0.7881	0.0196	0.7937	0.0154	1.0071	0.7857	40.21
UN	Low	F	0.6285	0.0296	0.6485	0.0193	1.0318	0.6520	21.23
UA	High	M	0.6371	0.0119	0.6450	0.0080	1.0124	0.6723	53.54
TC	High	M	0.8151	0.0228	0.8206	0.0184	1.0067	0.8070	35.75
		F	0.7758	0.0339	0.7863	0.0259	1.0135	0.7640	22.88
	Low	M	0.7880	0.0390	0.7991	0.0300	1.0141	0.7692	20.21
		F	0.7710	0.0295	0.7804	0.0225	1.0122	0.7627	26.14
HDLC	High	F	0.6660	0.0222	0.6786	0.0152	1.0189	0.6847	30.00
	Low	M	0.7248	0.0492	0.7449	0.0345	1.0277	0.7012	14.73
NF	High	M	0.7071	0.0781	0.7411	0.0527	1.0481	0.6748	9.05
		F	0.5968	0.0361	0.6248	0.0225	1.0469	0.6233	16.53
	Low	M	0.3960	0.0118	0.4213	0.0060	1.0639	0.5085	33.56
		F	0.5535	0.0371	0.5886	0.0221	1.0634	0.5957	14.92
WBC	High	M	0.5211	0.012	0.5358	0.0075	1.0282	0.5906	41.03
	Low	M	0.6173	0.0175	0.6300	0.0114	1.0206	0.6514	35.27
RBC	High	M	0.7043	0.0096	0.7089	0.0070	1.0065	0.7292	73.36
Fe	High	M	0.4659	0.0466	0.5291	0.0248	1.1357	0.5322	10.00
	Low	M	0.4973	0.0431	0.5487	0.0238	1.1034	0.5522	11.54
		F	0.6572	0.0810	0.7020	0.0515	1.0682	0.6358	8.11

small difference, the ratio of estimate (s/3/β) was 0.8, which indicates that the estimate by Model2 is less than that by Model1 by approximately 20%. High-AST, low-NF, high-WBC (males), Fe, etc. showed large differences between the estimates of two models with approximately 0.5-0.6 of the s/3/β.

4. Discussion

Using the blood tests performed over a 3-year period, we attempted to analyze the variability of blood constituents by correlation coefficients, and estimates of continual abnormality proportions

and abnormality incidence proportions. Items with comparatively high correlations were Cr, UA, TC, HDLC, RBC, Hb, Ht and PLT, and items with low correlations were AST, ALT and Fe. For continual abnormality proportions, no significant differences were found between the estimates by Model 1, which assumed annual coming and going of normal and abnormal subjects, and by Model 2, which ignored coming and going. For abnormality incidence proportions, however, Model 2 tended to yield smaller values than Model 1.

The reason that large differences were not seen in the continual abnormality proportions of the two models is thought to be that the abnormality incidence proportions of the blood test items covered here were much lower than the continual abnormality proportions. Conversely, the large differences observed in the abnormality incidence proportions between the models were probably caused by the fact that the abnormality incidence proportions were low and were, therefore, more easily influenced by abnormal subjects who became normal the next year and abnormal the next year. For many blood test items, the abnormality incidence proportion is generally lower than the continual abnormality proportion. Therefore, models that assume the coming and going of abnormal subjects and normal subjects are better for estimation of abnormality incidence proportion. On the other hand, it is thought that the continual abnormality proportion is not influenced much by coming and going due to low abnormality incidence proportion, and that relatively good estimates can also, therefore, be obtained by the simple model that does not assume the coming and going.

Model 1 assumes that the probability that normal subjects will become abnormal after 1 year and the probability that abnormal subjects will be abnormal after 1 year are constant every year, respectively; however, continually normal subjects and normal subjects who were previously abnormal are naturally included among the normal subjects. Continually normal subjects are generally thought to have a lower probability of becoming abnormal. In addition, continually abnormal subjects and subjects who became abnormal that year are also included among abnormal subjects. In this case as well, continually abnormal subjects probably have a higher probability of becoming abnormal. Therefore, it is necessary to emphasize that the estimates of this report are based on these assumptions.

Abnormality incidence proportions based on Model 1 were approximately 0.01-0.08, and continual abnormality proportions were 0.8 for high items and 0.5-0.7 for many items. Reports on the dynamic states of blood constituents in young adulthood are relatively few, and no reports were found on abnormality incidence proportion. Even for issues of continual abnormality proportion, although there are quite a few reports on tracking phenomena [Boulton et al, 1995;Fuentes et al, 2003; Kelder et al, 2002; Moilanen et al, 1987; Omura et al, 1991; Patel et al, 2007; Porkka et al, 1994; Spyckerelle et al, 1992; Webber et al, 1991], no reports were found that addressed continual abnormalities after 1 year. **Table 5** summarizes the reports on tracking phenomena [Boulton et al, 1995; Fuentes et al, 2003; Kelder et al, 2002; Moilanen et al, 1987; Omura et al, 1991; Porkka et al, 1994; Spyckerelle et al, 1992; Webber et al, 1991].

According to these reports, serum lipids during childhood have correlation coefficients between 0.45-0.55 (5 years) and 0.71-0.78 (2 years). Relatively high correlations are observed even when the observation interval is long. The correlation coefficients of NF in this report are somewhat low; however, the correlation coefficients of TC and HDLC closely resemble the values of these reports. NF fluctuates to a relatively high degree because of the influence of meals, etc. Meals before blood sampling were not restricted this time; therefore, this might have influenced the low correlation of NF. No reports were found on the tracking phenomena of blood constituents other than serum lipids; consequently, adequate bibliographical consideration is not possible. However, except for the fact that TP, WBC, Ht, etc. are affected greatly by exercise, there is no mention in books, etc. of the items covered here fluctuating greatly during everyday life. Therefore, we think that the correlations of 1st-year and 4th-year values present a picture of tracking of blood constituents to some extent.

Except for A/G ratio and NF, the 1st-year and 4th-year abnormality proportions do not differ by more than two times. This fact does not mean the turnover between normal subjects and abnormal subjects is low. Actually, the abnormality-abnormality proportions are approximately 0.55 for high items and approximately 0.1 for low items, and at least half of these rates are 0.3 or less. Furthermore, the estimates

Table 5 Summary of literature on tracking phenomena of blood constituents and other characteristics in young subjects

Authors	Subjects	Term	Item	Correlation Coefficient
Fuentes et al	7-15 years old	8 years interval	Total cholesterol	0.655
Kelder et al	3-8 school year	6 years interval	Body weight BMI Skinfold thickness Serum lipids Blood pressure	0.86 0.86 0.72-0.78 0.67-0.72 0.45-0.51
Boultonet al	13-15 years old	2 years interval	Serum lipids	0.71-0.78
Omura et al	Junior high school Student (First time test)	5 years interval	Total cholesterol Systolic blood pressure Diastolic blood pressure	0.45-0.55 0.28-0.33 0.19-0.36
Webber et al	Childhood - Adulthood	12 years interval	Serum lipids	LDLC＞ TC,HDLC
Moilanen et al	3-18 years old(First time test)	3 years interval	Serum linoleic acid arachidonic acid	0.58 0.61
Spyckerelle et al	4-17 years old(First time test)	5 years interval	Total cholesterol Uric acid Glucose	Over 0.5 Over 0.5 About 0.3
Porkka et al	9 years old(First time test) Male	3 years 6 years 9 years	Total cholesterol	0.70 0.73 0.59

for continual abnormality proportions were 0.8 for high items and 0.4 for low items, and at least half of these rates are 0.7 or less. These results indicate that for many items, 30% or more of abnormal subjects become normal after 1 year and 70% or more of abnormal subjects after 3 years.

The turnover between abnormal and normal subjects occurs considerably often; however, there is a great difference between the probability of abnormal subjects remaining abnormal (continual abnormality proportion) and of normal subjects becoming abnormal (abnormality incidence proportion). The abnormality-abnormality proportions were greater than 5 times higher than the normality-abnormality proportions for at least half of the items. Comparing the continual abnormality proportions (α) with abnormality incidence proportions (β), the difference is even greater. α/β value was low for Fe at about 10, and high for high-RBC at 73, and 20 or more for many items. These results show that even in young subjects, the probability of continual abnormalities is much higher than that of new abnormalities.

In light of the estimated values of continual abnormality proportion and abnormality incidence proportions, the dynamic state of blood characteristics for young subjects is thought to differ considerably by item. Serum lipids have high continual abnormality proportions and also have high abnormality incidence proportions. During the period from puberty until young adulthood, lipid metabolism changes to relatively high degree [Berenson et al, 1981; Porkka et al, 2008], and this change may be manifested in a relatively high abnormality incidence proportion. On the other hand, continual abnormality proportions are low and abnormality incidence proportions are high for Fe. The 1st-year-4th-year correlations for Fe are also low, and therefore, serum iron is likely to be characterized by large fluctuations. Incidentally, RBC, which has a close relation to Fe, showed high continual abnormality proportions, low abnormality

incidence proportions and correlation coefficients near 0.7. The dynamic states of Fe and RBC are thought to differ considerably.

The data we used were the results of blood tests carried out for all students entering School T of University C from 1995 to 1997. Among the subjects determined to be abnormal during the 1st year, subjects with severe abnormalities received second examinations. Some of these subjects, although few, were treated for anemia and impaired liver function. Therefore, it is difficult to rule out the possibility that the results relating to RBC, Fe, AST and ALT were influenced by treatment.

5. Conclusions

Approximately the same continual abnormality proportions were obtained from both models. Even the simple model that does not assume the coming and going of abnormal subjects provides good estimates. Blood constituents of university students had the following characteristics. Items with high 1st-year-4th-year correlations were TC, etc., and items with low correlations were AST, ALT, and Fe. The 4th-year abnormality proportions were higher than the 1st-year abnormality proportions for many items; however, with the exception of serum protein and NF, the differences were not significant. The 4th-year abnormality proportions of 1st-year abnormal subjects, compared to the 4th-year abnormality proportions of 1st-year normal subjects, were twice as high for low items and over 10 times as high for high items. The continual abnormality proportions of blood constituents in university students were estimated to be approximately 0.5-0.8, and the abnormality incidence proportions were estimated to be 0.01-0.08.

References

Berenson GS, Srinivasan SR, Cresanta JL, et al (1981). Dynamic changes of serum lipoproteins in children during adolescence and sexual maturation. Am J Epidemiol, 113: 157-170.

Berenson GS, Srinivasan SR, Bao W, et al (1998). Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults: The Bogalusa Heart Study. N Engl J Med, 338(23): 1650-6.

Boulton TJ, Magarey AM, Cockington RA (1995). Tracking of serum lipids and dietary energy, fat and calcium intake from 1 to 15 years. Acta Paediatr, 84(9): 1050-5.

Daviglus ML, Stamler J, Pirzada A, et al (2004). Favorable cardiovascular risk profile in young women and long-term risk of cardiovascular and all-cause mortality. JAMA, 292(13): 1588-92.

Fuentes RM, Notkola IL, Shemeikka S, et al (2003). Tracking of serum total cholesterol during childhood: an 8-year follow-up population-based family study in eastern Finland. Acta Paediatr, 92(4): 420-4.

Hemmingsson T, Lundberg I (2006): Is the association between low job control and coronary heart disease confounded by risk factors measured in childhood and adolescence among Swedish males 40-53 years of age? Int J Epidemiol, 35(3): 616-22.

Kelder SH, Osganian SK, Feldman HA, et al (2002). Tracking of physical and physiological risk variables among ethnic subgroups from third to eighth grade: the Child and Adolescent Trial for Cardiovascular Health cohort study. Prev Med, 34(3): 324-33.

Komatsu A, Sakurai I (1996). A study of the development of atherosclerosis in childhood and young adults: risk factors and the prevention of progression in Japan and the USA. The Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Research Group. Pathol Int, 46(8): 541-7.

Kronmal RA, Cain KC, Ye Z, et al (1993). Total serum cholesterol levels and mortality risk as a function of age: A report based on the Framingham data. Arch Intern Med, 153(9): 1065-73.

McMahan CA, Gidding SS, Malcom GT, et al (2006). Pathobiological determinants of atherosclerosis in youth risk scores are associated with early and advanced atherosclerosis. Pediatrics, 118(4): 1447-55.

Moilanen T, Viikari J, Räsänen L, et al (1987). Three-year tracking of serum fatty acids in Finnish boys and girls. Atherosclerosis, 67(2-3): 191-7.

Omura T, Takizawa Y, Kojima S, et al (1991). A five-year follow-up study on blood pressure and serum cholesterol in junior high school children. Jpn J Public Health, 38(6): 417-24. (in Japanese with English Summary)

Patel DA, Srinivasan SR, Xu JH, et al (2007). Persistent elevation of liver function enzymes within the reference range is associated with increased cardiovascular risk in young adults: the Bogalusa Heart Study. Metabolism, 56(6): 792-8.

Porkka KV, Viikari JS, Akerblom HK (1994). Short-term intra-individual variation and long-term tracking of serum lipid levels in children: the Cardiovascular Risk in Young Finns Study. Atherosclerosis, 105(1): 63-9.

Porkka KVK, Viikari JSA, Rönnemaa T, et al (2008). Age and gender specific serum lipid and apolipoprotein fractiles of Finnish children and young adults: The Cardiovascular Risk in Young Finns Study. Acta Paediatrica, 83: 838-848.

Spyckerelle Y, Steinmetz J, Deschamps JP (1992). Comparison of measurements of cholesterol, glucose and uric acid taken at 5-year intervals in children and adolescents. Arch Fr Pediatr, 49(10): 875-81. (in French with English Summary)

Stamler J, Daviglus ML, Garside DB, et al (2000). Relationship of baseline serum cholesterol levels in 3 large cohorts of younger men to long-term coronary, cardiovascular, and all-cause mortality and to longevity. JAMA, 284(3): 311-8.

Usui W, Takeda M, Taki K, et al (2001). A study of standard value for blood test in university students. Japanese Journal of School Health, 43(suppl): 248-9. (in Japanese)

Wamala SP, Lynch J, Kaplan GA (2001). Women's exposure to early and later life socioeconomic disadvantage and coronary heart disease risk: the Stockholm Female Coronary Risk Study. Int J Epidemiol, 30(2): 275-84.

Webber LS, Srinivasan SR, Wattigney WA, et al (1991). Tracking of serum lipids and lipoproteins from childhood to adulthood:

The Bogalusa Heart Study. Am J Epidemiol, 133(9): 884-99.
Yasui K, Shiraishi Y, Usui W, et al (2004). Estimation of tracking rate of blood test after one year by three-year intervals' test and the validity. Japanese Journal of School Health, 46(suppl): 418-9. (in Japanese)

Name:
Yasuo Shiraishi

Affiliation:
School of Management, Tokyo University of Science

Address:
500 Shimokiyoku, Kuki, Saitama 346-8512 Japan

Brief Biographical History:
1996- Assistant Professor, Health and Physical Education Science Center, Tokyo University of Science
2001- Associate Professor, School of Management, Tokyo University of Science

Main Works:
• "Reliability of Questionnaire Used to Survey Allergic Disease in School," Journal of Epidemiology, Vol.6 No.1, 23-30, March(1996)

Membership in Learned Societies:
• The Japan YOUSEI Society, Director
• The Japan Society of Epidemiology, Councilor
• The Japan Society of Physical Education