Correlation between Fitness Levels, Body Fat, Blood Lipids, HbA1c and Blood Pressure in Middle-aged and Elderly Men and Women

Toshimitsu EBISU*[1], Tomohisa YOKOYA*[1], Hiroki SUGIURA*[1] and Shinsaku YOSHIDA*[2]

*[1] Faculty of Sports and Health Sciences, Department of Sports and Health Sciences, *[2] Fukui Junior High School

The purpose of this study was to determine the correlation between fitness levels, body fat, blood lipids, hemoglobin A1c (HbA1c) and blood pressure in middle-aged and elderly men and women. Three hundred and sixty one individuals, 116 men and 245 women, volunteered to be subjects in this study. Informed consent was obtained from all of the subjects by explaining the purpose and the methods of this study. The variables of this study were: grip strength, open-eyes foot-balance, sit-ups, trunk flexion in sitting position, toe strength, total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), triglyceride (TG) and HbA1c, percent body fat (%Fat) and systolic and diastolic blood pressures. According to this study, toe strength values are positively correlated with grip strength and open-eyes foot-balance in almost all age groups. Significant interrelationships between TC, HDL-C, LDL-C, TG, HbA1c and systolic and diastolic blood pressure values can be seen.

Key Words: Fitness Levels, Body Fat, Blood Lipids, HbA1c, Blood Pressure, the Middle-aged and Elderly

1. Introduction

The relationships between blood lipids and body composition[(1)~(4)] and between blood lipids and cardiovascular endurance[(4)~(7)] have been already reported. The relationships between body composition and some motor abilities also have been already reported[(3)(8)(9)].

According to the literature, significant correlation between TC and %Fat and TG was detected in a study[(3)] although fractions of cholesterol besides the HDL were not determined in the study. Being overweight may influence TG but not cholesterol level, and obese individuals seem to show high cholesterol and TG[(1)~(4)]. In addition, the literature indicated that fitness levels were negatively correlated with %Fat[(1)~(4)]. Significant negative correlation was found between %Fat and endurance in male and female adults, and there was significant positive correlation between lean body mass and endurance in both male and female adults[(3)]. In these studies, trained and untrained subjects were intermixed.

Ebisu[(9)] reported significant relationship between %Fat and running broad jump, vertical jump, standing flexion and maximal oxygen consumption. In the study, subjects were untrained students. Since some studies[(7)(10)] show increase of HDL-C and decrease of LDL-C and very low density lipoprotein cholesterol (VLDL-C) due to chronic exercise, conducting a research study on the relationship concerning blood lipids is not appropriate if trained and untrained subjects were intermixed. Blood lipids, pulmonary function, body composition and various fitness elements have been also reported to improve due to chronic exercise but worsen due to lack of exercise[(11)]. Generally, obese and untrained subjects seem to show a rise in HDL-C and a reduction in LDL-C and VLDL-C due to chronic exercise.

To accurately research the relationship between fitness level, body composition and blood lipids, subjects should

*Received February 27, 2017
*[1] Faculty of Sports and Health Sciences, Department of Sports and Health Sciences
*[2] Fukui Junior High School
E-mail: tebisu@fukui-ut.ac.jp

be untrained and should be in the same age group. Fitness levels, %Fat, body composition and blood lipids are getting worse with the passing years. The age-related decrease in arterial distensibility, particularly central arterial distensibility, may increase systolic blood pressure and/or pulse pressure in the elderly[12].

As fitness starts to fall, blood lipids, HbA1c and blood pressure come to show unhealthy values when people get older. Correlation between these variables in middle-aged and elderly men and women has not often been reported. For middle-aged and elderly men and women, realizing the correlation between fitness levels, body fat, blood lipids, HbA1c and blood pressure could produce a lengthening of their healthy life-span.

Even though the correlation does not show any relation of cause and effect, such people will realize how they should have a healthy lifestyle. The purpose of this study is, therefore, to clarify the correlation between fitness levels, body fat, blood lipids, HbA1c and blood pressure in middle-aged and elderly men and women.

2. Methods

Three hundred and sixty one individuals, 116 men and 245 women, volunteered to be subjects in this study. Informed consent was obtained from all of the subjects by explaining the purpose and the methods of this study. The data of 274 individuals, 79 men and 195 women were analyzed in this study since another 87 subjects did not completely finish the measurements. The variables of this study concentrated on fitness: grip strength, open-eyes foot-balance, sit-ups, trunk flexion in sitting position and toe strength. The measurements of all variables on fitness besides toe strength were according to the instructions by the Ministry of Education, Culture, Sports, Science and Technology. Toe strength is defined as muscular strength of the lower limbs determined by picking up the knob of the measuring instrument between the first and the second toes (Nisshinsangyo Inc., 2015). Toe strength was measured in both right and left feet.

Variables also determined were: TC, HDL-C, LDL-C, TG, and HbA1c in blood composition. TC was determined by using a Determiner-L TC (Kyowa Medex Co., Ltd.). HDL-C was determined by using a MetaboLead HDL-C (Kyowa Medex Co., Ltd.). LDL-C was determined by using a MetaboLead LDL-C (Kyowa Medex Co., Ltd.). TG was determined by using a Determiner-L TG (Kyowa Medex Co., Ltd.). HbA1c was determined by using a Determiner-L HbA1c (Kyowa Medex Co., Ltd.). Additional variables in this study were: %Fat and systolic and diastolic blood pressures.

Correlation between these variables was examined by using a Pearson's correlation coefficient. The statistically significant criterion was set at $p<0.05$.

3. Results and Discussion

Mean and standard deviation values of all variables in all subjects are indicated in Tables 1. All of the correlation values are shown in Tables 2 through 7. The * and ** indicate the significant correlation at 5% and 1% levels of significance, respectively, in Tables 2 through 7.

All correlations between all variables found in this study can be summarized thus: (1) grip strength, open-eyes foot-balance and sit-ups decline while blood pressure increases with the passing years; (2) grip strength is positively correlated with open-eyes foot-balance, sit-ups, trunk flexion in the sitting position and toe strength; (3) open-eyes foot-balance is positively related to sit-ups, trunk flexion in the sitting position, toe strength and HDL-C and negatively correlated with Fat, HbA1c and systolic blood pressure, especially in female subjects; (4) sit-ups are positively correlated with toe strength and HDL-C and negatively correlated with %Fat and systolic blood pressure in female subjects; (5) %Fat is positively correlated with TG, HbA1c and both blood pressure values and negatively

Table 1. Mean and standard deviation values of all variables in all subjects

Variables	Male (n=79)	Female (n=195)
Age (yrs)	55.3 ± 18.5	58.7 ± 17.3
Grip Strength (kg)	28.8 ± 9.5	26.7 ± 7.4
Open-eye F. B. (sec)	95.5 ± 37.5	89.1 ± 39.6
Sit-ups (time)	10.2 ± 6.7	8.6 ± 6.3
Trunk Flexion, S. P. (cm)	38.3 ± 11.8	39.0 ± 10.9
%Fat (%)	24.2 ± 7.3	25.2 ± 7.2
Toe Strength [R] (kg)	3.4 ± 1.3	3.2 ± 1.1
Toe Strength [L] (kg)	3.3 ± 1.3	3.1 ± 1.1
TC (mg/dl)	202.9 ± 35.7	201.3 ± 37.7
HDL-C (mg/dl)	65.6 ± 18.2	66.2 ± 18.6
LDL-C (mg/dl)	119.4 ± 30.2	117.8 ± 31.0
TG (mg/dl)	141.3 ± 110.3	133.7 ± 99.0
HbA1c (%)	6.5 ± 9.9	6.2 ± 8.1
S. B. P. (mmHg)	124.5 ± 19.1	125.3 ± 19.2
D. B. P. (mmHg)	69.3 ± 13.0	69.3 ± 12.3

where: Open-eye F. B.= Open-eye Foot-balance
Trunk Flexion, S. P.= Trunk Flexion in Sitting Position
%Fat = Percent Body Fat
Toe Strength [R] = Toe Strength [Right]
Toe Strength [L] = Toe Strength [Left]
TC = Total Cholesterol
HDL-C = High Density Lipoprotein Cholesterol
LDL-C = Low Density Lipoprotein Cholesterol
TG = Triglyceride
S. B. P.= Systolic Blood Pressure
D. B. P.= Diastolic Blood Pressure

Table 2. Correlation values between all variables in all male subjects (50 yrs or older)

1 Age															
2 Grip Strength	−0.537**														
3 Open-eye F. B.	−0.477**	0.357**													
4 Sit-ups	−0.354**	0.368**	0.459**												
5 Trunk Flexion, S.P.	0.114	−0.009	0.085	0.385**											
6 %Fat	−0.211	−0.074	−0.008	−0.139	−0.229										
7 Toe Strength (R)	−0.214	0.404**	0.329*	0.268	0.135	−0.064									
8 Toe Strength (L)	−0.232	0.304*	0.372**	0.359**	0.090	−0.130	0.710**								
9 TC	−0.150	0.194	−0.030	0.227	0.079	−0.046	−0.046	−0.132							
10 HDL-C	0.092	−0.055	−0.086	0.097	0.173	−0.420**	−0.148	−0.194	0.382**						
11 LDL-C	−0.093	0.223	−0.035	0.189	0.005	0.078	0.049	−0.005	0.865**	−0.004					
12 TG	−0.382**	0.205	0.180	0.077	−0.056	0.218	0.085	−0.001	0.422**	−0.268*	0.306*				
13 HbA1c	0.121	−0.200	0.116	−0.060	−0.032	−0.015	0.230	0.197	0.693**	−0.414**	0.542**	−0.188			
14 S. B. P.	0.137	0.071	−0.164	−0.184	0.058	0.209	−0.136	−0.324*	0.319*	0.001	0.266*	0.301*	−0.390*		
15 D. B. P.	−0.240	0.444**	0.003	0.031	0.114	0.009	−0.011	−0.171	0.593**	0.258	0.442**	0.365**	−0.665**	0.671**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=52～79)

correlated with HDL-C in female subjects; (6) right toe strength is related to left toe strength; (7) TC is positively related to HDL-C, LDL-C, TG and HbA1c in all subjects and TC is, furthermore, positively related to both systolic and diastolic blood pressure values; (8) HDL-C is negatively related to TG; (9) LDL-C is positively related to TG and HbA1c; (10) TG is positively related to HbA1c; and (11) systolic blood pressure is positively related to diastolic blood pressure.

The right and left toe strength values are positively correlated with grip strength and open-eyes foot-balance in almost all of the age groups besides middle aged men. Subjects in this study might often walk in daily life since walking is considered to strengthen toe strength, and well-balanced walking possibly increases open-eyes foot-balance. By walking around in daily life, subjects might perform various movements and that might increase

Table 3. Correlation values between all variables in all female subjects (50 yrs or older)

1 Age															
2 Grip Strength	−0.364**														
3 Open-eye F. B.	−0.429**	0.327**													
4 Sit-ups	−0.289**	0.408**	0.327**												
5 Trunk Flexion, S.P.	−0.072	0.261**	0.159*	0.084											
6 %Fat	−0.144	0.013	−0.268**	−0.182*	−0.052										
7 Toe Strength (R)	−0.056	0.252**	0.102	0.139	0.084	0.153									
8 Toe Strength (L)	−0.085	0.440**	0.194*	0.214**	0.157	0.035	0.668**								
9 TC	−0.152	−0.043	0.091	0.101	0.016	0.134	0.018	0.007							
10 HDL-C	−0.103	0.016	0.189*	0.234**	0.018	−0.191*	0.005	0.148	0.373**						
11 LDL-C	−0.121	−0.045	0.055	0.022	0.040	0.160	0.0183	−0.078	0.908**	0.006					
12 TG	−0.04	−0.011	−0.150	−0.096	−0.118	0.310**	0.019	0.041	0.257**	−0.329**	0.231**				
13 HbA1c	0.047	−0.065	−0.293**	−0.111	−0.069	0.343**	0.125	0.061	0.233**	0.096	0.162*	0.217**			
14 S. B. P.	0.329**	−0.007	−0.161*	−0.163*	0.035	0.227**	0.090	0.102	−0.120	−0.130	−0.091	0.057	0.024		
15 D. B. P.	−0.022	0.073	0.025	−0.143	0.069	0.285**	0.066	0.099	0.012	−0.118	0.066	0.019	0.071	0.687**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=151～195)

Table 4. Correlation values between all variables in middle aged men (50～64 yrs)

1 Age															
2 Grip Strength	−0.043														
3 Open-eye F. B.	−0.644**	0.120													
4 Sit-ups	0.288	0.024	0.023												
5 Trunk Flexion, S.P.	0.405	−0.375	0.061	0.334											
6 %Fat	−0.187	0.009	−0.279	−0.108	−0.144										
7 Toe Strength (R)	0.320	0.304	0.398	0.323	−0.393	−0.112									
8 Toe Strength (L)	0.408	0.324	0.444	0.114	−0.509	−0.319	0.791**								
9 TC	0.121	−0.007	0.140	−0.056	−0.006	0.128	0.052	−0.067							
10 HDL-C	0.148	−0.119	0.288	0.049	0.357	−0.772**	0.002	0.019	0.036						
11 LDL-C	0.204	0.287	0.037	0.101	−0.186	0.278	0.356	0.238	0.745**	−0.254					
12 TG	−0.236	−0.278	−0.126	−0.396	−0.176	0.373	−0.356	−0.321	0.354	−0.521*	0.017				
13 HbA1c	0.341	0.011	0.221	−0.320	0.017	0.460	−0.177	−0.035	−0.069	−0.290	0.079	0.005			
14 S. B. P.	0.209	0.066	0.198	−0.357	0.009	0.525*	−0.086	−0.278	0.296	−0.389	0.145	0.550*	0.363		
15 D. B. P.	0.359	0.114	0.279	−0.299	0.121	0.328	−0.021	−0.174	0.529*	−0.249	0.340	0.510	0.347	0.862**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=15～24)

Table 5. Correlation values between all variables in middle aged women (50～64 yrs)

1 Age															
2 Grip Strength	−0.227*														
3 Open-eye F. B.	−0.170	0.290*													
4 Sit-ups	−0.371**	0.300*	0.180												
5 Trunk Flexion, S.P.	0.090	0.110	0.012	−0.112											
6 %Fat	−0.025	−0.087	−0.368**	−0.234	−0.054										
7 Toe Strength (R)	−0.096	0.240*	0.294*	0.058	−0.003	−0.012									
8 Toe Strength (L)	−0.012	0.375**	0.276*	0.094	−0.012	−0.119	0.685**								
9 TC	−0.139	−0.084	0.114	0.174	0.039	0.037	0.020	0.002							
10 HDL-C	−0.091	0.038	0.184	0.285*	−0.008	−0.367**	−0.001	0.205	0.381**						
11 LDL-C	−0.089	−0.092	0.088	0.063	0.111	0.104	0.044	−0.078	0.919**	0.065					
12 TG	−0.185	−0.008	−0.149	−0.046	−0.202	0.408**	−0.043	−0.085	0.192	−0.384**	0.141				
13 HbA1c	0.155	−0.045	−0.492**	−0.176	−0.100	0.408**	−0.079	−0.135	−0.046	−0.161	−0.001	0.167			
14 S. B. P.	0.070	0.098	−0.033	−0.111	0.054	0.389**	0.033	0.173	−0.182	−0.094	−0.188	0.114	0.172		
15 D. B. P.	0.039	0.077	−0.058	−0.133	−0.051	0.456**	0.061	0.142	−0.164	−0.244*	−0.113	0.171	0.178	0.863**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=70～93)

Table 6. Correlation values between all variables in elderly men (65 yrs or older)

1 Age															
2 Grip Strength	−0.336*														
3 Open-eye F. B.	−0.663**	0.339*													
4 Sit-ups	−0.375*	0.383*	0.538**												
5 Trunk Flexion, S.P.	0.005	0.217	0.125	0.445**											
6 %Fat	−0.222	−0.199	−0.013	−0.200	−0.248										
7 Toe Strength (R)	−0.463**	0.550**	0.335*	0.278	0.278	−0.055									
8 Toe Strength (L)	−0.457**	0.318*	0.358*	0.444**	0.300	−0.095	0.697**								
9 TC	−0.130	0.210	−0.092	0.253	0.113	−0.093	−0.064	−0.160							
10 HDL-C	0.003	0.033	−0.121	0.158	0.121	−0.350*	−0.177	−0.239	0.462**						
11 LDL-C	−0.104	0.181	−0.075	0.180	0.075	0.021	−0.021	−0.084	0.894**	0.062					
12 TG	−0.322*	0.375*	0.254	0.256	0.056	0.153	0.333*	0.171	0.508**	−0.160	0.502**				
13 HbA1c	0.089	−0.227	0.152	−0.04	−0.045	−0.011	0.253	0.234	0.744**	−0.461**	−0.610**	−0.263			
14 S. B. P.	0.215	0.089	−0.266	−0.129	0.077	0.129	−0.152	−0.343*	0.334*	0.109	0.309	0.159	−0.469**		
15 D. B. P.	−0.090	0.435**	−0.156	−0.001	0.152	−0.096	−0.008	−0.213	0.605**	0.428**	0.466**	0.218	−0.759**	0.662**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=38～55)

Table 7. Correlation values between all variables in elderly women (65 yrs or older)

1 Age															
2 Grip Strength	−0.141														
3 Open-eye F. B.	−0.322**	0.211													
4 Sit-ups	0.185	0.380**	0.306**												
5 Trunk Flexion, S.P.	0.015	0.315**	0.181	0.186											
6 %Fat	−0.376**	0.082	−0.256*	−0.163	−0.059										
7 Toe Strength (R)	−0.118	0.294**	0.006	0.248*	0.147	0.300**									
8 Toe Strength (L)	−0.107	0.516**	0.129	0.333**	0.285**	0.194	0.659**								
9 TC	−0.180	−0.062	0.051	0.030	−0.009	0.207	0.018	0.007							
10 HDL-C	0.029	−0.064	0.149	0.147	0.011	−0.074	0.011	0.096	0.360**						
11 LDL-C	−0.181	−0.044	0.018	−0.017	−0.009	0.203	0.001	−0.083	0.902**	−0.038					
12 TG	−0.156	0.032	−0.127	−0.080	−0.048	0.223*	0.070	0.179	0.318**	−0.284**	0.308**				
13 HbA1c	−0.064	−0.059	−0.214	−0.057	−0.047	0.316**	0.246*	0.205	0.378**	0.229*	0.252*	0.250*			
14 S. B. P.	0.076	0.158	−0.038	−0.030	0.104	0.145	0.139	0.099	−0.052	−0.097	−0.009	−0.029	−0.078		
15 D. B. P.	−0.161	0.097	0.095	−0.168	0.154	0.137	0.070	0.061	0.138	−0.030	0.199	−0.115	0.009	0.626**	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

* p<0.05
** p<0.01 (n=82～102)

motions like gripping something. If that is so, significant correlation between toe strength and grip strength can be easily understandable.

This study, furthermore, found that fitness levels decrease with the passing years, and individuals superior in a dimension of fitness usually show an overall fitness. Negative correlation seemed to be clarified between %Fat and open-eyes foot-balance and sit-ups in female subjects. That indicated that the fatter individuals are, the poorer the performance of open-eyes foot-balance and sit-ups by female subjects. A large amount of body fat is considered to impede smooth movement, especially moving the individual's body weight. Thus movements like jumping will be applicable since a study[9] showed that 50m running, running broad jumps and Sargent jumps are negatively correlated with %Fat. A large amount of body fat probably impacts endurance even in muscles since %Fat is negatively correlated with sit-ups. According to another finding of this study, excessive body fat may badly influence balance-function since %Fat is negatively correlated with open-eyes foot-balance.

Significant interrelationships between TC, HDL-C, LDL-C, TG, HbA1c and systolic and diastolic blood pressure values can be clarified in this study, especially as shown in Table 2. Significant correlation between blood lipids and blood pressure can be easily understandable since blood lipids obstructs arterial blood flow. The correlations concerning variables in blood composition of this study seem to show no differences regardless of age. Results of correlations in some variables in blood composition, however, need to be clarified by conducting further

studies, such as investigating the significantly negative correlation between age and TG shown in Table 2. These phenomena were also seen in some other tables.

A ratio, HDL/LDL, was proposed by Wood et al.[13] as an atherosclerotic index or, more accurately, as a safety index. Another ratio, HDL-C/TC, determined by Gerson et al.[14] was also calculated in their study. Such relationships might have been more clearly identified if both ratios had been calculated in this study.

4. Conclusion

According to this study, toe strength values are positively correlated with grip strength and open-eyes foot-balance in almost all age groups. Fitness levels seem to decrease due to getting old, and individuals superior in a dimension of fitness usually show an overall fitness. Significant interrelationships between TC, HDL-C, LDL-C, TG, HbA1c and systolic and diastolic blood pressure values can be seen.

References

(1) L.A. Carlson and M. Ericsson, "Quantitative and Qualitative Serum Lipoprotein Analysis: part 1. studies in healthy men and women", *Atherosclerosis*, Vo. 21 (1975), pp. 417-433.

(2) D.W. Edington and V.R. Edgerton, *The Biology of Physical Activity* (1976), Houghton Mifflin o., Boston.

(3) Y. Sawada and K. Karatsu, Relationship between Physical Fitness and Body Composition: characteristics of body composition in Japanese, In *Characteristics of Body Composition* (Research Report to Studies by 1980 Science Grant, section of total research A), rep. M. Sato (1981), pp.51-56.

(4) T. Ebisu, "Correlation between Blood Lipids, Body Composition and Cardiovascular Endurance." *Educational Medicine*, Vol.28 (1982), pp.12-27.

(5) L. Barart, M.C. Moore, L. Gremillion and A. Lopez-S, "Serum Lipids, Dietary Intakes, and Physical Exercise in Medical Students", *Journal of The American Dietetic Association*, Vol.64 (1974), pp.42-46.

(6) V. R. Lamb, *Physiology of Exercise: responses and adaptations* (1978), Macmillan Publishing Co., Inc.

(7) R.M. Lampman, J.T. Santinga, D.R. Bassett, N. Mercer, D.A. Hook, M.L. Foss and W.D. Block, "Normalizing Serum Lipids in Men with Type IV Hyperprebetalipoproteinemia", *Medicine and Science in Sports* (Abstracts of the 25th annual meeting of the American College of Sports Medicine), Vol.10, No.1 (1978), p.55

(8) K. Kitagawa, "Body Compostion: cont.", *Journal of Health, Physical Education and Recreation*, Vol.28, No.8 (1978), pp.550-557.

(9) T. Ebisu, “Differences of Motor Abilities between Various Body Composition Levels.” *Educational Medicine*, Vol.28 (1982), pp.28-36.

(10) T. Ebisu and H. Ebisu, "Effects of Ten Week Exercise on Serum Cholesterol, Triglyceride and Lipoproteins.", *Memoir of Faculty of Education (Physical Education Dept.), Fukui University*, No. 12 (1981), pp.23-29.

(11) T. Ebisu, M. Shimada, T. Okumura, H. HOri, H. Takashima, K. Kamimoto and K. Nakajima, "Influences of Detraining on Blood Components, Pulmonary Function, Body Composition and Various Fitness Elements", *The Journal of Clinical Sports Medicine*, Vol.4, No.12 (1987), pp.1473-1478.

(12) M. Matsui, “Effects of Aerobic Exercise on Arterial Distensibility.”, *Japan J. Phys. Educ. Hlth. Sport Sci.*, Vol. 51 (2006), pp.421-433.

(13) P.D. Wood, W.L. Haskell, S. Lewis, C. Perry and M.P. Stern, "Concentrations of Plasma Lipids and Lipoproteins in Male and Female Long-Distance Runner", In *3rd International Symposium on Biochemistry of Exercise*, eds. F. Landry and W. A. R. Orban (1978), pp.301-306.

(14) B. Gerson, L. Dean, and B.E. Copeland, "High-Density Lipoprotein Cholesterol-Significant Bias between Methods.", *American Society of Clinical Pathologists*, Vol.71, No.5 (1979), pp.564-569.

（平成 29 年 3 月 31 日受理）