Comparative clinical and radiographic study of the lumbar spine between parachute infantry soldiers and non-parachute infantry soldiers in Japanese Ground Self-Defense forces

Osamu Nemoto, A Kitada, S Naitou, T Tsuchihara, Y Ito, A Tachibana

ABSTRACT

Background The long-term effect of repetitive trauma by military parachuting on the lumbar spine is not well investigated. Therefore, the purpose of this study was to examine the development of lumbar degenerative changes during a 30-year follow-up in Japanese Ground Self Defense Forces (JGSDF) parachute infantry soldiers with normal lumbar radiographs at entry by comparison with those with non-parachute infantry soldiers.

Methods 79 non-parachutists and 65 parachutists were included for radiological examination and questionnaires for low back pain (LBP). All subjects were non-commissioned officers with similar socioeconomic status and life styles. The number of parachuting descent during the 30-year in the parachute group ranged from 208 to 630, with an average of 322.

Results The mean age of the subjects was 18.3 ± 0.5 years at entry and 48.5 ± 0.3 years at follow-up. LBP had been experienced by 37% in the non-parachute group and 25% in the parachute group with no significant difference. The nature of their LBP was judged as mild. The prevalence rate of degenerative changes was similar in both groups. Disc space narrowing was detected in 37 subjects (47%) in non-parachute group an 23 subjects (35%) in parachute group without significant difference. Vertebral osteophytes were detected in 52 subjects (67%) in non-parachute group and 47 subjects (72%) in parachute group without significant difference.

Conclusions This study did not identify any significant differences in the development of lumbar degenerative changes between the parachutists and non-parachutists over a 30-year follow-up, suggesting that military parachuting itself does not accelerate the development of intervertebral disc degeneration. Further studies are needed using large cohorts assessed by MRI as well as plain X-ray.

INTRODUCTION

Military parachuting has been recognised as a hazardous activity since it was first introduced in World War II and injuries due to parachuting have been described in many reports.1–3 Although the most commonly affected sites are the extremities, it is well known that the spinal column can also be injured by parachuting. Military parachuting frequently causes vertebral body fracture without spinal cord or nerve root injury and its distribution is characteristic with maximal frequency occurring at or around the first lumbar vertebra, and with 30% of cases having more than one vertebra involved.4,5 The fractures are typically of the wedge compression type and are usually caused by landing heavily on the buttocks.6,7

Like these, acute injury to the lumbar spine is well documented, but the long-term effect of repetitive trauma by military parachuting on the lumbar spine is not well investigated. Therefore, the purpose of this study was to examine the development of lumbar degenerative changes during a 30-year follow-up in Japanese Ground Self Defense Forces (JGSDF) parachute infantry soldiers with normal lumbar radiographs at entry by comparison with those with non-parachute infantry soldiers.

MATERIALS AND METHODS

The JGSDF has been conducting epidemiologic studies of lifestyle-related diseases including degenerative spondylosis since 1980 and this study was a part of the JGSDF-approved surveillance programme for servicemen’s health. In brief, out of new recruits conscripted into the 15 branches of JGSDF, more than 200 volunteers in each branch were randomly selected and registered annually. The first study established in 1980 enrolled 4738 recruits. They were subjected to a standardised medical examination by military doctors, followed by blood tests and radiographs. At entry, all subjects and their parents gave informed consent to enrol in the study. The same clinical and radiological examinations were performed at, or shortly before, the age of retirement. Informed consent was also obtained from the subjects at this follow-up study.

For investigating the effect of military parachuting on incidence of lumbar degenerative change, 100 non-parachute infantrymen (non-parachutist group) and 100 infantry parachutists (parachutist group) aged 18 or 19 years old were selected. Subjects included in this study had no history of
low back pain (LBP), sciatica, or neurogenic claudication. Additionally, anteroposterior, lateral and bilateral oblique lumbar spine radiographs showed that they had no abnormal radiologic findings such as vertebral osteophyte (VOs), disc space narrowing (DSN), spondylosis, spinal deformity, wedged vertebra, or irregularity of the endplate. For all subjects, the same radiological examination and questionnaires were performed at retirement. Height and weight were taken from JGSDF health records. LBP was defined as a current pain lasting ≥7 consecutive days experienced during the year prior to this study.13 A Visual Analogue Scale (VAS) was used for the subjective ability of the evaluation was estimated using the observations agreed on were used to analyse the data. The reliability and interobserver reliability and rated as follows: poor (κ < 0.2), fair (0.21–0.4), moderate (0.41–0.6), substantial (0.61–0.8) and excellent (κ > 0.81).

STATISTICAL METHOD
A univariate analysis of independent variables using Pearson’s χ² test with or without Yates control for qualitative variables, and Mann-Whitney or Student t test was performed. Statistical analysis was performed by SPSS statistical software package V11, and statistical significance was assigned to p values ≤0.05.

RESULTS
In 2010, 18 in the non-parachute group (NPG) and 23 in the parachute group (PG) had retired early from the military and could not be reached. Among 159 active duty personnel, eight (two NPG and six parachutists) with a history of lumbar surgery and 7 (one NPG and six PG) who had sustained spinal trauma were excluded from the analysis, leaving 79 non-parachutists and 65 parachutists to participate in the follow-up study.

All subjects were non-commissioned officers with similar socioeconomic status and life styles. PG subjects are volunteers who are highly motivated and receive additional pay to undertake military parachuting. The number of parachuting descents over the 30-year period ranged from 208 to 630, with a mean of 322 and were performed with ordinary round-type military parachutes, which are opened by a static line and are not steerable. The mean age of the subjects was 18.3 ± 0.5 years at entry and 48.5 ± 0.3 years at follow-up; there was no difference between the groups. Demographic data of the subjects are presented in Table 1.

LBP (≥7 days in the year of 2010) had been experienced by 37% in the NPG and 25% in the PG with no statistically significant difference. The median VAS score in both groups was 1, indicating that nature of their LBP was judged to be mild.

Analysis of the 144 lumbar radiographs at 2010 revealed the prevalence rate of degenerative changes was similar in both groups. DSN was detected in 37 NPG subjects (47%) and 23 PG subjects (35%) without statistically significant difference. DSN showed relatively equal distribution, although the incidence of DSN at L2/3 in the NPG seemed to be higher than that of the PG, again with no statistically significant difference. Prevalence of DSN by vertebral level is shown in Figure 1. VOs were detected in 52 NPG subjects (67%) compared to 47 PG subjects (72%) (p > 0.05). The incidence of VOs seemed to increase in the caudal direction (Figure 2). The κ values were 0.83 for DSN and 0.89 for VOs, indicating the excellent reliability between observers.

DISCUSSION
Lumbar intervertebral disc degeneration (IVD) is a dominant factor in the aetiology of LBP15 and is an age-related process which may be influenced by many factors such as genetics,16 systemic disorders17 and nutrient supply to the disc.18 Mechanical overloading has been identified as a major extrinsic component in the onset and progression of IVD.19 Recently, it has been reported that asymmetrical axial compression loading can induce IVD affecting cellular and structural responses.20 It is well known that significant axial forces act on the spine during parachuting. At the moment of parachute opening, the spine is subject to decelerations in the order of 4 g for a standard military parachute10 and on landing, peak deceleration g-forces on the spine are 3.2–17 g, depending on the type of parachute.21 Since the maximal spinal tolerance to deceleration g-forces has been reported to be at 20 g,22 the spinal column can tolerate the axial force during parachuting. However, the cumulative effects of submaximal strains on the spine by military parachuting has not been determined. Murray-Leslie et al21 investigated the radiographs of 46 ex-military parachutists aged 50 years or over. They reported a moderately increased prevalence of moderate and severe lumbar IVD in the parachutists compared to the general population with similar age, which did not seem to be directly related to the number of descents or subject’s weight, but related more to the subject’s

Table 1 Demographic data of the 144 subjects who completed the study

<table>
<thead>
<tr>
<th></th>
<th>Non-parachutist group</th>
<th>Parachutist group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recruitment in 1980</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.2 ± 6.2</td>
<td>170.0 ± 5.6</td>
<td>0.279</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.0 ± 7.5</td>
<td>66.5 ± 8.2</td>
<td>0.258</td>
</tr>
<tr>
<td>Retirement in 2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.7 ± 4.7</td>
<td>169.5 ± 3.3</td>
<td>0.376</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72.3 ± 10.1</td>
<td>74.3 ± 12.0</td>
<td>0.283</td>
</tr>
</tbody>
</table>

Values are expressed as mean±SD.
age. Similarly, Mustajoki et al\(^{24}\) reported in a controlled study that degenerative change was more frequent in the upper parts of the spine but not in the lumbar spine. In contrast, the study of lumbar radiographs in military parachuting instructors by Bar-Dayan et al\(^{25}\) showed that degenerative changes were more common among those who had more experience in parachuting. They concluded that repeated stress on the spine by parachuting could be a possible contributing factor to the development of IVD, although a comparative study between parachutists and non-parachutists hasn’t previously been performed. To focus on the effect of parachuting itself on the development of the lumbar degenerative changes, we compared parachute infantry soldiers with non-parachute infantry soldiers with equivalent demographic data and these results do not demonstrate any significant differences in the development of lumbar degenerative changes between the two groups, suggesting that military parachuting does not accelerate IVD; this is in marked contrast to those of Bar-Dayan et al.\(^ {23, 25}\) The exact reason for this difference is not known, but differences in the subjects, methods for evaluation and follow-up time may be the possible causative factors. Our results are comparable to the other two previously described studies,\(^ {23, 24}\) noting that they were was cross-sectional studies without statistical comparison of the incidence of degenerative changes between the parachutists and non-parachutists.

The principal limitation of this study is the still relatively small number of subjects and further studies are needed to investigate whether our findings are valid in a large population. Another drawback was a restricted radiological analysis using only plain radiographs and we are therefore planning to perform a similar longitudinal study using large cohorts imaged by MRI as well as plain X-ray.

CONCLUSIONS

This study demonstrates that after long term observation of well matched cohorts of parachute and non-parachute infantry soldiers, the development of lumbar degenerative changes is not accelerated by military parachuting. We suggest further prospective cohort study in a large population with modern imaging to further confirm these results.

Contributors ON contributed constructing an idea or hypothesis for research and/or manuscript, planning methodology to reach the conclusion and organizing and supervising the course of the project or the article and taking the responsibility. AK, SN and TT and AT contributed execution of the patient follow-up, data management and reporting. YI contributed statistical analysis.

Competing interests None.

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REFERENCES

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