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by [Gibbons LE](#), [Crites Batti M](#), [Videman T](#)

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Changes in occupational physical loading during the lifetimes of Finnish men

by Laura E Gibbons, MS,¹ Michele C Battié, PhD,¹ Tapio Videman, MD²

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Objectives The aims of this study were to compare summary measures for occupational physical loading based on different periods of work history and to describe how loading exposures change with age and vary by age group.

Methods Detailed work histories reported by 232 men, aged 35—69 years, were used to compare loading in the current, longest, and heaviest jobs and a lifetime measure and to graph changes in loading over time.

Results The longest job was the best surrogate for lifetime loading (correlation coefficient 0.90). The heaviest work tended to occur in the men's teens and early twenties. For older men, the current or longest job was a poor substitute for the job with the heaviest loading (correlation coefficients 0.24, 0.28). There appeared to be both a cohort and a period effect for sedentary work, lifting, and time spent in twisted or bent positions, but not for driving.

Conclusions If the true risk for back problems is not limited to current activities, exposure misclassification may occur in many studies.

Key terms back, bending, driving, epidemiology, lifting, sitting, work history.

One of the most commonly suspected risk factors for spinal degeneration, back pain, and related disability is occupational exposure to physical loading. However, research has yielded conflicting information on the effects of specific occupational exposures, in part because of limited exposure measurements. It is likely that the status of a person's spine is a consequence of a lifetime of exposures. It may also be that high peak loads or trauma is the most important etiologic factor and that slight or moderate loading has little effect. The goal of studies related to occupational physical loading should be to identify which specific factors in the worker's history have caused harmful effects. If the most relevant factors are not measured, exposure may be misclassified, which usually leads to an underestimate of risk (1).

Burdorf reviewed the literature for the period 1981—1990 to evaluate the exposure assessment for postural load of the back as an occupational risk factor (2). He criticized the majority of the studies for the quality of their measures and their lack of specific quantitative exposures. Of the 81 original works he reviewed, 38 used occupation or job titles as surrogates for the exposure, and nine more gave no exposure information. Most

of the studies not included in Burdorf's review or published since then have the same limitations. Usually the specific risk factor was inferred from the current or most recent occupation or job title (3—14), though at least one study set minimum time requirements (15). Some studies used quantitative measures, rating the level of physical loading on an ordinal scale (16—18) or reporting specific exposures on questionnaires (19).

Only a few studies considered more than just the current job. In addition to the studies reviewed by Burdorf (2), Videman et al (20) used the heaviest job held for at least five years as the exposure, while Virta et al (21) used the job of longest duration. Vingård et al (22) obtained the last 20 years of work history to compute a mean job loading score, weighted by the number of years in each job. Two studies (23, 24) used work histories to link the incidence of back pain with the job held at the time.

The question arises as to which part of the work history is the relevant risk factor and how highly it correlates with the current occupation, the exposure indicator used in most studies. Illis et al (25) found good agreement for the latest and usual (longest) occupation among

¹ Department of Orthopaedics, University of Washington, Seattle, Washington, United States.

² University of Jyväskylä, Jyväskylä, Finland.

Reprint requests to: Ms Laura E Gibbons, Department of Orthopaedics, RK-10, University of Washington, Seattle, WA 98195 USA.

patients aged 40–84 years who had incident cases of selected cancers. Occupations were coded using the 1980 United States Census Bureau Codes, and then grouped. Only groups with at least 10 people were analyzed, 22 occupational groups for women and over 40 for men. Latest and usual occupations were in the same group for 69% of the women and 77% of the men, with notable variation by race and occupation as well. Agreement was higher for each additional decade of age, and highest for white males (79%). Most skilled occupations (eg, health professions, engineering, tool and die making) also had higher agreement.

Some authors investigating back pain note that health problems may have caused some workers to switch to less physically challenging occupations (4, 26, 27), but we are unaware of any studies that have examined changes in physical loading over time. The changes may come as individual workers advance in their careers or can no longer do heavy physical work. In addition the nature of many jobs has changed over the decades. Thus cohort or period effects may be present, such that younger generations of workers would have different occupational histories than do older workers. A better understanding of such changes would help in assessments of surrogate exposures when lifetime occupational loading is of interest.

In this study, we used detailed, self-reported work histories to describe how occupational loading exposures change with age and vary by age group. The current, longest, and heaviest jobs are compared with each other and with a lifetime mean loading score that is weighted by the number of years in a given job.

Subjects and methods

Two hundred and thirty-two men aged 35–69 (mean 49) years were selected from the Finnish Twin Cohort (28), which contains virtually all twins born before 1958 and alive in 1975. The men had been selected for another study, according to discordance with their twin in three suspected risk factors for spinal degeneration and back pain, namely, occupational exposures, exercise habits, or smoking (Battié et al, unpublished results). The men were compared with all identical male twins in the Finnish Twin Cohort alive at the time of case selection. Due

to our selection criteria, the men in our study were more likely to be working and to be predominantly sedentary at work (40% sedentary versus 30% for the cohort). There were no significant differences in age, occupational category, outdoor versus indoor work, shift work, work monotony, social class, education, life satisfaction, or smoking.

Four trained interviewers were used, two professional medical interviewers, a researcher with degrees in public health and physiotherapy, and a research physician. One interviewer recorded heavier materials handling than the others, but this difference was consistent with the fact that she interviewed more twin pairs selected for discordance in heavy occupational loading. There were no other significant differences between the interviewers.

The interview included a detailed description of employment history, beginning as early as 12 years of age, through the current job or until retirement at 65 years of age. Any education or occupational training after basic schooling was considered a "job." For each position held, participants began with a general description of the job, and then assessed specific factors, including duration of employment, the average number of hours per day they spent sitting or driving, the minutes per day spent in different positions involving varying degrees of bending, twisting and stooping, the most common weight lifted, the frequency it was lifted, and the maximum weight lifted at least once a month. Later, one author (TV) gave each job an additional classification based on the interview data and the job title, with 1 = sedentary and 2–4 representing progressive amounts of materials handling and positional loading (2 = light-mixed loading, 3 = mixed-heavy loading, 4 = very heavy loading). Table 1 gives a more detailed description of each category.

For this study, we considered the following measures: current (or last) loading category, loading category for the longest nonseasonal job, lifetime mean-weighted loading category (weighted by the number of years at the job), and loading category for the heaviest job held for at least five years. Two other summary variables were formed, the minutes per day spent in bent or twisted positions and the most common loading (most common weight lifted times the frequency per day it was lifted).

Table 1. General guidelines for occupational loading categories.

Category	Code	Usual posture(s)	Lifting	Examples
Sedentary	1	Sitting	None	Secretary, student
Light-mixed	2	Standing, walking; < 30 min/day bending or twisting	Occasionally up to 35 Kg	Industrial supervisor, policeman
Heavy-mixed	3	Bending, twisting, lifting	Commonly 10–35 Kg	Construction worker, farmer, janitor
Very heavy	4	Bending, twisting, lifting	Commonly > 35 Kg	Logger, forklift operator

The percentage of agreement was calculated for the categories for the current, longest, and heaviest jobs. The intraclass correlation coefficient (29) was also computed, since this statistic was weighted by the magnitude of the disagreement. The correlations of these three categories with the mean-weighted loading category were computed with Spearman's rank correlation coefficients. Since some occupational studies use duration of employment to quantify exposure, years in the current job were compared with years in the longest job and with total duration of employment, using Spearman's rank correlation coefficients. The years in the heaviest job were not compared, due to the restriction to jobs held for at least five years. To investigate the possibility that the nature of work or work patterns had changed over time, the men were stratified by the following three categories for their age at interview: 35—44 years (78 men), 45—54 years (94 men), and 55 years and older (62 men), and similar measures were examined.

So that changes as a worker aged could be observed, each worker's history was divided into three to five segments, depending on his age at interview. The first three segments were ages 12—24, 25—34 and 35—44 years. Men over 45 years of age had a 45- to 54-year segment, and men 55 years and older had a 55- to 64-year segment as well. These segments have been referred to as "historical age." The mean loading category and the mean hours spent sitting and driving were computed for each of the five historical segments. Medians were computed for the most common and the maximum weight lifted, the most common loading, and the time in twisted or

bent positions so as not to give undo weight to extremely large values.

Results

Relationship between summary measures

The lifetime mean-weighted loading category had a correlation of 0.85 with the current or last job, 0.90 with the longest job, and 0.72 with the heaviest job held for at least five years. The correlations varied slightly by age group (table 2). The correlation of the mean-weighted loading category with the heaviest job was lowest for those aged 55 years and older.

The current and longest jobs had the same loading category 79% of the time, more often for those aged 45—54 years and less for those under 45 years (table 3). Overall agreement with the heaviest job was 51% for the current job, and 63% for the longest job, but it was much lower for those aged 55 years and older (table 3). The intraclass correlation coefficients for the heaviest and longest job indicate that the differences were often large.

Years in the current job had a correlation of 0.70 with years in the longest job and 0.47 with the total years employed, with little variation by age cohort.

Changes in risk factors over time

The mean loading category decreased steadily from the time the men started working until they were 35—44 years of age. Figures 1—3 illustrate the percentage of jobs in each category, stratified by age at interview. Heavy-mixed and very heavy jobs predominated in the teens and early twenties. The proportion of jobs in each category was relatively stable after 35 years of age. Stratification by current age shows that younger workers had lighter jobs at any given age than those in earlier birth cohorts. Of the men currently 55 years of age and older (born 1923—1937), 89% had heavy-mixed or very heavy jobs when they were 12—24 years of age. For those 45—54 years of age (born 1938—1947), the percentage

Table 2. Spearman correlation coefficients for the relationship of the mean-weighted loading category with current (or last), longest, and heaviest loading categories.

	Age (years)			All ages
	35—44	45—54	55—69	
Current job	0.80	0.88	0.84	0.85
Longest job	0.87	0.93	0.91	0.90
Heaviest job	0.74	0.75	0.58	0.72

Table 3. Percentage of agreement and intraclass correlation coefficients for the relationship of current, longest, and heaviest loading categories.

	Age (years)						All ages	
	35—44		45—54		≥ 55		% agree	Intraclass correlation coefficient
	% agree	Intraclass correlation coefficient	% agree	Intraclass correlation coefficient	% agree	Intraclass correlation coefficient		
Current and longest jobs	74	0.70	86	0.90	76	0.80	79	0.81
Current and heaviest jobs	55	0.46	61	0.55	32	0.24	51	0.44
Heaviest and longest jobs	81	0.57	71	0.60	45	0.28	63	0.51

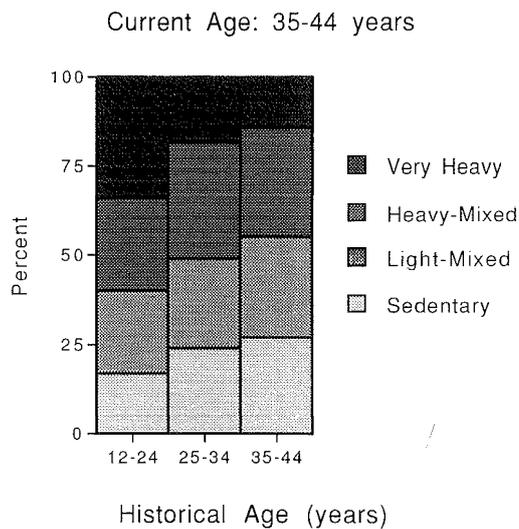


Figure 1. Percentage of jobs in each loading category, by historical age, for the men aged 35—44 years at the time of the interview.

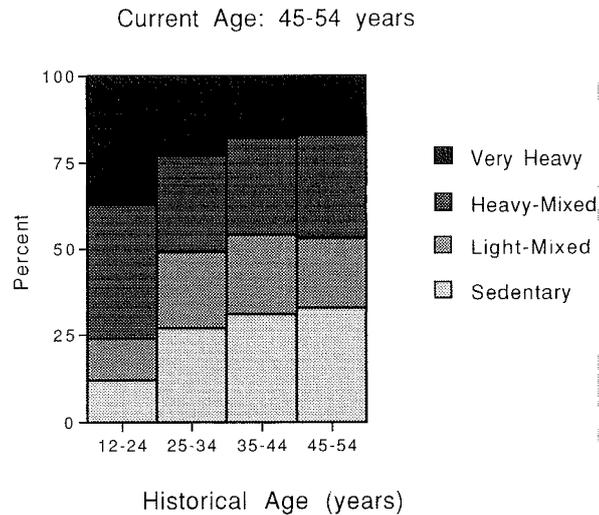


Figure 2. Percentage of jobs in each loading category, by historical age, for the men aged 45—54 years at the time of the interview.

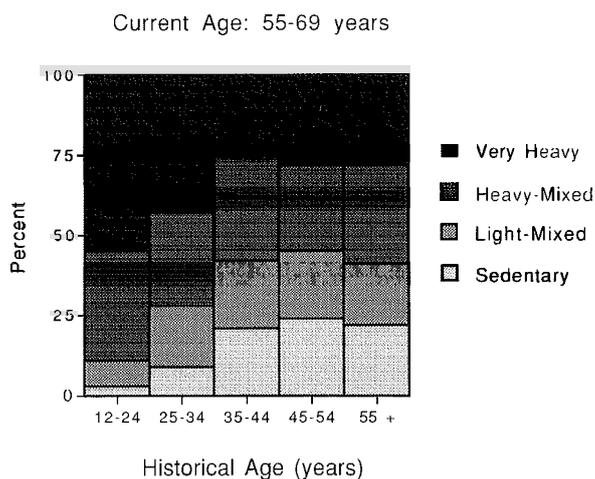


Figure 3. Percentage of jobs in each loading category, by historical age, for the men aged 55—69 years at the time of the interview.

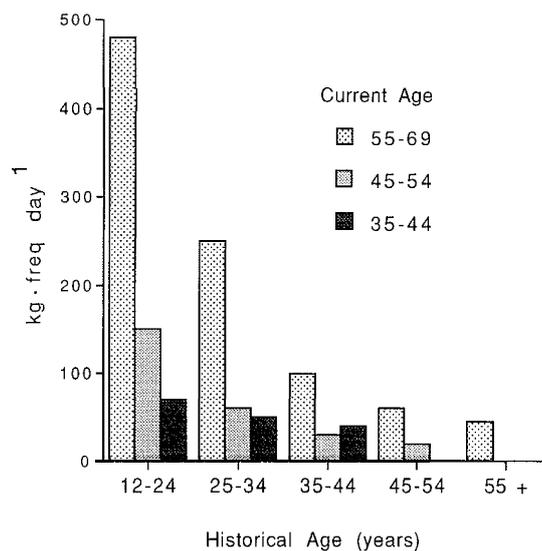


Figure 4. Median values, by historical age group, for usual occupational loading (kilograms lifted times frequency per day), stratified by age at interview.

was 77%, and for those 35—44 years of age (born 1948—57) it was 60%.

The median most common loading (most common weight lifted times frequency per day) (figure 4) decreased steadily as the men aged. As was reflected in the job category, men born in earlier decades had much heavier loading throughout their careers. Both the weight and the frequency decreased, the median most common weight lifted decreasing from 10—20 kg at ages 12—25 years to 5—10 kg at ages 35—44 years. The median maximum weight lifted followed a similar pattern. When the historical age span of 12—24 years was examined in more detail, another difference in the cohorts was observed. Men currently 55 years of age

and older lifted the heaviest weights and had their peak load in their early twenties, while the younger men lifted their heaviest loads in their teens, if they worked then.

The median time spent in twisted or bent positions also varied by birth cohort (figure 5). Men under 55 years of age when they were interviewed had a steady decline to nearly zero between 35 and 44 years of age. For the older men, the mean time was 2.5 h when they were 12—24 years of age, and it fell to an hour or less when they were 35 years of age and over.

The switch to lighter work was usually not due to health problems. When asked "Has your health ever influenced your choice, or a change, of jobs?" only 13

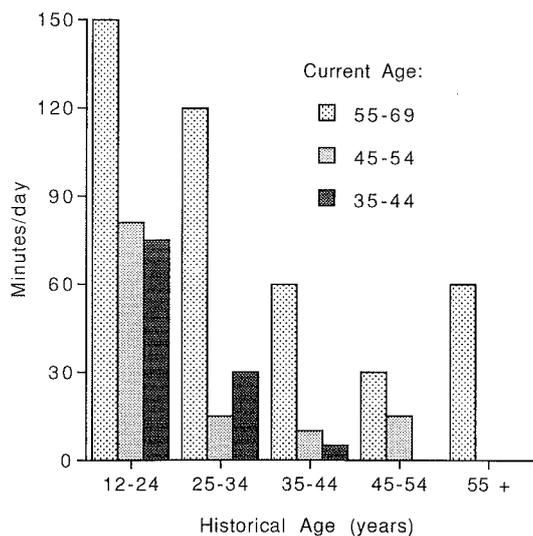


Figure 5. Median values of usual minutes per day in twisted or bent positions at work, by historical age group, stratified by age at interview.

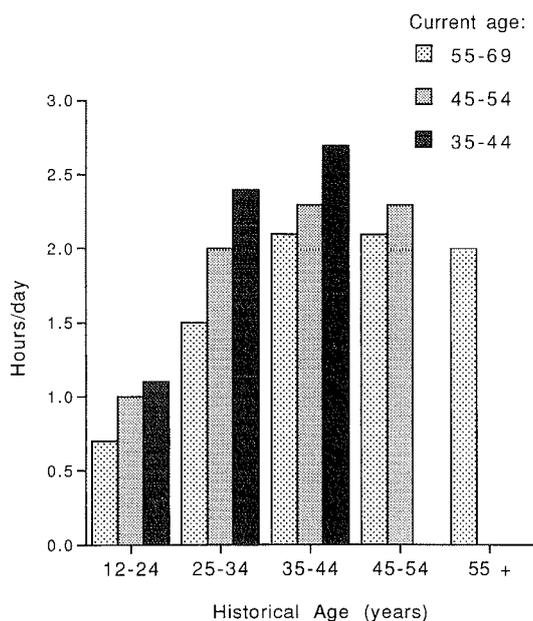


Figure 6. Mean usual hours per day spent sitting at work, by historical age group, stratified by age at interview.

(6%) said it had, and, of the 13, nine said the reason was back-related.

Mean hours spent sitting at work rose from one or less at 12–24 years of age to more than 2 h when the men were 35–44 years of age and decreased slightly thereafter. Those in the group under 45 years of age were the most sedentary throughout most of their work history; those over 55 years of age were the least sedentary (figure 6).

Those whose job title involved driving (80 men, 143 jobs) averaged around 6 h per day driving at work, for all ages and age groups. However the amount of lifting required by those whose principal activity was driving decreased steadily. The median maximum weight lifted by men currently 55 years and older was 50 kg when they were 12–34 years, 15 kg at 35–44 years, and 5 kg at ages 45 years and up. Those now 45–54 years of age lifted 50 kg at ages 12–24 years, 30 kg at 25–34 years, and 10 kg thereafter. Men now 35–44 years of age lifted 40 kg at 12–24 years of age, and 15–20 kg thereafter.

Discussion

With accurate lifetime occupational histories, we could look at various factors in different periods of life to see which aspect of physical loading is the most important risk factor. Unfortunately, only partial information is likely to be available and must substitute for the ideal measure. If lifetime physical loading is the most important factor, then classifying occupational exposure using the longest job is likely to be the best surrogate, partly due to the fact that the longest job accounts for much of the total duration of employment, 60% in our population. If the heaviest job is the relevant exposure, loading in the current or longest job is a poor substitute for those over 55 years of age, though it may be sufficient for younger workers.

Our loading classification was more consistent than was duration of employment. The current loading category had a correlation of 0.85 with lifetime loading, and 0.82 (Spearman, 0.81 intraclass correlation coefficient) with loading in the longest job, while years in the current job had a correlation of 0.47 with duration of employment and 0.70 with years in the longest job. This result suggests that for studies of occupational loading, it may be better to make at least crude categories of exposure.

Illis et al (25) found that agreement between current and usual occupation increased with age. We did not find such a pattern for agreement on the level of physical loading between the current and usual job, in a younger group of men.

Overall, the heaviest work was done in the men's teens and early twenties, and sedentary work increased until leveling off between the ages of 35 and 44 years. The change to lighter work as the men aged was seldom due to health. In most cases it may have been due to professional advancement, as seen among the drivers. Older drivers drove the same number of hours, on the average, but had jobs that required less lifting than did younger drivers. The three age groups had different patterns of physical loading over the course of their work lives, suggesting a cohort effect. Men 55 years and older did their heaviest work and spent the most time in twist-

ed or bent positions in their early twenties; for younger men the two occurred in their teens. This difference may have occurred because more of the older men entered the work force in their teens, and hence were employed at a wider range of jobs. From their twenties on they had heavier jobs than did the younger workers. Steady, skilled jobs involved more physical loading in that era, so there may be a period effect as well. The youngest group was the most sedentary, and the oldest group was the least sedentary, although the differences were not large. These differences, and the differences in the relationships between the summary measures, indicate that age should be controlled for in the design or analysis of occupational loading studies that use current occupation or other surrogates of lifetime occupational loading.

Several factors may limit the generalizability of our findings. First, only men were chosen, as few female twin pairs with discordance on physical loading at work, smoking, or exercise were available. Now that more women are involved in these activities, future studies with women should be possible. Participants were selected from surveys of the Finnish Twin Cohort in 1975 and 1981. Those selected on the basis of occupational exposures were more likely to be included if they had similar discordance with their co-twin in both surveys. Thus our sample may be more stable than normal with respect to occupational loading. Another consequence of selecting for discordance is that our study had a higher proportion of drivers and men with sedentary jobs than would be found in the general population.

All of our data are based on interviews, and therefore there could be some concern about accuracy, particularly in the recall of jobs held decades ago. Recall bias may differ for the three age cohorts. Even for the current occupation, problems with the reliability of self-reported postural loading exposures have been documented (30, 31). Reliance on job title alone can also be inaccurate, since most occupational title groups are not homogeneous. To help alleviate these problems, our classification into loading categories considered both the job title and the detailed description of activities.

Most occupational loading studies in the literature are based on current occupation. On the assumption that the true risk is not limited to current activities, our findings suggest that misclassification may occur due to changes in physical loading as workers age and the decades pass. The degree of misclassification is dependent on the age of the workers and the nature of the true risk.

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