

## Comparative Analysis on the Visual Body Proportion of Girls in Middle and High School

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**Abstract :** The purpose of this study was to identify the body proportions of girls in middle and high school who have been a major sales target of clothing manufacturers and thus to provide the basic information on the proportion of human body, which is essential for manufacturer to produce clothing and for individual consumers to select right apparels to wear and purchase. The subjects were 133 girls in middle school and 141 girls in high school. As measuring instruments, the Martin's anthropometer, tapelines, and belts for marking waist line were used. In order to analyze the data, t-test and factor analysis were used. The measurement of vertical distance between vertex and measuring points, showed a significant difference between the high school group and middle school group in every item. In the comparison of eight head proportion between the two groups, middle school students had 7.2 head proportion while girls in high school had 6.9 head proportion in detail. The factor analysis of major divided body parts of the two groups indicated that waist-hip and hip-crotch, constituting lower trunk together, vertex-apex nasi, and apex nasi-back neck point, constituting head together, back neck point-spina scapula and spina scapula-waist, constituting posterior of upper body together, and mentum-bust point and bust point-waist, constituting anterior of upper body together, were in inverse proportion.

**Key words :** visual body proportion, middle and high school girls, head proportion, factor analysis

### INTRODUCTION

Ultimately, apparels should be seen as something to be put on a human body rather than isolated, self-containing artifacts(Haruko,1994). Therefore, for effective and efficient use of clothes, it is important to identify the proportion of human body as the object of wearing. Types of human body vary across age, sex, and race. However, even within the same age and race, individual differences are significant, and there exist idiosyncratic characteristics according to individuals.

Cousin asserted that the eight head proportion index is not simply a height index, but that if each proportion index of a body does not pass a designated point, this body cannot be considered to have a beautiful proportion. Also, the golden proportion which Wacoal, a Japanese lingerie maker, proposes has the proportion of 1:1.618 for vertex-waist and waist-sole of the foot.

Moreover, the proportion of human body shows a significant variation in accordance to different eras, races, and individual tastes. Hence, there cannot be an ideal, absolute value of measurement, but only relative values can be obtained (Lim,1985).

When studied through history, the ideal form of body

was considered thin and muscular type with 6.5 head proportion in ancient Egypt era. In Gothic Age, ideal beauty of human body was considered a little extended in length with 8.5 or so head proportion, 8 head proportion was the best during in Greek and Roman period, and 7 head proportion was the best as the original figure in Baroque and Rococo era. Especially in Rococo era, people have a preference for the baby style having short leg with 6 head proportion. In Classicism Age, people was fond of long underneath bust line, and ideal proportion was extended 8.5 head proportion, and glamour and pyknic type was considered as beauty in the Romanticism era. At those time 7.5 head proportion was the best as real(Ryu & Kim, 1992).

Park and Ryu also claim that(Park & Ryu 1998), clothes need to compensate weak points and emphasize strong points of the particular body in question, with reference to the persons satisfaction level for each part of his/her body. According to Park and Ryu, this is because the level of satisfaction with ones own body during the juvenile period is a crucial factor in the formation of positive attitude toward life. Consequently, it is essential for each person to identify the proportion of his/her body.

Therefore, the present study aims at identifying body proportions of girls in middle and high school who have been a major sales target of clothing manufacturers and

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thus providing basic information on the proportion of human body, which is essential for manufacturer to produce clothing and for individual consumers to select right apparels to wear and/or purchase.

## RESEARCH METHODS AND PROCEDURES

### Subjects and Research Period

The subjects were 133 girls in middle school and 141 girls in high school. All the subjects in teenager had been residing in Daegu at the time of this study. The measuring of the subjects was accomplished from 5 June, 1997 through 15 June of the same year.

### Research Method

**Instrument and Methods for Measurement :** As measuring instruments, adhesive labels for marking measuring points, the Martin's anthropometer, tape-lines, and belts for marking waist line were utilized. As measuring methods, the subjects were instructed to wear the panties and braziers, which were specifically designed for measurement, to put marking labels on the designated standardized points for measurement, and to stand still with the eyes fixed to be level with the horizon.

The subjects were directly measured by the researchers and research assistants who had been trained for this study. Terminologies and methodologies for measuring

were adopted from KS A 7003 and KS A 7004, respectively. Finally, measuring items required for this study were determined by the researchers with reference to previous studies (Korean Agency,1997. Sagakura, 1998).

**Measuring Items :** In this study, only proportions for height were analyzed. Therefore, the measuring items used for this study were a total of 19 separate control points or measuring points which were considered to be important inflection points on lateral form of human body; (1) stature, (2) apex nasi, (3) mentum, (4) back neck point, (5) side neck point, (6) front neck point, (7) shoulder point, (8) spina scapula, (9) bust point, (10) lateral waist, (11) navel, (12) abdominal protrusion, (13) hip protrusion, (14) crotch, (15) mid knee point, (16) malleous point, (17) elbow point, (18) wrist point, and (19) dactylion 3.

**Analysis of Data :** First of all, descriptive statistics of measurements and indexes of the items for direct measurement of 274 female middle and high school students were obtained. Then, in order to examine group differences between the middle school students and high school students, t-test was performed. Second, in order to analyze body proportions of the subjects, body structure was divided into three parts head, body, and limb, using the separate control points of the eight head proportion, based on the body structure that most of the subjects had.

Table 1. Mean and standard deviation of measuring items Item/Group

Item/Group	High		Middle		T-value
	Mean	SD	Mean	SD	
Stature	158.8	5.04	156.5	6.08	3.411**
Apex nasi	143.7	5.08	142.9	5.94	1.105
Mentum	135.8	4.95	135.2	5.80	0.956
Back neck point	134.0	4.76	132.9	5.69	1.667
Side neck point	133.4	4.78	132.7	5.78	1.100
Front neck point	128.9	4.71	128.5	5.69	0.529
Shoulder point	128.2	4.54	126.4	5.37	3.055**
Spina scapula	118.2	4.51	118.6	5.67	-0.653
Bust point	113.0	4.47	111.8	4.51	2.220*
Lateral waist	98.6	3.83	97.5	4.17	2.264*
Navel	93.3	4.00	92.6	4.18	1.320
Abdominal protrusion	87.3	3.88	88.3	4.45	-1.995*
Hip protrusion	76.5	3.56	77.4	4.19	-2.006*
Crotch	71.5	3.32	71.2	3.82	0.645
Mid knee point	41.9	1.93	41.5	2.11	1.258
Malleous point	4.9	0.45	4.8	0.52	0.550
Elbow point	98.0	4.50	97.8	4.75	0.417
Wrist point	73.5	3.48	74.1	4.90	-1.220
Dactylion 3	56.6	3.07	56.9	3.48	-0.784

\*P<.05, \*\*p<.01, \*\*\*p<.001

**Table 2** Data of the physical average in 1997, Korea

Item/Age	data of the physical average in 1997 (Only Girls)							
	13 yrs.		14 yrs.		16 yrs.		17 yrs.	
	M	SD	M	SD	M	SD	M	SD
Stature	155.4	5.6	158.2	5.0	159.7	5.0	159.3	5.2
Height of back neck point	132.0	4.8	134.5	4.4	135.6	4.9	135.3	5.0
Height of shoulder point	125.7	5.0	129.6	3.1	129.4	4.5	130.8	3.7
Height of lateral waist	95.7	4.1	997.0	3.8	98.1	4.0	97.8	4.0
Height of crotch	71.8	3.6	72.8	3.9	72.7	3.4	72.1	3.4

\* just compared with same items

Also, it was divided into six parts and ten parts according to the body structure and inflection points of body. Then, detailed separate control points including arm area were added. Finally, factor analysis of the measurements and important divided body parts was performed in order to analyze major composed contents of human body. The factor analysis used principal ingredient analysis, and only the factors whose eigenvalues were more than 1.0 were selected. The obtained factors were then orthogonally rotated employing the Varimax method, in order to investigate their factors. SPSS (Win 10) was used for the analysis of data.

## RESULTS AND DISCUSSIONS

### Descriptive Statistics by the Mean Value

**The comparison of mean and standard deviation :** The mean and standard deviation of subjects are shown in Table 1 below. The obtained values were compared in groups; middle school students and high school students.

The measuring data of high school students group were higher than those of middle groups in the stature, from the bottom to the shoulder point, from the bottom to the bust point, and from the bottom to the lateral waist point, while the data of middle group were higher than high group in from the bottom to abdominal protrusion, and from the bottom to hip protrusion.

It means that measurements of height were not reciprocal proportional to stature. It seems to have changed measurements of height because of deposit of fat in the growth period. The less difference of two groups as compared against the preceding year was shown owing to fast growing of middle students. As compared with data of the physical average of teenagers in 1997, means of subjects' measuring data were similar to average (Table 2).

**The comparison of count numbers using vertex as the datum point :** In consideration of body proportion index, the analysis of the vertical distance from vertex is necessary. To help easier understanding, the vertical distance

between vertex and each of the measuring points, which vertically divide the human body as the object of wearing, was measured. The results are shown in Table 3 below. All the measurements had the statistical difference between middle group and high group ( $p < .001$ ).

**The comparison of measurements of major divided body parts :** Table 4 presents the results of the comparison of measurements of major divided body parts. First, when the divided body parts are categorized into the three groups head, trunk, and limb (legs only) girls in high school had larger proportions of body than those of girls in middle school. This means that the high school group was better at developing trunk than the middle school group. Second, in the case that each of head, body, and limb is divided into six parts based on lateral inflection point, the length of lower trunk increased as the age increased.

In dividing into anterior and posterior parts according to the the body structure based on 8 head proportion and inflection points of body, measurements of head and neck area (vertex-mentum), waist-hip protrusion, back neck point-spina, back neck point-front neck point, and waist-abdominal protrusion were higher in girls of high school as significant level  $p < .001$ . However, Girls in the middle school were higher in measurements of mentum-bust point, hip-mid knee point, spina-waist, and hip-crotch as significant level  $p < .001$ .

Finally, when anterior and posterior body is divided into parts according to inflection points of body, girls in high school appeared to have bigger heads, longer lower body, and shorter thighs. However, there were no differences between the two groups in lower leg. For posterior body proportion, girls in high school had smaller proportions of the spina scapula-waist part and the hip-crotch part. They also had longer necks.

**Body proportion considered by the numerical index**  
**Whole body proportion considered by the stature :** The results of the comparison of index measurements con-

**Table 3** Vertical distance from vertex to measuring point

Item/Group	High		Middle		t-value
	M	SD	M	SD	
Vertex - apex nasi	15.1	1.25	13.5	1.24	10.360***
Vertex - mentum	23	0.97	21.3	0.84	15.219***
Vertex - back neck point	24.8	1.09	23.6	1.06	9.560***
Vertex - side neck point	25.4	1.11	23.8	1.08	12.057***
Vertex - front neck point	29.9	1.32	28	1.33	12.232***
Vertex - shoulder point	30.6	1.7	30.1	1.65	2.293***
Vertex - spina scapula	40.6	2.07	37.9	1.8	11.469***
Vertex - bust point	45.7	2	44.7	2.47	4.028***
Vertex - lateral waist point	60.2	2.11	59	2.58	4.231***
Vertex - navel	65.5	2.26	63.9	2.8	5.326***
Vertex - abdomen protrusion	71.4	2.46	68.1	3.04	9.903***
Vertex - hip protrusion point	82.3	2.87	79.1	3.17	8.879***
Vertex - crotch	87.3	2.7	85.3	3.62	5.210***
Vertex - mid knee point	116.9	3.65	114.9	4.54	4.007***
Vertex - malleous point	153.9	4.99	151.7	6	3.415***
Vertex - elbow point	60.8	2.67	58.7	2.9	6.129***
Vertex - wrist point	85.3	3.08	82.4	4.73	6.089***
Vertex - dactyloin 3	102.2	3.63	99.6	4.02	5.637***
Vertex - bottom(stature)	158.8	5	156.5	6.1	3.411***

\*\*\*p&lt;.001

**Table 4** The comparison of measurements of major divided body parts

Item/ Group	High		Middle		t-value
	M	SD	M	SD	
Stature	158.8	5.04	156.5	6.08	3.411***
Vertex - back neck point	24.8	1.09	23.6	1.06	9.560***
Back neck point - crotch	62.5	2.46	61.7	3.19	2.248*
Crotch - bottom	71.5	3.32	71.2	3.82	0.645
Vertex - apex masi	15.1	1.25	13.5	1.24	10.360***
Apex masi - back neck point	9.7	1.3	10	1.43	1.928
Back neck point - lateral waist	35.4	1.98	35.1	2.17	0.162
Lateral waist - crotch	27.1	1.58	26.3	1.89	3.883***
Crotch - mid knee point	29.6	1.8	29.6	2.27	0.118
Mid knee point - bottom	41.9	1.93	41.5	2.11	1.258
Vertex - mentum	23	0.97	21.3	0.84	15.219***
Mentum - bust point	22.8	1.95	23.4	2.29	2.278
Bust point - alteral waist	14.4	1.96	14.3	1.45	0.528
Alteral waist - hip protrusion	22.1	2.08	20.1	1.64	8.957***
Hip protrusion - mid knee point	34.6	2.18	35.9	2.51	4.410***
Back neck point - spina scapula	15.8	1.74	14.4	1.4	7.597***
Spina scapula - lateral wais	19.6	2.24	21.1	2.4	5.318***
Hip protrusion - crotch	5	1.63	6.2	1.86	5.771***
Mid knee - malleous	37	1.89	36.7	1.96	1.182
Malleous - bottom	4.9	0.45	4.8	0.52	0.550
Back neck point - front neck point	5.1	1.13	4.4	1.15	5.218***
Front neck point - bust point	15.8	1.89	16.7	2.18	3.543***
Lateral waist - abdomenprotrusion	11.2	1.91	9.1	1.7	9.587***
Back neck point - shoulder point	5.8	1.48	6.5	1.38	4.480***
Side neck point - shoulder point	5.2	1.41	6.4	1.47	6.489***
Front neck point - shoulder point	0.7	1.54	2.2	1.48	8.202***

\*p&lt;.05 \*\*\*P&lt;.001

sidered by the stature are shown in Table 5. There were the statistical differences between the two groups with the exception of vertex-shoulder point, vertex-lateral waist, and vertex - malleous point( $p<.001$ ). There was the statistical difference between the two groups in vertex-bust

point, and vertex-mid knee point( $p<.05$ ), and there was the significant difference in crotch( $p<.01$ ).

Data of subjects' proportion of this study were compared with 8 head proportion suggested by Cousin, an anatomist from Fance, according to dividing by stature. As the result, the first head proportion index of high school students was 14.5 while Cousin's assertion was 12.5. Concretely speaking, the difference of the mentum points between girls in high school and 8 head proportion was 2.

The second head proportion index was 28.8 while Cousin's data was 25, so bust point of high school students was lower as the difference 3. Navel, the third head proportion index was 41.3 compared with Cousin's proportion 37.5. Because The fourth head proportion index of high school students was 55 while 8 head proportion by Cousin was 50, crotch point of girls in high school was low as the difference 5.

Therefore mentum, bust point, navel, and crotch of high school student were lower than those of 8 head proportion asserted by Cousin. However, if considering the hip pro-

trusion height, not crotch, that was adjacent to 8 head proportion. Mid knee point was close to the data of Cousin because the sixth head proportion index was 73.65.

On the other hand, when considered inflection points of body, spina height of this study was 25.6. That was close to the second head proportion index based on Cousin's data 25.0. Because the third head proportion index was 37.5 based on Cousin's 8 head porportion, it was approximately to waist height 37.9. Because spina spacular height was 25.6, it was close to the second head proportion index, and hip protrusion height was similar to the fourth head proportion index based on Cousin's data.

Nakano insisted the golden proportion which hip height is measured as 50 if stature is considered as 100 (Nakano,1968), although the numerical values of each part are different, if keeping the balance between each part height and stature.

In the proportion of high school students studied from this research, waist height was 37.9, and hip height was 51.9. Therefore the form of the body was big head, long mentum-bust point, low bust point height, short waist and low crotch height. In summary, trunk of the body of girls in high school was long and the waist of those was short.

Data of girls in middle school were similar to those of high school students. In a concrete way, stature index of mentum height was smaller than that of high

**Table 5.** Comparison of index in 19 measurements/stature

(unit : %)

Item/Group	High		Middle		T-value	
	M	SD	M	SD		
Head						
Part	apex nasi/stature	9.52	0.813	8.66	0.791	8.838***
	mentum/stature	14.48	0.693	13.62	0.590	11.029***
Trunk	back neck point/stature	15.64	0.690	15.08	0.675	6.796***
	side neck point/stature	15.98	0.709	15.20	0.738	8.902***
	front neck point/stature	18.86	0.830	17.88	0.866	9.489***
	shoulder/stature	19.27	0.966	19.26	0.906	0.93
	spina scapula/stature	25.60	1.190	24.26	1.204	9.234***
	bust point/stature	28.82	1.164	28.53	1.047	2.145*
	lateral waist/stature	37.92	0.964	38.80	0.917	1.899
	navel/stature	42.28	1.175	40.83	1.082	3.302***
	abdominal protrusion/stature	45.00	1.224	43.55	1.389	9.181***
	hip protrusion/stature	51.86	1.282	50.56	1.371	8.124***
	crotch/stature	55.00	1.097	54.51	1.404	3.198**
Limb	elbow point /stature	38.30	1.547	37.54	1.450	4.193***
	wrist point /stature	53.73	1.348	52.65	2.397	4.622***
	dactylion 3/stature	64.38	1.403	63.67	1.437	4.173***
	mid knee point /stature	73.65	0.727	73.45	0.800	2.097*
	malleous/stature	96.93	0.283	96.91	0.327	0.655
	sole of the foot/stature	100.00	0.000	100.00	0.000	0.000

\*  $p<.05$  \*\* $p<.01$  \*\*\* $p<.001$

school students. Moreover, spina point, waist point, hip protrusion height, and crotch height were closer to 8 head proportion ratio than high school students, though stature of middle school students was shorter than that of high school students. It means that girls in middle school were more approximate to 8 head proportion.

Through this study, girls in high school appeared to have bigger heads, longer trunk, and shorter waist. Even though mean of girls in middle school were shorter than that of high school students in the stature, girls in middle school had much closer index than high school students in 8 times stature in proportion to head. Middle school students had 7.2 head proportion while girls in high school had 6.9 head proportion in detail. Since sampling for this study was limited in subject and place, this result from this study should be accepted carefully on the spread of explanation.

In the recent fashion, wearing with short crotch height had a better effect on the upper body proportion from bust point to waist. It seems to be longer as a kind of optical

illusion, however, people with long waist are explained from a different way. It needs to decide upon choice or rejection of latest fashion according to considering the own form of the body.

**Comparison of major divided body parts considered by the stature** : Table 6 shows the results of the comparison of major divided body parts considered by the stature.

When body structure was divided into three parts(head, body, and limb) using the separate control points of the eight head proportion, based on the body structure, there were the statistical differences between two groups in the leg length and in the head part. Girls in middle school had longer leg, while high school students had bigger head part( $p < .001$ ).

However, as body structure was divided into six parts, there were the statistical differences between two groups in all measurements. High school students was longer in vertex-mentum at a significant level  $p < .001$ . Girls in middle school were longer in mentum-back neck point, back

**Table 6.** Comparison of index in major divided parts/stature

Item/Group	Total	High		Middle		T-value
		M	SD	M	SD	
Vertex - back neck point	15.37	15.64	0.690	15.08	0.675	6.796***
Back neck point - crotch	39.40	39.36	1.091	39.43	1.318	-0.518
Crotch - sole of the foot	45.24	45.00	1.097	45.49	1.404	-3.198**
Vertex - apex nasi	9.10	9.52	0.813	8.67	0.791	8.838***
Apex nasi - back neck point	6.26	6.12	0.800	6.42	0.905	-2.878**
Back neck point -lateral waist	22.45	22.28	1.034	22.62	0.905	-2.930**
Lateral waist - crotch	16.95	17.08	0.920	16.81	1.129	2.168**
Crotch - mid knee point	18.79	18.65	0.811	18.94	1.144	-2.449*
Mid knee point - sole of the foot	26.45	26.35	0.727	26.55	0.979	-2.097*
Vertex - mentum	14.06	14.48	0.693	13.62	0.590	11.129***
Mentum - bust point	14.62	14.35	1.129	14.91	1.174	-4.086***
Bust point - lateral waist	9.13	9.10	1.185	9.17	0.929	-0.557
Lateral waist - hip protrusion	13.41	13.94	1.260	12.85	1.082	7.634***
Hip protrusion - mid knee point	22.33	21.79	1.071	22.90	1.064	-8.598***
Back neck point - spina scapula	9.58	9.96	1.043	9.18	0.923	6.500***
Spina scapula - lateral waist	12.87	12.32	1.372	13.44	0.287	-6.959***
Hip protrusion - crotch	3.54	3.14	1.028	3.96	1.162	-6.173***
Mid knee point - malleous point	23.37	23.29	0.756	23.46	0.755	-1.850
Malleous point - sole of the foot	3.08	3.07	0.283	3.09	0.327	-0.655
Back neck point - front neck point	3.02	3.22	0.713	2.81	0.742	4.683***
Front neck point - bust point	10.30	9.97	1.164	10.65	1.193	-4.810***
Lateral waist - abdominal protrusion	6.49	7.08	1.203	5.85	1.098	8.855***
Back neck point - shoulder point	3.90	3.63	0.911	4.18	0.847	-5.170***
Side neck point - shoulder point	3.67	3.29	0.860	4.06	0.896	-7.239***
Front neck point - shoulder point	0.88	0.41	0.964	1.38	0.933	-8.385***
Shoulder point - wrist point	33.94	34.45	1.289	33.39	2.399	4.626***
Shoulder point - elbow point	18.67	19.03	1.459	18.28	1.265	4.536***
Elbow point - wrist point	15.27	15.42	1.310	15.11	2.498	1.307
Wrist point - dactylion 3	10.83	10.66	1.845	11.02	2.303	-1.710

**Table 7.** Factor analysis of measuring area from vertex to measuring point

Item/Factor	Factor 1	Factor 2	Factor 3
Vertex - bust point	0.729	0.188	0.320
Vertex - lateral waist point	0.817	0.215	0.359
Vertex - navel	0.849	0.278	0.212
Vertex - abdomen protrusion point	0.793	0.452	0.142
Vertex - hip protrusion point	0.784	0.418	0.231
Vertex - crotch	0.886	0.239	0.253
Vertex - mid knee point	0.826	0.142	0.467
Vertex - malleous	0.749	0.080	0.548
Vertex - apexnasi	0.069	0.773	0.088
Vertex - mentum	0.24	0.826	0.111
Vertex - back neck point	0.299	0.780	0.282
Vertex - side neck point	0.32	0.704	0.285
Vertex - front neck point	0.242	0.673	0.412
Vertex - spinascapula	0.233	0.834	0.286
Vertex - shoulder point	0.287	0.296	0.646
Vertex - elbow point	0.271	0.351	0.734
Vertex - wrist point	0.336	0.236	0.740
Vertex - dactylion 3	0.458	0.239	0.755
lgenvalue	0.604	4.48	3.47
Proportion(%)	33.5	24.9	19.3
Cumulative proportion(%)	33.5	58.4	77.7

neck point-waist, crotch-mid knee point, and mid knee point-bottom at a significant level  $p < .01$ . Data from waist to crotch of high school students was longer statistically ( $p < .01$ ).

Girls in middle school had longer leg and for posterior body proportion, girls in high school had smaller proportions of the spina scapula-waist part in whole body proportion considered by stature. In addition, there were significant differences in all section except bust point-waist, mid knee point-malleous point, malleous point-bottom, elbow point-wrist point, and wrist point-dactylion 3 in the comparison of stature index in the section divided in detail.

Girls in high school had bigger stature index in back neck point-front neck point, shoulder-wrist, and shoulder-elbow section. Middle school girls had bigger proportion in another divided section of neck and shoulder.

### Factor Analysis of Measurements

**Factor analysis of measuring area from vertex to measuring point:** Three factors were obtained through the factor analysis of measurements from vertex to the bottom (Table 7). Factor 1 was drawn from vertex to bust point, lateral waist point, navel point, abdominal protrusion, hip protrusion, crotch, and mid knee point. This factor represented trunk and leg covering from bust point to lower leg.

Its eigenvalue was 6.04 and cumulative proportion was

33.54%. Factor 2 was drawn from vertex to the apex nasi, mentum, back neck point, side neck point and front neck point, and spina scapula, including the head part through spina scapula. Its eigenvalue was 4.48 and cumulative proportion was 24.9%.

Factor 3 was drawn from shoulder point to dactylion 3 constituting the arm area of the limbs. Its eigenvalue was 3.47 and cumulative proportion was 19.3%. Total cumulative proportion of factors was 77.7%. The results of factor analysis as index considered by stature were same measurements and contents in Factor 1 and Factor 2.

Because one of Factor 1, malleous point height, was drawn in Factor 4 independently, as a result, four factors was drawn and cumulative percentage was 67.4 that means stronger power of explanation by real measurement rather than index value. Hence, table of index factor analysis was omitted in this paper.

**Factor analysis of major divided body parts:** Factor analysis was also performed for major divided body parts based on inflection points of body, indicating the proportion of the human body. The results were shown in Table 8.

Factor 1 was drawn from lower trunk factor, including waist-hip and hip-crotch. The eigenvalue was 2.13, and cumulative proportion was 16.4%. Factor 2 was drawn from the head part, including from vertex to apex nasi, from apex nasi to back neck point, and from vertex to

**Table 8.** Factor analysis of major divided body parts

Item/Factor	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Lateral waist - hip protrusion	.907	-.075	.064	.120	.132	.047
Hip protrusion - crotch	-.788	-.085	-.050	.033	.307	.322
Lateral waist - navel	.614	.154	-.137	.347	.361	.219
Vertex - apex nasi	.247	.891	.109	.154	-.027	.120
Apex nasi - back neck point	.145	-.862	.106	.039	.056	.138
Vertex - mentum	.390	.655	.139	.179	.007	.281
Crotch - mid knee	.116	.031	.849	-.047	-.114	-.141
Mid knee - malleous	-.042	-.051	.831	.069	.057	.130
Back neck point - spina scapula	.054	.103	.258	.878	-.033	.105
Spina scapula - lateral waist	-.198	-.079	.334	-.823	.047	.243
Mentum - bust point	-.071	-.278	.464	-.181	.711	.128
Bust point - lateral waist	-.093	-.059	.235	-.021	-.828	.300
Malleous - bottom	-.031	.068	-.003	-.050	-.123	.826
Igenvalue	2.13	2.11	1.93	1.68	1.47	1.16
Proportion (%)	16.4	16.2	14.8	13.0	11.3	8.9
Cumulative proportion (%)	16.4	32.6	47.4	60.4	71.7	80.6

**Table 9.** Comparison of factors between groups from vertex to measuring point

Group/Factor	Factor 1	Factor 2	Factor 3	Factor 4
Total	Content	trunk part - leg	head & neck part - spina scapula	arm(shoulder point-dactyl- ion 3) - spina scapula
	Cumulative proportion(%)	33.5	58.4	77.7
High	Content	trunk part - leg	arm(shoulder point-dactyl- ion 3) - spina scapula	head & neck part
	Cumulative proportion(%)	32.0	53.5	72.9
Middle	Content	trunk part - leg	neck part(back neck point- front neck point) - spina scapula	arm(shoulder point-dactyl- ion 3) head part (vertex-mentum)
	Cumulative proportion(%)	35.5	54.6	71.5

mentum.

Its eigenvalue was 2.11, and cumulative proportion was 16.2%. Factor 3 was drawn from leg part, including crotch-mid knee point and mid knee point-malleous point. The eigenvalue was 1.93, and cumulative proportion was 14.8. Factor 4 was drawn from posterior area of upper body, including back neck point-spina and spina-waist.

It's eigenvalue was 1.68, and cumulative proportion of factor 4 was 13.0%. Factor 5 was explained by anterior area of upper body, including from mentum to the waist. The eigenvalue was 1.47, and cumulative proportion was 11.3%. Finally, Factor 6 was drawn from

ankle part. It's eigenvalue was 1.16, and cumulative proportion was 8.9%. Total cumulative proportion of factors was 80.6%.

The results of the comparison in factors between the two groups of major divided body parts are shown in Table 9.

The first factor of high school students was explained the head part, while factor 1 of middle group was leg length part. The contents of factors were similar between the two groups from factor 1 to factor 3 in spite of the difference of the order in factors.

As Table 8 shown the common result from factor analysis of major divided body parts between the two



groups, it is drawn obviously that Factor 1(waist-hip protrusion point, hip protrusion-crotch as lower trunk part), Factor 2(vertex-apex nasi, apex nasi-back neck point), Factor 4(back neck point-shoulder, shoulder-waist), and Factor 5(mentum-bust point, bust point-waist) were in inverse proportion. It came out more distinctly in high school students than middle school students.

## CONCLUSIONS

The purpose of this study was to identify the proportion of human body as the object of wearing. The analysis of the data obtained through measuring 274 girls in middle and high school yielded the following results.

(1)The measurements from the bottom to various measuring items revealed that girls in high school had larger proportions of the bottom-shoulder point, the bottom-bust point, and the bottom-lateral waist point than those of girls in middle school. However, the middle school girls had larger proportions of the bottom-abdomen point and the bottom-hip.

The measurement of vertical distance between vertex and measuring points, which was used as visual aid of understanding body proportion, showed a significant difference between the high school group and middle school group in every item.

(2)The comparison of major divided body parts based on major inflection points indicated that girls in high school had larger proportions of head (vertex-mentum) and lower body(waist-crotch). No difference was found between the two subject groups in lower leg.

However, girls in high school had a smaller proportion of thigh. For posterior body proportion, girls in high school had a shorter proportion of spina scapula-waist and a larger proportion of neck than those of girls in middle school.

(3) In the comparison of eight head proportion between the two groups, middle school students had 7.2 head proportion while girls in high school had 6.9 head proportion in detail. More specifically speaking, in the data of total subjects, the bust point had low as the second head proportion index. Navel point as the third head proportion index was approximate to the waist, and the fourth head proportion index was similar to the hip protrusion, Therefore the form of the body was possessed of slight drooped bust, and shorter waist.

(4) There were the statistical difference between two groups in the results of the comparison of index measurements considered by the stature. Girls in middle school appeared to have longer leg, longer upper trunk than those of

high school students, while girls in high school were longer in the lower trunk part.

(5) The factor analysis of measuring area from vertex to various measuring points yielded three factors: Factor 1 representing the points of body and leg, Factor 2 representing head (head-front neck point) and shoulder, and Factor 3 representing arm (shoulder point-dactylion 3).

(6) Six factors were obtained through the factor analysis of major divided body parts on the basis of inflection points of body: Factor 1 representing lower body, Factor 2 representing head, Factor 3 representing the length of leg, Factor 4 representing posterior of upper body, Factor 5 representing anterior of upper body, and Factor 6 appearing independently.

(7) The factor analysis of major divided body parts of the two subject groups indicated that waist-hip and hip-crotch, constituting lower trunk together, vertex-apex nasi, and apex nasi-back neck point, constituting head together, back neck point-spina scapula and spina scapula-waist, constituting posterior of upper body together, and mentum-bust point and bust point-waist, constituting anterior of upper body together, were in inverse proportion.

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