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BACK DISORDER INTERVENTION STRATEGIES FOR MASS TRANSIT OPERATORS EXPOSED TO WHOLE-BODY VIBRATION—COMPARISON OF TWO TRANSIT SYSTEM APPROACHES AND PRACTICES

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Occupational long-term whole-body vibration (WBV) has been recognized as a major risk factor for low back disorders, one of the most important reasons for medical impairment and early permanent disability among mass transit operators. Although no firm health and safety vibration exposure threshold limits have been established, the available data suggests that rail vehicle operators would probably fall under the proposed WBV "action levels" of the EU directive provisions for protection from physical hazards. This provision calls for technical, administrative and medical controls. This paper examines and compares the current conditions, provisions and plans of two major mass transit systems, the New Yorker MTA and the Munich MVV. The available data, information and publications (English/German) on working conditions, vibration exposure, epidemiology and intervention strategies (primary and secondary prevention) for rail bound mass transit workers were reviewed. Results strongly suggest that the MTA transit system has currently and in the near future no effective and meaningful controls in place to significantly reduce the WBV exposure of subway operators. It appears that the MVV system has more and better control measures in place to reduce harmful effects of WBV. Results of a scientific evaluation of a participatory, collaborative project in the MVV system suggest that the MVV may have developed a successful method of a "condition prevention" (Verhältnisprävention)—and "behavioral prevention" (Verhaltensprävention) intervention strategy, which appears beneficial for WBV exposed workers with existing low back pain. Long-term outcomes and benefits need to be assessed further.

1. BACKGROUND

Low back disorders are among the most expensive and most frequently filed compensation claims. Whole-body vibration (WBV) exposure, besides heavy lifting and awkward body posture, has been recognized by a NIOSH expert panel as one of the most important risk factors in the pathogenesis of back disorders [1]. Back disorders have been listed among the most important reasons for medical impairment and early permanent disability among mass transit operators. In the U.S. approximately eight million workers are exposed to WBV, among them about 100 000 rail-based vehicle operators, including 53 000 locomotive engineers. There are only very few studies about the epidemiology and exposure conditions of rail vehicle operators, in particular of mass transit operators. However, the available data and our clinical experience suggest that transit operators are

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exposed to significant WBV, have many ergonomic stressors and have a relatively high rate of back disorders. New York City transit operators criticized the work environment with respect to cab design (size), seat design and lack of adjustability, vibration and shock exposure, climate, air quality and lighting [2, 3]. Similar complaints regarding the ergonomic working conditions were found among transit operators (subway, trolley and bus) of the Munich Mass Transit system (MVV) [4]. The magnitude of vertical vibration in rail vehicles is generally considered to be well below many other types of vehicles [5, 6]. One has found that the combination of vertical and lateral vibration results in high multidirectional vibration (vector sum) exceeding proposed EU safety guidelines [2]. The proposed EU directive calls for technical, administrative and medical provisions for operators with exposures exceeding the "action level" of $0{\cdot}5\ m/s^2$ [7, 8]. Specifics about medical surveillance and monitoring of WBV-exposed workers have been previously reviewed [9]. This paper describes the results of a comparison of control and prevention measures of two major transport systems with different national and labor-relations backgrounds.

2. METHOD

The available data, information and publications (English/German) on working conditions, vibration exposure, epidemiology and intervention strategies (primary and secondary prevention) for rail bound mass transit workers were reviewed for the New York City Transit Authority (MTA) and the Munich Mass Transit System (MVV). Any technical, administrative and medical provisions or intervention programs regarding rail bound vehicle operators were checked by contacting management, labor or employee health representatives from the respective systems. Strategies to reduce or control the exposure or behavioral aspects were compared following widely accepted occupational hazard control principles [10] and recommendations for WBV prevention [11, 12]: (a) technical control; (b) administrative control; (c) medical control.

3. RESULTS

The comparative results of the three-tier hierarchy of controls for WBV hazards are presented in Table 1 for the transit system MTA and MVV. The preferred approach to prevent and control WBV related ergonomic hazards are to design the work environment in a fashion that WBV exposure is at best eliminated or at least substantially reduced. This can be achieved for example by optimizing track conditions, improving vehicle suspension characteristics and using cab isolation techniques. Comparing the two systems' existing infra-structure and its vehicles indicates that the MVV system appears to be generally in better physical condition, possibly because the system is newer and more modern (subway system built in the 60s), smaller and better financed. The results of the review of specific technical controls showed the following conditions.

3.1. TECHNICAL CONTROL

Vibration source control through improved track conditions (continued rail and advanced track support are now being installed), train stock and maintenance/repair (costly and time intensive) is still not sufficient throughout the MTA subway system. To date, most of the oldest type trains with the worst vibration levels (so called: R10-series) have now been replaced with newer, somewhat less vibrating equipment (R68s-series). The primitive seat and cab design, however, which typically result in an awkward body posture of the train operators (no lumbar support available) has not been changed. Effective

vibration attenuation (suspension) seats have not been installed in currently used equipment. New train vehicles ordered for the years after 2000 are based on current design specifications without special consideration regarding WBV exposure reduction. The MTA conducted an internal vibration exposure study, confirming that exposure levels on some trains and tracks exceeded the ISO 2631 guidelines [13]. Two subsequently tested prototype suspension seats transmitted 5–19% more overall vibration levels to the train operators than the standard, simple design seat [14]. Methodological weaknesses and study limitations have been pointed out: i.e., the design of the study and the measurements were not done following currently acceptable standards and recommendations for suspension seats [15]. With respect to the MVV system no system specific vibration exposure data is available. The German Industrial Disability Insurance Carrier (Berufsgenossenschaft),

TABLE 1

Comparison of administrative, technical and medical strategies to control WBV risk among the New York (MTA) and the Munich (MVV) transit system operators (rail)

Control type	MTA	MVV
1) Administrative		
Exposure duration (actual vehicle operation)	increased	no change
Total exposure duration (retirement age)	increased (to age 65 y) flexible, above age 56 y	reduced
Exposure pattern (recovery/rest periods)	− (overall reduced)	no change
Senior worker provision	−	+
Labor–management Co-operation	−	+
Training/education	−	−/+
Research	+	+
Participatory research	−	+
2) Technical		
Source control		
Track conditions	varies, recent improvement	generally good, maintained
Track type (continuous rail)	−/+ (now being installed)	+
Vehicle maintenance/service	significant improvement	good
Isolation/ergonomic design:		
cab design/size	majority too small/cramped (app. 1 m^2)	trolley: too small/cramped subway: good (train width)
Seat design/posture control	inadequate, no suspension	Suspension, adjustable seats
Research		
Exposure assessment	+	− (no site specific data avail.)
Susp. seat prototype testing	+ (but tested 2 seats failed)	−
Future/new equipment design improvement	−/+	+
3) Medical		
WBV surveillance/monitoring	− (no specific provision)	−/+ (according to general driver fitness regulation (BG)
Physician qualification	Internist/GP	Occupational Medicine Spec.
Medical health/risk survey	+	+
Accelerated return to work provision/behavioral research	+ (managed care intervention)	−

+ = yes or present; − = no or absent/not done; −/+ = more or less/no special WBV emphasis; BG = Berufsgenossenschaft (Insurance fund).

responsible for health and safety of the transit workers, concludes that WBV exposure would be below the proposed action level. Data substantiating this claim has not been provided. Based on a plant inspection and survey of technical personnel, it appears, that the physical conditions, the vehicles and available technical equipment are generally superior and are more likely to meet modern ergonomic expectations compared to the MTA system. Older vehicles have been retrofitted with improved suspension seats with better ergonomic design features (adjustable, lumbar or not, lateral torso support available). All newer trains come with substantially improved ergonomic cab and seat designs. However, the turnover of technical equipment and innovative changes are considerably slower in comparison to bus vehicles. The life-time cycle of the rail vehicles is about five to eight times that of buses. In a survey the MVV bus operators reported the best results regarding ergonomic conditions [4].

3.2. ADMINISTRATIVE CONTROLS

According to the MTA, the average train operation time has increased in the last few years, and 56% of the subway operators are now working more than eight hours in one shift (up from 49% in 1984). Operators' ''cab time'' (i.e., exposure duration) has increased 7% since 1992 due to increased productivity requirements by the management. Relay times have been shortened and rest periods have not been extended (frequent train delays result in reduced rest periods). Retirement benefits of senior train operators depend on time spent operating subways in revenue service. Retirement age has been raised to age 65 years from a previous contract requiring a minimum of 20 years of service. This all results in a net-increase of the lifetime WBV exposure duration.

Within the MTA system, no joint management–labor study, committee or intervention programs are in place or planned regarding back disorders or WBV risk assessment and prevention. The MTA management recently contracted an internal, more general, four-year prospective study to investigate ''acute phase predictors of outcome in low back pain'' and factors of prolonged back related sick leaves.

With respect to the MVV system, a joint management–labor committee and program—with input from occupational health physicians and experts—are in place to address WBV, ergonomics and medical surveillance issues. For senior drivers (age above 56 years) a work schedule reduction has been instituted with full pay (8h q two weeks). Instead, eligible drivers have been offered a structured health promotion and fitness program [4]. The MVV recently completed a joint union–management pilot project combined with a research study to assess the benefits of the multitask intervention addressing physical and psychological factors in bus, trolley, and subway operators with a minimum of 15 years seniority and a minimum age of 45 years. The medical department was involved in the general supervision of the intervention project. The MVV program included primarily administrative and medical controls. The total vehicle exposure time was reduced (8h q 2 weeks) and a structured one-year activity program was offered instead. The program included cardiovascular excercises, back school, relaxation, stress management and diet counseling. The project was scientifically evaluated by using comprehensive medical evaluations and tests conducted before and after the intervention (study subjects $n = 96$) and comparison with a non-structured control group ($n = 26$) [4]. Back complaints and ergonomic factors were queried by using questionnaires similar to the one used in the earlier MTA study [3]. In summary, bus operators with newer vehicle-design and suspension seats had the least complaints about ergonomic factors compared to subway and trolley operators. Subjective scoring of vibration intensity and back complaints showed a remarkable correlation ($r = 0{\cdot}48$; $p < 0{\cdot}001$) for all vehicle operators. The prevalence and severity of self-reported back complaints were significantly

reduced after the completion of an intervention program for all transit operators. The greatest gains were seen among trolley operators (73%) compared to subway operators (43%) and bus drivers (38%) and the control group. The absenteeism was significantly reduced among the participants in the intervention group after the one year study period. The intervention program for senior transit operators has been continued. No further scientific evaluation and long-term effect study are currently planned due to financial constraints.

3.3. MEDICAL CONTROLS

For the MTA system a medical surveillance and monitoring program targeting WBV specific health risks is not in place. The physician in charge of employee health is not specially qualified or experienced in occupational medicine. The main emphasis is on the ''managed care'' of workers' injury: i.e., expedited return-to-work decisions and cost containment of medical expenditures and sickness benefits. A targeted workplace ergonomic or WBV related prevention or rehabilitation program for operators with low back disorders is not in place or planned. A four-year prospective study has been commissioned to an outside consultant by the Transit Authority to ''identify patients (clinical parameters, attitudinal factors) and workplace characteristics (physical workload) that are predictive of delayed recovery from low back pain'' based on review of internal documents, medical records and interviews. The study does not have the support of the transit workers' union (TWU).

For MVV system a WBV-specific medical surveillance and monitoring program is not in place. All vehicle operators are examined and qualified (''medically fit'') by the occupational health physician of the MVV according to regulations established by the industry insurance fund (Berufsgenossenschaftliche Grundsätze). This screening evaluation focuses primarily on cardiovascular, musculoskeletal and sensory organ condition and function. The physician in charge is trained and professionally active in occupational medicine. Modified work duties (part time work) for transit workers with back injuries are in place. No ''managed care'' type programs are instituted or planned to question medical absenteeism and expedite return-to-work. Job rotation (subway to bus vehicles) is not possible. The general goal of the prevention activities was stated to be the consecutive improvement of working conditions as well as of behavioral aspects of workers through collaborative and participatory efforts.

4. CONCLUSION

Based on the review of the available data and information, it appears that in the MTA mass transit system there are currently or in the near future no effective technical, administrative or medical controls in place to reduce significantly the WBV exposure of subway operators. The MVV system has more provisions in place to control adverse health effects of WBV exposure, although tram vehicles are in great need of ergonomic improvement. A participatory and collaborative health promotion project of the MVV appears effective and promising. The MVV developed a combined intervention strategy of ''condition changes'' and ''behavioral prevention'', which resulted in a net reduction of the WBV exposure dose for senior drivers and better health outcomes during a one year study period. Long-term effectiveness and health outcomes of such ergonomic risk reduction programs need to be further assessed.

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