Enhancement of a Sense of Coherence and Natural Killer Cell Activity which Occurred in Subjects who Improved their Exercise Habits through Health Education in the Workplace

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Abstract: Enhancement of a Sense of Coherence and Natural Killer Cell Activity which Occurred in Subjects who Improved their Exercise Habits through Health Education in the Workplace: Hiroyuki Nakamura, et al. Department of Environmental and Preventive Medicine, Graduate School of Medical Science, Kanazawa University—We have previously demonstrated that a sense of coherence (SOC), a candidate for a mediating stress factor, is involved in natural killer cell activity (NKCA) reduced in smokers, whereas the relationship among exercise, NKCA and SOC is unclear. To clarify the effects of exercise on SOC and NKCA, we examined the changes in SOC and NKCA before and after health education to encourage exercise. Of one-hundred and one male office workers who received the health education for one year, 27 improved, 65 were unchanged and 9 had deteriorated exercise habits. The repeated measures analysis of variance showed that SOC in workers with improvement in the exercise habit were increased more significantly by the health education than those in workers without improvement (p<0.05). Although the change in NKCA produced by health education was recognized to be significantly different in those who had never smoked from that in current smokers (p<0.05), multiple regression analysis demonstrated that improvement in health practice significantly contributed to increases in both SOC (p<0.01) and NKCA (p<0.05) in never smokers, independently of other psychological factors. These results suggest that subjects with improvement in exercise enhance NKCA through increased SOC in never smokers.

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SOC, a candidate for a mediating stress factor, is studied in the framework of Antonovsky’s salutogenesis paradigm, which emphasizes the origin of health1–4). Life events stressors, depression and anxiety as well as work-setting characteristics, particularly work stressors, influence levels of SOC5–7). Emotional stress was reported to be associated with a decrease in cellular immune function including natural killer cell activity (NKCA) in humans8, 9). SOC is involved in NKCA in relation to work stress10) and life stress11). We have suggested that SOC may be an important psychological modifier in determining the relationship between NKCA and smoking10).

Besides smoking cessation, a worksite exercise program is one of the principal policies to promote health in Japan and other countries12–14). Exercise enhances NKCA directly or through changes in lifestyles such as cessation of smoking, reduction of weight or possibly psychological outcomes15, 16), although little is known about the psychological significance of exercise on SOC and NKCA. In the present study, therefore, we examined SOC and NKCA in office workers who improved their exercise habits after health education to clarify the effects of exercise on SOC and NKCA.
Methods

1. Subjects and health education

The subjects consisted of 101 male office workers with mean age ± standard deviation (SD) of 43.0 ± 12.0 yr, engaged in a computer corporation with a workforce of 215 in Ishikawa Prefecture, Japan. We performed health education to encourage exercise in all workers in the corporation according to the total health promotion plan protocol, which the Japanese Ministry of Health, Labor and Welfare is actively promoting. The subjects in the present study included all male workers whose ages were 20–70 yr except 20 male workers who had hypertension, hyperlipidemia, diabetes mellitus, angina pectoris, or acute common cold. None of the subjects was exposed to any toxic substances in the workplace. They had taken no medical drugs or had a history of diseases known to affect the immune system. After giving informed consent, the subjects completed a self-administered questionnaire regarding the SOC described by Antonovsky and the health locus of control (HLC). A Japanese version in which Yamazaki translated the SOC described by Antonovsky was used in the actual SOC questionnaire. The lower the SOC score, the poorer was one’s psychological attitude to SOC. Assessment of HLC was performed with the Japanese version in which Horige had modified the multidimensional HLC scales described by Wallston et al. The Japanese version of HLC was designed to measure five separate dimensions of locus of control beliefs related to health behavior for Japanese: Internal (I), Professional (P), Family (F), Chance (C), and Supernatural (S) HLC. Each contains five 6-item scales. In addition, the 14-item perceived stress scale described by Cohen et al. was used to assess the degree to which situations in life were perceived as stressful. Items on the perceived stress scale were designed to measure the degree to which the subjects felt their lives were unpredictable, uncontrollable, and overwhelming. A higher score on the stress index indicated a greater degree of stress. Mean scores ± SD in the SOC, IHLC, PHLC, FHLC, CHLC, SHLC, and the stress index were 127.3 ± 19.7, 24.9 ± 2.93, 19.1 ± 4.70, 14.6 ± 4.93, 12.0 ± 5.26, and 28.3 ± 6.10, respectively. Physical exercise habits were ascertained by individual interviews. The responses to physical exercise habits were coded as never, a few days and always according to the frequency of the exercise performed per week. Slight exercise including walking with a duration above 30 min successively was regarded as physical exercise in the case of the questionnaire.

After performing a self-administered questionnaire, with the ambient temperature kept at 23°C, the subjects remained still and were prohibited from smoking or drinking for at least 30 min before physical and blood chemical examination. The body mass index (BMI) was examined as an obesity index. In blood samples drawn from heparinized venipuncture from a cubital vein, NKCA was determined by the method described below. Blood samples were taken uniformly at AM 9:00 from fasting subjects. According to their level of cigarette smoking, subjects were coded into current smokers (N=44), never smokers, (N=37) and ex-smokers (N=20).

After 1 year, SOC and NKCA were examined in the subjects who received the health education in the manner described above. The health education improved the smoking behavior of only 1 subject who smoked before the health education.

2. NKCA

Peripheral blood mononuclear cells (PBMC) were isolated from heparinized venous blood by differential centrifugation through Ficoll-Hypaque (Pharmacia, Piscataway, NJ, USA). NKCA was measured in a standard 4 h chromium (Cr) release assay that was performed in 0.2 ml volumes in U-bottom microplates. The K562 erythroleukaemia cell line derived from a patient with human chronic myeloid leukemia in blastic crisis was used as the target for detecting NK cell cytotoxicity. K562 cells, suspended in culture in RPMI 1640 medium, were labeled with Na2CrO4 of 1 mCi/ml (New England Nuclear, Boston, MA, USA) for 1 hr at 37°C. Cells were washed 4 times in a tissue culture medium consisting of RPMI 1640 and resuspended in fresh medium, counted and aliquoted at 1 × 10⁶ target cells/well into 96-well U-bottom microtiter plates containing isolated PBMC as effector cells at predetermined concentrations. The effector: target cell ratios (E/T) were 40: 1, 20: 1, 10: 1, to 5: 1. After the plates were incubated in 5 % CO2 in air at 37°C for 4 h, the assays were terminated by centrifuging the plate at 400 g for 5 min, after which the medium was harvested from each well with a supernatant-harvesting apparatus (Flow, McLean, VA, USA). All determinations were done in triplicate. Radioactivity was counted in a gamma counter. The spontaneous ⁵¹Cr release, determined by incubating labeled target cells in the medium alone, did not exceed 10 % of the maximum release that was determined by adding 1 % Triton X-100. The NKCA as percentage specific lysis was determined according to the formula: 100 × (mean experimental cpm–mean spontaneous cpm)/(mean maximal cpm–mean spontaneous release cpm). Percent cytotoxicity was calculated at each E/T, and these values were converted to lytic units at 20 % (LU20) according to the method of Pross et al.

3. Statistical analysis

We assessed improvement in exercise after performing health education with a change in exercise frequency. The subjects were divided into the following three groups: subjects with less, unchanged and more frequent exercise.
when they reported that their exercise frequency was decreased, unchanged and increased, respectively. Variables including SOC, HLC, stress score, NKCA showed normal distributions. Correlation was analyzed by using Pearson’s correlation coefficient. Statistical analysis of differences among mean values of three groups of exercise habit improvement were performed by the two-way analysis of variance (ANOVA), followed by post-hoc Dunnett test. The factors included the group which was composed of three levels (less, unchanged and more frequent exercise) and smoking status which was composed of three levels (never smokers, current smokers, and ex-smokers). In particular, changes in NKCA and SOC produced by health education in three groups were analyzed by repeated measures ANOVA. The factors included the group which was composed of three levels (less, unchanged and more frequent exercise) and health education which was composed of two levels (before and after). To detect significant differences as compared to the initial value before health education, post-hoc Dunnett test was performed after the repeated measures ANOVA. Furthermore, multiple regressions analysis for changes in SOC and NKCA was performed. The improvement in exercise was coded 1 for less, 2 for unchanged and 3 for more frequent exercise. Independent variables included age, SOC, HLC, stress score and BMI as well as exercise improvement. All statistical tests were two-tailed. P values less than 0.05 were regarded as indicating statistical significance.

**Results**

Comparing exercise frequency before and after health education, we found 9, 65 and 27 subjects with less, unchanged and more frequent exercise, respectively (Table 1). The \( \chi^2 \) test demonstrated that the distribution was statistically significantly different (p<0.001), showing that exercise habits were totally improved by the health education. At the same time, Table 1 shows numbers of smokers, demonstrating statistically significant distribution of smokers (p<0.001). Fig. 1 shows correlations between SOC and NKCA before and after health education, respectively. \( \chi^2 \) for all subjects=62.3, p<0.001. \( \chi^2 \) for smokers=21.8, p<0.001.

<table>
<thead>
<tr>
<th>Exercise frequency before health education</th>
<th>Exercise frequency after health education</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>A few days per week</td>
<td>A few days per week</td>
</tr>
<tr>
<td>Every day</td>
<td>Every day</td>
</tr>
</tbody>
</table>

Values in parenthesis are the number of subjects who still smoked after health education. Nine (6), 65 (29) and 27 (9) subjects showed less frequency, unchanged and increased frequency of exercise after health education, respectively.

Fig. 1. Correlation between NKCA and SOC before (a) and after (b) health education. Regression equations and lines, where Y and X represent NKCA and SOC, respectively, are shown in the upper (a) and lower figures (b).
after health education. We recognized significantly positive correlations between SOC and NKCA at both time points (both p<0.05). Table 2 reveals the association of SOC and NKCA after health education and changes in SOC and NKCA produced by health education with the initial value in variables before health education in never smokers, current smokers and ex-smokers. Variables before health education included age, HLC, stress, and BMI. Stress before health education was positively correlated to a change in SOC in never smokers (p<0.01), and negatively correlated to SOC after health education in current smokers (p<0.01) and ex-smokers (p<0.05). SOC after it was positively correlated to FHLC in never smokers (p<0.01) and negatively correlated to CHLC in current smokers (p<0.01). The change in NKCA was negatively correlated to SHLC (p<0.01) and CHLC (p<0.05) in current smokers.

Fig. 2 shows changes in SOC and NKCA produced by health education in the three groups. There were significant main effects of the group on SOC (F (2,

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**Table 2.** Correlation of SOC and NKCA after health education and changes in SOC and NKCA to initial values for health locus of control, SOC and other behavioral factors according to smoking status

<table>
<thead>
<tr>
<th>Initial values before health education</th>
<th>Never smokers (N=37)</th>
<th>Current smokers (N=44)</th>
<th>Ex-smokers (N=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After education</td>
<td>Change in</td>
<td>After education</td>
</tr>
<tr>
<td></td>
<td>SOC (score)</td>
<td>NKCA (LU20)</td>
<td>SOC (score)</td>
</tr>
<tr>
<td>Age (year)</td>
<td>0.136</td>
<td>0.144</td>
<td>0.251</td>
</tr>
<tr>
<td>SHLC (score)</td>
<td>-0.129</td>
<td>0.115</td>
<td>0.248</td>
</tr>
<tr>
<td>IHLC (score)</td>
<td>0.208</td>
<td>0.127</td>
<td>-0.095</td>
</tr>
<tr>
<td>CHLC (score)</td>
<td>-0.238</td>
<td>-0.043</td>
<td>0.215</td>
</tr>
<tr>
<td>FHLC (score)</td>
<td>0.400*</td>
<td>-0.097</td>
<td>-0.041</td>
</tr>
<tr>
<td>PHLC (score)</td>
<td>0.270</td>
<td>0.307</td>
<td>0.287</td>
</tr>
<tr>
<td>Stress (score)</td>
<td>-0.097</td>
<td>-0.001</td>
<td>0.426**</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>0.242</td>
<td>-0.046</td>
<td>-0.137</td>
</tr>
</tbody>
</table>

Pearson’s correlation coefficient, *: p<0.05, **: p<0.01
Table 3. SOC and NKCA before and after health education and changes in SOC and NKCA according to change in exercise and smoking status

<table>
<thead>
<tr>
<th>Smoking status practice</th>
<th>Number of subjects</th>
<th>Age (year)</th>
<th>Before health education</th>
<th>After health education</th>
<th>Change in SOC</th>
<th>SOC (score)</th>
<th>NKCA (LU20)</th>
<th>SOC (score)</th>
<th>NKCA (LU20)</th>
<th>Change in NKCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never smokers (N=37)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less frequent</td>
<td>2</td>
<td>41.5 ± 16.3</td>
<td>113 ± 23.3</td>
<td>38.2 ± 3.11</td>
<td>411.5 ± 33.2</td>
<td>39.5 ± 3.54</td>
<td>-1.00 ± 9.90</td>
<td>1.30 ± 0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchanged</td>
<td>2</td>
<td>42.8 ± 13.2</td>
<td>134 ± 24.1</td>
<td>38.4 ± 8.64</td>
<td>312.0 ± 13.1</td>
<td>36.8 ± 9.29</td>
<td>-2.25 ± 19.0</td>
<td>-1.58 ± 8.76</td>
<td></td>
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</tr>
<tr>
<td>More frequent</td>
<td>15</td>
<td>45.1 ± 9.23</td>
<td>135 ± 12.1</td>
<td>31.9 ± 6.61</td>
<td>143.8 ± 9.60</td>
<td>35.9 ± 7.56</td>
<td>12.8 ± 5.75</td>
<td>4.70 ± 6.61</td>
<td></td>
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<tr>
<td>Current smokers (N=44)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less frequent</td>
<td>6</td>
<td>38.7 ± 13.0</td>
<td>119 ± 14.5</td>
<td>31.7 ± 9.53</td>
<td>124.5 ± 13.0</td>
<td>28.0 ± 6.73</td>
<td>-7.33 ± 15.0</td>
<td>-6.03 ± 4.59</td>
<td></td>
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</tr>
<tr>
<td>Unchanged</td>
<td>29</td>
<td>41.3 ± 11.6</td>
<td>119 ± 14.2</td>
<td>30.9 ± 8.08</td>
<td>123.0 ± 16.4</td>
<td>29.8 ± 7.31</td>
<td>4.00 ± 14.6</td>
<td>-1.10 ± 6.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More frequent</td>
<td>9</td>
<td>33.6 ± 5.36</td>
<td>129 ± 33.9</td>
<td>36.4 ± 12.0</td>
<td>131.8 ± 17.5</td>
<td>37.8 ± 8.92</td>
<td>2.78 ± 25.6</td>
<td>1.47 ± 9.00</td>
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</tr>
<tr>
<td>Ex-smokers (N=20)</td>
<td></td>
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</tr>
<tr>
<td>Less frequent$</td>
<td>1</td>
<td>49</td>
<td>116</td>
<td>34.3</td>
<td>124</td>
<td>31</td>
<td>-8</td>
<td>-3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchanged</td>
<td>16</td>
<td>49.6 ± 13.3</td>
<td>128 ± 13.2</td>
<td>30.7 ± 9.43</td>
<td>134.3 ± 10.7</td>
<td>34.5 ± 7.69</td>
<td>6.00 ± 11.3</td>
<td>3.81 ± 7.01</td>
<td></td>
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</tr>
<tr>
<td>More frequent</td>
<td>3</td>
<td>51.0 ± 9.64</td>
<td>144 ± 19.5</td>
<td>35.0 ± 2.95</td>
<td>147.7 ± 5.51</td>
<td>33.3 ± 6.03</td>
<td>3.67 ± 14.3</td>
<td>3.63 ± 3.81</td>
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</tr>
</tbody>
</table>

Only the mean is shown in ex-smokers with less frequent exercise (N=1). Statistical analysis of difference was performed by two-way ANOVA. Significant main effects of exercise frequency on SOC before health education (F (2, 92)=3.18, p<0.05) and SOC after health education (F (2, 92)=6.37, p<0.01) and smoking status on age (F (2, 92)=3.19, p<0.05) and NKCA after it (F (2, 92)=3.03, p<0.05). Significant differences found by Dunnett’s post-hoc test as compared to the value for less frequent exercise, *: p<0.05.

Table 4. Initial values for health locus of control, and other behavioral factors according to change in exercise and smoking status

<table>
<thead>
<tr>
<th>Smoking status practice</th>
<th>Number of Subjects</th>
<th>Value (Mean ± SD)</th>
<th>SHLC (score)</th>
<th>IHLC (score)</th>
<th>CHLC (score)</th>
<th>FHLC (score)</th>
<th>PHLC (score)</th>
<th>Stress (score)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never smokers (N=37)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less frequent</td>
<td>2</td>
<td>10.0 ± 1.41</td>
<td>27.0 ± 4.24</td>
<td>12.5 ± 4.95</td>
<td>20.0 ± 1.41</td>
<td>20.5 ± 3.54</td>
<td>25.0 ± 1.41</td>
<td>20.8 ± 0.05</td>
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</tr>
<tr>
<td>Unchanged</td>
<td>20</td>
<td>11.8 ± 4.79</td>
<td>24.3 ± 3.21</td>
<td>13.5 ± 5.40</td>
<td>19.7 ± 5.46</td>
<td>16.4 ± 4.69</td>
<td>26.3 ± 5.00</td>
<td>22.1 ± 2.18</td>
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<tr>
<td>More frequent</td>
<td>15</td>
<td>12.3 ± 5.98</td>
<td>26.3 ± 2.53</td>
<td>14.5 ± 5.33</td>
<td>25.0 ± 3.36</td>
<td>20.5 ± 3.85</td>
<td>27.3 ± 5.35</td>
<td>23.2 ± 2.92</td>
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<tr>
<td>Current smokers (N=44)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Less frequent</td>
<td>6</td>
<td>17.3 ± 7.03</td>
<td>24.7 ± 3.08</td>
<td>16.0 ± 7.46</td>
<td>24.8 ± 3.06</td>
<td>19.7 ± 6.53</td>
<td>25.8 ± 6.91</td>
<td>24.7 ± 4.53</td>
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</tr>
<tr>
<td>Unchanged</td>
<td>29</td>
<td>12.3 ± 4.78*</td>
<td>24.6 ± 2.88</td>
<td>15.9 ± 3.72</td>
<td>22.3 ± 3.56</td>
<td>19.9 ± 4.18</td>
<td>31.1 ± 5.97</td>
<td>22.4 ± 3.55</td>
<td></td>
</tr>
<tr>
<td>More frequent</td>
<td>9</td>
<td>9.33 ± 4.06</td>
<td>25.0 ± 2.00</td>
<td>13.6 ± 3.68</td>
<td>23.0 ± 3.97</td>
<td>17.4 ± 3.32</td>
<td>30.6 ± 7.67</td>
<td>22.0 ± 2.29</td>
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<tr>
<td>Ex-smokers (N=20)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Less frequent$</td>
<td>1</td>
<td>11.3 ± 4.17</td>
<td>23.8 ± 2.96</td>
<td>13.1 ± 4.73</td>
<td>21.1 ± 4.15</td>
<td>20.3 ± 4.60</td>
<td>27.8 ± 6.15</td>
<td>22.5 ± 2.03</td>
<td></td>
</tr>
<tr>
<td>Unchanged</td>
<td>16</td>
<td>7.33 ± 1.15</td>
<td>28.0 ± 2.00</td>
<td>16.3 ± 6.66</td>
<td>23.7 ± 1.53</td>
<td>16.3 ± 8.50</td>
<td>22.0 ± 1.73</td>
<td>24.6 ± 0.55</td>
<td></td>
</tr>
</tbody>
</table>

Only the mean is shown for ex-smokers with less frequent exercise (N=1). Statistical analysis of difference was performed by two-way ANOVA. Significant main effects of exercise frequency on SHLC (F (2, 92)=6.11, p<0.01) and interactive effect of exercise and smoking on SHLC (F (4, 92)=3.03, p<0.05). Significant differences found by Dunnett’s post-hoc test as compared to the value for less frequent exercise, *: p<0.05.

A two-way ANOVA demonstrated significant main effects of exercise and smoking status on SOC (F (2, 92)=1031, p<0.001), and an interactive effect of group and time on SOC (F (1, 98)=3899, p<0.001). The post-hoc test showed that SOC after health education in subjects with more frequent exercise increased as compared to the initial value before health education (p<0.05). We could not recognize main effect, but an interactive effect on NKCA (F (1, 98)=1031, p<0.001). Dividing subjects into three groups according to the improvement in exercise habits, we examined SOC and NKCA before and after health education and changes in SOC and NKCA according to change in exercise and smoking status (Table 3). Two-way ANOVA demonstrated significant main effects of exercise.
Table 5. Multiple regression analysis for changes in SOC and NKCA with health locus of control and other behavioral factors before health education and improvement in exercise as independent variables

<table>
<thead>
<tr>
<th>Initial values before health education</th>
<th>Never smokers (N=37)</th>
<th>Current smokers (N=44)</th>
<th>Ex-smokers (N=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Change in SOC</td>
<td>Change in NKCA</td>
<td>Change in SOC</td>
</tr>
<tr>
<td>Age (year)</td>
<td>0.272</td>
<td>0.195</td>
<td>-0.202</td>
</tr>
<tr>
<td>SHLC (score)</td>
<td>0.018</td>
<td>0.006</td>
<td>0.037</td>
</tr>
<tr>
<td>IHLC (score)</td>
<td>-0.746</td>
<td>-0.143</td>
<td>-0.48</td>
</tr>
<tr>
<td>CHLC (score)</td>
<td>-0.264</td>
<td>-0.086</td>
<td>-0.514</td>
</tr>
<tr>
<td>FHLC (score)</td>
<td>-0.641</td>
<td>-0.207</td>
<td>-0.184</td>
</tr>
<tr>
<td>PHLC (score)</td>
<td>0.969</td>
<td>0.282</td>
<td>0.922</td>
</tr>
<tr>
<td>Stress (score)</td>
<td>1.26</td>
<td>0.389*</td>
<td>0.588</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>-2.09</td>
<td>-0.324</td>
<td>-0.339</td>
</tr>
<tr>
<td>Exercise*</td>
<td>13.4</td>
<td>0.486**</td>
<td>6.10</td>
</tr>
<tr>
<td>Multiple regression coefficient</td>
<td>0.582**</td>
<td>0.538*</td>
<td>0.611*</td>
</tr>
</tbody>
</table>

$Partial regression coefficient, *Improvement in exercise was coded 1 for less, 2 for unchanged and 3 for more frequent exercise.

*: p<0.05, **: p<0.01.

Discussion

Some follow-up studies as well as cross-sectional ones demonstrate that SOC has salutogenic effects. Suominen and associates find that a strong SOC predicts good health in 4 yr of follow-up of adults, suggesting that SOC can contribute to a favorable development of the subjective state of health. The Helsinki Heart Study has shown that SOC determines the risk factors for coronary heart disease such as total cholesterol, systolic blood pressure and BMI and smoking habit after 8 yr follow-up in white-collar workers. In addition to the involvement of SOC in lifestyle-related diseases, Lutgendorf and colleagues examined SOC and NKCA in healthy older adults with life stress accompanying voluntary housing relocation, demonstrating that SOC moderates the relationship between stress and NKCA. The positive correlation between SOC and NKCA seen in the present study supports our previous report showing that SOC is involved in NKCA. Therefore, SOC may lead to the development of health by promoting immune functions.

Physical and psychological stress can influence immunological parameters, especially NK cells and their functions. Poor lifestyle indicators such as smoking, alcohol, body fat as well as lack of exercise, reduce NKCA as sole or mutual actions. Several psychological outcomes such as moderation of stress, anxiety,
motivated to change their lifestyle including exercise.

results suggest that SOC changes as the subjects are

is little evidence showing that exercise enhances immune

exercise enhanced not only SOC, but also NKCA. This implies that the improvement in

NKCA significantly more than those with less frequent

exercise did. This implies that the improvement in

the increase was not statistically significant. However,

exercise, health education increased NKCA, regardless

change NKCA. On the other hand, in subjects with more

frequent or unchanged exercise, health education did not

In never smokers or current smokers with either less

frequent or unchanged exercise, health education did not

change NKCA. On the other hand, in subjects with more

exercise, health education increased NKCA, regardless

of smoking status as never or current smokers, although

the increase was not statistically significant. However,

the findings coincide well with that of the multiple

regression analysis showing that NKCA was increased

by exercise followed by health education in never

smokers. Furthermore, we have found a greater increase

in NKCA in ex-smokers after health education than that

in current smokers, although age distribution in the two

groups was different. Tollerud and his associates report

that NK cells were also decreased among ex-smokers,

including subjects who had not smoked for more than 20

yr. Many researches have demonstrated that smoking

behavior contradicted with exercise habits. Whether the

improvement in exercise increases NKCA in ex-

smokers should be clarified in a follow-up study. In

current smokers, high SHLC (supernatural HLC) was

recognized as a factor hindering improvement in exercise

habits. As high SHLC has an external component,

SHLC seems to be an important factor in considering the

outcome of health education.

In conclusion, our results demonstrated that subjects

with improvement in exercises enhance NKCA through

increased SOC in never smokers.

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