Paper : Fitness and Physical Activities

Effects of sports experience and exercise habits on physical fitness and motor ability in high school students

Koya Suzuki[*] **and Takahiko Nishijima**[**]

[*]Faculty of Integrated Cultures and Humanities, University of East Asia
2-1 Ichinomiyagakuen-cho, Shimonoseki, Yamaguchi 751-8503 Japan
suzuki@toua-u.ac.jp
[**]Graduate School of Comprehensive Human Sciences, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8574 Japan

[Received May 24, 2005 ; Accepted September 20, 2005]

The purpose of this study was to measure physical fitness, motor ability, exercise habits, and exercise or sports experience in youth through a number of tests and to verify the causal relation between the constructs. The subjects in this study were 2,856 high school students comprising 1,626 males and 1,230 females. Eight items used in the Japan Fitness Test were measured for physical fitness and sixty-one items of exercise attainment were self-rated by the subjects according to three ranks for motor ability. The time spent on exercise and the frequencies of exercise were measured for exercise habit, and the numbers of sports events and days spent on exercises were measured for sports experience. The study was conducted using structure equation modeling. The results showed that exercise or sports experience directly and indirectly through exercise habit affected physical fitness and motor ability, and that exercise or sports experience more strongly affected exercise habit than physical fitness and motor ability. It is also suggested that exercise habit had a stronger effect on physical fitness than on motor ability, and that sports experience had a stronger effect on motor ability than on physical fitness. Consequently, the comparison of causal model goodness of fit in respective genders did not result in indications of significant differences between genders.

Keywords: youth, improvement in physical fitness, number of sports events, structural equation modeling

[School Health Vol.1, 22-38, 2005]

1. Introduction

Physical fitness and motor ability are essential for humans to act creatively along with their development and maturity, and are also major factors of the ‘zest for living (IKIRUCHIKARA)’ (Sports and Youth Bureau of Ministry of Education, Culture, Sports, Science, and Technology: MEXT, 2002a). In Japan, a survey of physical and motor ability (MEXT, 2004) has been conducted nationwide since 1964. Physical fitness and motor ability of the youth have been measured through performance tests, and the measurement findings have been highly regarded statistically. Nishijima et al. (2001), and Noi and Masaki (2002) show that physical fitness and motor ability in the youth have shown a downward tendency since 1985 until the present, although the statistics had shown a marked increase until 1975. It has been demonstrated that the decline in the physical fitness, in particular, has been in progress among the parties below the mean value of statistics (Nishijima et al., 2003).

Based on the above circumstances, the Central Council for Education gave its verdict on the "Comprehensive strategies to improve physical fitness in youth" on September 30, 2002 (MEXT, 2002). The Council targeted an increase in the means of the total values shown in the physical fitness and motor ability survey, which means it sought an improvement in physical fitness so that children and youth can perform exercise, and at the same time the Council targeted a decrease in the values of factors resulting in lifestyle diseases. The Council wants an improvement in physical fitness so that youths can live healthfully. Under the verdict, the environmental situation reflecting on exercise and sports has been improved as a part of national measures to raise physical fitness of children and youth. These measures are aiming at both short and long term so that children and youth who will shoulder the future destiny of Japan can construct and maintain a vital society. To encourage the formation of lifelong habitual exercise, an educational approach is strongly required.

Much of the research on various elements contributing to physical fitness and motor ability of children and youth has noted the high relation to both exercise habit (Nishijima et al., 2003; Kawakami et al., 1996; Naka and Demura, 1994, 1992; Kim et al., 1993; Morimoto et al., 1991; Taks et al., 1991; Park et al., 1990), and exercise and sports experience (Morimoto et al., 1993; Tatano, 1981; Tokunaga, 1981). In turn, exercise habit is highly related to the environmental situations of the exercise performed at the present time as well as the exercise experienced in the past. (Naka and Demura, 1992; Kanzaki et al., 1981; Kumeno et al., 1979; Komuku and Kageyama, 1978). Tokunaga (1975), on the other hand, reported that the number of years children and youth have experienced exercise and sports was not necessarily contributed to an improvement in their physical fitness and motor ability.

It is surmised that the discrepancies in the results of these studies are attributed to several shortcomings in the research methodology. Firstly, the sampling method and the sample size are inadequate. In most of the previous studies, the sample size is around a few hundred, while the sampling is conducted among subjects in a similar environmental area. Taks et al. (1991) indicate that life style children and youth have contributes to differences in development of their physical fitness (between those living in cities and those living in farming villages). This indication suggests that large scale sampling is required in order to generalize from conclusions, taking regional variances into consideration based on the idea that the whole country should be regarded as the population sample. The small scale of sampling possibly makes comparison and examination according to detailed attributes more difficult. Secondly, the causal relationship model hypothesized is insufficient. According to the knowledge gained from the previous studies, it can be surmised that numerous factors such as exercise habit and exercise and sports experience complexly contribute to the development of physical fitness and motor ability. Matsuura (1984) indicates that the comprehensive involvement of the constructs regarding a number of observed variables comprised of each factor as compound variables should be examined because the numerous factors are not independently but interactively related to the development of physical fitness and motor ability. Some previous studies, however, have not proved the causal relationship between latent variables measuring the factors contributing to physical fitness and motor ability but instead proved the causal relationship between observed variables and physical fitness and motor ability. When the past sports experience and the current exercise habit are both included as causal variables, it can be assumed that the effects in the same level as the current exercise habit contributes are difficult to be found on sports experience. Since the maximum developing rapidness in the nerve system appears at infancy (Matsuura, 1982), it is possible to anticipate that the sports experience at the early stage has greater effects on the motor ability than the physical fitness because the former relates closely to the nerve system.

Thus, it is worthwhile to examine the causal relationship models which differentiate between direct and indirect participation by using large scale samples in order to determine the various factors affecting physical fitness and motor ability. The purpose of this study was to explore direct and indirect causal relationships between respective constructs after measuring the physical fitness and motor ability of children and youth, exercise habit, and sports experience through a number of items by using a large scale sample as well as to verify gender differences in the relationships.

2. Methods

2.1. Subjects

The subjects in this study were selected by the stratified multi-stage sampling method which views the whole country as the population. Those selected were 2,856 students comprising 1,626 males and 1,230 females in 10 high schools, located in Hokkaido, Aomori, Gunma, Tokyo, Fukui, Aichi, Kyoto, Okayama, Ehime, and Saga Prefectures (See **Table 1**). Prior to the measurement and survey, the purpose of this study was explained to both the subjects themselves and their parents by both the municipal boards of education and the school principals and their consent for collaboration were obtained. The entire measurement and survey were conducted from April through October 2001.

Table 1 Subjects

High schoolgrade	Male	Female	Total
first-year	613	508	1,121
second-year	524	353	877
third-year	489	369	858
Total	1,626	1,230	2,856

2.2. Measurement items

2.2.1. Physical fitness

Among the items of the Japan Fitness Test, performed by the youth aged from twelve to nineteen (MEXT, 2001), Grip Strength, Sit-ups, Sit & Reach, Side Step, Endurance Run (1,500 meters for male and 1,000 meters for female), 20m Shuttle Run, 50m Dash, Standing Long Jump, and Handball Throw were selected and measured in this study. The results were converted into scores according to the score table, and the sum total scores were calculated. The physical fitness levels were classified into five categories from A to E in the division of ages and genders according to the comprehensive evaluation chart. In the event that both of the measured values of the Endurance Run and 20m Shuttle Run are provided, the higher value of the two was adopted for the endurance score.

2.2.2. Motor ability

There are a total of 61 exercise items described in the Curriculum Guidelines for elementary and junior high schools, consisting of 37 individual exercises and 24 ball exercises. The individual exercise is made up of 4 items of short-rope jumping, 3 of mounting on vehicles, 10 of floor exercise, 5 of horizontal bar, 7 of vaulting, and 8 of swimming. Ball exercise comprises 7 items of basketball, 10 of soccer, and 7 of baseball (**Appendix 1**).

The level of the attainment the subjects gained in each exercise was measured (Kokudo et al., 2003) using a self-rating, 3-point interval scale with the following items: "to do successfully: 2 points," "able to do: 1," and "unable to do: 0." The attainment score of individual exercise was calculated according to the grand total of the points of respective items of individual exercise. The attainment score of ball exercise was also calculated in the same way.

2.2.3. Sports experience

In much previous research (Morimoto et al., 1993, 1991; Odamiya, 1981; Kanzaki et al., 1981; Tatano, 1981; Kumeno et al., 1979; Komuku and Kageyama, 1978), the subjects' previous participation in club activities was utilized as measured variables related to sports experience. In this study, however, for detailed exploration of correlation, the number of sports events experienced in the past and the average number of days spent on sports per a week were used as the measured variables of sports experience (Appendix 3). The average number of days spent on sports in a week for respective events was calculated and all the average numbers were totalled. Kokudo et al. (2001) state that retrospective surveys using questionnaires reveal low reliability in the period of the time the subjects exercise and the time they spent on exercise per a week in their infancy. In this study, therefore, the duration and the time spent on exercise per a week were excluded from the analysis, and the definition of sports experience was determined based on specifying only the experience the subjects have had.

2.2.4. Exercise habit

The items measured for exercise habit were the period of the time spent in a day and the frequency of exercise. The self-rating method in a 4-point interval scale was used as an alternative to the former (excluding time spent on PE classes at school) with the following items: "less than 30 minutes: 1"; "30 minutes or more but less than 1 hour: 2"; "1 hour or more: 3"; "2 hours or more: 4". For the frequency of exercise (excluding time spent on PE classes at school), a similar self-rating method in 4-point scale was utilized: "3 days or more: 4"; "1 or 2 days a week: 3"; "1 to 3 days a month: 2"; "never: 1". In the Structural Equation Modeling (SEM) method, which is utilized to verify causal relationships, however, items on a higher level than the interval scale are required. Even in the event the ordinal scale is adopted, the items can be regarded as metric variables if the interval points are four or more (Bentler and Chou, 1987). For this reason, the statistic analysis was conducted with the frequency regarded as the metric variable.

2.3. Definition of physical fitness and motor ability

In this study, the ability measured in Japan Fitness Test was defined as the physical fitness, while the ability measured from the level of the attainment of 61 items of exercise, which are described in the Curriculum Guidelines, is defined as the motor

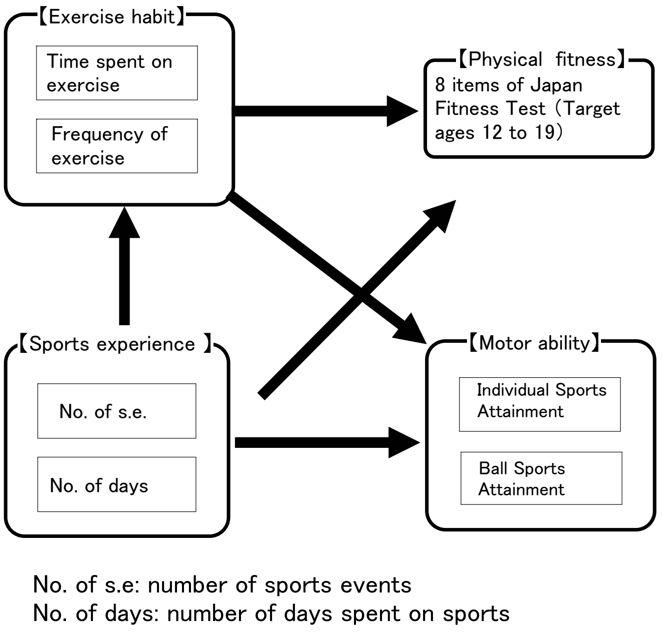


Figure 1 Hypothesised Model

ability. Among the items measured in the Japan Fitness Test, 50m Dash, Handball Throw, and Endurance Run were included in Motor Ability Test in the previous fitness test conducted until the year of 1998, and thus it is difficult to say that these items are not relevant to motor ability at all. Although motor ability strongly contributes to the throwing movement itself in handball-throwing, which is shown in the evaluation of Handball Throw, the distance a ball is thrown is evaluated in reality. Accordingly, it is likely that the grades of Handball Throw greatly contribute to energetic fitness ability, especially muscular strength. For the level of exercise fulfilled, in contrast, whether or not the subjects were able to do certain exercise was evaluated, so that it is possibly judged that the constructs in measuring the level of exercise fulfilled are different from those in the Japan Fitness Test in which the energetic fitness ability evaluated by time and distance greatly contributes. Referring to the classification by Ishiko (1971) and Ikegami (1990), this study operationally defined the ability to take actions, or the ability measured in the Japan Fitness Test, which is greatly attributed by the ability to sustain an action, as physical fitness, and defined the ability measured in the level of exercise fulfilled, which is greatly attributed by the ability to control the action, as motor ability.

2.4. Hypothesized Model

In order to verify the causal relationships between exercise habit, sports experience, physical fitness and motor ability, the authors hypothesized a causal structure model shown in **Figure 1** referring to previous studies. The causal relationships between sports experience and exercise habit are apparent in terms of time precedence. The causal relationships from exercise habit and sports experience to physical fitness and motor ability are hypothesized in a number of previous studies, and are judged to be valid. In order to compare the degrees of the effects on physical fitness with those on motor ability, a causal structure model was respectively built up. According to the classification of Ishiko (1971) and Ikegami (1990), the physical fitness defined in this study is a construct (latent variable) deeply related to the ability to take an action and sustain the action, while the motor ability is a latent variable deeply related to the ability to control an action. Therefore, taking into consideration that any difference of effects on each latent variable is evidence to indicate the necessity of another pedagogical approach for an improvement in the physical fitness and the motor ability, we built up the causal structure models in distinction between physical fitness and the motor ability. Among the observed variables measuring respective constructs, only the items possible to be handled as metric variables are utilized.

2.5. Statistical analysis

SEM (e. g., Kano and Miura, 2002; Bollen, 1989) was used to analyze the direct and indirect causal relationships between constructs. To estimate the parameters, the maximum likelihood method, widely used in applied studies, was adopted (Toyoda, 1992), With concern to model identification, the variance of latent variables (constructs) was fixed at 1 for exogenous latent variables (latent variables receiving one or more of paths), while paths toward observed variables (measured items) from latent variables was fixed at 1 for endogenous latent variables (latent variables receiving no path). The validity of the measured items was judged by path coefficients toward observed variables from latent variables. As indexes to evaluate the validity of the model, the indexes for absolute evaluation such as AGFI (Adjusted goodness of fit index), TLI (Tucker-Lewis

Table 2 Traits of the subjects (ordinal scale)

Item	Number of subjects	Gender	Category				
Comprehensive evaluation of physical fitness			A	B	C	D	E
	1,496	Male	16.5%(15.7)	43.6%(35.1)	30.9%(34.8)	8.2%(11.8)	0.7%(2.6)
	1,065	Female	12.4%(9.5)	28.4%(22.2)	37.2%(36.4)	19.5%(25.5)	2.5%(6.4)
Frequency of exercise performed			3 days or more a week	1 or 2 days a week	1 to 3 days a month	Never	
	1,588	Male	58.8%(59.1)	20.5%(16.0)	11.5%(11.5)	9.3%(13.4)	
	1,160	Female	42.0%(41.5)	16.7%(18.1)	15.3%(19.1)	26.0%(21.4)	
Time spent on exercise			less than 30 minutes	30 minutes or more but less than I hour	1 hour or more but less than 2 hours	2 hours or more	
	1,590	Male	25.5%(25.5)	16.7%(13.7)	19.8%(17.2)	38.0%(43.7)	
	1,141	Female	45.4%(50.0)	11.8%(14.2)	17.2%(13.2)	25.6%(22.6)	

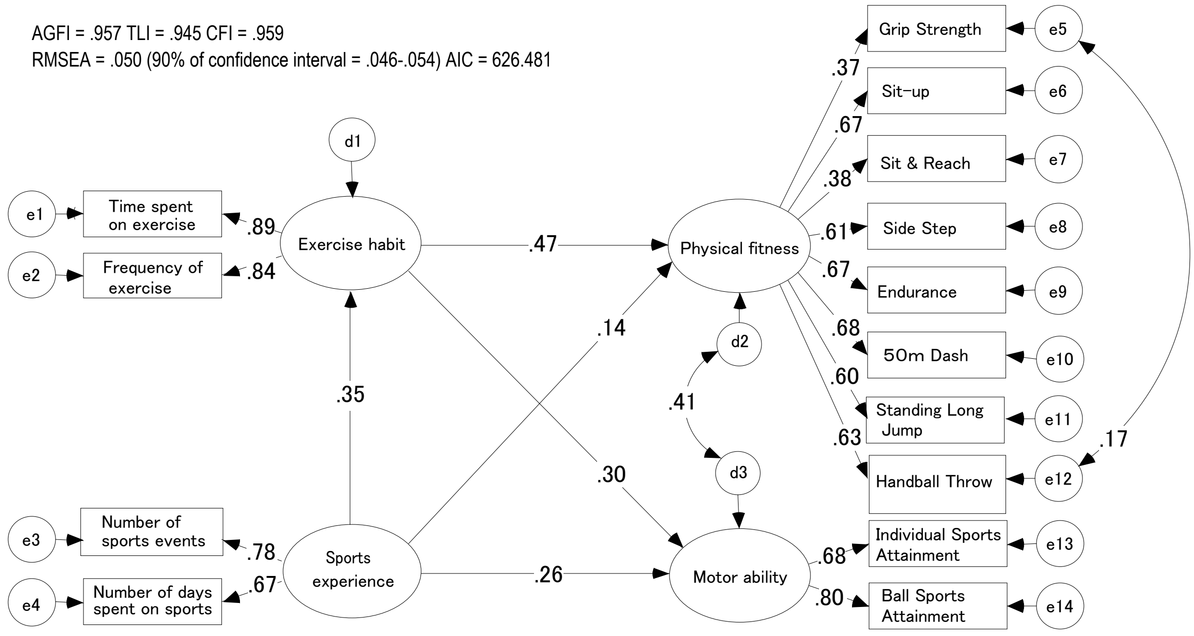
Note: The numbers in the brackets refer to the national average for the same age.[2)]

index), CFI (Comparative fit index), RMSEA (Root mean square error of approximation), and 90% of confidential interval of RMSEA were utilized, a chi square difference test for effective comparison between a number of models and AIC (Akaike information criterion) and finally the goodness of fit of the models was determined. AGFI is an index whereby GFI is adjusted by degree of freedom. GFI originally indicates degrees to explain how sample variance covariance matrix is comprised. TLI and CFI, on the other hand, evaluate how effective the model is compared with an independent model. The criterion in the three indexes is 0.90 or more to approve the model. RMSEA is a value of which the minimum distance between the model and the real population variance covariance matrix is excluded by degree of freedom, and goodness of fit of the model is determined approval by the value from 0.08 to 0.05 or less. Although there are no criteria for adoption of the confidence interval, the narrowness indicates the credibility of point estimation. The absolute value of AIC is has little meaning, but the smaller the value shows the better the fit compared with other model. In order to test the significance of the path coefficient, the correlation coefficient (covariance), and variance, the unvariate Wald test (Critical ratio: C.R.) was adopted. A modification index was utilized to modify the model, with an additional path provided only if the relationship between variables was scientifically approved. In order to examine gender differences between the causal relationships, a causal structure model for each gender was formulated and the goodness of fit of the model was respectively confirmed. A significance level was set for $P < 0.05$. The SPSS 11.5J and Amos 5.0J were used for data analysis.

3. Results

3.1. Effects of sports experience and exercise habit

Table 2 shows the traits of the subjects. The overall evaluation of the subjects' physical fitness tended to have more AB group than DE group compared to the nationwide value. With regard to exercise undertaken, a tendency for the proportion of the subjects who do not take any exercise was shown to be smaller in males and larger in females. The descriptive statistics of other variables used for the analysis are presented in **Appendix 2**. **Figure 2** illustrates the final solution (standardized solution) of the hypothesized model of all the samples in the use of structure equation modeling. For the hypothesized model, correlation (covariance) was added to error variables of the scores of Grip Strength and Handball Throw by a modification index. The final model with error correlation added showed more significant improvement in χ^2 value than the earlier model, while the modified model indicated better values than the earlier model in AIC (**Table 3**). The fit index of the final model was shown at 0.95 or more in AGFI, TLI, and CFI, while in RMSEA it was shown at 0.05 or less exceeding the criterion for the adoption of a model. The path coefficient from the constructs to



Note: All the path coefficients in the figure were siginificant($P < .05$).

Figure 2 Causal relationships between sports experience, exercise habit, physical fitness, and motor ability: All samples

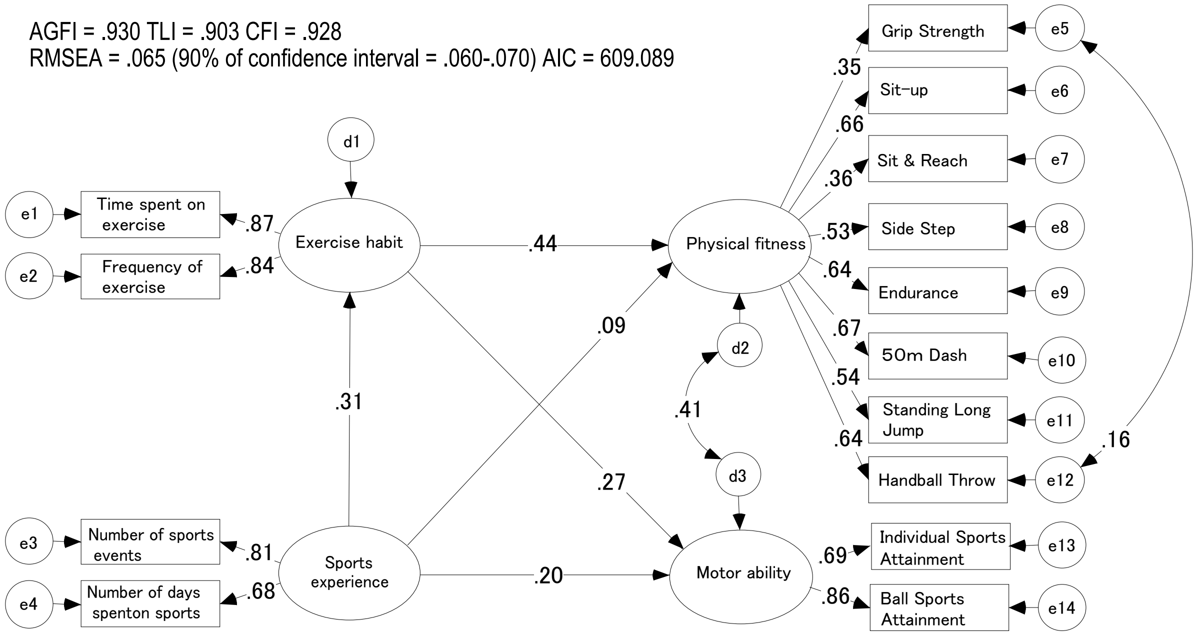
Table 3 Comparison of model goodness of fit (all samples)

Model	χ^2	*df*	AGFI	TLI	CFI	RMSEA (90% of confidence interval)	AIC
Initial model	734.134	71	.946	.928	.944	.057 (.053-.061)	802.134
Final model [1]	552.481	70	.957	.945	.959	.050 (.046-.054)	626.481
Model with path coefficients equated							
Model A [2]	645.783	71	.952	.936	.951	.054 (.050-.058)	717.783
Model B [3]	633.988	71	.951	.937	.952	.053 (.050-.057)	705.988
Comparison of models	$\chi^{2\ \text{difference}}$	*df difference*				*p*	
Initial model —Final model	181.653	1				<.05	
Model A — Final model	93.302	1				<.05	
Model B — Final model	81.507	1				<.05	

Note:
1 e5 and e12 of error correlation are added to the initial model in the final model.
2 Model A equates the path coefficient from exercise habit to physical fitness with the one to motor ability.
3 Model B equates the path coefficient from sports experience to physical fitness with the one to motor ability.

the measured items indicated 0.37 to 0.89. Among the path coefficients between constructs, from sport experience to physical fitness was lowest at 0.14, while exercise habit to physical fitness was highest at 0.47. All the estimated parameters were found to be statistically significant (**Figure 2**).

To explore differences in the direct effect on exercise habit which contribute to physical fitness and motor ability as well as those on sports experience, it was assumed that the path coefficients from exercise habit to physical fitness and motor ability were equal in Model A, while it was assumed that those from



Note: All the path coefficients were siginificant ($P < .05$).

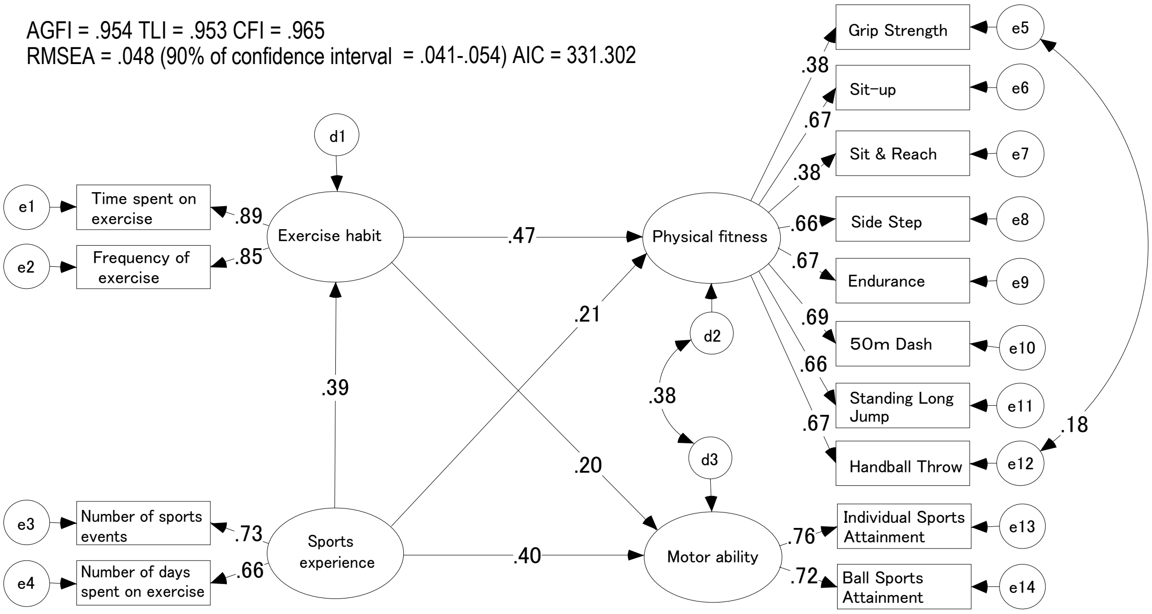
Figure 3 Causal relationships between sports experience, exercise habit, physical fitness, and motor ability: Male

sports experience to physical fitness and motor ability were equal in Model B. In both models, models without equality constraint were made (same as the final model), and a comparison between Model A and the final model as well as that between Model B and the final model was performed. There were significance differences found in χ^2 values in all the comparisons, and the fix indexes of all the models displayed better values in the final model (**Table 3**). The path coefficient from exercise habit to physical fitness was 0.47, higher than that from exercise habit to motor ability of 0.30. By contrast, the path coefficient from sports experience to physical fitness was 0.14, lower than that from sports experience to motor ability of 0.26 (**Figure 2**).

3.2. Causal structure model and gender difference

Applying the model in **Figure 2**, **Figures 3** and **4** illustrate the final solutions (standardized solutions) according to gender distinction. The correlations (covariance) between error variables which had been added as seen in **Figure 2** were also added to the models to both genders. When comparing those models with models prior to the addition, significance was found in chi square test data, while the AIC showed low in value (See **Table 4** for males and **Table 5** for females). The goodness of fit between genders in the final model showed 0.90 or more in AGFI, TLI, and CFI, and 0.08 or less in RMSEA, so that it is probable that the model adoption criterion was fulfilled. All the path coefficients within the models were statistically significant (**Table 6**).

In the same way as the model built up in the use of all the samples, differences between the path coefficients from exercise habit to physical fitness and motor ability as well as those from sports experience to physical fitness and motor ability were examined in both gender models. The indexes of the goodness of fit of the model in both genders showed superiority to Model A and B of which path coefficients were equalized (**Table 4** and **5**). Among the path coefficients starting from exercise habit, those to physical fitness (0.44 for males and 0.47 for females) tended to show higher in value than those to motor ability (0.27 for males and 0.20 for females) in both genders. Among the path coefficients starting from sports experience, in contrast, those to motor ability (0.20 for males and 0.40 for females) tended to show higher value than those physical fitness (0.09 for males and 0.21 for females). Comparing the path coefficients between latent variables of males with those of females, all the path coefficients except from exercise habit to motor ability tended to show higher in females. Additionally, the comprehensive effects (direct and indirect effects) from sports experience to physical fitness and motor ability showed higher



Note: All the path coefficients were siginificant($P < .05$).

Figure 4 Causal relationships between sports experience, exercise habit, physical fitness, and motor ability: Female

Table 4 Comparison of model goodness of fit (males)

Model	χ^2	*df*	AGFI	TLI	CFI	RMSEA (90% of confidence interval)	AIC
Initial model	660.056	71	.918	.883	.909	.071 (.067-.076)	728.056
Final model ^{1}	535.089	70	.930	.903	.928	.065 (.060-.070)	609.089
Model with path coefficients equated							
Model A ^{2}	647.416	71	.919	.882	.910	.072 (.067-.077)	719.416
Model bB^3	557.211	71	.929	.900	.924	.066 (.061-.071)	629.211
Comparison of models	$\chi^{2\ \text{difference}}$	*df difference*				*p*	
Initial model — Final model	124.967	1				<.05	
Model A — Final model	112.327	1				<.05	
Model B— Final model	22.122	1				<.05	

Note:
1 e5 and e12 of error correlation are added to the initial model in the final model.
2 Model A equates the path coefficient from exercise habit to physical fitness with the one to motor ability.
3 Model B equates the path coefficient from sports experience to physical fitness with the one to motor ability.

tendencies in females (0.39=0.21+0.18 for the former and 0.48=0.40+0.08 for the latter) than in males (0.23=0.09+0.14 for the former and 0.28=0.20+0.08 for the latter) (**Table 6**).

4. Discussions

4.1. Effects of sports experience and exercise habit

The exploration of various factors relevant to

Table 5 Comparison of model goodness of fit (females)

Model	χ^2	*df*	AGFI	TLI	CFI	RMSEA (90% of confidence interval)	AIC
Initial model	318.459	71	.946	.941	.954	.053 (.047-.059)	386.459
Final model [1]	257.302	70	.954	.953	.965	.048 (.041-.054)	331.302
Model with path coefficients equated							
Model A [2]	268.840	71	.953	.951	.963	.049 (.043-.055)	340.840
Model B [3]	329.310	71	.942	.936	.952	.055 (.049-.061)	401.310
Comparison of models	$\chi^{2\ \text{difference}}$	*df difference*				*p*	
Initial model — Final model	61.157	1				<.05	
Model A — Final model	11.538	1				<.05	
Model B— Final model	72.008	1				<.05	

Note:

1 e5 and e12 of error correlation are added to the initial model in the final model.

2 Model A equates the path coefficient from exercise habit to physical fitness with the one to motor ability.

3 Model B equates the path coefficient from exercise or sports experience to physical fitness with the one to motor ability.

Table 6 Presumed values of respective genders in the final model

	Male				Female			
Path	non-standardized solution (standardized solution)	Standard error	Uniqueness variance	Standard error	non-standardized solution (standardized solution)	Standard error	Uniqueness variance	Standard error
Construct → Measured variable								
Sports experience → No. of sports events	.48 (.81)	.03	.13	.02	.44 (.73)	.02	.17	.02
Sports experience → No. of days spent	3.84 (.68)	.22	17.56	1.50	2.94 (.66)	.16	11.42	.83
Exercise habit → Frequency of exercise	1.00 (.84)	-	.07	.01	1.00 (.85)	-	.06	.01
Exercise habit → Time spent on exercise	2.62 (.87)	.12	.35	.05	2.62 (.89)	.11	.32	.05
Physical fitness → Grip Strength score	.58 (.35)	.05	1.93	.07	.54 (.38)	.05	2.61	.11
Physical fitness → Sit-up score	1.36 (.66)	.08	1.85	.08	.99 (.67)	.05	1.87	.09
Physical fitness → Sit & Reach score	.80 (.36)	.07	3.38	.12	.58 (.38)	.05	3.12	.13
Physical fitness → Side Step score	1.10 (.53)	.07	2.38	.09	1.10 (.66)	.06	2.45	.12
Physical fitness → Endurance Run score	1.32 (.64)	.08	2.02	.09	1.09 (.67)	.06	2.24	.11
Physical fitness → 50m Dash score	1.33 (.67)	.06	1.70	.08	1.02 (.69)	.05	1.82	.09
Physical fitness → Standing Long Jump score	1.00 (.54)	-	1.92	.08	1.00 (.66)	-	2.07	.10
Physical fitness → Handball Throw score	1.31 (.64)	.08	1.98	.08	1.08 (.67)	.06	2.27	.11
Motor ability → Individual Sports Attainment score	1.00 (.69)	-	79.45	4.84	1.00 (.76)	-	51.69	4.69
Motor ability → Ball Sports Attainment score	1.05 (.86)	.07	27.52	4.51	.65 (.72)	.04	27.73	2.10
Construct → Construct (direct effect)								
Sports experience → Exercise habit	.12 (.31)	.01	.14	.01	.16 (.39)	.02	.15	.01
Sports experience → Physical fitness	.08 (.09)	.03	.61	.06	.27 (.21)	.05	1.03	.09
Exercise habit → physical fitness	.98 (.44)	.08			1.40 (.47)	.12		
Sports experience → Motor ability	1.66 (.20)	.30	61.09	5.07	3.32 (.40)	.38	51.25	5.03
Exercise habit → Motor ability	5.62 (.27)	.72			4.06 (.20)	.81		
Construct → Construct (indirect effect)								
Sports experience → Exercise habit → Physical fitness	.12 (.14)				.22 (.18)			
Sports experience → Exercise habit → Motor ability	.67 (.08)				.65 (.08)			
Covariance								
d2←→d3	2.52 (.41)	.27			2.78 (.38)	.36		
e5←→e12	.31 (.16)	.06			.43 (.18)	.08		

physical fitness and motor ability is summarized through several procedures of examination. One of those is a method seeking simple or partial correlation, ranging from simple correlation between each item involved in sports experience and each fitness test (Tatano, 1981), and partial correlation between numerous items involved in sports experience and each fitness test revealed from multiple regression analysis (Naka and Demura, 1992; Tatano, 1981). A simple correlation was found between each item involved in sports experience and exercise habit (Kanzaki et al., 1981; Kumeno et al., 1979; Komuku and Kageyama, 1978), and a partial correlation between numerous items involved in sports environmental factors and exercise habit were shown in multiple regression analysis (Komuku and Kageyama, 1978). Although all of these correlations are seen as statistically significant, the coefficient itself is low at 0.10 to 0.20.

The purpose of this study was originally to examine the effects of the constructs including exercise habit and sports experience. However, in reality the coefficient of the simple correlation between a single item representing the constructs and a single item representing physical fitness and motor ability was calculated. This fact as well as the correlation coefficient attenuated by measurement error of each item seemingly caused the low coefficient (Kano, 1997). As a phenomenon of the attenuation occurs irrelevant to the real effects, Kim et al. (1993) and Park et al. (1990) adopted factor analysis for their studies. Their studies had certain physical fitness test items as factors, and examined correlation between the items measuring the factors at the state that measurement errors were mathematically removed. However, previous research exploring the relationships between the latent variables on the assumption that the constructs are seen as the latent variables (factors) has yet to be found.

Another procedure used to explain the causal relationships which would affect physical fitness and motor ability is to divide the subjects into groups depending on the frequencies of exercise taken and their participation in club activities in the past, measuring their exercise habit and sports experience and to make a comparison between the mean values between the groups (Kawakami et al., 1996; Naka and Demura, 1992, 1994; Morimoto et al., 1991, Tokunaga, 1981; Tokunaga and Hashimoto, 1975). Independent variables (groups) must be randomly selected among the population, otherwise the results are not generalizable. (Tachibana, 1986). Also, as time spent on exercise, frequencies of exercise taken, or quantity of sports experienced are metric variables, it is desirable to examine the causal relationships depending on the correlation between the variables.

In this study, to resolve the problems mentioned earlier, it was decided to built up a causal structure model showing each factor seen as a latent variable comprising several observed variables, and then to verify the causal relationships among sports experience, exercise habit, physical fitness and motor ability. All the path coefficients ranging from the latent variable to the observed variable were 0.37 or more in the causal structure model which used all samples. Thus, the index of goodness of fit of the model satisfied the adoption criteria and the validity of the model was confirmed. The error correlation (covariance) between the scores of Grip Strength and Handball Throw added to the initial model was surmised to explain the factors related to the operational ability of the upper arms commonly measured in both tests. Grip Strength test is utilized as a simplified measurement of the muscular strength of the whole body, but it is not intended to measure the muscular strength peculiar to the upper arm. Therefore, estimating the error correlation of scores of Handball Throw, the scores of Grip Strength are likely to have neared to the real value in variance.

The relationships between exercise habit to physical fitness and motor ability as well as those from sports experience to exercise habit and physical fitness and motor ability were comprehensively verified in this study. **Figure 2** illustrates that sports experience not only gives direct effects on physical fitness and motor ability but also gives some effects through exercise habit.

Focused on path coefficients, one starting from exercise habit to physical fitness was 0.47, and another from exercise habit to motor ability was 0.30. This data suggests that exercise habit had a stronger effect on physical fitness than on motor ability. According to the comparison of the goodness of fit of model shown in **Table 3**, the final model, in which the effects on both physical fitness and motor ability caused by exercise habit were hypothesized different, showed higher fitting than Model A, in which the effects were hypothesized equal. It was revealed that there was statistic difference shown between the effects on physical fitness and motor ability caused by exercise habit, and that the effects on physical fitness were stronger than motor ability. By contrast, focusing on the effects on physical fitness and motor ability caused by sports experience, the results of the comparison of the goodness of fit of the models showed that the effects on motor ability were stronger than physical fitness.

Similar to previous studies, the results demonstrate that an improvement in exercise habit is effective in developing physical fitness and motor ability. It is surmised that exercise habit especially contributed greatly to the progress of physical fitness than motor ability. It is suggested that sports experience contributed to encouragement of exercise habit and indirectly affected the progress of physical fitness and motor ability through the encouragement although the experience had less direct effects than the habit did.

The causal structure model verified in this study shows that sports experience could promote sport to become habitual and improve physical fitness and motor ability in consequence. Sallis and Owen (1999) cite in their review of the factors determining physical activities, that pleasure and self-esteem gained from doing sports are attributing to psychological and cognitive factors to further encourage physical activities. In this study, however, while a survey on physical fitness and motor ability in the past was not conducted, it is assumed that past sports experience is related to the pleasure of doing sports, and that the past experience of feeling self-esteem due to improvement in physical fitness and motor ability is leading to habitual and continuous and finally to the progress of the current physical fitness and motor ability. In consequence, it is possibly anticipated that if we provide children with activities leading to their pleasure as a measure taken to encourage them to play sports and the pleasure makes them take habitual exercise, so that the habitual exercise results in their progress of physical fitness and motor ability over a sustained period.

4.2. Gender difference of effects

After the causal structure model verified by all the from each gender, the model hypothesized from the initial model that there had been an error correlation between the scores of Grip Strength and Handball Throw was adopted as the final model, which was in the same way as the final model was gained by all the samples (**Figure 3** and **4**). After differences of effects on physical fitness and motor ability caused by exercise habit as well as by sports experience were examined in each gender model, both gender models showed similar differences to the model gained by all the samples.

Focusing on the relations between the constructs, it was verified that females tended to show higher relativity than males except in the path coefficient starting from exercise habit to motor ability. With regard to the overall effects from sports experience to physical fitness and to motor ability, females also tended to show a higher relation (**Table 6**).

The subjects participated in this study are all high school students. The development of females seemingly slows down around age of fourteen and it almost stops at high school age, while that of males stops approximately at age of eighteen or nineteen (Matsuura, 1982). It can be said that the development of males' height does not stop at their high school days irrespective of individual differences. As the timing of the development of physical fitness and motor ability is similar, the progress of their physical fitness and motor ability arising from the development of their growth is recognizable (Matsuura, 1982). In spite of their exercise habit and sports experience, males in their remarkable physical development individually tend to have high values in physical fitness and motor ability. This tendency seems to have affected correlation between the constructs, and consequently the path coefficients in the male model seem to have indicated lower than those of females. The results mentioned above clarify the direct effects on the progress of physical fitness and motor ability sports experience give as well as the indirect effects exercise habit gives, which were found by all the samples, are confirmed in both genders, and that the degree of the effects is generally higher in females than males.

However, considering that the path coefficient starting from exercise habit to motor ability is higher in males than females, further careful consideration is necessary with the possibility of their bias caused by the methodology of measuring motor ability, and using self-rating method.

4.3. Future issues

To generalize the knowledge gained in this study, some limitations need to be considered. Firstly, we need to consider the number of items surveyed for sports experience. In this study only the numbers of sports events and days spent on exercise were investigated as a measure of the subjects' sports experience. Questions such as what kinds of sports the subjects have experienced, whether or not they have experienced another exercise-like play except sports, how vigorous the exercise or sports were, and when they started, were not asked. We need to view the improvement in children's physical fitness in the long term and to make concrete activity guidelines in order to encourage further progress in children's physical fitness and motor ability. In particular, an exploration of what is effective in improving physical fitness and motor ability such as when to start exercise and the degree of performance need to be further investigated in subsequent studies.

The second limitation lies in the use of a retrospective survey. It is generally considered that the longer time the respondents retrospect the lower the reliability becomes because the retrospective survey is heavily dependent on the subjects' memories. As the SEM is able to examine the relativity between the real constructs with measurement errors removed, the effects seem to be restricted minimum. The reliability of knowledge gained in this study needs to be heightened by examining the causal relationships in future long-term follow-up studies. In the event that the structure equation model is adopted explaining the causal relationships through correlation, as Kano(2002) suggests, several problematic areas need to be examined such as whether (cross) factors and fluctuation occurring within individuals which are not utilized in the model are simulated as if they occurred between individuals. That is, the causal inference is conducted as if the longitudinal data were obtained based on the cross-sectional data.

5. Conclusion

The purpose of this study was to verify the causal relationships between sports experience, exercise habit, physical fitness and motor ability before examining effects on gender differences in these areas. The subjects were 2,856 high school male and female students obtained through nationwide survey sampling. Recalling the limitations of the study mentioned earlier, the following conclusions are drawn.

1. Sports experience directly affects physical fitness and motor ability, and indirectly through exercise habit. Exercise habit has a greater effect on physical fitness than motor ability, while sports experience has a reverse effect.
2. The causal relationships between sports experience, exercise habit, physical fitness, and motor ability equal in both genders. There are gender differences between effects on physical fitness and motor ability caused by exercise habit as well as effects on physical fitness and motor ability by sports experience.

Acknowledgment

This study used partial data found in "The analytic research on factors underlying a decline of physical fitness in youth in the lights of their growth and social life" by Kando Kobayashi (Project reader) which was subsidized by a Grant-in-Aid for Scientific Research of the academic years 2000 to 2002 (12800014 of Grant-in-Aid for Special Purposes).

References

Bentler, P. M. and Chou, C. P. (1987) Practical issues in structural modeling. Sociological Methods and Research 16: 78-117.

Bollen, K. A. (1989) Structural equations with latent variables. New York: Wiley.

Ikegami, H. (1990) Exercise prescription: Theory and practice. Tokyo: Asakura-Shoten (in Japanese).

Ishiko, T. (1971) Sports and physique. Iwanami Shinsho: Tokyo, (in Japanese).

Kano, Y. (1997) Covariance structure model and software: Some covariance structure models (4). BASIC mathematics January: 40-46 (in Japanese).

Kano, Y. (2002) Structural equation modeling, causal inference, and disnormality. In K. Takeuchi (Ed.) Expansion of multivariate analysis (pp. 65-129). Tokyo: Iwanami Shoten (in Japanese).

Kano, Y., and Miura, A. (2002) Graphical multivariate analysis. Kyoto: Gendai-Sugakusha (in Japanese).

Kanzaki, R., Tatano, H., Tokunaga, M., and Hashimoto, K. (1981) A study on the factors predicting sport activity (1): Analysis of sociological factors. Journal of health science, Kyushu University 3: 55-69 (in Japanese with English abstract).

Kawakami, Y., Ozawa, H., Ichinose, Y., Tanaka, F., and Fukunaga, T. (1996) Effect of physical activity in school sports clubs on physical and fitness characteristics of children. Report of Research Center in Physical Education 24: 29-34 (in Japanese with English abstract).

Kim, H. K., Tanaka, K., Inagaki, A., Suzuki, K., Mukouyama, T, Nakamura, N., Koiso, T., and Matsuura, Y. (1993) Daily living conditions related to physical fitness and motor ability in boys 12 through 14 years of age. Japan Journal of Physical Education 38: 215-227 (in Japanese with English abstract).

Kokudo, S., Matsumoto, K., and Okuda, D. (2001) Reliability of exercise experiences of junior and senior high schools by retrospective research method [Abstract]. Proceedings of Japan society of Physical Education, Health and Sport Sciences, Japan, 52, 468 (in Japanese).

Kokudo S., Nishijima, T. Ohsawa, S., Ozawa, H., Suzuki, K., Kagaya, A., Yagi, N., Noda, Y., Naito, H., Aoki, J., and Kobayashi, K. (2003) Achievement probability and development stage of fundamental movement-control skills and gymnastic skills in Japanese youth. International Journal of Sport and Health Science 1: 154-163.

Komuku, H., and Kageyama, K. (1978) An analysis of the effect of work factors on sport involvement: A quantitative study by multiple regression model. Japan Journal of Physical Education 22: 311-319 (in Japanese with English abstract).

Kumeno, Y., Ikeda, M, and Yamaguchi, Y. (1979) A study on sport involvement of college students: An exploratory path analysis. Health and Sport Science, Tsukuba Univ. 2: 23-30 (in Japanese with English abstract).

Matsuura, Y. (1982) Development of physical fitness. Tokyo: Asakura-Shoten (in Japanese).

Matsuura, Y. (1984) Prospective study of daily living conditions related in development of physical fitness. Report on grant-in-aid for scientific research, Education Ministry (in Japanese).

MEXT (2001) Japan Fitness Test: For significant uses. Tokyo: Gyosei (in Japanese).

MEXT (2002a) Central Council for Education, "comprehensive strategies for improving physical fitness of children", abstract of an interim report. The monthly journal of Monbukagakusho, 16 -19 (in Japanese).

MEXT (2002b) Central Council for Education : Comprehensive strategies for improving physical fitness of children (verdict). Tokyo: Author (in Japanese).

MEXT (2003) Report on physical and motor ability survey in fiscal year 2002. Tokyo: MEXT (in Japanese).

Morimoto, M., Mikami, T., and Sakamaki, T. (1991) Relation between extra-curricular exercise experience and physical fitness tests: Elementary school students of low and middle grades 12: 77-83 (in Japanese).

Morimoto, M., Mikami, T., and Sakamaki, T. (1993) A study on exercise experience and motor ability in elementary school students of low and middle grades. The bulletin of liberal arts and sciences, Nippon Medical School 14: 51-63(in Japanese).

Naka, H., and Demura, S. (1992) Examination on sports consciousness and conditions influencing sports activity and physical fitness in adolescent male students. Japan Journal of Physical Education 37: 269-281 (in Japanese with English abstract).

Naka, H., and Demura, S. (1994) Influence of habitual exercise on physique and physical fitness in adolescent male students: From an examination of three-year longitudinal data. Japan Journal of Physical Education 39: 287-303 (in Japanese with English abstract).

Nishijima, T., Kokudo, S. and Suzuki, K. (2001) Secular changes of physical fitness and motor ability during 1964-97 in Japanese youth. Japanese Journal of School Health 42 (Suppl.): 172-173.

Nishijima, T., Nakano, T., Takahashi, S., Suzuki, K., Yamada, H., Kokudo, S., and Ohsawa, S. (2003) Relationship between changes over the years in physical ability and exercise and sports activity in Japanese youth. International Journal of Sport and Health Science 1: 110-118.

Noi, S., and Masaki, T. (2002) The educational experiments of school health promotion for the youth in Japan: analysis of the ‘sport test’ over the past 34 years. Health Promotion International 17: 147-160.

Odamiya, A. (1981) The development characteristics of motor ability based upon different experiences in sports participation: Factor analytic study with longitudinal data. Japan Journal of Physical Education 26: 19-28 (in Japanese with English abstract).

Park, T., Matsuura, Y., and Inagaki, A. (1990) A study on the major influential items of living condition affecting physical growth and development of school children. Japan Journal of Physical Education 34: 345-358 (in Japanese with English abstract).

Sallis, J. F., and Owen, N. (1999) Physical activity & behavioral medicine. Thousand Oaks: Sage.

Tachibana, T. (1986) Inappropriate uses and evils of statistical tests in medical science, education, and psychology. Tokyo: Medical Book (in Japanese).

Taks, M., Renson, R., Beunen, G. Claessens, A, Colla M., Lefevre, J., Ostyn, M., Schueremans, C., Simons, J., Gerven, D. V., and Vanreusel, B. (1991) Sociogeographic variation in the physical fitness of a cross-sectional sample of Flemish girls 13 to 18 years of age. American Journal of Human Biology 3: 503-513.

Tatano, H. (1981) A study on social contributory elements to physical fitness. Journal of health science, Kyushu University 3: 37-54 (in Japanese with English abstract).

Tokunaga, M. (1981) A longitudinal study on the relationship between experiences in physical activities and growth and development. Journal of health science, Kyushu University 3: 3-13 (in Japanese with English abstract).

Tokunaga, M., and Hashimoto, K. (1975) The relationships between the experiences in physical activity and the growth and development: The case for senior high school athletes. Research Journal of Physical Education 20: 109-116 (in Japanese with English abstract).

Toyoda, H. (1992) Covariance structure analysis with SAS. Tokyo: University of Tokyo Press (in Japanese).

Name:
Koya Suzuki

Affiliation:
Faculty of Integrated Cultures and Humanities, University of East Asia

Address:
2-1 Ichinomiyagakuen-cho, Shimonoseki, Yamaguchi 751-8503
Japan

Brief Biographical History:
2002- Doctoral Program in Health and Sport Sciences, University of Tsukuba
2005- Lecturer, University of East Asia

Main Works:
- Suzuki, K. and Nishijima, T. (2004) Confirmatory factor analysis. In S. Demura et al.(Eds), Introduction to SPSS for Health and Sports Science (PP. 131-157). Tokyo: Kyorin Shoin.
- Suzuki, K. et al. (2006) A significance of measurement and evaluation in health and sport science. Toua Journal of Human Science 6, in print.

Membership in Learned Societies:
- Japan Society of Physical Education, Health and Sport Sciences
- Japanese Society of Test and Measurement in Health and Physical Education
- Japanese Society of Physical Fitness and Sports Medicine
- American College of Sports Medicine (ACSM)
- American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD)
- Japanese Association of School Health
- The Behaviormetric Society of Japan
- Japanese Society of Science and Football
- The Japan Association for Research on Testing
- Japanese Society of Public Health

Appendix 1 Questions about the attainment of exercise assigned

Q21: Can you do the following exercises? Please circle the exercises you are most competent in.
Put a double circle if you think you are able to perform well.

Example: you are able to ride a bicycle, and you are able to ride a unicycle.

Example: Vehicle	*[✓ Bicycle] Bamboo stilts [✓ Unicycle]*
Short Jumping Rope	Ordinary jumping Reversal jumping Double jumping
Vehicle	Bicycle Bamboo stilts Unicycle
Floor Exercise	Straddle from roll Piked forward roll Handstand forward roll Straddle back roll Backwards piked roll Back extension roll Handstand against wall Cartwheel Head spring Neck spring
Horizontal Bars	Half knee circle forward upward Forward upward flip Hip circle forward Hip circle backward Kip
Vaulting	Straddle Squat Hecht Drive roll onto a platform Neck spring Head spring Forward hand spring
Swimming	Soak face in water Open eyes in water Flutter kick with a board Crawl breathing Breast stroke breathing Turn Quick turn Starting dive

Q22: Can you do the following exercises? Please circle the exercises you are most competent.
Put a double circle if you think you are able to perform well.

Basketball	Set shoot Shoot jumping Shoot running Shoot dribbling Pivot Dribble with dominant hand Dribble with non-dominant hand
Soccer	Inside kick In-front kick Instep kick Outside kick Inside volley Instep volley Chest trap Sole trap Inside trap Outside trap
Baseball	Catch Bunt Safety bunt Catch and throw a grounder Catch a fly Slide to a base Pitch

Appendix 2 Inquiries about exercise or sports experience

Q19: We would like to ask about your club activities at school or sports clubs you joined.
Please look at the examples below and fill in the chart.

- ＊ Fill in all the sports you have ever experienced since your infancy (kindergarten or nursery school) until now.
- ＊ Write ″Present″ in the column of period for the sport you are doing at this time.
- ＊ Calculate the time spent on exercise as 30 minutes are the minimum unit per week. Write '0.5' even if the time is over 30 minutes.
- ＊ Describe any change in the number of days and time spent on exercise.
- ＊ For the description of the grade at kindergarten, write the 1st for the junior (3 years old), 2nd for the sophomore (4 years old), and 3rd for the senior (5 years old).

Example1: *I used to play mini-basketball till I graduated from elementary school. The practice was three days a week, every Monday, Wednesday, and Friday. It lasted from 3:30 to 4:30 when I was in the 5th grade, and from 3:30 to 5:00 in the 6th grade.*

Example 2: *The time when I started to play soccer was during summer vacation (July) in the 6th grade. I am now in the 8th grade, and still playing it. The practice was for 2 hours on every Tuesday, Friday, and Saturday when I was an elementary school student.*
At junior high school, it starts at 3:30 and ends at 5:30 on weekdays, but it starts at 1:00 and ends at 4:00 an Saturday.

	Sports event	Period	days a week spent on exercise	hours a week spent on exercise
Ex. 1	**Miniature Basketball**	K / E / J / S **5th** Grade **4** Month ～ K / E / J / S **5th** Grade **3** Month	**3** days	**3** hours
		K / E / J / S **6th** Grade **4** Month ～ K / E / J / S **6th** Grade **3** Month	**3** days	**4.5** hours
Ex. 2	**Soccer**	K / E / J / S **6th** Grade **7** Month ～ K / E / J / S **6th** Grade **3** Month	**3** days	**6** hours
		K / E / J / S **1st** Grade **4** Month ～ K / E / J / S **Til now**	**6** days	**13** hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours
		K / E / J / S Grade Month ～ K / E / J / S Grade Month	days	hours

K: Kindergarten E: Elementary school J: Junior high school S: Senior high school

Appendix 3 Characteristics of the subjects (Interval scale or proportional scale)

Area	Items	Number of samples	Male (mean±standard deviation)	Number of samples	Female (mean±standard deviation)
Physical fitness (On a maximum scale of 10 points respectively)	Grip Strength	1,567	6.3±1.5	1,124	6.1±1.8
	Sit-up	1,597	7.7±1.8	1,170	7.1±1.9
	Sit & Rearch	1,602	6.5±2.0	1,178	6.2±2.0
	Side Step	1,591	7.5±1.8	1,168	6.8±2.1
	Endurance [1]	1,591	6.7±1.9	1,180	6.1±2.1
	50m Dash	1,577	6.6±1.8	1,158	6.2±1.9
	Standing Long Jump	1,601	6.3±1.7	1,172	5.9±2.0
	Handball Throw	1,585	6.1±1.9	1,163	6.1±2.1
Motor ability	Individual Exercise Attainment (74 points)	1,626	29.3±12.3	1,230	27.6±11.0
	Ball Sports Attainment (48 points)	1,626	19.6±10.3	1,230	10.3±7.6
Exercise or sports experience	Number of sports events (4 at the most)	1,626	1.2±0.6	1,230	1.1±0.6
	Number of days spent on sports / week	1,626	4.4±3.2	1,230	4.0±3.0

Note:
1 20m Shuttle Run or Endurance Run (1500m for male and 1000m for female)