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A Comparative Analysis of Body Composition, Physical Fitness, and Physical Self-Concept between Gifted Students in Math and Science and Non-Gifted Students

송강영*, 안정덕**
동서대학교*, 부산대학교**

Kang-Young Song(sky-soccer@hanmail.net)*, Jeong-Deok Ahn(ajd@kaist.ac.kr)**

요약

본 연구는 수학·과학 영재학생들로 구성된 Korea Science Academy 학생들의 신체 조성과 체력 및 신체적 자아개념 형성을 일반계 고등학교 학생들과 비교 분석하였다. KSA학생들은 3단계로 진행되는 창의적 문제해결력과 영재성판별 과정 및 과학캠프를 통과하여 2009학년도에 입학한 117명의 남학생들로 구성되었다. 비교그룹으로 참여한 일반 학생들은 서울,경기를 포함한 전국 5개시도 지역에서 무선 추출 되었다. 2년간 사전·사후 측정 방식에 의한 공변량분석 결과 신장($p<.05$)은 영재학생들이 일반학생들에 비해 유의하게 큰 반면, BMI($p<.05$)와 PBF($p<.001$)에서는 유의하게 낮았다. 신체적 자아개념 하위영역 중 외모($p<.05$)와 근력($p<.05$)자아개념은 영재학생들이 일반학생들에 비해 유의하게 낮았으며, 이러한 결과는 내적참조준거 모델과 Big fish Litter Fond Effect(BFLFE) 이론을 지지하는 것이다. 지구력 자아개념 요인에서는 영재학생들이 일반학생들보다 높았는데($p<.01$), 이것이 높은 과제 집착력을 나타내는 영재들의 특성에기인한 것인지에 대해서는 미래 연구과제로 남아있다.

■ 중심어 : | 과학영재 | 신체조성 | 신체적 자아개념 |

Abstract

This study compared and analyzed body composition, physical fitness, and physical self-concept between gifted students in mathematics and science attending Korea Science Academy (KSA) and non-gifted students attending traditional high schools. The KSA students were 117 males who entered the school in 2009. As a control group, a total of 117 non-gifted students were randomly selected from 5 cities. The results of covariate analysis taken 2 year interval, pretest (2009) and posttest (2010), indicated that gifted students were significantly taller ($p<.05$) than non-gifted students, and were lower in BMI ($p<.05$) and PBF ($p<.001$). There was no significant difference in physical fitness between gifted and non-gifted students. But non-gifted students have a significantly higher self-concept in physical appearance ($p<.05$) and physical strength ($p<.05$). The internal/external frame of reference model and the Big Fish Little Pond Effect (BFLPE) theory were supported. Especially, gifted students were significantly higher ($p<.01$) in endurance self-concept than non-gifted students. We have discussion this result as the future research subject whether it come from the characteristics of the gifted's tenacity at high level tasks.

■ keyword : | Gifted Students | Body Composition | Physical Self-concept |

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Ⅰ. INTRODUCTION

Self-concept is defined as 'how a person views oneself'[1]. The concept includes all the perceived self-evaluations regarding individuals'academic, social, physical, and overall aspects. There have been continuous research developments in self-concept related to gifted children in mathematics, science, and language[2-4]. After Hoge and Renzulli[5] conducted 15 meta-analysis on gifted students and non-gifted students, they found the following characteristics. First, gifted students were slightly higher in academic and behavioral self-concepts than non-gifted students but were slightly lower in physical self-concept. Second, self-concept of gifted students in gifted group was lower than those who are gifted but in the normal student group.

These findings could be described using the internal/external frame of reference model and the Big Fish Little Pond Effect(BFLPE)theory. The internal/external frame of reference model was introduced by Marsh[6] to delineate processes that result in developing self-concept. The internal frame of reference includes an individual student′s appraisal of his/her ability in one academic domain in comparison to that of another domain. The external frame of reference is the student′s evaluation of competence in that academic domain relative to the perceived ability of his or her peers. The internal/external frame of reference model hypothesizes that achievement in one area has a direct positive influence on similar-domain self-concept and a negative influence on the other self-concept domains. Using self-description questionnaireII(SDQII;March[7]), Plucker and Stockingz[8] investigated whether Marsh's[6] internal/external frame of reference model was applicable to 131 gifted adolescents'(mean age=14 years) mathematics or verbal domain. Mentioning the internal/external frame of reference model is useful to understand gifted students'academic self-concept development, they argued that gifted students in math have positive impact on self-concept of mathematics but it could be negative in self-concept of language. In addition, Rudasill & Callahan[2] administered self-concept profiles for children (SPPC)[9] and self-concept profiles for adolescents(SPPA)[10] to 264 children (grades 5-7) and 241 adolescents (grades 8-11) who were recommended by their teachers based on standardized achievement scores, IQ scores, and essay responses. In this study, both gifted students and gifted-adolescents recognized their scholastic competence as high but have relatively lower feeling in athletic competence. Tobe specific, the average score in the scholastic competence of male students in the children group showed the highest score (M=3.42) among the sub-domains of SPPC, but showed the lowest score (M=2.85) in athletic competence. The adolescent group also showed the highest score (M=3.41) in scholastic competence among the sub-domains of SPPC, while the lowest score (M=2.80) in athletic competence was found. Because this tendency was also shown in the female student groups, it can be considered that self-concept is developed by an internal frame of reference. To illustrate, gifted students feel strong achievement in academic competence but have relatively lower successful experiences in sport and physical competence. Therefore, it could be assumed that gifted students are positively aware of their academic self-concept domain but form a lower self-concept in sport or physical domain.

The BFLPE model was developed by Marsh and Parker[11] and has been supported by empirical studies[12-14]. According to the BFLPE model, students compare their ability (academic or physical)

with that of their classmates, and apply this social comparison impression as a basis of forming their own academic or physical self-concept. Therefore, it could be said that equally abled students tend to have higher academic or physical self-concept when attending a school where the average ability of the other students is low, and lower academic or physical self-concept when attending a school where the average ability is higher than his/her own. In this regard, a few researchers also have found that gifted individuals who are surrounded by equally gifted peers have lower academic self-concept than gifted individuals who are surrounded by those not academically gifted[12][15-17]. Similar results in physical self-concept with athletes are found using the BFLPE model[18-20]. For example, if there are two athletes, one who is in an elite athlete group while the other is in an average-level athlete group, then the physical self-concept of the athlete in the average-level athlete group is higher than that of the athlete in the elite athlete group.

Physical self-concept, as one of the sub-domains of self-concept, is composed of multiple aspects; and it is defined as a person's feelings about their physical ability, physical appearance, and fitness components [18]. Compared with the studies in the scholastic self-concept or social self-concept fields, research regarding gifted students' physical self-concept has been neglected in the academic field. Nevertheless, we were able to find a few meaningful research findings. An example can be Marsh et al's research[18]. By observing the results of the pretest and posttest of gifted students who were participating in a 'gifted and talented program' for one year, they discovered that gifted students' physical self-concept is, on average, lower than their self-concept in other domains. In addition, using meta-analysis, Hoge and Renzulli [5] insisted that gifted students have slightly lower physical self-concept than ordinary students.

Meanwhile, there has been research showing the significant improvement of gifted students'physical self-concept as a result of their participation in physical activities. Ference[21] found that gifted students participating in team sports have a physical self-concept that is positively related to a feeling of athletic competence, and experience higher perception of athletic competence, physical appearance, and social acceptance. In addition, in Rinn and Wininger's research[22] with 264 gifted adolescents participating in the summer camp, it was revealed that there was a relationship between sport participation and multi-dimensional self-concept as gifted adolescents, who have been engaged in sports, have higher self-concept in physical ability and physical appearance than gifted adolescents who do not. Regular participation in physical activity may have close relationships to body composition, physical fitness, and physical self-concept. In general, students who feel over-weight or obesity are negatively related to physical self-concept, while normal-weight students have relatively higher self-concepts in physical domain [23]. Apparently, active physical activities can produce positive changes in the physical domain, and gifted-adolescents participated in more physical activities than their non-gifted counterparts. Olszewski-Kubilius and Lee[24]conducted a research with 247 gifted-adolescents regarding extracurricular and outside school activities, and the result showed that 72% of the research participants have been involved in sport activities, and sport-related activity was most popular. Such participation rate is higher than McNeal's report[25] of 55.5% and Vdeon's report[26] of 54.6%of adolescents' participation in sport activities. In a research with 1,000 gifted-adolescents, Bucknavage & Worrell[27] also found that participation rate in physical activities is

higher than other activities such as band, academic club, or student government. In addition, in a research with 264 gifted-adolescent, Wininger & Rinn[28] reported that 62.5% of research participants (gifted-adolescents) have been participated in sport activities, and this rate is same or slightly higher than normal students. Additionally, Wininger and Rinn [28]found that gifted-adolescents participated in sport activities at higher level than general population.

Regular participation in sports activities, body composition (e.g., height, weight, BMI), and factors of fitness (e.g., cardio endurance, agility, muscle strength, flexibility) are closely related to physical self-concept. Research participants in aforementioned case studies were students who had participated in gifted summer camp administrated during the summer vacation and attended in ordinary school during the semester. However, research on the relation among the body composition, physical fitness, and physical self-concept of gifted students who have been applied by particular gifted educational curriculum in a school for gifted students and ordinary students has not yet been conducted.

In this regard, Korea Science Academy(KSA) provides good samples for this research. KSA, which was established in 2003 by Korean government, is a specialized school for gifted students in mathematics and science. Students at KSA are selected through a three-step filtering system focused on their gifted features. A total of 144 students are selected a year, and all of them are required to stay in a boardinghouse year-round. For recent four years, the competition rate to enter KSA, on average, was 18 to one and it indicates that KSA is one of the best gifted-school in Korea. While ordinary high school students are making a great effort to get a better score in the government-sponsored scholastic aptitude test for university admission, students in KSA are able to enter KAIST (Korea Advanced Institute of Science and Technology), POSTEC(Pohang University of Science and Technology), and SNU(Seoul National University) which are the top three universities through the particular contracts and in-depth interviews without taking the government-sponsored scholastic aptitude test. This kind of environment provides KSA with the special condition that students in KSA can invest more time for the development of creative research competence, leadership-related activities, and various sport activities. Therefore, investigating body composition and physical self-concept of gifted students who possess excellent potential and superiority in academics must be an interesting issue. Also the meaning of the study lies in analyzing and comparing KSA students'body composition and physical fitness mixed with physical self-concept with normal students. More specifically following research questions will be explored. First, what are the differences in body composition and physical fitness between gifted students and non-gifted students?

Second, what differences exist in physical self-concept between gifted students and non-gifted students? Third, can the internal frame of reference model or the BFLFE model be applicable?

In order to explore the research questions, hypotheses were set up as follows; first, gifted-students maintain a better condition in body composition than non-gifted students. Second, physical fitness of gifted students is same as non-gifted students. Third, physical self-concept of gifted students appears to be lower than that of non-gifted students depending on the internal/external frame of reference model or the BFLFE model.

II. METHODS

2.1 Participants

The participants of the study were 234 high school freshmen: 117 males from KSA and 117 males from normal schools. The KSA students were selected among 2,654 applicants (competition rate: 18.4:1) through a 3-step filtering process. In the first step, 1,500students were selected based on their GPA, statement of purpose, personal creativity, and achievement test score. In the second step, 226 students were selected based on their scholastic ability in each domain of mathematics, physics, chemistry, biomechanics, earth science, and information science. In the third step, 144 students were finally selected after their participation in a science camp that they attended for four days and three nights. At the camp, students' task concentration and creative problem solving ability were tested (In this study, 13 female students and male students who could not continuously participate in this study were eliminated). The KSA students who pass the most difficult filtering process in mathematics and science receive special support and are guided by the Korean government. The IQ of the average KSA student was 136.

As a comparative group, the ordinary students were selected from each normal high school in five provinces (Kyeonggi province, Southern Junla province, Southern Chungchung province, Kangwon province, and Busan city). A total of 147 male students were participated in the survey. They were typical freshmen in high-school who were pursuing to go on the college. When selecting the participants, individual interviews were conducted with the class teachers. Particularly, students who have inherent talent in mathematics and science so that they had taken special education program provided by a college or education office, as well as students who were experiencing intellectual developmental disability, were excluded from the research. Similar to the KSA sample, a total of 117 students'data were used for data analysis after eliminating students who could not complete the pre-test or post-test due to personal reasons. The average IQ of this group of students was measured to be 112.

KSA students are those who are fond of math and science (physics, chemistry, biology, earth science, and information science) and are considered having outstanding achievement and talent in the fields. So in-depth courses have been applied to the KSA curriculum, which is different from other ordinary high schools'. Specifically, freshmen in KSA compressively learn math and science for only one year that generally takes three years in ordinary high schools. Also sophomore and senior at KSA learn professionalized subjects that are taught in the first two years in college in general. In addition, the credits they received from KSA can be redeemed when they entered a college that can shorten duration of the college graduation.

While ordinary students have to stay focused on preparation for the college entrance examination for three years, KSA students have more time to participate in clubs and sports activities since KSA has contracts with high-profile universities that enable their students to engage in an in-depth interview process with these universities in lieu of an SAT score. Particularly, KSA has provided sport programs that other schools hardly have operated. The most representative sports program for KSA students was Taekwondo, which is mandatory for freshmen (four days a week). In addition, following sport events were provided for all students to participate as a whole. An environmental marathon event (students are required to select from a 5km,

Table 1. Characteristics by groups and intramural sport activities

Group	Gender	Age (yr) M (SD)	IQ* M (SD)	Regular P. E hours	Required sport program	Participation rate intramural sport club (selective)
KSA students (n=117)	Male	17.3 (1.2)	136 (9.4)	2h (week)	•Taekwondo 120 h/year •Tracking Mt. Jiri(3nights 4days) •KNN Marathon	•Participation rate: 49.5%(n=58) •Average hours a week:108 minutes •number of clubs: 11, football(n=10), basketball(n=5), tennis(n=4), badminton(n=6), table tennis(n=6),rowing(n=5), climbing(n=5), traditional archery(n=4),dance(n=3), weight lift(n=4), Kendo(n=6)
Normal students (n=117)	Male	17.6 (0.7)	112 (8.9)	2h (week)	none	•Participation rate:31.6%(n=37) •Average hours a week:86minutes •number of clubs: 7 : football(n=12), basketball(n=5), tabletennis(5),badminton(4),dance(5) weight lift(4),Kendo(2)

*Korean Education Developmental Institute-Wechsler Intelligence Scale for Children[29].

10km, or 20km event) organized by a local broadcasting company; and climbing Mt. Jiri

(the second highest mountain in Korea) within four days and three nights, which is required of all freshmen (divided into four groups) during the summer vacation. [Table 1] shows the characteristics of KSA students and ordinary students. Comparing to the ordinary students' schools, KSA has operated diverse sport clubs (KSA: 11 clubs, Ordinary schools: 7 clubs), has a higher participation rate (KSA: 49.5%, Ordinary students: 31.6%), and has scheduled higher portion of time in the average exercise time per week (KSA: 108 minutes, Ordinary students: 86 minutes)

2.2 Instruments

2.2.1 Body Composition and physical fitness

To measure weight, height, body mass index (BMI) and percent body fat (PBF), 'Inbody 520,' a body composition analysis measurement tool[30], was used. It was designed to measure different parts of the human body, like the arms, legs, and torso using the impedance technique. Using six different frequencies, this technique can accurately measure 30 different impedance body composition data types, such as total body water, protein, mineral, body fat mass, soft lean mass, fat free mass, height, weight, BMI, PBF, and waist-hip ratio. Height, weight, BMI and PBF were used as the main body composition variables in this research. Inbody 520, which obtained ISO9001 in its reliability, validity, and accuracy, is a device to measure body composition and the device is widely used in elementary schools, middle schools, high schools, and hospitals in Korea.

In BMI, the format is weight (kg) / height $(m)^2$, which is the standard index for obesity in the human body. PBF is a standard index for the measurement of the percent of fat in the human body. 20~25% of fat means obesity, and over 25% means extreme obesity. However, males and females have different standards for healthy PBF. 10~20% of body fat for males and 18~28% of body fat for females are regarded as healthy fat levels[31]. Health guideline of American College of Sports Medicine[32] indicates PBF according to age and gender, and average of 20-29 males is 15.9% and 22.1% for females in the same age group.

The primary factors for physical fitness were measured through cardio respiratory endurance,

speed, muscular strength, and flexibility as related with a healthy lifestyle. The following criteria: running 1,600m for cardio-respiratory endurance, running a 50 m dash for speed, doing push-ups for muscular strength, and sitting while stretching forward for flexibility were measured. The criteria are mandatorily used to measure physical fitness of grade4 elementary students and above up to high school students by Ministry of Education, Science, and Technology twice a year. Each criterion has been created and measured based on the data from nation-wide-measured samples that is categorized by the five levels (very low, low, normal, high, and very high) on each gender and grade. For example, for sophomore in high school, 'normal'level in 1,600 m running ranges between 443 second and 535 second, 50 m dash ranges between 7.51 second and 7.90 second, push-ups ranges between 25 and 41 times, sitting while stretching forward ranges between 5.0 and 10.9 cm.

2.2.2 Physical Self-Concept

The Physical Self-Description Questionnaire (PSDQ) developed by Marsh et al[33] and translated into Korean by Kim[34] was used, quoted, and applied to the Physical Self-Concept of subjects developed by Choi, Jeong, and Kim[35] to fit the Korean research environment. This questionnaire is organized with a 6-point Likert scale, with a total of 35 questions with 8 factors (appearance, health, flexibility, regular exercise, body fat, muscularity, sports confidence, and cardio endurance). Cronbach's α for appearance, .904 for flexibility, .899 for body fat, .854 for health, .870 for muscularity, .877 for regular exercise, and .852 for cardio endurance respectively, and there values are regarded as an acceptable level. Physical self-concept was measured in 8 categories and 35 items and the confirmatory factor analysis was conducted to test the appropriateness of the model using the AMOS 18.0 program. A model is deemed to be appropriate if the Q value (χ^2/df) is less than 2.0; also, the GFI, AGFI, NFI, and CFI, with values ranging from 0 through 1, are considered to be a good fit if the numbers are higher than .90[36]. Suggesting a cutoff value close to .95 for TLI, CFI, RNI, and Gamma, Hu and Bentler [37]pointed out that it is hard to reach cutoff value .95 in CFI and NNFI. Therefore, most research accept Bentler's suggestion[36] that agrees model's appropriateness once it reaches cut off value .90 in GFI, AGFI, NFI, and CFI. RMSEA is considered an excellent fit if it is below .06, and a good fit if it is between .06-.08. When the RMR is below .05, the model is usually considered a good fit for the research paper[38].

The result of the confirmatory factor analysis regarding the physical self-concept questionnaire showed that it was not acceptable in its appropriateness of the initial model. The Q value at 2.535 was not statistically a good fit, and GFI, AGFI, NFI, CFI, RMSEA, and RMR were all below the recommended value. In order to find a proper beginning model, a model that had 6 items with an SMC (Squared Multiple Correlations) value below a level of .04 deleted was used. This model gave a Q value of 1.983, GFI=.927, AGFI=.915, NFI=.913, CFI=.955, RMSEA=.065, and RMR=.044, values that were a good fit index. For this research, a survey with 8 factors and 29 items was used in order to measure physical self-concept. 6 items were eliminated from the original instrument due to research subjects'cultural and environmental differences. Cronbach's α values that present the 8 factors' number of questions and inner consistency were as follows; Sports confidence (4 items) =.913, Physical appearance (5 items) =.926, Flexibility (4 items) =.904, Body fat (3 items) =.899, Health (4

items) =.854, Muscularity (3 items) =.870, Regular exercise (3 items) =.877, Cardio endurance (3 items) =.852.

2.2.3 Procedure

The measurement was conducted twice: once during the pretest and once during the posttest. The pre-test was conducted between September 20 and October 10, 2009, which was the period of the students' regular physical ability measurement and beginning of the fall semester. Each subject was measured on their physical ability (cardio-respiratory endurance, agility, muscular strength, and flexibility), body composition (height, weight, BMI and PBF) and an additional 8 variable physical self-concepts. To make this research more reliable and valid, first, a joint research with theSports Science Lab in Seoul National University, which has established and organized the PAPS (Physical Activity Promotion System) with a commitment from the Ministry of Education Science and Technology of the Korean government, was initiated. Second, the terms, sequences, methodologies, and even measurement equipment of KSA and the 5 selected ordinary high schools were combined. Every measurement set had to be initiated and completed between September 20 and October 10 because it was not possible for the measurement terms of all of the schools to be at the exact same time or even at a similar time. However, except for the term, the measurement sequence and equipment were combined and applied to each subject under the same condition following the PAPS regulations[39].

The post test was conducted between September 20 and October 10, 2010 in the same way as the pretest, and with high school students who had already spent a year in their school and was now sophomores. The students who had already participated in the pretest were selected as subjects, and some students who had privacy issues were eliminated from the measurement and data collection.

2.3 Data Analysis

A year's worth of data of body composition, physical fitness, and physical self-concept were collected from the gifted students and non-gifted students through the pre test and post test, respectively. The collected data was analyzed by SAS 9.1 version, and descriptive data such as average and standard deviation were presented. To clarify the differences among the groups, an analysis of covariate was conducted with the pretest scores as a covariate. In particular, the tests to prove the hypothesis that the equality of regression line slope of the pretest and posttest for each variable used as a covariate are the same was conducted. When the interaction had no significance, an analysis of covariate was conducted.

Ⅲ. RESULTS

1. Difference verification of body composition and physical fitness between gifted and non-gifted students

To clarify the differences in body composition and physical fitness between the gifted students in mathematics and science who have been guided under KSA, a school for such gifted students, and the non-gifted students who have been attending normal high schools, the results of the analysis of covariate on body composition and physical fitness variables are presented in [Table 2].

In [Table 2], regression line slope was to investigate whether the data of this study can be used

Table 2. Results of the analysis of covariate on body composition and physical fitness variable

Variables	Gifted Students (n=117)		Normal Students (n=117)		Regression line slope		group difference	
	Pre-Test M(SD)	Post-test M(SD)	Pre-Test M(SD)	Post-Test M(SD)	F	p	F	p
Height (cm)	171.06(4.77)	173.86(3.96)	169.34(5.77)	172.03(4.30)	1.79	ns	4.23	.0408*
Weight (kg)	63.02(9.55)	65.94(9.47)	61.68(10.20)	66.23(13.18)	2.15	ns	0.17	ns
BMI	21.70(3.05)	21.44(2.78)	21.73(3.13)	22.52(4.43)	0.85	ns	4.16	.0424*
PBF	15.84(6.02)	16.01(5.40)	16.45(6.65)	18.72(6.75)	0.42	ns	11.65	.0008***
cardiorespiratory endurance (1600m:sec)	484.14(63.47)	471.61(59.73)	493.95(86.81)	485.47(88.57)	0.67	ns	1.67	ns
speed (50m:sec)	7.48(0.54)	7.51(0.46)	7.65(0.60)	7.59(0.50)	0.10	ns	1.51	ns
Muscular Strength (push ups)	27.18(11.02)	27.24(8.38)	26.77(9.49)	28.52(8.84)	0.07	ns	1.34	ns
flexibility (cm)	12.11(7.47)	11.19(7.25)	12.88(8.75)	11.45(6.34)	0.45	ns	0.02	ns

* $p<.05$, *** $p<.001$

for the covariate analysis through investigating interactions between pre-test, which is covariate, and treatment effect of each school. If this interaction has significance, the covariate analysis cannot be utilized because it means that regression line slopes of pre-test values on covariate were different on each treatment effect[40], but fortunately the interactions between pre-test value and treatment effect is not significant, the covariate analysis could be utilized.

The results of the treatment effect showed that the KSA students were significantly taller than the ordinary students as $p<.05$ level in height, even though there was not a significant difference in weight. Particularly, the PBF values of the gifted students were significantly lower than the ordinary students ($p<.001$). Also the BMI values measured for the KSA students were significantly lower than those of the ordinary students as $p<.05$. This result means that gifted students have same weight but higher height and have maintained sound conditions in percentage of body fat and BMI value. Therefore, hypothesis 1 "KSA students maintain a better condition in body composition than normal students" is supported.

However, significant difference in the pretest and posttest measuring 1,600m running (cardio-respiratory endurance), 50m dash (speed), push-ups (muscle strength), and sitting while stretching forward (flexibility) during the one-year interval was not found between KSA students and ordinary students. This result means that KSA's sport activities are not as effective and strong as to make significant changes of KSA students' physical fitness compared to ordinary students. Ahn [41]already proposed recording the one-time test scores of 120 male KSA freshmen in 50m running, sit-ups, standing long jump and upper body stretching against the average scores of these activities of 300 male students attending normal high schools.

2. Verification of Physical self-concept between gifted and ordinary students.

The physical self-concept of KSA students and ordinary students was measured twice, via a pre-test and a post-test at a year interval, by a physical self-description questionnaire (PSDQ) for Korean adolescents[35]. Separate descriptive statistics and the covariate analysis based on the pre-test as covariate is shown in [Table 3].

[Table 3] indicates that covariate analysis can be

Table 3. Result of the covariate analysis on each sub-factor of physical self-concept

Variables	Gifted Students (n=117)		Normal Students (n=117)		Regression line slope		group difference	
	Pre-Test M(SD)	Post-test M(SD)	Pre-Test M(SD)	Post-Test M(SD)	F	p	F	p
Appearance	3.36(1.17)	3.70(0.91)	3.52(1.00)	4.03(1.08)	0.01	ns	5.99	.0151*
Health	4.15(0.93)	4.37(0.97)	4.13(0.91)	4.53(1.02)	0.18	ns	1.22	ns
Regular Exercise	3.02(1.14)	3.68(1.24)	3.34(1.10)	3.67(1.14)	0.02	ns	0.06	ns
Sports Confidence	3.19(1.13)	3.81(1.00)	3.56(1.12)	4.19(1.97)	0.66	ns	2.95	ns
Body Fat	3.88(1.23)	4.06(1.12)	4.03(1.16)	4.06(1.20)	0.19	ns	0.00	ns
Muscular Strength	3.31(1.08)	3.38(1.98)	3.50(0.89)	3.66(0.96)	1.43	ns	4.18	.0420*
Flexibility	2.99(1.15)	3.37(1.19)	3.23(0.96)	3.36(1.15)	0.00	ns	0.01	ns
Endurance	3.26(1.16)	3.89(0.82)	3.25(0.94)	3.50(0.97)	0.09	ns	8.34	.0043**

* $p<.05$, ** $p<.01$

utilized because interactions after investigation into sameness of regression line slope on pre-test value of sub-variables of physical self-concept were not significant. The results of treatment effect on each school could be explained in two folds. First, it was indicated that KSA students significantly regard their physical appearance ($p<.05$) and muscle strength ($p<.05$) as low compared to normal students. Despite KSA students are taller and have nicer body composition in PBF and BMI, they evaluate their self-concepts in physical appearance and muscle strength as lower as ordinary students. In addition, although it is not statically significant, average score of self-concept in health and sport confidence, KSA students are less confident than normal students[Table 3]. This finding supports hypothesis 3 "physical self-concept of gifted students appears to be lower than that of normal students, and particularly, this tendency is compatible with Hoge and Rezulli's[5] finding that gifted students'self-concept in physical appearance and athletic competence are lower than normal students. Second, as a peculiar finding, among KSA students'physical self-concepts, endurance factor ($p<.01$) was highly noticed by them. It seems that endurance factor might be related with task attachment that needs an ability to achieve a task with endurance[42], which is one of important features of gifted students. More discussion is needed in this result.

Ⅳ. DISCUSSION

Recently, there is great amount of research dealing with gifted students in math and science and their academic and cognitive abilities, but their physical aspect has not been paid attention in the academic sphere. In this regard, this study is preceded and focused on the body composition, physical fitness, and physical self-concept of gifted students participating in a special program as students of KSA in Korea.

First, the results indicated that KSA students had no significant difference in body weight compared to ordinary students, but gifted students were taller in height and in better condition in terms of their BMI and PBF quotients. Korean Society for the Study of Obesity[43] recommends 18.5~22.9 as the BMI standard range for the Asian adult male. Both groups of students are in the recommended category (gifted: 21.6, non-gifted: 22.5), but it couldbe understood that the gifted students in KSA are more stable than ordinary students. The PBF standard for male adults is suggested to be between 10-20%[31] both groups

were in the standard category. However, the fact that KSA students' body fat is significantly lower although no difference in weight with ordinary students was found means that KSA students have more muscle than their counterparts. Therefore, this result suggests that KSA students have the same weight but higher height with more muscle than ordinary students, and have maintained a healthier body composition.

The results may be due to the completely different school life of KSA students compared to students attending ordinary schools. KSA is composed of the gifted in mathematics/science and operates a totally different education system from ordinary schools in Korea. Students in ordinary schools in Korea spend their school time mostly focusing on the very competitive college entrance exam, and are not exposed to physical activities. On the other hand, KSA students already have confirmation that they will attend one of the high-profile universities in Korea as a result of contracts between KSA and the institutions. Thus, KSA operates its education system focusing on fostering the qualities required for global scientists and cultivating research abilities as well as focusing on leadership activities, sports, and work-study program. KSA has a high-quality sports complex (2 indoor gyms for basketball and volleyball, a natural turf grass soccer field, a fitness center, a rock climbing site, and a tennis court) and many kinds of physical activity programs. For example, KSA offers a 120-hour taekwondo training program. Taekwondo program in KSA has been provided under the following goals. First, Taekwondo is effective in developing physical fitness and team-work spirit of gifted students through the program in which all the students in the class move and act as a whole even the gym is not spacious enough. Second, Taekwondo is the most globalized martial art in the world and Korean is designated as the origin of it[44]. In this regard, Taekwondo and the mission of KSA, which is to foster global scientists who can contribute to the world, are compatible one another, and because of this fact, Taekwondo program has been run in KSA. In addition, all the freshmen participate in Mt. Jiri hike lasting 4 days and 3 nights during summer vacation. All students of KSA must participate in an environmental marathon event organized by a local broadcasting company in April and have the opportunity to attend an optional ski camp in January. Those activities have been scheduled in addition to regular physical education classes. More dynamic programs, which are rarely carried out in normal high schools, are in progress in KSA. For example, in normal high schools in Korea, students'schedule is composed of regular classes, which end at 4 p. m., followed by extra classes in mathematics, English, science and the Korean language, which run until 6 p. m. Then, the self-study session runs until 10 p.m. Such a tough schedule for high school students has caused serious stress and negative impacts on students'mental health. Meanwhile, KSA students can participate in a variety of sports programs and other academic club activities as they wish. [Table 1] shows that gifted students, compared to ordinary students, have continued more diverse andhigher level sport club activities spending great amount of time. This finding is compatible with Wininger&Rinn's report[28]. Because of these dynamic physical activities, KSA students seem to have a more ideal body composition than ordinary students. However, studies investigating whether KSA students'body composition is influenced by diet, genetic background, or stress related to studying utilizing a path analysis with vertical tracking work are needed.

Physical fitness includes cardio-respiratory endurance (1,600m running), speed (50m dash),

muscle strength (push-ups), and flexibility (upper body stretching). There was no statistically significant difference between KSA students and ordinary students. Ahn [41]supports the results of this study that a comparison analysis of the physical fitness between KSA students and ordinary students results in significantly indifferent statistics. It means that the physical activity programs and the dynamic outdoor activities of KSA are not influential in increasing the physical fitness of KSA students compared to students attending ordinary schools. At the same time, this result goes paradoxically against the view that KSA students'physical fitness is poor because of their intellectual-activity-focused lifestyle. Moreover, the cardio-respiratory endurance level of KSA students is not statistically significantly higher than that of ordinary students; however, on average, KSA students showed a higher level than ordinary students.

Meanwhile, when carefully looking at the result of covariate analysis related to physical self-concept between the groups can be summarized in three ways. First, ordinary students are indicated to have significantly higher positive improvement than KSA students in self-concept related to their appearance and muscle strength. Second, there was no significant difference between the groups in health, regular exercise, sports confidence, body fat, and flexibility factor of self-concept. However, it is found that KSA students are slightly lower in the average of health and sport confidence self-concept. Third, KSA students are unusually indicated to have a significantly higher self-concept of endurance factor than ordinary students.

There are two ways associated with the internal/external frame of reference model and Big-Fish-Little-Pond Effect to interpret the tendency of KSA students who have lower self-concept of physical appearance and muscle strength even though they are taller and have more ideal body composition than ordinary students. Moreover, the fact that KSA students have lower physical self-concept, even though they had more affluent and diverse sport activity programs and clubs compared to what ordinary students had, is very interesting result that supports frame of reference model and BFLPE. According to the internal/external frame of reference model, KSA students who have outstanding talent in mathematics and science form higher self-concept in academic areas, while developing lower self-concept in physical activity areas. KSA students are required to spend a great amount of time on studying mathematics and science and other academic subjects instead of engaging in physical activities in order to be admitted to KSA. This environment plants the seeds for them to form higher self-concept in academic areas and lower self-concept in physical areas. In this regard, Marsh et al[12] insisted that gifted students tend to under-evaluate their physical self-concept more than other types of self-concepts. Practically, by conducting a meta- analysis, Hoge and Renzulli discovered that gifted students have lower self-concept in physical appearance and athletic competence than ordinary students[5]. In addition, Rudasill and Callahan's study also suggested that gifted students positively perceive their scholastic competence but negatively perceive their athletic competence, supporting this study for the most part[2].

BFLPE, which has been continuously proved in studies dealing with the self-concept of gifted students, can explain the tendency as well. According to BFLPE, gifted individuals who are surrounded by equally gifted peers have lower academic self-concept than gifted individuals who are not in an academically selective environment, seemingly because of the

social comparison process[46]. Similarly, a study related to physical self-concept on elite and non-elite athletes by Marsh[19] mentioned this BFLPE phenomenon in physical appearance and total physical self-concept factors. Considering the fact that the KSA students had passed a 3-step filtering system measuring their abilities in mathematics and science, their physical appearance self-concept and muscle strength self-concept were under-evaluated based on the BFLFE model.

The result that higher endurance factor among physical self-concept is presented in KSA students describes a slightly different point from the internal/external frame of reference model and BFLPE theory. The internal/external frame of reference model and BFLPE theory suggest that gifted students participate in sports activities more than ordinary students during their free time[24][27][45] and participate in sports at higher levels[28]. They also suggest that they evaluate their physical self-concept comparatively lower than their academic self-concept. Also, the BFLPE results show low self-concept in a group environment composed only of the gifted. However, self-concept is multi-dimensional and hierarchical[19]. Also, it is possible to simultaneously have positive and negative views of oneself, depending on the context[2][8]. Therefore, KSA's active sports programs, which have been carried out as a school policy, positively functioned to promote students' confidence in endurance among the different types of physical self-concept. Practically, Rinn and Wininger reported that participating in sports programs enhances the physical self-concept of gifted students[22].

In other dimensions, KSA operates an advanced education process which requires high-level task tenacity. High-level task tenacity is one trait of the gifted[42], and it is based on strong psychological endurance marked by persistence and patience. This psychological endurance would positively influence not only physical endurance, but also perceived self-evaluation of cardio endurance of physical self-concept. However, all the explanations describing gifted students which indicate that they possess higher endurance physical self-concept than ordinary students are just an analogical interpretation only for physical self-concept. Therefore, it is highly recommended that follow-up studies investigate the factors that may influence the higher cardio endurance physical self-concept of KSA students and if it was an outcome of the influence of KSA's sports activity programs, KSA'seducation system requiring higher task tenacity, or a complex interaction between these two.

V. CONCLUSION

Personal body composition, physical fitness, and physical self-concept are critical factors to determine general self-concept. High self-concept is likely tied to other important constructs, such as motivation[47], aspirations[48], and academic achievement[49]. On the other hand, low self-concept may be related to depression, inactivity, and poor perceived health[50]. After conducting a pre-test and post-test, this study came to the following conclusions. First, gifted students have maintained more ideal body composition than ordinary students; also, KSA students are taller and have more muscle at the same weight. Second, KSA students have kept an equal level of physical fitness. These results disprove the stereotypical view that gifted students are characterized by poor physical fitness due to their heavy concentration on academic tasks. Third, the self-concept in physical appearance and muscle

strength of KSA students was lower than that of ordinary students. This result supports the internal/external frame of reference model and BFLFE. Fourth, KSA students recorded higher self-concept in endurance. It is analogized that mental endurance, which is one of the characteristics of talent and can be developed through an intensified level of tenacity to study, has influenced this result. However, more research remains to be done. The conclusions of this study provide useful scholastic meanings in the physical education of gifted students.

This study is especially meaningful in that it provides a case study regarding the effects on physical domain of KSA's education for gifted students, which is designed by Korean government since 2002 in attempt to nurture the future leading and global scientists. In the future studies, we encourage to trace three-year changes of KSA students during their time in the high school, using longitudinal study. In addition, it might produce interesting findings if a study explores the differences in forming self-concept after participating in sport programs between two cases; a case of the program that mixed with KSA students and ordinary students; and the other case that operates KSA and ordinary students separately. Particularly, if a study investigates direct or indirect effects on endurance domain among physical self-concepts of KSA students using path analysis, it would help in-depth understand on gifted students in mathematics and science and the effects of education system designed for gifted students.

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저 자 소 개

송 강 영(Kang-Young Song) 종신회원

- 1999 : 서울대학교 박사학위취득
- 2000년 ~ 2014현재 : 동서대학교 교수재직
- 2013년 ~ 현재 : 체육인재육성재단 이사장

<관심분야> : 스포츠 산업/ 정책

안 정 덕(Jeong Deok Ahn) 정회원

- 1986년 2월 : 경상대학교 졸업
- 1995년 8월 : 서울대학교 석사취득
- 2002년 8월 : 부산대학교 이학박사 취득
- 2003년 3월 ~ 2014년 현재 : 부산대학교 및 경상대학교 강의

<관심분야> : 스포츠심리, 운동학습