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*World Journal of Orthopedics*  
Baishideng Publishing Group Inc  
7901 Stoneridge Drive, Suite 501, Pleasanton, CA 94588, USA  
Telephone: +1-925-2238242  
Fax: +1-925-2238243  
E-mail: [editorialoffice@wjgnet.com](mailto:editorialoffice@wjgnet.com)  
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## Observational Study

# Upper extremity disorders in heavy industry workers in Greece

Thomaella Tsouvaltziidou, Evangelos Alexopoulos, Ioannis Fragkakis, Eleni Jelastopulu

Thomaella Tsouvaltziidou, Eleni Jelastopulu, Department of Public Health, Medical School, University of Patras, 26500 Patras, Greece

Evangelos Alexopoulos, Medical School, University of Athens, 11527 Athens, Greece

Ioannis Fragkakis, Department of Orthopaedic Surgery, General Hospital of Patras "Agios Andreas", 26335 Patras, Greece

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Correspondence to: Eleni Jelastopulu, MD, PhD, Professor of Public Health, Department of Public Health, Medical School, University of Patras, Hippocrates Avenue, 26500 Patras, Greece. [jelasto@upatras.gr](mailto:jelasto@upatras.gr)  
Telephone: +30-2610-969878  
Fax: +30-2610-991606

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## Abstract

### AIM

To investigate the disability due to musculoskeletal disorders of the upper extremities in heavy industry workers.

### METHODS

The population under study consisted of 802 employees, both white- and blue-collar, working in a shipyard industry in Athens, Greece. Data were collected through the distribution of questionnaires and the recording of individual and job-related characteristics during the period 2006-2009. The questionnaires used were the Quick Disabilities of the Arm, Shoulder and Hand (QD) Outcome Measure, the Work Ability Index (WAI) and the Short-Form-36 (SF-36) Health Survey. The QD was divided into three parameters - movement restrictions in everyday activities, work and sports/music activities - and the SF-36 into two items, physical and emotional. Multiple linear regression analysis was performed by means of the SPSS v.22 for Windows Statistical Package.



## RESULTS

The answers given by the participants for the QD did not reveal great discomfort regarding the execution of manual tasks, with the majority of the participants scoring under 5%, meaning no disability. After conducting multiple linear regression, age revealed a positive association with the parameter of restrictions in everyday activities ( $b = 0.64$ ,  $P = 0.000$ ). Basic education showed a statistically significant association regarding restrictions during leisure activities, with  $b = 2.140$  ( $P = 0.029$ ) for compulsory education graduates. WAI's final score displayed negative charging in the regression analysis of all three parameters, with  $b = -0.142$  ( $P = 0.0$ ),  $b = -0.099$  ( $P = 0.055$ ) and  $b = -0.376$  ( $P = 0.001$ ) respectively, while the physical and emotional components of SF-36 associated with movement restrictions only in daily activities and work. The participants' specialty made no statistically significant associations with any of the three parameters of the QD.

## CONCLUSION

Increased musculoskeletal disorders of the upper extremity are associated with older age, lower basic education and physical and mental/emotional health and reduced working ability.

**Key words:** Upper extremity disorders; Heavy industry; QuickDASH; Movement restrictions; Occupational diseases

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**Core tip:** To our knowledge, this is the first study to use the QuickDASH questionnaire for the evaluation of the physical functionality of the upper extremities in the heavy industry sector. Furthermore, it has proved that the presence of musculoskeletal disorders is negatively associated with the reported working ability of the participants, as well as their physical and emotional health. These data will assist in taking measures for the prevention of occupational accidents and injuries in manual labor.

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## INTRODUCTION

Working in the heavy industry sector can cause the manifestation of occupational diseases and injuries, having a direct impact on the employee, the employer and the state's economy. It can lead to permanent disability or even the death of a worker, the loss of working hours and the reduction of production, as well as the indebtedness of pension funds due to compensations and disability pensions<sup>[1]</sup>. According to the World Health

Organization's (WHO) data, one third of all occupational illnesses are musculoskeletal disorders, with 23.3% being located in the upper extremities<sup>[2]</sup>.

The mechanism involved in the manifestation of musculoskeletal disorders of the upper arm include the use of intense muscular strength, vibrations, painful working positions and rapid and repeated movements, which all result in the great manual strain of the upper extremities<sup>[3-5]</sup>. Several questionnaires have been suggested for the measurement and evaluation of the physical functionality and the restriction of movement of the upper arm, amongst them the Quick Disabilities of the Arm, Shoulder and Hand (QD) Questionnaire.

The purpose of this study was to analyze disability due to musculoskeletal problems of the upper extremity in heavy industry workers and to identify relationships between movement restrictions in work, everyday and leisure activity and specific individual and job-related characteristics as well as the working ability of the population under study.

## MATERIALS AND METHODS

The population under study consisted of 802 employees, both white- and blue-collar, working in a shipyard industry in Athens, Greece. The white-collar category consisted of secretaries, managers-engineers (civil-, mechanical-, chemical-, metallurgy-, electrical-), draughtsmen, accountants, clerks, computer operators, nurses, electricians with license, inspectors, supervisors, store workers, material suppliers, tool repairs, security men and fire watchmen, while the blue-collar population included manual labor workers, *i.e.*, sand (grit) blasters (simon operators), painters, welders, flame cutters, riggers, dry-dock laborers, fitters, platters, plate fitters, crane operators, chippers, riveters, carpenters and technicians.

Data were collected through the distribution of questionnaires as part of the employees' periodic medical examination in the occupational health department during the period 2006-2009. All employees gave their informed consent for their participation. At the beginning of this study the participants were asked to answer questions regarding individual and job-related characteristics such as age, duration of employment, specialty and basic education. The questionnaires used were the QD Outcome Measure and the Work Ability Index (WAI) for the evaluation and recording of their symptoms and their ability to perform specific tasks, as well as the Short-Form-36 (SF-36) Health Survey, for the assessment of the respondents' general health.

The QD questionnaire evaluates the musculoskeletal symptoms of the participants, as well as their ability to perform certain activities. It consists of three sections. The first section includes eleven five-point scale questions regarding the execution of everyday tasks. The other two parts of the questionnaire are optional and involve 8 five-point scale questions in total, which measure performance during the execution of the participants' usual work demands and sport/music activities. The

**Table 1 Individual and job-related characteristics of the population under study (*n* = 802)**

	<i>n</i> (%)
Sex	
Male	763 (95.1)
Female	39 (4.9)
Age (yr)	
< 40	407 (50.7)
40-50	301 (37.5)
> 50	94 (11.7)
Marital status	
Married	63 (7.9)
Single	739 (92.0)
Basic education	
University/PhD	83 (10.3)
Technical school	503 (62.7)
Elementary/high school	216 (27)
Specialty	
White-collar workers	91 (11.3)
Blue-collar workers	711 (88.7)

scores of the three items of the QD range between 0 (no disability) and 100 (most severe disability)<sup>[6,7]</sup>.

The WAI questionnaire evaluates the participants' ability to work. It consists of seven dimensions, which cover the participants' current work ability compared with their lifetime best, their work ability in relation to the demands of the job, the number of current diseases diagnosed by a physician, their estimated work impairment due to diseases, the amount of sick leaves during the past year, their own prognosis of their work ability in two years time and their mental resources. The total WAI score results from the sum of the subscores of the seven parameters (7-49 points) and is divided into four categories: Poor (7-27 points), medium (28-36), good (37-43) and excellent (44-47) work ability<sup>[8]</sup>.

The SF-36 health survey includes 36 descriptive questions that involve the evaluation of eight parameters of the physical and mental/emotional health of the correspondent. In particular, it includes questions regarding the physical functionality, the bodily pain, role restrictions due to physical or emotional problems, mental state, social functionality and general perception of the patient's health, as well as questions regarding the participant's subjective opinion of the change in the state of his/her health. By summing up the scores of the eight parameters, two further categories are formed the physical and the mental/emotional component of the SF-36. In particular, the physical component consists of the four parameters of physical functionality, bodily pain, general perception of health and role restrictions due to physical health, while the remaining four parameters form the emotional component. The final score for each component ranges from 0 to 100, with a high score predicting a more favorable situation<sup>[9,10]</sup>.

Descriptive analysis took place for the available measurements per occupational category. Linear regression analysis was performed to evaluate the influence of possible determinants on the physical dysfunction of the upper

extremity. Coefficients (b) with 95% confidence intervals (95%CI) were calculated as measure of association. For the initial selection of potential factors that influence the ability to perform certain activities, univariate regression analysis was used with a significance level of  $P < 0.05$ . Subsequently, all independent variables that showed significant associations were considered for inclusion into the multiple linear regression model. Data entry and analysis were conducted by means of the SPSS v.22 for Windows Statistical Package.

## RESULTS

The population under study consisted of 802 heavy industry employees, mostly male (95.1%) and under 50 years of age (88.2%). The majority (88.7%) were blue-collar workers, while only 27% were compulsory education graduates (Table 1).

The answers given by the participants for the QD did not reveal great discomfort regarding the execution of manual tasks. The final scores and the mean values for each of the three categories, everyday, work and sports/music activities, are shown in Table 2, with the majority of the participants scoring under 5%, meaning no disability. Full disability wasn't recorded in any of the categories, with the highest scores reaching 77.27%, 87.5% and 75% respectively. Comparing the mean values, the work category scores were slightly lower than the other two, with a 1.704 mean value (Table 2).

The univariate analysis linear regressions that were conducted for the parameters of the QD - daily activities, work and leisure - revealed statistically important associations with WAI's final score and SF-36 two components, physical and emotional. Furthermore, age was linked with everyday and work restrictions of movement of the upper arm, while basic education showed statistically important correlation with the sports/music parameter. The participants' specialty made no statistically significant associations with any of the three parameters of the QD.

After conducting multiple linear regression, age revealed a positive association with the first parameter of everyday restrictions ( $b = 0.64$ ,  $P = 0.000$ ), but was rejected in the regression model of the work parameter. Basic education remained statistically significant regarding restrictions during leisure activities, with  $b = 2.140$  ( $P = 0.029$ ) for lower educated workers. WAI's final score displays negative charging in all three analyses, while the physical and emotional components of SF-36 associated with movement restrictions in daily activities and work (Tables 3-5).

## DISCUSSION

The general health of every person depends largely on the nature of their work, on the working environment and on the physical and psychological burden involved in their job. Reasonably, the heavy industry sector is associated with increased morbidity, affecting the level

**Table 2** Final scores and mean values of the three categories of the QuickDASH Questionnaire

	Mean value	Score (0-100)	n (%)
Everyday restrictions (n = 802)	2786	< 5	681 (85.1)
		5-50	118 (14.5)
		> 50	3 (0.4)
Work restriction (n = 802)	1704	< 5	731 (91.2)
		5-50	66 (8.2)
		> 50	5 (0.6)
Sports/music restrictions (n = 364)	2490	< 5	324 (89)
		5-50	33 (9.1)
		> 50	7 (1.9)

< 5 = no disability, 5-50 = slight disability, > 50 = medium to full disability.

**Table 3** Multiple linear regression of upper arm disability during everyday activities

	P-value	b	95%CI	
			Lower	Upper
Age	0	0.64	0.28	0.1
Physical SF-36	0	-0.157	-0.194	-0.12
Mental SF-36	0	-0.061	-0.093	-0.028
WAI	0.08	-0.142	-0.246	-0.037

Covariates of the final model ( $P < 0.05$ ), b = unstandardized coefficient. CI: Confidence interval; SF-36: Short-form-36; WAI: Work Ability Index.

of workers' health, increasing the number of absences from work and thus reducing productivity. The upper extremities are a part of the body that receives intense strain during manual labor, resulting into frequent injuries and causing transient or even permanent disabilities. Therefore, it is important to investigate the links between musculoskeletal disorders of the upper arm and the individual and job-related characteristics of heavy industry workers.

The QD questionnaire was used in the present study as a measuring tool of the physical functionality and the musculoskeletal disorders of the upper extremities, which constitute a main stress point of the body in heavy industry workers. In all three parameters which involve movement restrictions in daily activities, work and leisure, the results showed a positive outcome, since the majority of the participants denied any restrictions in the functionality of their upper extremities. This could be attributed to efficient prevention strategies being applied in the specific shipyard industry, which prevent the impairment of an upcoming disability.

The statistically important association of the everyday restriction parameter with age was expected and comes to match previous studies<sup>[11]</sup>. Workers over 40 years of age are linked with greater difficulty in executing daily activities, because of their reduced strength and their increased musculoskeletal disorders. The fact though that the same association wasn't noticed for the work parameter of the QD is a paradox. Especially given certain specialties in the heavy industry sector involve

**Table 4** Multiple linear regression of upper arm disability during work

	P-value	b	95%CI	
			Lower	Upper
Physical SF-36	0	-0.066	-0.102	-0.03
Mental SF-36	0.008	-0.042	-0.073	-0.011
WAI	0.055	-0.099	-0.2	-0.002

Covariates of the final model ( $P < 0.05$ ), b = unstandardized coefficient. CI: Confidence interval; SF-36: Short-form-36; WAI: Work Ability Index.

**Table 5** Multiple linear regression of upper arm disability during sport/music activities

	P-value	b	95%CI	
			Lower	Upper
Elementary/high school education	0.029	2.14	0.223	4.056
WAI	0.001	-0.376	-0.593	-0.16

Covariates of the final model ( $P < 0.05$ ), b = unstandardized coefficient. CI: Confidence interval; WAI: Work Ability Index.

great strain of the joints of the upper extremities, and in combination with the reduced stamina and osteoarthritis lesions that accompany older age, there should be a statistically significant association with the final score of the work QD. A possible explanation for this outcome could be the tactic of the industry to place younger workers in positions that require great manual strain. However, this result could also be justified by a possible reluctance of the participants to express their true opinion regarding their physical functionality under the fear of dismissal.

Both parameters of the SF-36, physical and mental/emotional, are negatively associated with everyday and work restrictions of the upper limb<sup>[12]</sup>. Lower values of the physical component of the SF-36 are interpreted as restriction of movement and bodily pain, similar to the higher scoring of the QD. In the same way and in agreement with other studies, depression, fatigue and emotional restrictions that are expressed through the emotional component of the SF-36 are associated with greater upper extremity disability and a higher QD score<sup>[13]</sup>.

The strongly negative association of WAI's final score with all three parameters of the QD can be explained accordingly, although no previous studies have been conducted to support our findings. Work ability is highly affected by any dysfunction of the upper limbs due to repetitive and stereotyped movements and maintenance of awkward positions for prolonged periods of time, both in white- and blue-collar workers. Additionally, blue-collar workers are often exposed to vibration or heavy loads, while white-collar workers perform more computer-based tasks and have more constrained posture, which can also lead to cumulative musculoskeletal disorders. According to previous studies, chronicity, fatigue and pain

severity are the primary factors that determine care-seeking and sickness absenteeism and subsequently lead to financial consequences and productivity loss due to medical expenses and workers' compensations<sup>[14-17]</sup>.

The basic education of the participants proved to be statistically significant only regarding the sports/music parameter, with compulsory education graduates being associated with greater disability of the upper arms. Lower educated workers are usually occupied in positions with more intense manual strain, which could justify the high scores in movement restrictions, in contrast with university graduates, who are usually white-collar employees<sup>[18]</sup>. Moreover, lower educated workers are usually related to lower incomes, which comes to agree with previous studies declaring that socioeconomic deprivation is associated with poorer health status<sup>[19]</sup>.

It is very interesting though, that the same association wasn't noticed for the other two parameters of the QD, everyday activities and work. This could be attributed to similar levels of strain of the upper extremities in both educational categories and by extension in both working categories, since the majority of blue-collar workers have a lower educational level, while white-collar workers are usually university graduates. The difference lies in the mechanisms that lead to movement restrictions in these two categories and not in the level of discomfort or the severity of pain that is caused. Musculoskeletal disorders in the heavy industry sector, both acute and cumulative, can be caused by various mechanisms such as repetitive movements, maintenance of awkward postures, vibration exposure and handling of heavy loads. Office work, which is usually computer-based, can also lead to cumulative musculoskeletal disorders, since it involves stereotyped movements of the upper arm and a more restricted posture for prolonged periods of time<sup>[20]</sup>.

The positive outcomes of this study are very encouraging and could be attributed to the proper appliance of prevention strategies by the shipyard industry and the occupational doctors. Prevention and early interventions are in the benefit of both the employer and the employee, in order to reduce disabilities, as well as sickness absences<sup>[21]</sup>.

## COMMENTS

### Background

The heavy industry sector has been linked with occupational accidents and injuries, a great percentage of which involving musculoskeletal disorders of the upper extremities. This can lead to permanent disability of a worker, the loss of working hours and the reduction of production, influencing both, employer and employee. The Quick Disabilities of the Arm, Shoulder and Hand (QD) Questionnaire provides an effective tool for the assessment of the physical functionality of the upper arm and the recording of musculoskeletal problems in manual labor.

### Research frontiers

Various studies have aimed to investigate the prevalence of musculoskeletal disorders of the upper extremities and possible aggravating factors in the industry sector. To the author's knowledge, this is the first study to use the QD questionnaire and correlate it with the working ability and the general physical and emotional health status of a heavy industry worker.

## Innovations and breakthroughs

The present study is the first to use the QD questionnaire for the evaluation of physical dysfunction in heavy industry and to demonstrate its effectiveness in recognizing musculoskeletal disorders of the upper arm. Age and lower basic education have been highlighted as aggravating factors. Furthermore, important negative associations have been made with working ability and the physical and emotional health status of the workers.

## Applications

The provided data may assist industries in planning prevention strategies to reduce occupational injuries of the upper extremities and motivate occupational physicians into using the QD questionnaire as a screening tool for physical dysfunctions of the upper arm. This study forms a base for future research investigating larger groups of heavy industry workers to provide the most reliable data on upper extremity disabilities.

## Peer-review

This manuscript is well-written. The introduction and purpose statement were appropriate. The methods were clearly described. Overall, presentation of the results was appropriate and conclusions appear to be appropriate given the data collected and analysis conducted.

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