A Study on the Impact of High-rise Living on the Health of Residents

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Abstract
The high-rise apartment is considered to be a representative housing type in Korea and many people believe this housing type is inevitable because it provides convenience and economy without consuming vast amounts of scarce land resources. However, many debates have been arisen because some have expressed concern that high-rise living may jeopardize the health of residents. The objectives of the current study are to analyze the impacts of the residential floor level of high-rise apartment buildings on the health status of residents and to identify the detrimental factors. The study methods are as follows:

(1) Based on the previous studies, detrimental factors concerning the health status of residents, which are currently being raised as an issue, have been analyzed. (2) An analysis has been carried out on residents who have received a medical check-up at the health promotion center of a tertiary medical center, in order to ascertain the correlation between their present medical symptoms and their residential floor level. (3) Based on the results of primary medical examinations, an analysis has been performed to identify the correlation with the residential floor level. Thus, detrimental factors regarding the health status of residents have been extracted based on objective data.

The results were as follows:

(1) Homogeneous results indicating that residents at a higher-floor level of apartment housing had a poor health status are not reliable. (2) Higher-rise living may potentially have a detrimental effect on the respiratory system. (3) Lower-rise living may is exposed to inflammatory factors probably due to the exterior environment.

The focus of this study has been to find out whether there is a significant correlation between high-rise living in apartment housing and the health problem of residents. Further study is essential to find out the detrimental factors affecting the health status and to prepare the appropriate measures. Henceforth, further systematic studies are warranted to protect the residents at high-rise apartment buildings.

Keywords: high-rise apartment; residential health

1. Introduction
With persistent urbanization, the supply of high-rise apartment housing (including high-rise residential-commercial complexes) has been rapidly distributed for the efficient use of urban land. This phenomenon is based on the trend that urban residents favor the use of convenient high-rise apartment buildings considering the efficient and economic aspects of an urban lifestyle. Based on this, high-rise apartment buildings have been accepted as a representative type of urban residence. Henceforth, high-rise apartment buildings of over 50-stories is expected to rise. With the intensification of urban high-rise living, the health problems of residents have been raised as social issues. The high time for that is to be examined through a scientific analysis is long overdue.

In recent years, with the increased social interest in health issues, continual debates have been conducted regarding the residential environment of high-rise apartment housing where many people reside. Studies which were carried out before 2000 mainly focused on anxiety factors and behavioral effects due to high-rise living, the psychological effects on residents, behavioral characteristics and pathological effects. A critical point of view and approach have been adopted within these representative studies which disclosed a negative point of view concerning high-rise buildings. Newman (1972) maintained that a less than 6-story residential structure has the highest degree of safety as well as defense against crime.

According to some Korean studies which were conducted to examine the correlation between high-rise dwelling and health, the frequency of hospital
visits among residents of high-rise buildings of more than 16-stories were more than twice compared to two times those in low-rise apartments of less than 5-stories. (Choi et al., 1998). Residents in high-rise apartments were reported to be under severe stress due to noise, lift accidents, crime, a feeling of being isolated from the ground, and anxiety regarding their protection from accidents (Shim et al., 1996). It was also argued that a higher floor level was associated with a higher degree of stress and that children at a higher floor level had less chance to get along with other children. In addition, it was also maintained that there was a detrimental effect in terms of self-reliance of children (Kang, 2000). Park, Lee and Kim (1993) also reported the detrimental effects of high-rise living, noting that although the correlations between the pathological conditions due to high-rise living and the physical environment had not been substantially demonstrated, closeness to the ground level was associated with residents' health. Kim and Ha (1996) pointed out that a feeling of being isolated from the ground in residents at a higher floor level had a detrimental effect on residents both psychologically and physiologically. Experiments have shown that the degree of anxiety was found to be relatively higher and the incidence of hypertension also increased in a more than 18-story building, based on which it was maintained that there might be detrimental effects only on elderly people and infants. The recent critical point of view regarding high-rise buildings, illustrated in journalism and the media, is commonly associated with the difficulty of ventilation, risks of fire and damage due to wind from adjacent areas, according to which there are detrimental effects only on residents' health and safety. In addition, architectural structures with a transverse length greater than the vertical is desirable. It was also argued that excessive energy consumption may threaten the environment. With the increased demand since 2000 for high-rise apartment buildings, studies regarding high-rise living and residents' health have been developed in a somewhat acceptable manner. According to Kim, Shim and Park (2005), of all facilities, community space and well-being space were pointed out as being most commonly needed by residents, regardless of age and gender. Here, indoor facilities of various types were prepared for the convenience of daily living such as indoor sports space, meditation space, sauna, audio-visual room and culture information room. According to the authors, regardless of the residential floor level, various health-related facilities were of help in promoting the health of residents. In an attempt to clarify the correlation between the residential floor level and the health of residents, Kang (2003) collected the medical data of residents in a super tall building and then analyzed it. However, the authors could not clarify the above correlation.

The overseas findings and assumptions that health problems result from residential environment arise could not be simply applied to Korean situation due to the differences in culture, building structure and lifestyle. In Korea, despite the presence of the incompleteness of reports on the issues, there is a strong tendency that health problem issues of high-rise living have been focused on psychological stress rather than physical health. There have been strong limitations of previous studies because they have had a small-size samples of the residents of high-rise living. This study is based on a substantial, quantitative analysis of the medical records. The current study has aimed to identify the impacts of high-rise living on the health of residents and the health factors that have a direct detrimental effect. This is essential in order to provide a scientific basis for the decision of further provision of high-rise apartment buildings because there is a tendency of wide-spread of such buildings.

2. Method
This study has attempted to perform a practical analysis in order to examine the differences in the status of residents' health with respect to residential floor level of apartment housing. Residents in general detached housing, villas or row houses were excluded from the current analysis.

The analysis has used the subjects' data from a questionnaire survey, which has been performed at "The Total Medical Examination Center" of a general hospital located in Kyounggi Province and from primary medical examinations. Of the Data of 34,240 subjects who underwent a regular medical check-up in 2005 and 2006, and that of 22,875 apartment residents were analyzed. The apartments higher than 24 floors were excluded from the current analysis because the total sample size per floor was smaller than 100.

Questionnaire data was obtained through a self-reported health assessment, by which respondents were asked to respond to a questionnaire about their health status. In many countries, there is a broad spectrum of experience with this questionnaire survey and various types of measurement tools have also been developed. Self-reported health assessment has been demonstrated to have substantial validity and reliability concerning the predictability of health status, diseases and mortality (Peter Franks et al., 2003). In this study, the data consisted of a questionnaire, which was developed by "The Total Medical Examination Center" and was composed of questions regarding the respondents' general characteristics and 104 symptoms of 13 systems (Appendix 1.). A total of 53 results of the primary medical examination, which was performed in 15 areas were applied to the current analysis (Appendix 2.).

In this study, an analysis was performed for the residential floor level, the proportion of subjects...
who complained of symptoms per each floor and the correlation between the residential floor level and the proportion of subjects whose medical examination results were determined to be abnormal. Determination criteria were based on those of the department of laboratory medicine of the corresponding medical institution. In addition, the frequency of exercise per week and the correlation between income, level of expenditure and residential floor level were also analyzed.

3. Results

3.1 General characteristics of the respondents

A review of the general characteristics of residents was made, and this showed that residents in their forties were majority and those in their forties to sixties accounted for the next majority (Table 1.). In other words, these results indicate that the residents were financially stable enough to receive a medical check-up. There was no significant correlation between age and the residential floor level. Regarding the distribution of floor level, residents with floors ranging from 1 to 15 accounted for 86.78%. These results indicate that most of the apartments had a residential floor level of < 15 in Korea. Also, the number of residents whose residential floor level exceeded 21 abruptly decreased. These results indicate that the number of residents in a high-rise building was relatively smaller. As described here, although the number of residents in a high-rise building corresponded to a minimal number of urban residents, a serious debate concerning the health problem of residents suggests that the social distribution effects of a high-rise building were not of a lower level. Regarding the frequency of exercise by residents per week, three times a week was the most prevalent. Overall, there was an even distribution extending from one to five times a week. However, the proportion of non-respondents was shown to be 55.76%. These results indicate that more than half of the respondents have no regular exercise habit. Likewise, there was no significant correlation between the frequency of major exercise and the residential floor level. By contrast, the level of monthly income expenditure, an indicator of economic status, correlated significantly with the residential floor level. Residents with a higher monthly income expenditure were shown to reside at a higher floor level, while the degree of financial satisfaction was shown to be relatively higher in residents at a lower floor level. Regarding the level of monthly income expenditure, the proportion of non-respondents was relatively higher (42.71%). Although unreliable, the proportion of respondents whose level of monthly expenditure ranged between KRW 1 million and 3 million was shown to be the highest.

3.2 Residential floor level and present symptoms

The present symptoms seen in the questionnaire were the subjective symptoms of respondents, which could not directly determine the presence of diseases. Despite the greater number of symptoms, a poor health status and symptoms are not identical in the strict sense. However, these findings could be applied as the baseline data for interpreting the results of primary medical examination.

To analyze the correlation between the residential floor level and the present symptoms, an analysis was first performed to examine the correlation between the mean of frequency of symptoms, which respondents complained of, based on the systems of medical center and the residential floor level. The mean in each system was the greatest in the field of the mental and neurological system (mean=2.04), and had a negative correlation with the residential floor level (r=-0.50, sig.=0.01). In addition, the mean number of symptoms was shown to have no significant correlation with the residential floor level. Therefore, the correlation between health and the residential floor level could not be positively explained by the frequency of symptoms and the residential floor level (Table 2.).
In regard to detailed symptoms concerning the mental and neurological system, such as 'anxiety' and 'depression', previously described as problems associated with residence in a high-rise building, the mean of symptoms had a negative correlation (Table 3.). Nevertheless, no other detailed symptoms were found to have a significant correlation with the residential floor level. Also, the musculoskeletal symptoms due to inconvenient facilities and behavioral restrictions had no significant correlation with the residential floor level. By conversely, a higher proportion of respondents with frequent heartbeat was observed in those who resided in a lower-rise building. These results might present data contrary to the previous reports that suggested that residents in a higher-rise building presented with a higher degree of the stress and anxiety.

3.3 Results of medical examination and the residential floor level

The primary medical examinations are referred to as a medical check-up that is routinely performed for the purpose of confirming health status, preventing diseases and detecting them at an earlier stage, and are composed of such test regimens as physical examination, diagnostic test, histopathologic examination and imaging studies. In the current analysis, quantitative measurements were applied, while qualitative medical findings based on imaging and visual determination were excluded.

For objective analysis of the correlation between the residential floor level and the health status of residents, an analysis was performed to obtain the correlation between residential floor level and the proportion of subjects whose medical examination results were determined to be abnormal (Appendix 2). As a result, 12 of a total of 53 tests in 15 areas were shown to have a statistical significance (sig. <0.05). Of these, eight tests were found to have a negative correlation and only four tests were found to have a positive correlation. These results indicate similar trends to an analysis of the questionnaire results which were seen previously.

Tests whose results were determined to be abnormal in residents at a higher floor level include intraocular pressure (right eye) found in the ophthalmologic examination, hemoglobin in the general blood test, TSH in the thyroid function test and FVC in the respiratory system test. In regard to the intraocular pressure (right eye), intraocular pressure (left eye) was found to have no correlation with the residential floor level. Therefore, the reliability of statistical significance cannot be accepted. It is a common feature that both hemoglobin and TSH are test regimens with no statistical significance cannot be accepted. It is a common feature that both hemoglobin and TSH are test regimens which are associated with women. It is necessary however, to investigate whether these results are due to environmental factors. Hemoglobin level was shown to decrease in cases of a lower floor level. However, as no
significant correlations were found with the hematocrit test it cannot be concluded that the test results were reliable. Moreover, a higher level of monthly income was associated with a lower level of the incidence of vertigo as specified in the questionnaire data (r=-0.797, sig.=0.010). Therefore, it also cannot be concluded that environmental factors were involved. The thyroid function test, TSH, could not be considered to be statistically significant because there was a negative correlation between the blood phosphate test associated with the parathyroid gland and the residential floor level. It cannot therefore be concluded that the results were statistically significant. In regard to FVC, the respiratory system function, however, 'the foreign body sensation in the neck' and 'hoarse voice' frequently appeared in cases of a higher floor level in the questionnaire. It can therefore be concluded that the results are statistically significant.

Tests in which results were frequently determined to be abnormal in cases of a lower floor level include blood phosphate (bone metabolism parameter test), fasting blood sugar (diabetes test), serum cholesterol and low-density cholesterol (blood lipid test), general blood test (WBC counts and ESR), PSA (tumor marker test) and urine acidity (urinalysis) had a significant correlation with the residential floor level. Blood phosphate is associated with osteoporosis and is also associated with the functions of the parathyroid gland. However, the results were contradictory to TSH and those of the thyroid function test, so it cannot also be concluded that environmental factors were involved. Fasting blood sugar and urine acidity are test regimens that are performed to assess the functions of the pancreas and kidney in association with diabetes mellitus. It is therefore highly probable that living habits rather than the living environment of residents is a more responsible factor. Serum cholesterol and low-density cholesterol are associated with the circulatory system. These findings should be interpreted by assessing the lifestyle rather than explaining the direct correlation with the residential floor level. WBC counts and ESR (general blood test) and urine acidity (urinalysis) had a significant correlation with the residential floor level. These factors which were detrimental to the health status of residents at a lower floor level include blood phosphate (bone metabolism parameter test), fasting blood sugar (diabetes test), serum cholesterol and low-density cholesterol (blood lipid test), general blood test (WBC counts and ESR), PSA (tumor marker test) and urine acidity (urinalysis) had a significant correlation with the residential floor level. WBC counts and ESR (general blood test) are tests which are associated with inflammations including bacterial infection. Based on the fact that 'swelling', one of the present symptoms, had a negative correlation with the residential floor level, further studies are warranted to examine the correlation between the residential floor level and the infection. Besides, the symptoms of swelling had a significant negative correlation with the level of monthly income expenditure (r=-0.76, sig.=0.02), which also correlated with the residential floor level. Therefore, economic factors could not be completely ruled out. However, the proportion of respondents whose ESR, one of the quantitative parameters, was abnormal had a positive correlation with the level of expenditure (r=0.73, sig.=0.03). This can provide the basis for correlations between the proportion of respondents in a lower floor level who had an abnormal ESR profile and the environmental factors. In addition, there was no correlation between the difference in air pressure and decreased hearing ability. Henceforth, however, further studies are warranted to examine the detrimental factors due to vertical displacement on the hearing ability in residents of buildings more than 50-stories.

4. Discussion

According to the current study, it can be presumed that the residential floor level has an effect on the health status of residents. However, the results were not in agreement with the previous reports that high-rise living had a detrimental effect on the health status of residents. The results were as follows:

There was no evidence that the health status of residents at a lower floor level is better superior to that of residents at a higher floor level. According to the results of the questionnaire concerning the present symptoms, the number of negative correlations (n=7) was greater than that of positive correlations (n=3). The primary medical examination also showed similar results. Although the residential floor level is one of the potential factors that affect health status, the above results were not in agreement with the opinions that high-rise living is associated with a poor health status. According to the previous studies, high-rise living had detrimental effects such as psychological anxiety and stress in residents, however this has not been evidenced. In the current study however, due to an insufficient number of samples with a more than 23-floor level, there was a limitation in arriving at a definitive result. Further specialized studies are warranted to assess the psychological symptoms in cases of super high-rise buildings. On the other hand, in residents at a higher floor level, mental health may be positively affected by securing an outstanding view. In addition, practical studies are also warranted to analyze the effects of a feeling of being isolated from the ground and that of being insulated.

The factors which were detrimental to the health status of residents at a higher floor level proved to be the respiratory system. Of the interview categories, 'foreign body sensation in the neck' and 'hoarse voice' had a correlation with the residential floor level. These results are based on the significant correlation with forced vital capacity (FVC). Regarding the problems with the respiratory system, however, there are also detrimental factors due to respiratory inflammations (pneumonia, bronchitis and laryngitis) rather than the measurement of lung capacity. It is therefore necessary to analyze more specific data concerning medical examinations of the respiratory system. Also in regard to the difference in the respiratory symptoms in residents at a higher floor level, the degree of humidity, the amount of light exposure, the amount of ventilation...
and the ventilation capacity vary depending on the residential floor level. In association with this, the environmental variables should be clarified.

At a lower floor level, residents are more exposed to inflammatory factors such as bacteria and virus. This speculation is based on the questionnaire results suggesting that a lower floor level had a negative correlation with swelling, there was a higher prevalence of WBCs and the ESR level was relatively lower. This allows the speculation that residents at a lower floor level are more exposed to bacterial infection routes (mosquitoes, insects or dust). This study proposed the possibility that the residential floor level might be a potential detrimental factor in the residential environment. However, further studies should be conducted to clarify the physical difference in the indoor residential environment depending on the residential floor level.

In order to analyze the correlation between the residential floor level and the health status of residents, the current study applied the data from a questionnaire and medical examinations which were carried out on residents and thereby extracted the potential factors that may affect their health status. Through the current study however, a causal relationship between the health status of residents and the residential floor level could not be clarified. As the factors affecting health are very complex and diverse further intensive studies are warranted to identify the potential factors involved. The level of monthly expenditure, an indicator of the economic status of residents, had a strong correlation with some of the results of the medical examinations. There is a possibility that residents with a poor health status may prefer a lower floor level to a higher one. Therefore, studies concerning the residential preferences of such respondents' would be of significance.

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Footnotes

1 Distortion of a super-high residential-commercial complex 'Frequent sudden wind and lack of drainage of contaminants', Kookmin Ilbo (December 6, 2006).
2 'A lack of the availability of super-high residential-commercial complex', Naeil Newspaper (December 26, 2005).
## Appendix 1. Correlation between Detailed Symptoms and Residential Floor Level

| Category             | System                                      | r     | sig. |
|----------------------|----------------------------------------------|-------|------|
| General symptoms     | Bad complexion                              | 0.018 | 0.937|
|                      | Fever                                        | -0.046| 0.835|
|                      | Chill                                        | 0.031 | 0.891|
|                      | Cold sweat                                   | 0.004 | 0.988|
|                      | Sleeping disorder                            | -0.152| 0.490|
|                      | Decreased appetite                           | -0.095| 0.668|
|                      | Lethargy                                     | -0.261| 0.230|
|                      | Body stiffness                               | 0.307 | 0.155|
| Dermatologic system  | Rash                                         | 0.024 | 0.916|
|                      | Urticaria                                    | -0.338| 0.116|
|                      | Boils                                        | -0.389| 0.067|
|                      | Swelling                                     | -0.650| 0.011**|
|                      | Pruritis                                     | -0.401| 0.059|
| Visual system        | Visual acuity disorder                       | 0.198 | 0.366|
|                      | Blurred vision                               | 0.228 | 0.296|
|                      | Diplopia                                     | 0.118 | 0.595|
|                      | Eye pain                                     | -0.479| 0.021**|
|                      | Eye tightness                                | -0.043| 0.846|
|                      | Eye glare                                    | -0.323| 0.133|
|                      | Frequent synthesis of eye mucus              | -0.286| 0.188|
|                      | Congestion                                   | -0.062| 0.781|
| Hearing system       | Decreased hearing ability                    | 0.159 | 0.471|
|                      | Otic pain                                    | -0.493| 0.017**|
|                      | Otic discharge                               | 0.142 | 0.520|
|                      | Tinnitus                                     | 0.005 | 0.984|
|                      | Vertigo (visually)                           | 0.347 | 0.106|
|                      | Vertigo (feeling)                            | 0.174 | 0.428|
| Respiratory system   | Sneezing                                     | -0.440| 0.036*|
|                      | Pain in the neck                             | 0.175 | 0.425|
|                      | Foreign body sensation in the neck           | 0.699 | 0.001**|
|                      | Hoarseness                                   | 0.453 | 0.031*|
|                      | Coughing                                     | -0.349| 0.104|
|                      | Sputum                                       | -0.298| 0.168|
|                      | Blood glucose                                | 0.134 | 0.545|
|                      | Hemoptysis                                   | 0.194 | 0.377|
|                      | Breathlessness                               | 0.030 | 0.893|
| Circulatory system   | Respiratory distress                         | -0.124| 0.574|
|                      | Frequent heartbeat                           | -0.459| 0.028*|
|                      | Chest pain                                   | -0.077| 0.728|
|                      | Throbbing chest                              | -0.323| 0.134|
|                      | Irregular pulse rate                         | 0.168 | 0.445|
| Digestive system     | Dyspepsia                                    | -0.310| 0.151|
|                      | Belching                                     | 0.454 | 0.030**|
|                      | Upper gastric discomfort                      | -0.121| 0.586|
|                      | Gastric pain at fasting state                | 0.253 | 0.246|
|                      | Gastric pain after a meal                    | -0.298| 0.169|
|                      | Vomiting                                     | -0.201| 0.360|
|                      | Gastric pain unrelated to a meal             | -0.496| 0.017**|
|                      | Vomiting                                     | -0.263| 0.227|
|                      | Jaundice                                     | 0.017 | 0.940|
|                      | Lower abdominal discomfort                    | -0.344| 0.109|
|                      | Constipation                                 | -0.038| 0.865|

| Category             | System                                      | r     | sig. |
|----------------------|----------------------------------------------|-------|------|
| Renal and urogenital system | Frequent urination during the night | 0.418 | 0.054|
|                      | Pain during urination                         | 0.308 | 0.164|
|                      | Difficulty in urinating                      | 0.315 | 0.155|
|                      | Intolerability to urination                  | 0.375 | 0.087|
|                      | Decreased urine output                       | -0.142| 0.529|
|                      | Body swelling                                | -0.161| 0.475|
|                      | Decreased libido                             | -0.159| 0.482|
|                      | Urinary incontinence                         | 0.166 | 0.461|
| Gynecologic system   | Irregular menstruation                       | 0.206 | 0.346|
|                      | Dysmenorrhea                                 | 0.045 | 0.839|
|                      | Irregular bleeding                           | 0.363 | 0.090|
|                      | Prolonged menstrual period                   | 0.152 | 0.489|
|                      | Increased amount of menorrhrea               | 0.236 | 0.281|
|                      | Increased discharge from the womb            | -0.079| 0.721|
|                      | Pruritis of the pudendum                     | -0.229| 0.294|
|                      | Frequent damage of the pudendum              | -0.117| 0.596|
|                      | Decreased sensation                          | -0.097| 0.660|
|                      | Pain associated with sexual intercourse       | -0.143| 0.517|
| Endocrine system     | Increased urine output                       | 0.250 | 0.252|
|                      | Enlargement of the thyroid gland             | 0.338 | 0.116|
|                      | Intolerability to hot weather                | 0.349 | 0.103|
|                      | Excessive sweating                           | -0.276| 0.203|
|                      | Face flushing                                | -0.298| 0.169|
|                      | Increased appetite                           | -0.121| 0.585|
|                      | Decreased appetite                           | -0.087| 0.695|
|                      | Vertigo                                      | 0.217 | 0.322|
|                      | Nasal bleeding                               | 0.193 | 0.380|
|                      | Gingival bleeding                            | -0.260| 0.232|
|                      | Susceptibility to bruising                   | 0.450 | 0.032*|
|                      | Lymphadenopathy                              | -0.275| 0.205|
|                      | Musculoskeletal system                       | 0.047 | 0.834|
|                      | Waist pain                                   | 0.059 | 0.790|
|                      | Severe joint pain                            | 0.128 | 0.563|
|                      | Joint motion difficulty                      | -0.047| 0.834|
|                      | Stiffness of back of neck                    | 0.372 | 0.081|
|                      | Shoulder pain                                | 0.208 | 0.343|
|                      | Paralysis of extremities and pain            | 0.310 | 0.151|
|                      | Headache                                     | 0.297 | 0.169|
|                      | Nervous breakdown                            | -0.172| 0.434|
|                      | Decreased concentration                      | -0.033| 0.885|
|                      | Mild irritability                            | -0.082| 0.713|
|                      | Decreased memory                             | 0.210 | 0.337|
|                      | Difficulty in speaking                       | -0.233| 0.286|
|                      | Paralysis of the limbs                       | 0.349 | 0.104|
|                      | Abnormal sensation of the extremities        | 0.129 | 0.560|
|                      | Transient loss of appetite                   | -0.128| 0.564|
|                      | Depression                                   | -0.231| 0.291|
|                      | Anxiety                                      | 0.179 | 0.417|
|                      | Insomnia                                     | 0.043 | 0.848|

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### Appendix 2. Clinical Implications of Primary Medical Examinations and Correlation with the Residential Floor Level

| Category                  | Test details                  | Academic terms            | Normal range  | Clinical implications                                                                 | R  sig. |
|---------------------------|-------------------------------|---------------------------|----------------|---------------------------------------------------------------------------------------|---------|
| Physical examination      | Body fat rate                 | Percent body fat          | 10–20         | The proportion of fat in the body                                                       | -0.307  0.153 |
| Hearing ability test      | Hearing (Lt, 500Hz)           | ~30                       |                | The measurement of sensitivity of hearing ability                                       | 0.248  0.253 |
|                           | Hearing (Lt, 1000Hz)          |                           |                |                                                                                        | 0.121  0.582 |
|                           | Hearing (Lt, 2000Hz)          |                           |                |                                                                                        | 0.370  0.081 |
|                           | Hearing (Rt, 500Hz)           |                           |                |                                                                                        | 0.267  0.216 |
|                           | Hearing (Rt, 1000Hz)          |                           |                |                                                                                        | 0.098  0.653 |
|                           | Hearing (Rt, 2000Hz)          |                           |                |                                                                                        | 0.193  0.375 |
| Ophthalmologic test       | Eyesight (L)                  | 10–21                     |                | Exceeding – glaucoma, lowering – Atrophia bulbi                                        | 0.256  0.237 |
|                           | Eyesight (Rt)                 |                           |                |                                                                                        | 0.564  0.005** |
| Bone metabolism marker test | Serum calcium level           | Calcium                   | 8.4~10.2      | A diagnosis and monitoring of treatment courses in cases of diseases, in the liver      | 0.207  0.192 |
|                           | Serum phosphate level         | In.PHosphorus             | 2.7~4.5       | Metabolites of Creatine Phosphate as a measure of renal function                        | -0.424  0.043** |
|                           |                               |                           |                | Increased – acute DIC, liver diseases and thrombosis treatment                          | 0.046  0.311 |
| Diabetes test             | Fasting blood sugar           | Glucose (AC)              | 70–110         | The measurement of blood glucose                                                      | -0.659  0.006** |
| Atherosclerotic factors test | Fibrinogen                   | Fibrinogen                | 200–469       | Increased – Pregnancy or inflammation promotes the synthesis of fibrinogen in the liver | 0.056  0.796 |
| Renal function test       | Serum creatinine              | Creatinine                | 0.5~1.4       | Metabolites of Creatine Phosphate as a measure of renal function                        | 0.278  0.198 |
|                           | Blood nitrogen                | BUN (Bloodureanitrogen)   | 8~25          | As a measure of renal function and the final product of protein metabolism, intralobular release is mainly via urea cycle in the liver | 0.002  0.990 |
| Rheumatic test            | Uric acid                     | Uric acid                 | 3.5~7.2       | A diagnosis of abnormal nuclear protein or renal dysfunction                           | -0.101  0.645 |
| Gastrointestinal test     | Total protein                 | T.Protein                 | 6~8.5         | An assessment of the overall status of abnormal protein indicating changes in the physiologic function and lesions of living body tissue or organs | -0.018  0.933 |
|                           | Albumin                       | Albumin                   | 3.5~5.3       | An indicator of the abnormality of liver parenchyma or abnormal protein metabolism      | -0.007  0.974 |
| Serum lipid test          | Serum triglyceride            | Triglyceride              | ~250          | A diagnosis of and monitoring of the courses in patients with diabetes mellins, hepatic obstruction, abnormal lipid metabolism and endocrine diseases | -0.403  0.056 |
| General blood test        | WBC counts                    | WBC (White Blood Cell)    | 4~10          | Increased – various bacterial infections and leukemia                                  | -0.491  0.017** |
|                           | RBC counts                    | RBC (Red Blood Cell)      | 4.5~6.3       | Increased – severe vomiting or diarrhea, chronic blood diseases                        | 0.237  0.275 |
|                           | Hemoglobin                    | Hemoglobin                | 11~17         | Decreased – anemia and leukocytopenia                                                  | 0.024  0.913 |
|                           | Hematocrit                     | Hematocrit                | 38~52         | Anemia                                                                                 | 0.353  0.057** |
|                           | Lymphocytes                   | Lymphocyte                | 24~44         | Chronic and acute lymphoblastic leukemia                                               | 0.160  0.465 |
|                           | Monocytes                     | Monocyte                  | 2~10          | Increased – fever, measles, eye diseases and viral infections                          | -0.197  0.367 |
|                           | Eosinophils                   | Eosinophil counts         | 1~5           | Increased – acute DIC, liver diseases and thrombosis treatment                          | -0.027  0.899 |
|                           | Basophils                     | Basophil                  | 0~1           | Immune responses to parasites in the body                                              | 0.156  0.474 |
|                           | Platelet counts               | Platelet                  | 140~400       | AIDS                                                                                  | 0.280  0.195 |
|                           | ESR                            | ESR                       | 0~25          | Increased – increased inflammation or fibrinogens                                       | -0.634  0.001** |
| Tumor marker test         |AFP                            | AFP                       | 0~7           | A screening test for congenital malformation in the fetus. Tumor marker test           | -0.185  0.396 |
|                           |CEA                            | CEA                       | 0~4.7         | Tumor marker test for diagnosis of Colorectal Carcinoma                                | -0.263  0.225 |
|                           |CA 125                         | Cancer Antigen 125        | 35~100        | Early detection of gynecologic cancer                                                 | -0.162  0.458 |
|                           |CA 19-9                        | Carbohydrate Antigen 19-9 | ~27           | Detection of pancreatic cancer, cholangioma and cystic cancer                         | 0.194  0.374 |
|                           |PSA                            | Prostatic Specific Antigen | ~4            | An assessment of cancer progression using prostate-specific antigens                   | -0.554  0.006** |
| Thyroid hormone test      | TSH                            | Thyroid-stimulating hormone | 0.35~5.5   | A diagnostic test for hypothyamus-hypophysis-thyroid gland                           | 0.540  0.007** |
|                           | Free T4                       | Free T4                   | 0.8~1.5       | A screening test for thyroid hormones and thyroid diseases                             | 0.112  0.610 |
| Respiratory function test | FVC                            | Functional Vital Capacity | 80            | Forced vital capacity (%)                                                              | 0.551  0.006** |
|                           | FEV1/FVC                      | Forced Expiratory Volume / 1 Second | 70           | Forced Expiratory Volume in 1 Second                                                  | 0.161  0.458 |
| Urinalysis                | Urine Specific Gravity        | Urine Specific Gravity    | 1.003~1.103   | Confirmation of abnormal results in the kidney                                       | -0.220  0.313 |
|                           | Urine pH                      | Urine pH                  | 5~8           | Diagnostic indicators in cases which are suspected to have renal dysfunction, diabetes mellitus, renal and urinary tract inflammation, renal stones, urethritis, cystitis and renal inflammation | -0.609  0.006** |
|                           | Proteinuria                   | Proteinuria               | Negative      |                                                                                       | 0.351  0.100 |
|                           | Urine Glucose                 | Urine Glucose             | Negative      |                                                                                       | -0.398  0.059 |
|                           | Ketone                        | Ketone                    | Negative      |                                                                                       | -0.128  0.560 |
|                           | Occult Blood                  | Occult Blood              | Negative      |                                                                                       | 0.114  0.603 |
|                           | Urobilinogen                  | Urobilinogen              | ~1            |                                                                                       | -0.211  0.332 |