筑波大学体育科学系紀要　Bull. Health & Sports Sciences, Univ. of Tsukuba　11:239—252, 1988.

A study on prediction of future status of physique and physical fitness of Japanese boy

using the annual data from 1964 through 1985.

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日本人青少年の体格・体力の将来予測に関する研究

——1964年から1985年までの逐年資料を用いて——

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文部省の体力・運動能力調査は1964年に開始され，1985年の結果まですでに報告されている。1982—1983年の２年間文部省科学研究費（A）の補助を受け，本学情報処理センターのFACOM780/20の共用ファイル上にこれらの結果の一部をデータ・ベースとして構築し，1985年，1986年の結果もすでに此のデータ・ベースに添加した。このデータ・ベースを用いて，スポーツ・テストのすべての項目について1964年から1985年までの逐年変化の分析と，その分析結果を用いて1986年から2000年までの逐年変化の予測を試みた。

予測は次の手続に従って実施された。１）用いるデータ数の決定(m)，２）予測値推定のために用いる年度を独立変数とした多項式の次数の決定，３）与えられた過去のデータ（mこ）を用いて多項式を最小二乗法によって決定する，４）m＋１をこの多項式に代入し１つの未来値を決定する，５）（m－１）この過去のデータと今決定された未来値を加えたmこのデータを用いて多項式を再度決定し，此れに(m＋１)を代入して，次の未来値を決定する，６)此のように逐次回帰の方法で，1986年から2000年までの未来値を決定する，７）過去のデータについて，此の方法で推定を実施し，残差を評価し，残差が無作為であることを系列相関係数を用いて確かめる，８）・６)で得られた未来値数列に適当な正規乱数を加えて，第２次未来値とした，９）第２次未来値数列に一回の移動平均法による平滑化を施し，乱数の影響を軽減する，この平滑化された未来値数列を最終予測値とする，10)・７)で評価された残差の標準偏差を用いて95%の信頼限界を決定しband estimationの考えを利用してband predictionを試みた。このような予測をすべての項目について試みたが，本論文では身長，体重，背筋力，体力診断テスト合計点についてのみ10，13，16歳の男子について討論することにした。さらに，測定項目を10歳では10領域，13，16歳では11領域に分類し，1964年から1985年までのデータの平均値，標準偏差を用いて，過去の価及び未来値を標準化して，各領域の得点を求め体力プロフィールを描いて2000年の日本人青少年の体力の特徴を1964年及び1985年のそれらと比較した。

Key words:　Prediction, Physique, Physical fitness, Youth.

Ⅰ. Introduction

Various studies on secular trend of physique growth have been accomplished since Virey, G. (1816) and Villerme, L.R.(1828) attempted. All of them have investigated in the physique growth; particularly stature and body weight. Tanner, J.

M. (1966) reviewed more than a hundred publications concerning secular trends in growth and maturation in different countries and reported several important knowledges concerning secular growth changes of stature and body weight. Matsuura, Y.(1964) devised certain effective indices to analyze the secular trends of physique growth and reported.Kawahata, A. and et. al. (1963) investigated the annual changes of stature and body weight from 1900 through 1965 with those indices Matsuura devised in his work, which was not published yet at that time. However, all of these studies were only to analyze the secular changes in growth and development and did not attempt to predict the future changes with the knowleges regarding the secular changes obtained. To predict the future status of physical growth and development is an interesting but very difficult problem, because the secular changes influenced by various factors. Actually all of these factors have not been identified yet so completely. Particularly the degree of contribution has never been determined. However, Ministry of Health and Welfare (1979) and Takaishi, M. (1982) attempted to predict the future status of stature and body weight for Japanese and reported, but any attempts have never been made on prediction of physical fitness in any countries.

Physical fitness survey of youth was started in 1964 by Ministry of Education, Science and Culture, so we have the annual data concerning physical fitness of Japanese youth ; 10 years old through 29, for 22 years up to 1985. In these years, growth acceleration emerged and was said to cease in 1970s. As long as the recent annual trend of physique ; say, for recent 10 years, investigated, it may be concluded that physique of Japanese youth is still continuing to become larger. Such a changing trend has been different in different year intervals. However, Matsuura. Y. (1984) reported that growth acceleration seemed to cease in 1974-1976 and the recent changing trend of physique and physical fitness seemed to be rather stable.

Tanner, J.M. (1966) reported the close relationship of socioeconomic conditions with secular changes, so it is very difficult to predict the future status of physical growth and development with the changing socioeconomic conditions taken into consideration. However, it is something meaningful to predict the future stauts of physical growth and development with various influential conditions made constant. In other words, these conditions are put tinto a black box and it is hypothesized that annual changing trend be the data of time-series. Of course, this assumption must be tested with the data given, and then, the future prediction should be worked out.

In this study, it is assumed that the 22-years annual data of physical growth and development from 1964 to 1985 are data of time-series and annual changing trends can be expressed with a certain mathematical manipulation without taking various influential conditions into consideration. First of all, this assumption will be tested in this study. Then, the prediction of physical growth and development will be attempted under such delimitation as described previously. For prediction practice, it is another inevitable problem to determine the optimal procedure to estimate the future value with the data given.

Tanner, J.M. and et. al. (1956, 1975) reported that successful prediction of individual's adult height could be worked out with height, bone age and occurance of menarche, at age 4 to 16. Several predicton studies of this type have been reported but the procedure with which prediction was carried out could not be applied to prediction of secular changing trend, because the individual's growth curve is quite different in shape and nature from the secular trend one. Author attempted to apply logistic function to the secular trend curve but it could not be determined mathematically (1984). Therefore, it could be concluded that prediction of individual's growth curve is quite different in mathematical nature from the one of secular trend curve (1984).

II. Method and procedure.

1) Data of annual trend.

The physical fitness survey has been carried out by Ministry of Education, Science and Culture since 1964 and the results have been published annually. Fortunately, the data base including these results was constructed in FACOM780/20 of University of Tsukuba Science Information Processing Center by author himself in 1984 with research grant (A) from Ministry of Education, Science and Culture. Since then, this data base has been updated annually with new results of every year, so the data from 1964 through 1986 were filed in this data base now. When this paper was written, however, the data up to 1985 were filed, so these data were used in this study. The data base includes sample size, mean and standard deviation in each sex, each age ; 10 through 29, and each measure, respectively. In this paper, however, discussion will be made on stature, body weight, back strength and physical fitness score for 10, 13 and 16 years of age, because of limitation of pages.

The available data are not from census but sampling, so a certain limitation of sampling survey is involved in this study, although the sample sizes are very large every year.

2) The procedure used for prediction.

In general, two procedures can be utilized for prediction ; e. g. use of one predetermined equation or equations, and successive extrapolation idea that is one of simulation procedure. The former one is rather easy if the optimal equation could be determined, but, as long as author's previous works (1983, 1984) reported and the secular changing trends of physical fitness elements investigated, it was concluded that it was impossible to determine any mathematical equation or equations to describe the secular trend curves. Therefore, the latter was utilized in this study. However we have various kinds of formulas for extrapolation, so author tried to apply these available formulas to the actual data in trial and error bases. After all, it was found very sufficient to determine one degree of polynomial from linear, quadratic or cubic with optimal number of data given ; m, to extrapolate only one value at $t=m+1$, to determine same degree of polynomial with $(m-1)$ data given plus the value extrapolated just one step before, then to extrapolate only one value at $t=m+1$, and so on. The successive extrapolation of this type is based just on the idea of simulation procedure. The successive computation of this type could be worked out very easily by electronic computer.

Determination of optimal number of data used and degree of polynomial used was worked out by following procedures.

(1) To attempt to estimate the actual data by three kinds of polynomials ; linear, quadratic, and cubic, with $5 \leqq m$ (no. of data) $\leqq 17$.

(2) To evaluate mean error, mean absolute error, and standard error.

(3) To evaluate serial correlation of errors to check the randomness of errors.

(4) Then, m and degree of polynomial were determined so as to secure minimum mean error, minimum mean absolute error and minimum standard error, and non-significant mean serial correlation coefficient.

III. Theoretical and practical background for computational procedure.

1) Determination of number of data used for prediction ; m, and degree of equation applied.

Let X_1, X_2, X_3,·········Xn be actual annual data given, and these data were drawn on CRT display of personal computer ; actually HP-85 computer used. Then, more data than 5 in recent years were approximated with a straight line, and the number of data described by this straight line was evaluated as an initial number of data ; m, for prediction. Then, applying least square procedure, three kinds of equations ; linear, quadratic, and cubic, were determined with m data ; X_1, X_2, X_3,……Xm. For computational convenience, the initial year was transformed to 1, so the data used were as follows ;

Xi : X_1, X_2, X_3,…………Xm, and
t : 1, 2, 3,…………………,m.

Then, $X=at+b$; $X=at^2+bt+c$, and $X=at^3+bt^2+ct+d$, were determined with Xi and ti. Then, X′m+1 was determined with (m+1) put into the equations determined just now. Then, using m data ; X_2, X_3, X_4,……Xm and X′m+1, Xm+2 was determined on the same way. After all, for one m, (22−m) values could be determined. Then, according to this procedure mentioned above, the residuals ; Ri=Xm+i−X′m+i, were evaluated and their randomness was checked by serial correlation coefficient. Furthermore, the figures of annual changing trends were very likely to involve the random fluctuation. Table 1 shows the mean serial correlation coefficients to check the randomness of residual trends in each number of data used in stature of 10 years old boy. Although the randomness check tables could not be shown for all cases, it could be concluded that the residual trends were random in all cases as long as the number of data used was less than 12. This might suggest that the random fluctuation of actual changing trend should be taken into consideration to make prediction more precise and real.

2) Random adjustment of predcted values.

As mentioned previously, the actual annual changing trends seemed to involve some sort of irregular fluctuation. As mean serial correlation coefficients showed, the residulas of predicted values from the actual annual data were found random, so it is likely to be reasonable to adjust the predicted values with random number for correcting the residuals. Then, let X′m+1, X′m+2, X′m+3,……, and X′n be the predicted values to the actual data ; Xm+1, Xm+2, Xm+3,……,Xn, ei=(Xm+i−X′m+i), and $SE^2=\Sigma(ei-\bar{e})^2/(n-m)$; residual variance, and $\bar{e}=\Sigma\ ei/(n-m)$. The absolute value of adjustment was determined by finding such random number obtained from normal random number generator as being equal in the significant figures to $\bar{e}$ and less than or equal to 1. 96 $\bar{e}$. Then, the integer part of this random number was extracted and positive sign was given if it is even and negative one if it is odd. That is, let a be an absolute value of normal random numder that satisfies the conditions mentioned previously and i be its integer part, and if i is even, the adjustment value is R=a, but R=-a if i is odd. However, if a is less than unity, i is equal to zero, so the integer part of this random number can not be found. For this case, a was multiplied by 10^k such that the significant figure of integer part is equal to 1, and even—odd diagnosis was made on integer part of $a\times10^k$

Then, let the residual adjustment value be Rm+i for X′m+i. Then, the predicted value adjusted was given by X″m+i=X′m+i+Rm+i.

Table 1 Mean serial correlation coefficients for checking randomness of residual trends; 10 years old boy.

	5	6	7	8	9	10	11	12
Stature	−.100	−.100	−.055	−.117	−.116	−.140	−.106	−.095
Body wt.	−.081	−.115−	−.015	−.010	.010	.100	.123	.141
Back st.	−.057	−.025	.016	−.043	−0.12	−.080	−.113	−.106
P.F.Score	−.036	−.064	−.091	−.137	−.219	−.321	−.141	−.069

Note : Body wt is body weight, Back st. back strength, and P.F.Score physical fitness score.

Table 2 Standard errors of three kinds of equations for each number of data used; Stature of 10 years boy

No. of data	1	2	3
5	.478	.608	1.822
6	.431	.634	1.012
7	.444	.548	.963
8	.408	.571	.774
9	.457	.492	.755
10	.421	.543	.646
11	.448	.499	.613
12	.458	.501	.623

Note : 1 means linear equation, 2 means quadratic and 3 means cubic.

With these predicted values adjusted, mean errors were caluculated and shown only for stature of 10 years old boy in Table 2, These statistics showed that the annual trends could be estimated with considerable precision by mathematical manipulation.

3) Second adjustment to the predicted values adjusted.

In order to reduce the degree of influence of random adjustment to X′m+i, moving average procedure was applied once to the series of X″ m+i ; i=1, 2, 3,……(n−m). Let these adjusted values be X°m+1, X°m+2, X°m+3,………X°n. If i extends to more than (n−m) ; e. g. n−m+p, where p stands for number of years for prediction made with n actual data given, then prediction of future status can be worked out. These adjusted values are the final adjusted values of prediction.

4) Determination of bounds for band prediction.

It is reasonable that some sort of allowance should usually be taken into considiration for prediction. For this, the idea of band estimation was utilized in this study. For band estimation, the upper and lower bounds should be determined. Then, let the annual data given be X_1, X_2, X_3,……Xn, and the final predicted values be X°m+1, X°m+2, X°m+3,……X°n, respectively, and the final errors be Ei=Xm+i−X°m+i, and evaluate error variance ; $SE^2=\Sigma (Ei-\bar{E})^2/(n-m)$, where $\bar{E}=\Sigma Ei/(n-m)$. It could be reasonably assumed that Ei distributes as normal, so the upper bound was determined as UBn+j=Xn+j+d. SE, and the lower bound as LBn+j=Xn+j−d. SE, where d is equal to 1.96 for significance level of 95%, or 2.56 for 99%, and j=1, 2, 3,………p.

IV. Results and discussion.

1) Stature

Fig. 1 shows the actual annual changing trend of stature for 10 years old boy. Table 3 suggested the number of data used for prediction was 8 and linear equation might produce the best prediction values. Thus, according to the procedure mentioned in the previous section, the predicted value for 1986 was determined with 8 data from 1978 through 1985. Then, the one for 1978 was determined with 7 data from 1979 through 1985 and the predicted value of 1986. Fig. 2 shows the actual trend from 1964 through 1985 and the predicted trend from 1986 through 2000. Fig. 3 shows the actual trend and the trend of predicted values adjusted that were adjusted with taking random fluctuation into consideration, and Fig. 4 shows the actual trend plus the final predicted trend from 1986 through 2000. Finally, Fig. 5 shows the actual trend and predicted trend with band prediction of 95%, confidence level. Table 4 shows the final predicted values, lower and upper bounds of

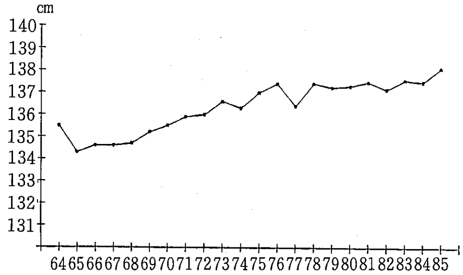

Fig. 1, Annual trend of Stature: 10 years boy

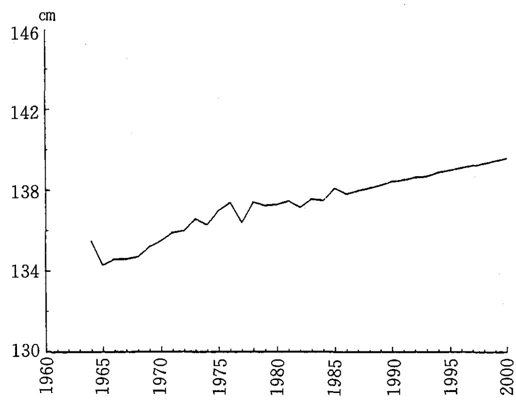

Fig. 2, Actual and predicted trend of Stature: 10 years boy

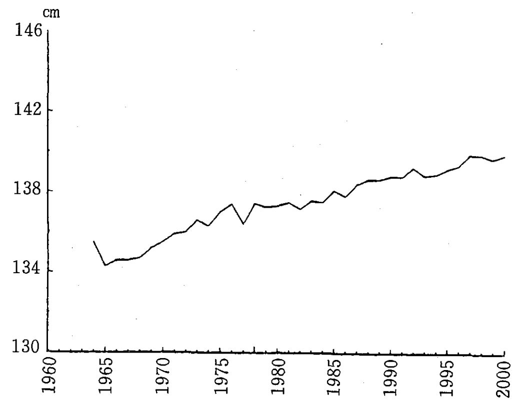

Fig. 3, Actual and predicted trend of Stature: with randomness taken.

Table 3, The prediction errors from actual data, their standard errors and serial correlations; stature of 10 years boy, linear equation used.

	No. of data used for prediction					
year	5	6	7	8	9	10
'69	.846					
'70	.250	.710				
'71	.260	.293	.711			
'72	−.200	−.053	.000	.387		
'73	.150	.193	.300	.343	.687	
'74	−.530	−.580	−.529	−.421	−.367	−.042
'75	.250	.193	.100	.103	.169	.200
'76	.290	.253	.228	.161	.169	.233
'77	−1.220	−1.154	−1.157	−1.161	−1.209	−1.193
'78	.470	.293	.234	.148	−.081	−.013
'79	−.156	−.093	−.200	−.231	−.294	−.348
'80	.058	−.156	−.117	−.217	−.256	−.323
'81	.136	−.149	−.029	−.006	−.101	−.145
'82	−.630	−.349	−.324	−.469	−.451	−.537
'83	.342	.006	.187	.184	.036	.003
'84	−.011	0.64	−.192	−.033	−.025	−.149
'85	.571	.564	.628	.410	.540	.546
S E *	.478	.431	.444	.408	.457	.421
MSC *	−.0998	−.1003	−.0551	−.1174	−.1158	−.1405
SD of SC	.2881	.2663	.3766	.2225	.3655	.2350

Note ; SE stands for standard error, MSC for mean serial correlation, and SD of SC for standard deviation of serial correlations.
Serial correlation was used for randomness check of prediction errors.

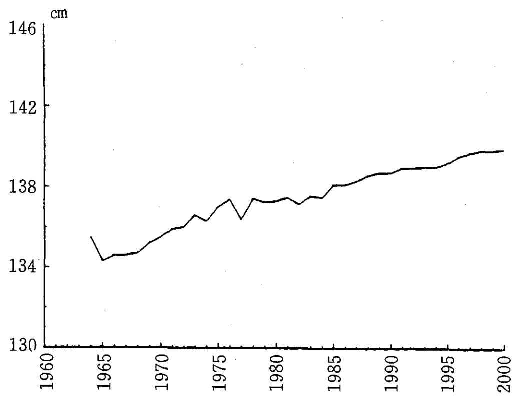

Fig. 4, Actual and predicted trend with moving average taken once.

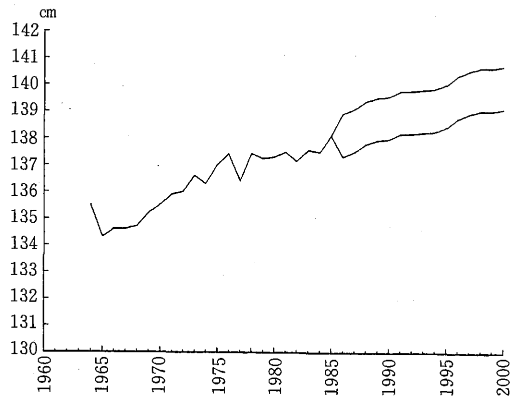

Fig. 5, Annual and predicted trend of Stature: 10 years boy

Table 4 Predicted values, upper and lower bounds; Stature of 10 years old boy.

YEAR	LB	PV	UB
1980	0.0	137.30	0.0
1981	0.0	137.48	0.0
1982	0.0	137.15	0.0
1983	0.0	137.57	0.0
1984	0.0	137.49	0.0
1985	0.0	138.11	0.0
1986	137.32	138.12	138.92
1987	137.50	138.30	139.10
1988	137.78	138.58	139.38
1989	137.92	138.72	139.52
1990	137.96	138.76	139.56
1991	138.16	138.96	139.76
1992	138.18	138.97	139.77
1993	138.21	139.01	139.81
1994	138.25	139.05	139.85
1995	138.41	139.21	140.01
1996	138.74	139.54	140.34
1997	138.92	139.72	140.52
1998	139.04	139.84	140.64
1999	139.03	139.83	140.63
2000	139.10	139.90	140.70

Note : LB; lower bound, PV; predicted value, and UB; upper bound

95% confidence level for 10 years old boy. Therefore it may be inferred that the growth acceleration seemed to cease in 1974 or '75 but the increasing trend might be still continuing, although the increase gradient was much less than one before 1975. The predicted trend after 1985 shows a certain gradually increasing one. Then, the stature of 10 years old boy may reach 139.9cm in 2000, so 1.79cm may increase from that of 1985 ; 138.11cm. In 2000 the lower and upper bounds of 95% confidence level were 139.1cm and 140.70cm, respectively, so it could be concluded that the stature of 10 years old boy may be between 139.1cm and 140.7cm with 95% confidence level in 2000. For 13 and 16 years old boys the same procedures as applied in the stature of 10 years old boy, that were mentioned previously, were utilized and their predicted trends and values are presented in Fig. 6 and 7.

For 13 years old boy, as Fig. 6 shows, the growth acceleration seemed to cease around 1977, and then the slow increasing tendency continued up to 1985. Then, thereafter the slow increasing tendency may still continue up to 2000. Compared in the increase gradient with 10 and 16 years old boys, 13 years old boy showed smaller one, so it could be inferred that the stature of 13 years old boy would not show so much degree of increase as those of 10 and 16 years old boy in future.

For 16 years old boy, as Fig. 7 shows, the actual annual trend seemed to be diveded into

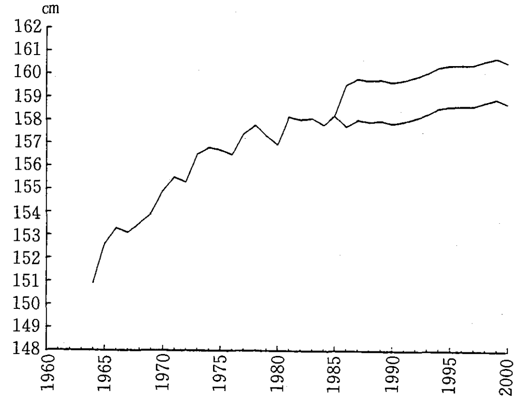

Fig. 6, Annual and predicted trend of Stature of 13 years boy

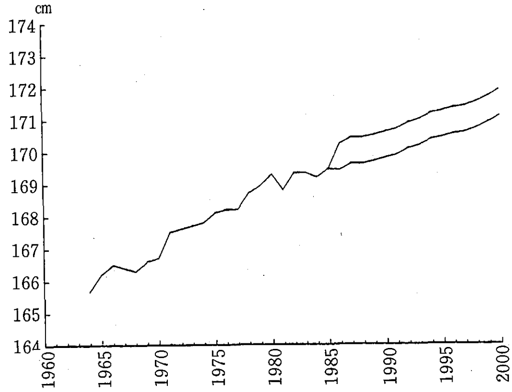

Fig. 7, Annual and predicted trend of Stature: 16 years boy

Table 5 Predicted values, upper and lower bounds; Stature of 13 years old boy.

YEAR	LB	PV	UB
1980	0.0	156.94	0.0
1981	0.0	158.15	0.0
1982	0.0	158.02	0.0
1983	0.0	158.09	0.0
1984	0.0	157.80	0.0
1985	0.0	158.20	0.0
1986	157.73	158.63	159.53
1987	158.01	158.91	159.80
1988	157.93	158.83	159.72
1989	157.98	158.87	159.77
1990	157.86	158.75	159.65
1991	157.95	158.85	159.74
1992	158.09	158.99	159.88
1993	158.26	159.16	160.05
1994	158.52	159.42	160.31
1995	158.61	159.50	160.40
1996	158.63	159.52	160.42
1997	158.63	159.53	160.43
1998	158.79	159.69	160.59
1999	158.93	159.83	160.72
2000	158.74	159.63	160.53

Note : LB; lower bound, PV; predicted value, and UB; upper bound.

Table 6 Predicted values, upper and lower bounds; Stature of 16 years old boy.

YEAR	LB	PV	UB
1980	0.0	169.28	0.0
1981	0.0	168.80	0.0
1982	0.0	169.32	0.0
1983	0.0	169.33	0.0
1984	0.0	169.19	0.0
1985	0.0	169.45	0.0
1986	169.41	169.82	170.22
1987	169.62	170.02	170.42
1988	169.61	170.02	170.42
1989	169.69	170.09	170.50
1990	169.79	170.19	170.60
1991	169.88	170.29	170.69
1992	170.07	170.47	170.87
1993	170.17	170.57	170.98
1994	170.35	170.76	171.16
1995	170.42	170.83	171.23
1996	170.52	170.93	171.33
1997	170.57	170.98	171.38
1998	170.70	171.11	171.51
1999	170.88	171.28	171.68
2000	171.08	171.49	171.89

Note : LB; lower bound, PV; Predicted value, and UB; upper bound.

three terms ; up to 1971, 1971 through 1979 and thereafter up to 1985. The increase gradient up to 1971 was largest, so it might be inferred that growth acceleration ceased in 1971. However, the increase gradient was still large in the second term and only a little less than the one up to '71, but the one of 1980 through 1985 became much smaller than those of previous two terms. The increase gradient of predicted trend seemed to be nearly equal to the one of second term ; 1971 thuough 1979. The increase gradient of 16 years old was nearly equal to that of 10 years old, but larger than that of 13 years old.

2) Body weight

Fig. 8, 9, 10 show the annual trend and the predicted trend with band prediction of body weight for, 10, 13 and 16 years old boys,respectively. The confidence intervals seemed to be a little larger in 13 years of age than in other ages. Although the reason was not so clearly identified, the growth of body weight may be accelerated at 13 years of age in conjunction with adolescent growth spurt, so the physical growth in such a term may be influenced more sensitively by some socioeconomic conditions than in other term. Furthemore, comparing with stature, the growth of body weight is much more influenced by such conditions. That is why the secular fluctuations were larger for this age;13 years of age, than other ages, so the confidence interval was larger than those of 10 and 16 years old, as shown in Fig. 9. But this could not be found for the stature growth.

In boys, the growth acceleration of body weight could not so clearly obsrved in 16 years old as in 10 and 13 years old, as observed in stature, and the predicted trend after 1986 showed a considerably sharp increase. This might be why the actual annual trend was such a consisted tendency as being able to be described even by one straight line, as shown in Fig. 10.

3) Back strength

Fig. 11,12,13 show the annual and predicted

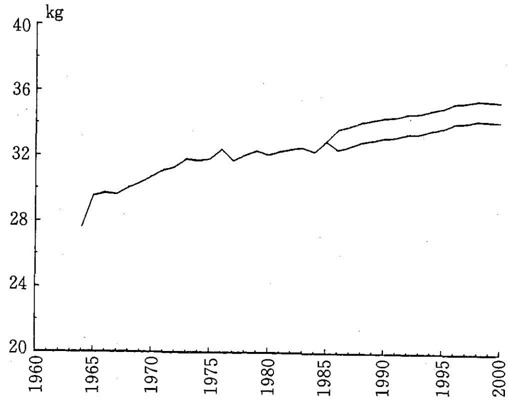

Fig. 8, Annual and predicted trend of Body weight: 10 years boy

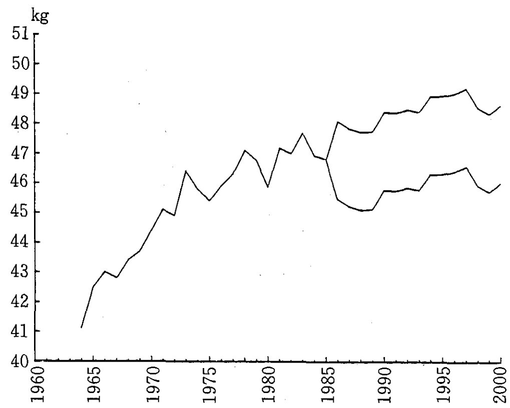

Fig. 9, Annual and predicted trend of body weight of 13 years boy

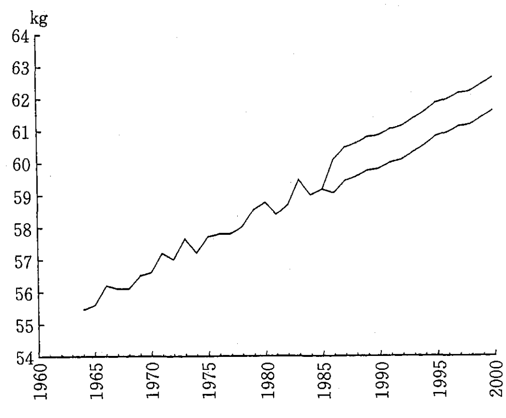

Fig. 10, Annual and predicted trend of Body weitht: 16 years boy secular trends of back strength for 10, 13 and 16 years old boys. As the annual trends from 1964 through 1985 showed, it was easily realized that the secular fluctuation was much larger than stature and body weight. Thus, the confidence interval naturally became so large. And the trend seemed to be gradually decreasing in 1964 through 1985 and this tendency may still be continuing up to before half of 1990s, and thereafter it seemed to tend to recover. After all, in 2000, back strength of 10 years old boy will be in the interval over 57.3kg and. 66.3kg The actual data of 1985 was 59.71kg, so it could be inferred that the significant increase may not be resulted in for 10 years old boy.

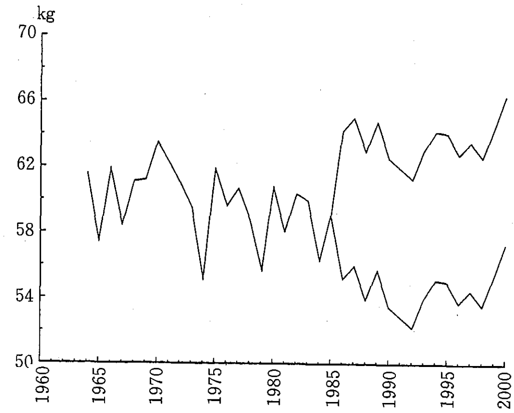

Fig. 11, Annual and predicted trend of back strength of 13 years boy

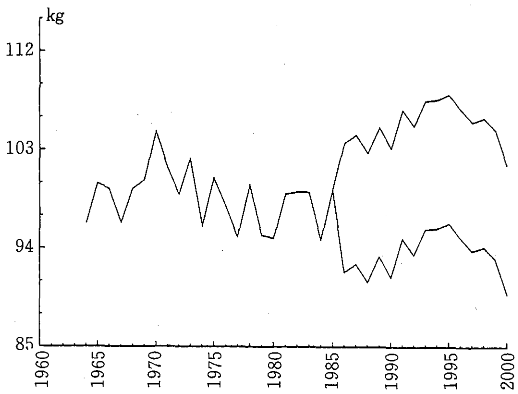

Fig. 12, Annual and predicted trend of Back Strength: 10 years Boy

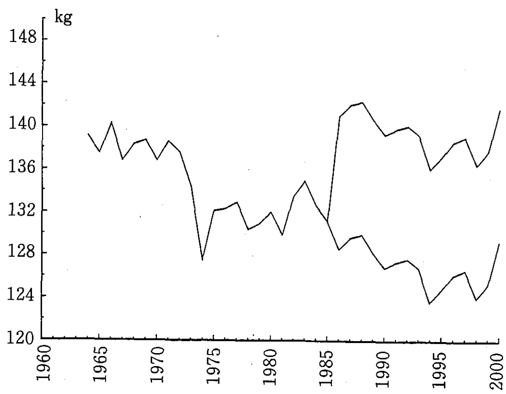

Fig. 13, Annual and predicted trend of Back Strength: 16 years Boy

Table 7 Precision statistics of prediction; Stature

		No. data	M.error cm	S.error cm	M.A.E. cm	M.S.C cm
Boy	10	8	−.0225	.5716	.4380	.0326
	13	6	.0250	.9498	.8182	.0020
	16	10	−.0722	.3382	.2931	−.1206
Girl	10	11	.0961	.3910	.3192	−.0667
	13	7	−.0430	.6070	.4502	−.1475
	16	7	.0014	.3568	.3046	−.0168

Note ; No. data stands for number of data used for prediction,
M.error for mean error, S.error for standard error,
M.A.E. for mean absolute error, and M.S.C. for mean serial correlation.

For 13 years old boy, the actual annual trend showed a certain decreasing tendency from 1970 through 1981, but thereafter, recovering tendency was just about to appear in 1982 or '83, so the predicted trend up to 1995 showed a certain increasing trend to some extent, but thereafter it may tend to decrease again. The secular fluctuation was so large in the term over 1964 and '85, as shown in Fig. 12, so the range of confidence interval was as large as observed in 10 and 16 years old. After 1995, the deceasing tendency may appear for 13 years old but, as Fig. 11 and 13 show, it may not do for 10 and 16 years old and, to contrary to 13, the increasing tendency may appear.

For 16 years old boy, the actual trend showed a certain rapid decreasing up to 1974 and thereafter up to 1985, no significant changes. Then, the predicted trend showed a certain decreasing trend up to first half of 1990s and thereafter it may tend to increase to same extent. This is just similar to that of 10 years old but just contrary to 13 years old. This may suggest that development of back strength would be accelerated at 13 and 16 years old for boy. These developmental characteristics might influence to the degree of secular fluctuation to some extent.

4) Physical fitness score.

Fig. 14, 15 and 16 show the actual annual trends up to 1985 and the predicted trends and their predicted values, lower and upper bounds, respectively. For 10 years old boy, Fig. 14 shows a comparatively sharp increasing trend up to 1972 and thereafter, the signficant change seemes not to be observed up to 1985. Then, the predicted trend showed a certain gradual increase of small extent up to 1996 and thereafter, the decreasing trend may appear for a short duration and then, the increasing trend may appear again. Such a future tendency as observed in 10 years old boy was also found for 13 years old boy. As Fig. 15 shows, the range of confidence interval was rather small, because of small secular changes in data, as shown by

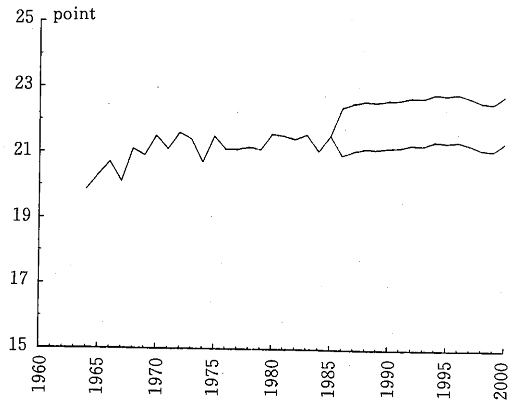

Fig. 14, Annual and predicted trends of P. F. Score: 10 years Boy

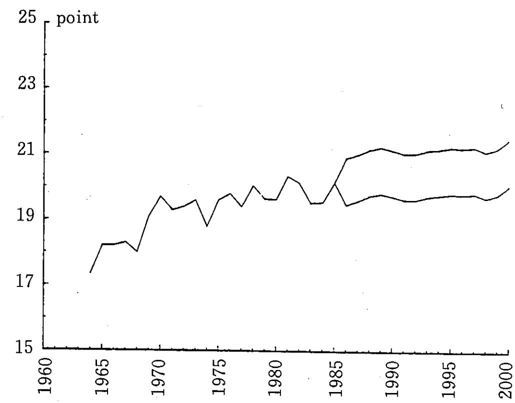

Fig. 15, Annual and predicted trends of P. F.Score: 13 years boy

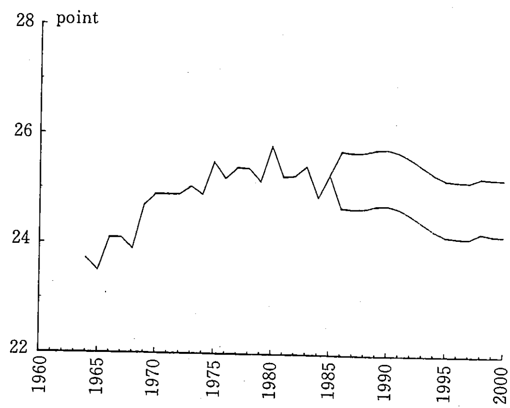

Fig. 16, Annual and predicted trends of P. F.Score: 16 years boy the actual annual data of 1980 thruough 1985. For 16 years old, the future trend was found quite different from those of 10 and 13 years old. That is, as Fig, 16 shows, somewhat an increasing trend was found up to 1975, but thereafter, no significant changes were observed, so this tendency might affect the predicted trend up to 1990 ; e. g., so-called plateau, but thereafter, a certain decreasing trend may appear up to 1997 or '98, and then no signif-icsant change may appear. Therefore, for 10 and 13 years old, the future trend may show no significant changing one, but a certain lowering trend may be predicted only for 16 years old. Thus it could be concluded that the predicted trends of physcal fitness of Japanese boy may show some clearly increaseng tendecy in 13 years old but some clearly decreasing one in 16 years old but no signficant change in others. The prediction precision was considered rather high, because the smaller amounts of standard error and mean absolute error were found in stature, body weight and physical fitness score than those in back strength, although these four attributes of physical fitness showed similar amount in mean error.

5) Physical fitness profile predicted.

Actually, prediction was attempted for all the items included in sports test of Ministry of Education, Science and Culture, although only five items were discussed in this paper. Therefore, let discuss on the future profiles of physical fitness of Japanese youth to investigate their characteristics.

The actual annual data and the predicted values were transformed into the standard score with the mean and standard deviation of actual annual data from 1964 through 1985 in each item, each sex and each age, respectively. Then, 10 profile domains for 10 years old and 11 domains for 13 and 16 were determined by following combinations of items :

(1) Body linearity ; stature and sitting height,
(2) Body bulk ; body weight and chest girth,
(3) Agility ; side step,
(4) Explosive strength ; vertical jump and 50m dash,
(5) Muscular strength ; grip and back strengths,
(6) Muscular endurance ; chinning or modified chinning,
(7) Flexibility ; trunk flexion and extension,
(8) Fundamental motor skill ; 50m dash, running long jump and ball throw,
(9) General physical fitness ; physical fitness score,
(10) General motor ability ; motor ability score,
(11) Endurance ; 1500m run for boy and 1000m for girl.

Then, the profile score was calculated with mean of standard scores of items included in each profile domain.

Fig. 17 through 19 showed the physical fitness profiles of 1964, 1985 and 2000 in 10, 13 and 16 years old boy. The degree of imbalance of profile may tend to be greater in 2000 than those of 1964 and 1985 in all ages for both sexes. For boys, most of ability domains seemed to be inferior to physique in 10 and 16 years old in 2000. Particularly fundamental motor skill may be very inferior to physique and furthermore, it may be inferior to all other domains in boys of all ages. Number of domains inferior to physique seemed to tend to increase annually after 1986, so it was predicted that Japanese youth tend to be larger in physique but physical fitness may tend not to improve in parallel to the increase of physique. As these profiles show, the youth of 2000 seemed to be inferior in flexibility to those of 1964 and 1986. For 10 and 13 years old, however, physical fitness in general seemed to be superior to that of 1964 and 1985 in 2000, but may show no significant difference for 16 years old boy. In general, the profiles were predicted to be more imbalanced than those of 1964 and 1985.

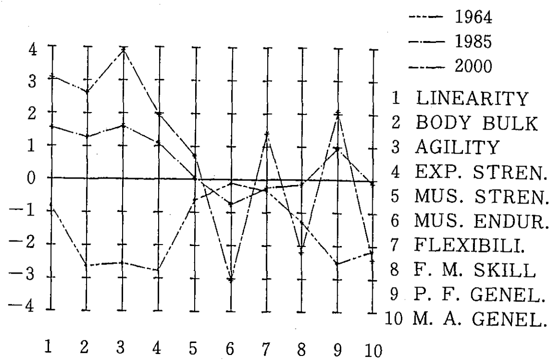

Fig. 17, Phtsical Fitness Profile: 10 years Boy

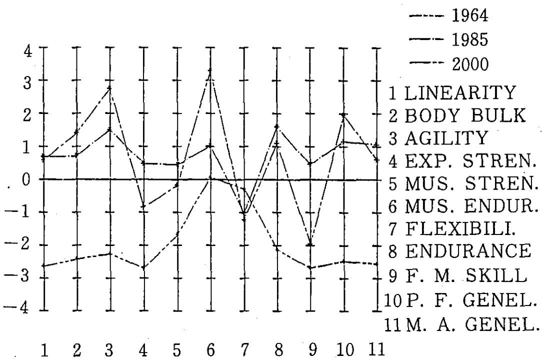

Fig. 18, Physical Fitness Profile: 13 years Boy

V. Conclusion

Successive extrapolation technique using linear equation was attempted to predict the future annual trends of physical fitness of Japanse youth in 1986 through 2000. This procedure was verified satisfactorily effective and precise to estimate the actual annual trends in the term over 1964 and 1985, so this was applied to prediction of future trends of physical fitness of Japanese youth. And the actual annual trends were also investigated briefly to make the prediction more accurate. Then, the following conclusions were obtained.

1) In 1970s, the growth acceleration tendency seemed to cease in most of physique elements, although the exact year in which the increase gradient changed to the less one was not identical for all elements and ages.

2) The developmental acceleration tendency could be realized in parallel to the growth acceleration for physical fitness and motor ability, even though their increase gradients were not identical with the ones of physique.

3) As long as the precision statistics determined with the actual annual data of 1964 through 1985 were investigated, mean errors and standard errors of estimate were satisfactorily small, so the predicted trends could be believed to show somewhat convinced future trends.

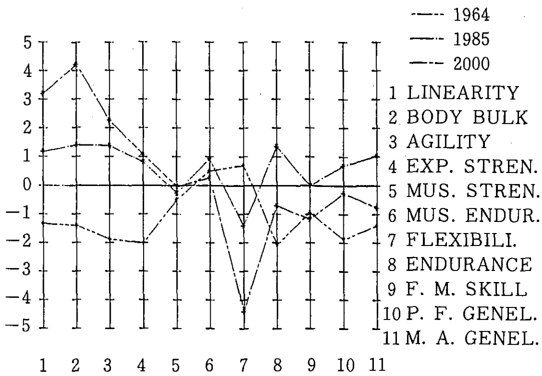

Fig. 19, Physical Fitness Profile: 16 years boy

4) Phsique elements were predicted to show a certain slow-increase trends up to 2000 in boys of all ages.

5) The data fluctuations were rather small in physique elements, so the confidence intervals of band prediction were also small. This suggested that the prediction of physique elements could be accomplished rather sharply.

6) In back strength, the data fluctuations were so large that it was rather hard to find a certain annual fixed tendency, so it was so difficult to predict its future trends. In the term over 1986 and 2000, both the increase trend and the decrease one were predicted to appear in all ages, so the back strength of 2000 was predicted to be not so changed from the ones of 1980s.

7) In physical fitness score, the predicted trends showed no significant ones different from the ones of before half of 1980s in 10 and 13 years old. In 16 years old, however, somewhat lowering trend was predicted.

8) The physical fitness profiles consisted of 10 axes for 10 years old and 11 for 13 and 16 showed quite different profiles from those of 1964 and also 1985. Most of ability domains were predicted to be inferior in relative sense to physique domains in boys of 10 and 16 years old.

9) Number of domains being inferior to physique was predicted to increase annually since 1986, so Japanese youth were predicted to be larger in body size but not to show a certain improvement of physical fitness in parallel to the increase of physique.

10) Particularly the youth of 2000 were predicted to be inferior in flexibility to those of 1964 and 1985. In general the profiles of 2000 were predicted to be somewhat more imbalanced than those of 1964 and 1985 in both sexes of all ages.

The prediction practice is one of very interesting but difficult problems and it needed a great deal of courage to publish the results, because it takes so long time to test whether the prediction was worked out successfully or not. It is of no use to publish them after the results would have been tested, so the author tried to publish this study as one of attempts to predict the future in physical fitness of Japanese boy under such assumption as the annual data given as data of time-series. Some other refined procedures should be devised further so as to be able to work out more accurate prediction.

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