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Load on the low back of teachers in nursery schools

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Abstract In order to evaluate the load on the low back of teachers in nursery schools, basic activity, working posture, child-lifting, and desk-lifting were analyzed for eight nursery teachers using video recording. The trunk inclination angle (TIA) was also measured continuously during full workshifts for 20 nursery teachers using an inclination monitor. The nursery teachers in the 0–1 (year) age class more often adopted low working postures, "sitting on the floor" and "kneeling," while teachers in the 4–5 age class more frequently adopted high working postures, "standing" and "sitting on a chair." The mean of TIA among all subjects was 20°. The time spent at a TIA of more than 20° represented 43% of the workshift. The mean and time distribution of TIA did not differ between the age classes. The frequency of trunk-lifting from severe bending forward (TIA > 45°) was 86 times/hour on average. The frequency of trunk-lifting was highest in the 0–1 age class. The number of times of child-lifting was 46 in the 0–1 age class, while it was 1 in the 4–5 age class.

Key words Nursery teacher · Low back load · Working posture · Trunk inclination angle · Child-lifting

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Introduction

In Japan, low-back pain among teachers in nursery schools was first noticed around 1970 [11]. At that time, the number of children per nursery teacher was large and the teachers hardly had time for noon recess due to continuous nursing of the children. Since then two or more nursery teachers have been placed in charge of one class, the number of children per nursery teacher has decreased, and the noon recess can be taken. With these improvements, the number of cases of severe low-back pain has decreased. However, recent medical examinations have still found nursery teachers who need treatment.

Occupational risk factors commonly identified in epidemiologic studies of low-back pain are heavy physical work, nonneutral working posture, prolonged standing or sitting, whole-body vibration, and heavy, frequent, or sudden lifting [1, 4, 5, 15, 16, 19]. For nursery teachers, nonneutral postures including "standing bent forward," "squatting," and "kneeling" are taken in order to nurse children aged 0–6 years. Furthermore, nursery teachers frequently lift heavy loads such as children and children's desks. This study evaluated the degree of these loads on the low back of nursery teachers.

The ages of children in nursery schools range from 0 to 6 years, with their physique and independence varying greatly with age. Thus, the degree of the load on nursery teachers depends on the age class that they are placed in charge of. This study also examined the difference in the load between the age classes.

Materials and methods

Nursery schools

The surveys were carried out in six municipal nursery schools, which consisted of 39 classes and employed 115 regular and 37 temporary

female nursery teachers. Of the regular nursery teachers, 101 took charge of the 0–5 age classes. Table 1 shows the numbers of children and nursery teachers by age class.

In Japan, the school year is from April to March of the following year. Because children aged 0 enter the "0 age class" at April, they become 1 year old before the following March. Consequently, children aged 0 and 1 belong to the 0 age class. Because our surveys were carried out from January to February, almost all children in the 0 age class were 1 year old. Similar explanations can be given for the other age classes.

The nursery schools adopted three workshifts: normal shift (0900–1715 hours) early shift (0800–1615 hours), and late shift (1000–1815 hours). The nursery teachers took turns at having a 45-min recess in the middle of the workshift to enable continuous nursing of the children. The actual work period was 7.5 h.

Video analysis

Two nursery teachers were selected from each of the 0, 1, 4, and 5 age classes, and their actions were recorded on video tape during full workshifts. Two video cameras (SONY CCD-TR 1000 and CCD-TR 705, Tokyo, Japan) were used: one for recording in the nursery room and another for recording outside. The video analysis was focused on "basic activity," "working posture," "child-lifting," and "desk-lifting."

The performed job was classified into eight basic activities (Table 2) every 30 s. The working posture classifications were defined as standing ($< 20°$ of bending forward, including walking), standing bent forward ($> 20°$), squatting (knees and hip did not touch the floor), kneeling (one or both knees touched the floor but the hip did not), sitting on the floor (hip touched the floor), and sitting on a chair. Standing bent forward was subclassified into mild (20–45°) and severe ($> 45°$) levels. The sampling interval for working posture was 30 s. Also, the number of times of child-lifting and the cumulative period were calculated. The number of times of desk-lifting was also counted.

Table 1 Numbers of children and nursery teachers

	Age class						Total
	0	1	2	3	4	5	
No. of children	41	56	60	133	152	148	620
No. of nursery teachers	20	16	19	19	16	11	101
Children/nursery teachers	2.1	3.5	4.7	7.0	9.5	13.5	

Trunk inclination angle

Four nursery teachers in each of the 0 and 1 age classes and three in each of the 2–5 age classes were selected, and the trunk inclination angle (TIA) was measured during a full workshift using an inclination monitor. The sampling interval was 1 s.

The definition of TIA had to be clarified, because the spine arches with forward bending, and the TIAs measured at the upper and lower back are considerably different. In this study, TIA was defined as the angle between the vertical line and a line passing the acromion and trochanter major (Fig. 1). It should be noted that TIA can express only the magnitude of trunk inclination and that various working postures, including standing and sitting, can have the same TIA value.

The inclination monitor developed by one of the authors (Seo) consists of an inclinometer (size: $55 \times 40 \times 20$ mm; weight: 40 g) attached at the upper back and a device (size: $150 \times 100 \times 40$ mm; weight: 500 g) including controller, memory, and battery at the waist [17]. It can measure the inclination angle continuously at a given

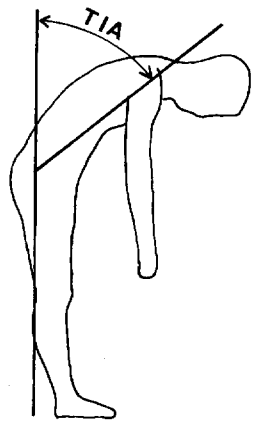

Fig. 1 Definition of trunk inclination angle (*TIA*)

Table 2 Time distribution of basic activities (unit: %) (*SD* standard deviation between subjects)

Basic activity	Age class				Sign.
	0–1 ($n = 4$)		4–5 ($n = 4$)		
	Mean	SD	Mean	SD	
1. Indoor group nurture	9.9	4.6	30.5	12.8	$P < 0.05$
2. Indoor free play	23.7	9.1	7.8	4.3	$P < 0.05$
3. Outdoor nurture	12.3	7.0	12.8	9.3	NS
4. Preparation and clearing away	8.8	2.3	10.2	4.4	NS
(for feeding)	(7.5)		(9.0)		
(for napping)	(1.3)		(1.2)		
5. Help and care	27.7	4.3	9.1	3.9	$P < 0.01$
(for feeding)	(12.5)		(8.2)		
(for napping)	(9.5)		(0.9)		
(for excretion and bathing)	(5.8)		(0.0)		
6. Clerical work	8.8	2.3	15.3	7.1	NS
7. Cleaning	1.5	0.9	3.2	2.5	NS
8. Others	7.4	4.9	11.2	4.9	NS

interval. Finally, the values recorded by the inclination monitor were corrected based on a regression line of the original values to the corresponding TIA values measured by reviewing the video tape for each subject. Figure 2 demonstrates that the corrected TIA values agreed well with the values from the video analysis.

TIA data were analyzed using a personal computer (NEC PC9801FA, Tokyo, Japan) and the mean of the TIA during a full workshift was calculated for each subject. TIA at each second was classified into three categories: inclination class I ($< 20°$), inclination class II (20–45°), and inclination class III ($> 45°$), and the time spent in each inclination class was analyzed for each subject. To evaluate the static postural load, the average period during continuous holding in each inclination class was calculated. To evaluate the dynamic postural load, the frequency of change in inclination class from III to I (denoted by III → I), that from III to II (III → II), and that from II to I (II → I) were analyzed. All of these changes represented a lifting action of the trunk from bending forward.

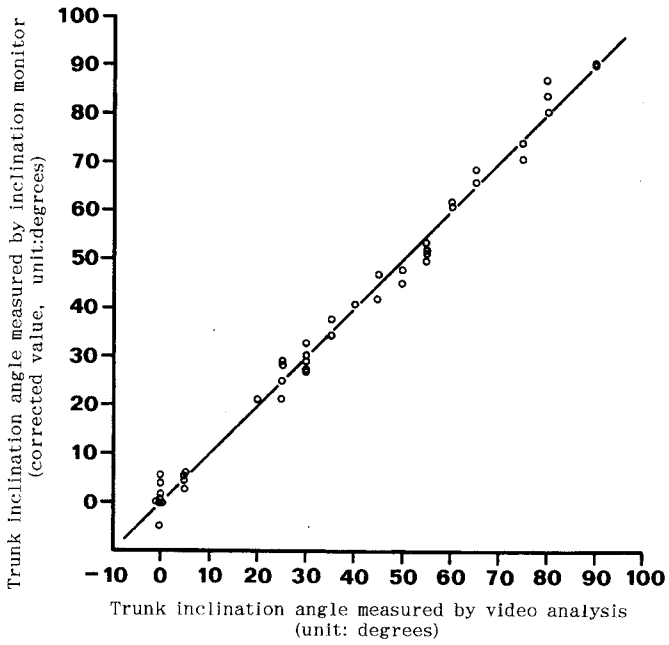

Fig. 2 Relationship between trunk inclination angle measured by inclination monitor and that measured by video analysis

Statistical tests

For comparison of the load between the age classes, the nursery teachers were divided into three groups, 0 and 1 age classes (0–1 age class), 2 and 3 age classes (2–3 age class), and 4 and 5 age classes (4–5 age class). Statistical testing of the mean values between the age classes was performed by the *t* test for two groups and by analysis of variance for three groups.

Results

Basic activity

Time distributions of the basic activities are shown in Table 2. These are mean values among the four nursery teachers of the 0–1 age class and those of the 4–5 age class. Half of the workshift was spent on "help and care" and "indoor free play" in the 0–1 age class, while "indoor group nurture" was the most frequent activity and "clerical work" the second most frequent in the 4–5 age class.

Working posture

Table 3 presents the percentages of working time spent in each of the six working postures. In the 0–1 age class, "sitting on the floor" was the most frequent posture and "standing" was the second most frequent. Thirty-five percent of the workshift was spent in nonneutral postures –"standing bent forward," "squatting," and "kneeling"–which was considered to cause a load to the low back. In the 4–5 age class, "standing" was the most frequent posture and "sitting on a chair" was the second most frequent. The total time spent in the three nonneutral postures was 23%.

Comparison between the age classes showed that "standing" and "sitting on a chair" were more frequent in the 4–5 age class, while "kneeling" and "sitting on the floor" were more frequent in the 0–1 age class, though a significant difference was not observed in sitting on the floor, probably due to the small sample

Table 3 Time distribution of working postures (unit: %) (*SD* standard deviation between subjects)

Working posture	Age class				Sign.
	0–1 ($n = 4$)		4–5 ($n = 4$)		
	Mean	SD	Mean	SD	
1. Standing	24.5	5.1	41.4	5.9	$P < 0.01$
2. Standing bent forward	16.8	5.6	14.2	5.3	NS
(20–45°)	(6.7)		(7.4)		
(45° or more)	(10.1)		(6.8)		
3. Squatting	5.5	3.4	4.2	3.3	NS
4. Kneeling	12.3	3.9	4.9	1.5	$P < 0.05$
5. Sitting on floor	32.0	15.7	9.1	2.1	NS
6. Sitting on chair	9.0	7.1	26.1	7.5	$P < 0.05$

number and large standard deviations [0–1 age class: SD = 15.7(%), 4–5 age class: SD = 2.1(%)]. This finding suggests that the working posture of the nursery teachers in the 0–1 age class was lower than that of the teachers in the 4–5 age class.

Trunk inclination angle

Table 4 presents the TIA means during the workshift and the time distributions of the inclination classes. The means of TIA in all subjects was 20°. The times spent in inclination class II and in inclination class III were around 32% and 11%, respectively. There was no significant difference between the age classes. Table 5 presents the average continuous periods in each inclination class. The periods in inclination classes I, II, and III were 11.8, 5.3, and 4.5 s, respectively. There was no significant difference between the age classes. Table 6 shows the frequency of trunk lifting. The action of "III → I," which has the highest load to the lower back, was observed twice as often in the 0–1 age class as in the 2–3 and 4–5 age classes. The action of "III → II," which has the second highest load, was more frequent in the 0–1 age class than the other age classes, but the difference was not statistically significant.

The total of frequencies of "III → I" and "III → II" was 86 times/hour for the nursery teachers, which suggests that they lifted their trunk from a severe forward bending posture about 600 times during a workshift.

Child- and desk-lifting

In the 0–1 age class, the frequency of child-lifting and the cumulative period were 46 times and 800 s, respectively, on the average; by contrast the frequency and the cumulative period were once and 4 s, respectively, in the 4–5 age class. Desk-lifting was observed twice in the 0–1 age class and 9 times in the 4–5 age class.

Table 4 Means of TIA and time distribution of inclination class[a] (*SD* standard deviation between subjects)

	All subjects ($n = 20$)		Age class 0–1 ($n = 8$)		2–3 ($n = 6$)		4–5 ($n = 6$)		Sign.
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Mean TIA (degrees)	20.3	4.5	20.7	3.3	21.8	6.3	18.5	2.6	NS
Time distribution (%)									
Inclination class I	57.0	10.9	56.2	8.4	53.9	14.6	60.9	7.8	NS
Inclination class II	32.2	8.0	32.4	6.2	34.9	9.2	29.5	7.7	NS
Inclination class III	10.6	4.5	11.3	4.0	11.1	6.3	9.5	1.9	NS

[a] I, < 20°; II, 20–45°; III, > 45°

Table 5 Average period during continuous holding in each inclination class[a] (unit: s) (*SD* standard deviation between subjects)

Inclination class	All subjects ($n = 20$)		Age class 0–1 ($n = 8$)		2–3 ($n = 6$)		4–5 ($n = 6$)		Sign.
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Inclination class I	11.8	3.3	10.9	3.2	11.5	3.7	13.4	2.4	NS
Inclination class II	5.3	1.2	5.1	1.2	5.8	1.2	5.2	1.2	NS
Inclination class III	4.5	1.1	4.1	0.8	4.9	1.5	4.8	0.7	NS

[a] I, < 20°; II, 20–45°; III, > 45°

Table 6 Frequency of trunk lifting (unit: times/h) (*SD* standard deviation between subjects)

Trunklifting[a]	All subjects ($n = 20$)		Age class 0–1 ($n = 8$)		2–3 ($n = 6$)		4–5 ($n = 6$)		Sign.
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
III → I	20.1	9.8	28.1	10.6	14.2	2.0	15.2	4.3	$P < 0.01$
III → II	66.3	24.0	74.0	27.4	65.2	26.1	57.2	8.3	NS
II → I	156.9	24.7	164.8	31.7	154.3	16.1	149.0	17.0	NS

[a] I, < 20°; II, 20–45°; III, > 45°

Discussion

As stated above, the risk factors for low-back pain include heavy physical work, nonneutral working posture, prolonged standing or sitting, heavy or frequent lifting, and whole-body vibration [1, 4, 5, 15, 16, 19]. Of these factors, nonneutral working posture and heavy lifting were observed in nursery teachers. Consequently, this study focused on the working posture and child- and desk-lifting.

The present analysis showed that the working posture of nursery teachers in the 0–1 age class was on the whole lower than that of the teachers in the 4–5 age class. Because the children in the 0–1 age class were about 70–90 cm tall [9], the nursery teachers had to sit or kneel on the floor in order to nurse the children. In the 4–5 age class, the children were about 100–120 cm tall [9], and the nursery teachers could work standing or sitting on a chair. Kosugo et al. [7] and Kumagai et al. [8] obtained the same result in postural analyses of other Japanese nursery teachers. This finding demonstrates that the working posture of nursery teachers is strongly restricted by the height of the children.

The postural analysis also showed that the times spent in nonneutral postures, standing bent forward, squatting, and kneeling accounted for a third of the workshift in the 0–1 age class and a quarter in the 4–5 age class. The three postures were adopted due to the low working surfaces such as children, children's instruments, and the floor. This suggests that there is considerable postural load on the low back in nursery teaching work.

In this study, TIA was measured as an indicator of the postural load on the low back. Holding the trunk bent forward requires greater activity of the muscles of the erector spinae than does the neutral upright posture [2, 13, 18], and it causes greater lumbar disc pressure [10, 13]. In general, if TIA is more than 20°, the trunk is considered to deviate from the neutral upright posture and there is increased risk of low-back pain [6]. Burdorf [3] reported that the percentages of time spent in TIA of more than 20° were 33% for crane operators, 25% for office workers, 13% for woodworking machinists, 12% for packers, and 5% for straddle-carrier drivers. In our unpublished study, the percentage for office workers was 17%. For the nursery teachers, the percentage was 43%, which was the highest among these occupational groups.

Punnett et al. [14] conducted a case-control study, in which the relationship between TIA and low-back pain was examined in automobile assembly workers. They reported that the odds ratio for exposure to inclination class III during 10% or more of the workshift (compared with nonexposure) was 8.9 and the odds ratio for exposure to inclination class II during 10% or more of the workshift was 6.1. In nursery teachers, because both of the times spent in inclination classes III and II were more than 10%, the postural load is considered to be an important risk factor for low-back pain.

Occupational postural load on the low back is dynamic as well as static in nature. In this study, the dynamic postural load was expressed by the frequency of trunk lifting. The nursery teachers lifted their trunk from a severe forward bending position (inclination class III) about 600 times during a workshift. Punnett et al. [14] analyzed the number of appearances of forward bending posture per minute as an indicator of the dynamic postural load in the above-mentioned case-control study, and reported 2.3 times/min for inclination class II and 0.9 times/min for inclination class III in the cases with low-back pain in comparison with 1.8 and 0.6 times/min, respectively, in the controls. For the office workers, the same analysis showed 1.6 times/min for inclination class II and 0.1 times/min for inclination class III (our unpublished data). For the nursery teachers, the corresponding values were 3.7 times/min for inclination class II and 1.4 times/min for inclination class III, showing that the nursery teachers had more severe dynamic postural load than the automobile assembly workers and the office workers. In particular, the nursery teachers in the 0–1 age class had a more frequent lifting action of "III → I" than did those in the 2–3 and 4–5 age classes. This finding suggests that the nursery teachers have a higher risk of low-back pain when taking charge of the 0–1 age class.

Children in the 0–1 age class correspond to heavy loads because they weigh about 10 kg. In other observational studies on child-lifting, Nishiyama et al. [12] and Kumagai et al. [8] reported 163 times (23 times/h) in the 0 age class and 165 times (24 times/h) in the 1 age class, respectively. The present study showed a mean of 46 times (7 times/h) for the 0–1 age class. Children's desks are also heavy loads because they weigh around 10 kg, but the desk-lifting observed was less than 10 times on the average. Wickstrom et al. [20] reported that lifting of material weighing at least 5 kg was 18 times/h for the concrete reinforcement workers and 5 times/h for maintenance house painting workers. These findings demonstrate that the nursery teachers in the 0–1 age class performed heavy lifting as frequently as the construction workers. On the other hand, the nursery teachers in the 4–5 age class scarcely performed child-lifting. This difference may cause variation in the occurrence of low-back pain among teachers in the different age classes.

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