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Development and Validation of a Physical and Psychosocial Job-Exposure Matrix in Older and Retired Workers

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ABSTRACT

Objectives: A general population job-exposure matrix (GPJEM) including physical and psychosocial demands as well as psychosocial resources applicable to older and retired workers was developed. Its validity was evaluated by examining associations of physical demands and iso-strain (combination of high psychosocial demands and low resources) with health.

Methods: Physical and psychosocial work exposures reported by 55–64 year olds were derived from the Netherlands Working Conditions Survey and linked to the Netherlands Standard Classification of Occupations 1992. A GPJEM with low, moderate, and high probability of exposure to demands and resources was developed. To examine associations with health, two groups of the Longitudinal Aging Study Amsterdam were selected: current (i.e. at the time of the interview, 55–64 years) and former workers (55–84 years). Linear and logistic regression models were applied.

Results: Use of force and work in uncomfortable positions were significantly associated with functional limitations and self-perceived health (SPH), but not hip or knee osteoarthritis (OA), in current and former workers. A moderate probability of repetitive movements was associated with functional limitations in former workers. A high probability of repetitive movements was associated with functional limitations in current and former workers as well as with SPH and hip and knee OA in former workers. Respondents formerly exposed to iso-strain had significantly higher diastolic blood pressure and more often hypertension. No such associations were found in current workers. No association was found with cardiovascular disease.

Conclusions: The results suggest that our GPJEM accurately classifies jobs according to physical demands and, although less clearly, iso-strain.

KEYWORDS: job-exposure matrix; older workers; psychosocial work demands and resources; physical demands

INTRODUCTION

General population job-exposure matrixes (GPJEMs), i.e. cross-tabulations of occupations in a population with a list of work exposures, have successfully been used in the past to determine work exposures and predict health effects. The Finnish JEM is possibly the most widely used GPJEM (Kauppinen *et al.*, 1998) to examine work exposures and predict health effects (e.g. Virkkunen *et al.*, 2006; Offermans *et al.*, 2012). A GPJEM designed by Schellart *et al.* (1990) and a revised version of this GPJEM (de Zwart *et al.*, 1997) are examples of GPJEMs using Dutch occupational classifications, designed to assess physical and psychological work demands. Additional Dutch GPJEMs have been designed, such as the Dutch Asbestos JEM (Swuste *et al.*, 2008) and the Dutch DOMJEM (Peters *et al.*, 2011), but these JEMs only assess exposure to selected carcinogens.

To date, a Dutch GPJEM including physical and psychosocial work demands as well as psychosocial work resources does not exist. Physical and psychosocial work demands have been shown to result in decreased work ability (e.g. van den Berg *et al.*, 2008), physical and mental health problems (e.g. Netterstrøm *et al.*, 2008), and sickness absence (e.g. Lund *et al.*, 2006). Psychosocial resources are thought to counteract any negative health effects of work demands (e.g. Stansfeld *et al.*, 1999) and may therefore be a useful asset to GPJEMs. Iso-strain (i.e. high psychosocial demands and low psychosocial resources) is thought to result in poor health according to the demand–control–support model (Karasek and Theorell, 1990). Information on psychosocial demands and resources may be used to determine exposure to iso-strain.

Nowadays, many European countries encourage older workers to remain in employment who would otherwise retire. One approach to retain older workers in the workforce is to reduce physical and psychosocial work demands and to foster psychosocial resources (Proper *et al.*, 2009). Therefore, we aim to take the first step toward constructing an accessible GPJEM, including physical and psychosocial work demands as well as psychosocial work resources, applicable to 55–64 year olds. The Netherlands Standard Classification of Occupations 1992 (NSCO92; Statistics Netherlands, 2001) is used, which can be linked to other occupational classifications, e.g. the internationally used International Standard Classification of Occupations 2008 (ISCO08). We examine the association of work demands and resources with health to provide an indication of the validity of the GPJEM. An underlying goal of this study is to use the GPJEM in population-based cohort studies.

METHODS

Study samples

To determine physical and psychosocial work exposure, the Netherlands Working Conditions Survey (NWCS) was used. The association between the GPJEM and health measures was examined using the Longitudinal Aging Study Amsterdam (LASA).

The NWCS is the largest periodic survey on working conditions in the Netherlands (Koppes *et al.*, 2011) . Starting in 2005, Statistics Netherlands drew random samples of 80 000 individuals annually from the National 'jobs register', which contains data on all jobs subsumed under the Dutch Employee Benefit schemes and that are liable to income tax. Since the response rate was known to be relatively low in employees aged younger than 25 years and in employees with a non-Western background, a 50% oversampling took place for these two groups. Sampled individuals received the NWCS questionnaire at their home address, or the questionnaire was filled in through the Internet. The responses were weighted by gender, age, educational level, sector, ethnicity, urbanization level, and geographical region to obtain a sample in which the distribution of these factors corresponded to the distribution in all employees in The Netherlands. Between 2005 and 2010, response rates ranged from 30.8 to 33.5%. Nearly all who did not participate indicated no interest or time. Data from 2005 through 2010 were merged and examined in this study (n = 138 848). Respondents aged 55–64 years were selected (n = 19 558). Respondents with missing data on occupational group (n = 481) or level of education (n = 140) were excluded, which resulted in an analytic sample of n = 18 937.

The LASA study is a continuing population-based cohort study that focuses on cognitive, social, emotional, and physical functioning in later life. A random sample of 55–85 year olds, stratified by age and gender according to expected 5-year mortality, was drawn from population registries in 11 municipalities in 3 geographical regions of the Netherlands. Data were collected through a face-to-face and medical interview.

The sampling, data collection procedures, and non-response have been described in detail elsewhere (Huisman *et al.*, 2011). In total, 3107 predominantly Caucasian (>99%) respondents were enrolled in the baseline examination in 1992–1993. An additional sample of 1002 respondents aged 55–64 years was drawn in 2002–2003 using the same sampling frame as the original cohort. Both cohorts were followed up approximately every 3 years. First, data from the first (1992–1993; n = 3107) and second (2002–2003; n = 1002) birth cohort were pooled for this analyses (n = 4109). By design, respondents aged 65 years and older (n = 2142) and respondents who were not employed (n = 1250) were excluded. A relatively large number of respondents have no job because the LASA study focuses on individuals aged 55–85 years and respondents were drawn from a population registry as opposed to a job registry. Also excluded were respondents with missing data on employment status (n = 21), occupational class (n = 52), or physical and psychosocial work exposures (n = 4). Of those with missing data on employment status, occupational class, or work exposures, n = 15 also had missing data on health measures. An additional n = 89 only had missing data on health measures. A total analytic sample of n = 551 was examined. Respondents with missing data on employment status, occupational class, or work exposures, but with data on health measures (n = 21 + 52 + 4 – 15 = 62) had significantly fewer functional limitations compared with those without missing data (n = 551). No differences were found regarding age, educational level, and other health measures. Second, we examined exposure during the longest held job, which was only asked during the first wave (1992–1993; n = 3107). By design, respondents were excluded if they currently had a job (n = 355) or reported to have never had a job (n = 307). Additionally excluded were respondents with missing data on longest job status because they underwent the short version of the interview (n = 173) or because the question was skipped (n = 3), respondent with missing data on occupational class (n = 61), or physical and psychosocial work exposures (n = 5). Of those with missing data on longest job, occupational class, or work exposures, n = 142 also had missing data on health measures. Finally, an additional n = 527 had missing data on health measures, resulting in an analytic sample of n = 1676. Compared with those without missing data (n = 1676), respondents with missing data on longest job, occupational class, or work exposures and with data on health measures (n = 176 + 61 + 5 – 142 = 100) were significantly older and had more functional limitations. No differences were found regarding level of education and other health measures. Some health measures were assessed during the medical interview, which was not performed in all respondents (Huisman *et al.*, 2011), resulting in a relatively large group of respondents with missing data for these health measures.

NWCS measures

Age (years), gender (male and female), and educational level (low: lower vocational education, or less; intermediate: higher general secondary education, intermediate vocational education; high: higher vocational education; university) were examined. From a list of 45 occupations, respondents were asked to tick the occupational title that best fitted their job. These occupations are grouped into 11 occupational groups. Respondents were asked how many hours they worked per week, according to their contract.

Physically demanding work was defined by the necessity to use force (Do you perform work for which you need to use a lot of force, such as in lifting, pushing, pulling or carrying or using force with work tools?), to work in uncomfortable positions (Do you perform work in an uncomfortable position?), and to perform repetitive movements (Do you perform work for which you need to make repetitive movements?). Response categories were no, sometimes, and regularly, and these were dichotomized into low (no and sometimes) and high (regularly).

Exposure to iso-strain was defined as high psychosocial demands and low psychosocial resources (Karasek and Theorell, 1990). Psychosocial demands were determined using three variables: time pressure (work at high pace and work under high time pressure), task requirements (work fast, much work, work hard, and hectic work), and cognitive demands (intensive thinking, need to keep focused, and requiring much concentration). Psychosocial resources were defined by job autonomy (decide how to perform the job, the sequence of tasks, work pace, when to take time off, and need to find solutions), variation in activities at work (variation in work, learn new things, and work requires creativity), co-worker support (my colleagues

help to get the job done, show personal interest in me, are friendly, and good at their job), and supervisory support (my supervisor is able to stimulate employees to cooperate, helps to get the job done, pays attention to what I say, and pays attention to employee well-being). Sum scores were calculated of all items for each exposure, i.e. time pressure and autonomy (no to regularly), social support (completely disagree to completely agree), task requirements, cognitive demands, and variation in activities (never to always). Sum scores were dichotomized based on the median value of all 55–64 year olds into low (≤median) and high (>median) psychosocial work exposures. Although the demand–control–support model (Karasek and Theorell, 1990) also includes cognitive demands as a relevant work demand, no studies that we know of actually included cognitive demands when examining the association with health. Therefore, job iso-strain was examined including and excluding cognitive demands.

LASA measures

Age (years), gender (male; female), and level of education (low: elementary school not completed; intermediate: general intermediate, intermediate vocational, general secondary education; high: higher vocational education, college education; university) were examined. Respondents were asked if they had a paid job and, if so, to precisely describe their job. Respondents interviewed in 1992/1993 who did not have a paid job, were asked what job they had performed the longest. The current or former occupation indicated by the respondent was coded according to the NSCO92. Respondents were asked how many hours weekly they (had) worked.

The following health measures from the LASA data were selected based on their association with physical and psychosocial work exposures: osteoarthritis (OA; e.g. Allen *et al.*, 2010; Palmer, 2012), functional limitations (Aittomaki *et al.*, 2005; Chau *et al.*, 2009), self-perceived health (SPH; Niedhammer and Chea, 2003; Wahrendorf *et al.*, 2012), blood pressure, hypertension (Clays *et al.*, 2007; Rosenthal and Alter, 2012), and cardiovascular diseases (CVDs; Tsutsumi *et al.*, 2009; Kivimäki *et al.*, 2012). Knee and hip OA were defined by an algorithm using self-report and general practitioner data (Verweij *et al.*, 2009) and categorized as no, possible, or definite OA. We examined OA that has proven to be present (i.e. definite OA) compared with no/possible OA in former workers. As only a small number of current workers had definite knee ($n = 5$) or hip OA ($n = 3$), OA categories were collapsed as no and possible/definite OA in analyses with current workers. Questions on difficulty experienced with cutting own toenails, using public transport, and walking up and downstairs were used to assess functional limitations, which was categorized into four severity groups and examined as a continuous measure: no difficulties, two without difficulty, one without difficulty, and all with difficulty. These three questions were selected from the validated Organization for Economic Co-operation and Development Questionnaire (Kriegsman *et al.*, 1997). SPH was assessed using the question 'How do you rate your health in general?' and answers were dichotomized as good (i.e. good or excellent) and poor (i.e. poor, sometimes good/sometimes poor, fair). While respondents were in a seated position, diastolic blood pressure (DBP) and systolic blood pressure (SBP; mm Hg) was measured at the upper left arm. Two calibrated oscillometric blood pressure monitors were used to assess blood pressure (model HEM-706; Omron M7 Corporation, Tokyo, Japan). In 1992–1993, blood pressure was measured three times in total at three different moments during the interview. We used the average of all three measurements. In 2002–2003, blood pressure was measured at two moments during the interview. At each moment, DBP and SBP were measured twice, resulting in four measurements for DBP and SBP. We used the average of all four measurements. Hypertension was defined if respondents either had diastolic (i.e. DBP ≥ 90 mm Hg) or systolic tension (i.e. SBP ≥ 140 mm Hg). According to an algorithm previously described (Bremmer *et al.*, 2006), the presence of CVD (i.e. cardiac disease, peripheral arterial disease, cerebrovascular accident) was measured using a combination of self-report, medication use, and general practitioners information. CVD was coded as no, possible, and definite. We examined CVD that has proven to be present (i.e. definite) compared with no/possible CVD.

General population job-exposure

To develop the GPJEM, NSCO92 classes were first assigned to occupational titles as defined in the

NWCS. Second, NSCO92 occupational classes were classified as having low, moderate, or high probability of exposure based on self-reported levels of work exposures from the NWCS.

Assignment of NSCO92 to NWCS occupational titles

Although a more recent NSCO exists (NSCO10), we chose to apply NSCO92 in the GPJEM. This classification is more valuable in the future, because starting from 2012, Statistics Netherlands will only apply the ISCO08, which can be linked to NSCO92 but not to NSCO10.

The NSCO92 classified 5 occupational levels, 43 classes, 121 groups, and 1211 titles, using the main domain (e.g. Agricultural, Management), the level of required skills (i.e. elementary through scientific; based on the necessary level of education, trial period, and work experience), and tasks (e.g. instruct, nurse) needed for the occupation. The NWCS survey did not fully fit the NSCO92, but adapted 45 occupational titles from the NSCO92 for the most frequently occurring jobs in the Netherlands and grouped them into 11 occupational groups (Koppes *et al.*, 2011). Because the NWCS did not classify all 1211 NSCO92 occupational titles, and we wanted to provide an exposure level for all NSCO92 occupational titles, we chose to assign the 43 occupational classes to the most applicable NWCS occupational group. Netherlands Statistics used the main domain and level of required skills needed for the occupation to determine occupational class. Therefore, we first matched the NWCS occupational group with the most applicable NSCO92 main domain. Second, to allocate an occupational class to NWCS respondents, the applied main domain in the NWCS was cross-tabulated with level of education (as a proxy for level of required skills). It was then determined whether the allocated NSCO92 classes were logical by checking the allocation of lower-level to higher-level classes. Supplementary Appendix 1 (supplementary data are available at *Annals of Occupational Hygiene* online) shows the assigned NSCO92 classes to NWCS occupational groups.

Level of work exposures

If >50% of NWCS respondents within one occupational class reported high physical demands, psychosocial demands, or psychosocial resources, the jobs belonging to that occupational class were classified as having 'high probability of exposure' to physical demands, psychosocial demands or resources, in line with cut-offs examined in previous studies (Kromhout *et al.*, 1992; Post *et al.*, 1994). We chose to classify jobs belonging to an occupational class as having 'moderate probability of exposure' if the proportion of respondents with high demands or resources was ≤50%, but above the NWCS-based total proportion reporting high demands or resources, which we considered as the normative. In the absence of a better method, previous studies have used various cut-offs to develop a GPJEM using self-reported data (Kromhout *et al.*, 1992; Post *et al.*, 1994; T' Mannetje *et al.*, 1999, 2011). Cut-offs of >50% (Kromhout *et al.*, 1992; Post *et al.*, 1994) and more than upper quartile (i.e. an interaction between prevalence and level of exposure was examined; T' Mannetje *et al.*, 1999) were used to determine high probability of exposure. Cut-offs of <5% (T' Mannetje *et al.*, 2011), <10% (Kromhout *et al.*, 1992; Post *et al.*, 1994), and less than lower quartile (T' Mannetje *et al.*, 1999) were used to determine low probability of exposure. The choice of the cut-off point in these studies was arbitrary. No consensus exists on which proportion of respondents with jobs belonging to one occupational class should have high work exposure, in order for the occupational class to be considered to have low, moderate, or high probability of exposure. The above-mentioned studies examined exposures, such as wood dust, asbestos, welding, or chromium (Kromhout *et al.*, 1992; Post *et al.*, 1994; T' Mannetje *et al.*, 1999, 2011), which is much harder to determine and less prevalent compared with physical and psychosocial exposures. Therefore, we feel that higher cut-offs were needed. To our knowledge, no studies exist that used proportional cut-offs examining physical demands, psychosocial demands or resources. Because no precedence exists, we used a cut-off based on our data by considering those classes as having 'low probability of exposure' if the proportion of respondents with high demands or resources was below the NWCS-based total proportion reporting high demands or resources. Of NWCS 55–64 year olds, in total 15.4, 9.2, and 30.8% regularly used force, worked in uncomfortable positions, and performed repetitive movements, respectively. In addition, 35.8, 37.3, and 47.8% experienced high time pressure, task requirements, and cognitive demands, respectively. High autonomy, variation of activities

in work, co-worker support, and supervisory support were experienced by 49.8, 45.7, 39.8, and 22.8% of all 55–64 year olds, respectively. To provide additional information on the GPJEMs validity, we examined a second cut-off of >50%. This was, as mentioned, based on the literature from Kromhout *et al.* (1992) and Post *et al.* (1994).

The proportion of NWCS individuals within occupational classes who reported to regularly perform physically demanding work, perform above median level of psychosocially demanding work, and have an above median level of psychosocial resources are given in Supplementary Appendices 2, 3, and 4 (supplementary data are available at *Annals of Occupational Hygiene* online). Supplementary Appendix 2 (supplementary data are available at *Annals of Occupational Hygiene* online) shows that within one occupational class, up to 26.7, 40.9, and 59.5% reported to regularly experience work in an uncomfortable position, regularly use force, and regularly move repetitively, respectively. Regarding psychosocial demands, up to 70.9, 66.5, and 71.8% within one occupational class reported to perform work with above median level of task requirements, time pressure, and cognitive demands (Supplementary Appendix 3, available at *Annals of Occupational Hygiene* online). Up to 31.8, 59.4, 73.4, and 83.6% within one occupational class reported to have an above median level of supervisory support, co-worker support, variation in activities, and autonomy, respectively (Supplementary Appendix 4, available at *Annals of Occupational Hygiene* online). Note that only few respondents (i.e. $n < 10$) performed jobs belonging to occupational class 64 (higher agricultural occupations) and 84 (scientific legal and administrative occupations). These classes were, therefore, excluded from further analyses.

Based on Supplementary Appendices 2, 3, and 4 (supplementary data are available at *Annals of Occupational Hygiene* online), occupational classes were classified as a having low, moderate, or high probability of physical demands, psychosocial demands, or psychosocial resources (Table 1). Supplementary Appendices 2, 3, and 4 (supplementary data are available at *Annals of Occupational Hygiene* online) show that no occupational classes were found in which >50% regularly used force, worked in an uncomfortable position, or had above median supervisory support. Occupational classes were, therefore, only classified to have low or moderate probability to exposure to use of force, work in an uncomfortable position or supervisory support. In addition, no occupational classes were found in which >NWCS-based total % and ≤50% had above median level of cognitive demands or autonomy. Occupational classes were, therefore, only classified to have low or high probability to exposure to cognitive demands or autonomy. Also note that most occupational classes from 62 and above (higher and scientific occupational classes) had a moderate or high probability of exposure to psychosocial demands and resources, whereas occupational classes <62 (lower and secondary occupations) had a moderate or high probability of exposure to physical demands.

Statistical analysis

To study the cross-sectional association of work demands and resources with functional limitations and blood pressure, linear regression analysis was performed. Logistic regression analyses were performed to examine the association with OA [reference group (ref): no and no/possible in current and former workers, respectively], SPH (ref: poor SPH), hypertension (ref: no), and CVD (ref: no/possible). All associations were adjusted for gender and age.

RESULTS

NWCS and LASA descriptive information

Table 2 shows that, among NWCS respondents aged 55–64 years, 38.0% were women and 31.9% attained a low educational level. On average, they were 58.0 years old and worked 31.5 h weekly. Table 2 additionally presents the proportion of NWCS respondents who had high physical demands, high psychosocial demands, and high psychosocial resources.

Of the currently employed LASA respondents aged 55–64 years, 39.9% were women and 38.1% attained a low educational level. On average, they were 58.8 years old and worked 30.9 h weekly. In addition, 10.7% had possible knee OA, 2.4% had definite knee OA, 7.3% had possible hip OA, and 1.5% had definite hip OA. On average, respondents had 0.2 functional limitations. Poor SPH was experienced by 21.1%. SBP was on average 133.8 mm Hg and DBP 80.8 mm Hg. Of these respondents, 38.1% had hypertension, 7.8% had possible CVD, and 3.8% had definite CVD.

Table 1. General population job-exposure matrix

NSCO92 classes	Physical demands			Psychosocial demands			Psychosocial resources			
	Use force	Uncomfortable position	Repetitive movements	Time pressure	Task requirements	Cognitive demands	Autonomy	Variation activities	Co-worker support	Supervisory support
11 Elementary occupations	**M**	**M**	**H**	L	L	L	L	L	L	L
21 Lower non-specialized occupations	**M**	**M**	**H**	L	L	L	L	L	L	L
22 Lower teachers sports courses	L	L	**M**	L	L	L	L	L	L	L
24 Lower agricultural occupations	**M**	**M**	**H**	L	L	L	L	L	L	L
25 Lower mathematical and scientific occupations	L	L	**M**	**M**	**M**	**H**	**H**	**H**	**M**	L
26 Lower technical occupations	**M**	**M**	**H**	L	L	L	L	L	L	L
28 Lower transport occupations	**M**	**M**	**H**	L	L	**H**	L	L	L	L
29 Lower (para)medical occupations	**M**	**M**	**M**	L	L	L	L	L	L	L
31 Lower administrative, commercial occupations	L	L	**M**	L	L	L	L	L	L	L
33 Lower security personal	**M**	**M**	**M**	L	L	L	L	L	L	L
37 Lower nursing occupations	**M**	**M**	**M**	L	L	L	L	L	L	L
42 Secondary teachers transport and sports courses	L	L	L	L	L	L	L	**H**	**M**	**M**
44 Secondary agricultural occupations	**M**	**M**	**H**	L	L	L	L	L	L	L
45 Secondary mathematical, scientific occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	L	L
46 Secondary technical occupations	**M**	**M**	**M**	L	L	L	**H**	L	L	L
48 Secondary transport occupations	**M**	**M**	**M**	L	L	**H**	L	L	L	L
49 Secondary (para)medical occupations	**M**	**M**	**M**	**M**	**M**	**H**	L	**M**	**M**	**M**
51 Secondary administrative, commercial occupations	L	L	**M**	L	L	L	**H**	L	L	**M**

Table 1. *Continued*

NSCO92 classes	Physical demands			Psychosocial demands			Psychosocial resources			
	Use force	Uncomfortable position	Repetitive movements	Time pressure	Task requirements	Cognitive demands	Autonomy	Variation activities	Co-worker support	Supervisory support
53 Secondary legal, administrative, and security occupations	L	L	L	L	L	L	L	L	L	L
55 Secondary linguistic, cultural occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	L	L
56 Secondary occupations in the field of behaviour and society	**M**	**M**	**M**	**M**	**M**	**H**	L	**M**	**M**	**M**
57 Secondary nursing occupations	L	L	L	L	L	L	L	L	L	L
62 Higher pedagogical occupations	L	L	L	**M**	**M**	**H**	L	**H**	**M**	**M**
65 Higher mathematical and scientific occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	**M**	**M**
66 Higher technical occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	**M**	**M**
68 Higher transport occupations	**M**	L	L	**M**	L	L	L	L	**M**	L
69 Higher (para)medical occupations	**M**	**M**	L	**M**	**M**	**H**	L	**H**	**M**	L
71 Higher administrative, commercial, economical occupations	L	L	L	**M**	**M**	L	**H**	L	L	**M**
73 Higher legal, administrative, security occupations	L	L	L	**M**	**M**	L	**H**	**H**	**M**	L
75 Higher linguistic, cultural occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	**M**	**M**
76 Higher occupations in the field of behaviour and society	**M**	**M**	L	**M**	**M**	**H**	L	**H**	**M**	L
77 Higher caring occupations	L	L	L	**M**	**M**	L	**H**	**H**	**M**	L
78 Managers (higher vocational education level)	L	L	L	**H**	**H**	**H**	**H**	**H**	**H**	**M**
82 Scientific pedagogical occupations	L	L	L	**H**	**H**	**H**	L	**H**	**M**	**M**

Table 1. ***Continued***

NSCO92 classes	Physical demands			Psychosocial demands			Psychosocial resources			
	Use force	Uncomfortable position	Repetitive movements	Time pressure	Task requirements	Cognitive demands	Autonomy	Variation activities	Co-worker support	Supervisory support
85 Scientific mathematical, scientific occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	**H**	**M**
86 Scientific technical occupations	L	L	L	**M**	**M**	**H**	**H**	**H**	**H**	**M**
89 Scientific (para) medical occupations	L	L	L	**H**	**H**	**H**	**H**	**H**	**M**	**M**
91 Scientific economical, administrative occupations	L	L	L	**M**	**M**	L	**H**	**H**	L	**M**
93 Scientific legal, administrative occupations	L	L	L	**M**	**H**	**H**	**H**	**H**	**M**	**M**
96 Scientific occupations in the field of behaviour and society	L	L	L	**H**	**H**	**H**	**H**	**H**	**M**	**M**
98 Managers (scientific level)	L	L	L	**H**	**H**	**H**	**H**	**H**	**H**	**M**

L, low probability of exposure; **M**, moderate; **H**, high. **M** and **H** are shown in bold, only to accentuate the patterning of L, **M**, and **H** within the GPJEM.

Table 2. Descriptive information of NWCS and LASA respondents

		Employed, 55–64 year olds		Previously employed, 55–85 year olds
		NWCS data	LASA data	LASA data
Total, *n* (100%)		18 937	551	1676
Women, *n* (%)		7195 (38.0)	220 (39.9)	823 (49.1)
Age (years), mean (SD)		58.0 (2.3)	58.8 (2.7)	70.7 (8.2)
Level of education, *n* (%)	Low	6039 (31.9)	210 (38.1)	1028 (61.4)
	Intermediate	7031 (37.1)	191 (34.7)	450 (26.9)
	Higher vocational	3717 (19.6)	109 (19.8)	155 (9.3)
	University	2149 (11.3)	41 (7.4)	41 (2.4)
Hours worked weekly, mean (SD)		31.5 (10.5)[a]	30.9 (17.4)[b]	47.6 (17.0)[b]
Self-reported work demands and resources (NWCS-based total), *n* (%)	Using force (regularly)	2860 (15.4)[c]		
	Uncomfortable position (regularly)	1074 (9.2)[d,e]		
	Repetitive movements (regularly)	3677 (30.8)[e,f]		
	Time pressure (>median)	6257 (35.8)[g]		
	Task requirements (>median)	4684 (37.3)[e,h]		
	Cognitive demands (>median)	6016 (47.8)[e,i]		
	Autonomy (>median)	9248 (49.8)[j]		
	Variation in activities (>median)	5750 (45.7)[e,i]		
	Co-worker job support (>median)	4803 (39.8)[e,k]		
	Supervisory support (>median)	2656 (22.8)[e,l]		
Functional limitations (0–3), mean (SD)			0.2 (0.51)	0.7 (1.0)
Poor SPH, *n* (%)			116 (21.1)	635 (37.9)

Table 2. *Continued*

		Employed, 55–64 year olds		Previously employed, 55–85 year olds
		NWCS data	LASA data	LASA data
OA knee, *n* (%)[m]	No		179 (86.9)	1265 (75.5)
	Possibly		22 (10.7)	302 (18.0)
	Definitely		5 (2.4)	109 (6.5)
OA hip, *n* (%)[m]	No		188 (91.3)	1337 (79.8)
	Possibly		15 (7.3)	244 (14.6)
	Definitely		3 (1.5)	95 (5.7)
SBP (90–220 mm Hg), mean (SD)			133.8 (21.0)	128.9 (20.0)
DBP (45–130 mm Hg), mean (SD)			80.8 (12.8)	72.6 (12.5)
Hypertension, *n* (%)			210 (38.1)	463 (27.6)
CVD, *n* (%)	No		487 (88.4)	1194 (71.2)
	Possibly		43 (7.8)	170 (10.1)
	Definitely		21 (3.8)	312 (18.6)

SD, standard deviation.
n = [a]308, [b]3, [c]413, and [d]1088 had missing data.
[e]Data on these items were unavailable for 2005–2006 (*n* = 6137).
n = [f]870, [g]685, [h]252, [i]212, [j]353, [k]1154, and [l]719 had missing data.
n = [m]345 had missing data because data on OA were unavailable for 2002–2003.

Of the formerly employed LASA respondents aged 55–85 years, 49.1% were women and 61.4% attained a low educational level. On average, they were 70.7 years old at the time of the interview (1992/1993) and reported to have worked 47.6 h weekly during their longest job. Eighteen per cent had possible knee OA, 6.5% had definite knee OA, 14.6% had possible hip OA, and 5.7% had definite hip OA. On average, 0.7 functional limitations were reported and 37.9% reported poor SPH. SBP was on average 128.9 mm Hg and DBP 72.6 mm Hg. Of these respondents, 27.6% had hypertension, 10.1% had possible CVD, and 18.6% had definite CVD.

Association of physical demands with health measures using LASA data

Table 3 shows that respondents who currently had jobs with a moderate probability of use of force or work in an uncomfortable position were significantly more likely to have more functional limitations and poor SPH than those with low probability. Significantly more functional limitations were found in respondents with a high compared with low probability of performing repetitive movements.

Respondents formerly employed in jobs classified as having a moderate probability of use of force or work in uncomfortable position were significantly more likely to have more functional limitations and to have poor SPH than those with low probability. Former workers with a moderate probability of performing repetitive movements had significantly more functional limitations compared with those with low probability. Respondents formerly employed in a job that had a high probability of repetitive movements were significantly more likely to have more functional limitations, poor SPH, and definite knee or hip OA compared with those with low probability.

Association of psychosocial work exposures with health measures using LASA data

Regarding currently employed respondents, psychosocial demands, psychosocial resources, and iso-strain including or excluding cognitive demands were not significantly associated with blood pressure, hypertension, and CVD (Table 4). Respondents formerly employed in jobs with a moderate and high probability of time pressure or task requirements were significantly more likely to have a higher DBP than those with low probability. Former employees of jobs with moderate probability of time pressure and task requirements were significantly less likely to definitely have CVD than those with low probability. No association was found for cognitive demands with blood pressure, hypertension, and CVD.

Significantly higher DBP and SBP was found in respondents formerly employed in jobs with a high probability of autonomy, variation in activities, a moderate probability of co-worker, and supervisory support compared with those with low probability. Respondents formerly employed in jobs with a moderate probability of co-worker support were significantly more likely to have hypertension than those with low probability.

Turning to the jobs with the combination of high psychosocial demands and low psychosocial resources, i.e. iso-strain jobs, no associations were found with blood pressure, hypertension, or CVD in formerly employed respondents. In contrast, respondents formerly employed in iso-strain jobs excluding cognitive demands had significantly higher DBP and significantly more often had hypertension than those without iso-strain jobs.

DISCUSSION

A GPJEM with low (≤NWCS-based total %), moderate (>NWCS-based total % and ≤50%), and high (>50%) probability of exposure to physical and psychosocial work demands as well as psychosocial work resources was developed. As a primary validation of the GPJEM, associations with health measures were examined.

In line with previous research, use of force and work in uncomfortable positions were associated with more functional limitations (e.g. Chau *et al.*, 2009) and poor SPH (e.g. Aittomaki *et al.*, 2005) in currently and formerly employed individuals. Physical demands most likely affect functional limitations and SPH indirectly, for instance through causing wear and tear, musculoskeletal disorders, occupational injuries (Chau *et al.*, 2009), or other chronic diseases (Aittomaki *et al.*, 2005). Use of force and work in uncomfortable position performed by current and former workers were not associated with OA. Still, studies show that specifically doing heavy work or lifting heavy object results

Table 3. Association of physical demands with functional limitations, SPH, and OA

Physical demands		*n*	Functional limitations		Poor SPH		*n*	Knee OA		Hip OA	
			B	95% CI	OR	95% CI		OR	95% CI	OR	95% CI
Current job		551					206[a]				
Use of force	Moderate (versus low)	272	**0.1**	**0.04–0.2**	**1.7**	**1.2–2.7**	105	1.6[b]	0.7–3.8	2.5[b]	0.9–7.5
Uncomfortable position	Moderate (versus low)	271	**0.1**	**0.04–0.2**	**1.8**	**1.2–2.7**	105	1.6[b]	0.7–3.8	2.5[b]	0.9–7.5
Repetitive movements	Moderate (versus low)	268	0.03	−0.1 to 0.1	1.2	0.7–2.0	111	3.0[b]	0.9–10.7	5.7[b]	0.7–45.6
	High (versus low)	117	**0.2**	**0.1–0.3**	1.6	0.9–2.9	44	2.4[b]	0.6–10.6	6.2[b]	0.7–56.4
Longest job		1676					1676				
Use of force	Moderate (versus low)	972	**0.1**	**0.02–0.2**	**1.4**	**1.1–1.7**	972	1.4	0.9–2.1	1.5	0.99–2.4
Uncomfortable position	Moderate (versus low)	971	**0.1**	**0.02–0.2**	**1.3**	**1.1–1.6**	971	1.4	0.9–2.1	1.5	0.99–2.4
Repetitive movements	Moderate (versus low)	820	**0.2**	**0.04–0.3**	1.3	0.99–1.7	820	1.1	0.6–2.1	2.1	0.99–4.6
	High (versus low)	525	**0.2**	**0.04–0.3**	**1.5**	**1.1–2.1**	525	**2.2**	**1.1–4.1**	**2.5**	**1.2–5.6**

Associations were adjusted for gender and age. Bold = significant ($P < 0.05$).
[a]Since no data on OA are available in 2002 and 2003, analyses were performed using data from 1992 to 1993 only ($n = 206$).
[b]Number of respondents with definite knee ($n = 5$) or hip ($n = 3$) OA was too low for analyses. Therefore, possible or definite knee and hip OA (versus no) was examined in current workers (as opposed to definite versus possible or no knee and hip OA in former workers).

Table 4. Association of psychosocial demands and resources with blood pressure and CVD

Psychosocial demands		*n*	DBP (mm Hg)		SBP (mm Hg)		Hypertension		CVD	
			B	95% CI	B	95% CI	OR	95% CI	OR	95% CI
Current job		**551**								
Time pressure	Moderate (versus low)	133	1.7	−0.8 to 4.2	1.8	−2.3 to 5.9	1.2	0.8–1.9	0.8[a]	0.3–2.1
	High (versus low)	26	−3.3	−8.4 to 1.7	−4.5	−12.8 to 3.8	0.6	0.2–1.4		
Task requirements	Moderate (versus low)	123	1.4	−1.2 to 4.0	1.7	−2.5 to 5.9	1.2	0.8–1.9	0.8	0.3–2.4
	High (versus low)	35	−0.6	−5.0 to 3.8	−1.3	−8.5 to 5.9	0.8	0.4–1.7	0.7	0.1–5.2
Cognitive demands	High (versus low)	161	0.6	−0.5 to 1.8	0.9	−1.1 to 2.8	1.2	0.8–1.8	1.8	0.6–5.5
Autonomy	High (versus low)	215	−0.3	−1.4 to 0.9	−1.3	−3.2 to 0.6	1.0	0.7–1.4	0.9	0.3–2.2
Variation in activities	High (versus low)	140	0.3	−1.0 to 1.5	0.3	−1.7 to 2.3	1.1	0.7–1.6	0.9	0.3–2.6
Co-worker job support	Moderate (versus low)	127	0.7	−1.9 to 3.2	1.0	−3.2 to 5.1	1.1	0.7–1.7	0.7[a]	0.2–2.2
	High (versus low)	9	−3.7	−12.2 to 4.7	−8.5	−22.3 to 5.2	0.4	0.1–1.9		
Supervisory support	Moderate (versus low)	201	−0.1	−2.3 to 2.1	−1.7	−5.3 to 2.0	1.0	0.7–1.4	1.0	0.4–2.6
Iso-strain		127	2.0	−0.6 to 4.5	2.5	−1.6 to 6.6	1.3	0.8–1.9	0.8	0.3–2.4
Iso-strain without cognitive demands		102	1.4	−1.4 to 4.1	1.6	−2.9 to 6.1	1.1	0.7–1.8	1.1	0.4–3.4
Longest job		**1676**								
Time pressure	Moderate (versus low)	257	**1.7**	**0.04–3.4**	2.4	−0.2 to 5.1	1.2	0.9–1.6	**0.6**	**0.4–0.9**
	High (versus low)	65	**3.6**	**0.5–6.7**	3.7	−1.2 to 8.7	1.3	0.7–2.1	1.6	0.9–2.8
Task requirements	Moderate (versus low)	248	**1.8**	**0.1–3.5**	2.6	−0.1 to 5.3	1.2	0.9–1.7	**0.6**	**0.4–0.96**
	High (versus low)	73	**3.1**	**0.2–6.1**	3.0	−1.7 to 7.7	1.1	0.7–1.9	1.5	0.9–2.5
Cognitive demands	High (versus low)	343	0.6	−0.2 to 1.3	0.9	−0.4 to 2.0	1.1	0.8–1.4	0.9	0.7–1.3
Autonomy	High (versus low)	563	**1.0**	**0.3–1.7**	**1.3**	**0.2–2.3**	1.2	0.9–1.5	1.0	0.8–1.4

Table 4. Continued

Psychosocial demands		*n*	DBP (mm Hg)		SBP (mm Hg)		Hypertension		CVD	
			B	95% CI	B	95% CI	OR	95% CI	OR	95% CI
Variation in activities	High (versus low)	293	**1.0**	**0.2–1.8**	**1.3**	**0.1–2.6**	1.2	0.9–1.6	0.8	0.5–1.1
Co-worker job support	Moderate (versus low)	229	**2.5**	**0.8–4.3**	**2.9**	**0.1–5.6**	**1.3**	**1.1–1.8**	0.7	0.5–1.0
	High (versus low)	49	0.97	−2.6 to 4.5	2.4	−3.3 to 8.1	0.6	0.3–1.3	1.1	0.6–2.2
Supervisory support	Moderate (versus low)	458	**2.3**	**0.97–3.6**	**2.7**	**0.6–4.8**	1.2	0.9–1.5	0.9	0.7–1.2
Iso-strain		267	0.9	−0.7 to 2.6	1.6	−1.0 to 4.2	1.2	0.9–1.6	0.9	0.7–1.3
Iso-strain without cognitive demands		203	**2.0**	**0.2–3.8**	2.8	−0.1 to 5.7	**1.4**	**1.0–1.9**	0.8	0.5–1.1

Associations were adjusted for gender and age. Bold = significant ($P < 0.05$).
[a]Categories moderate and high were merged because no respondents had high time pressure or co-workers support as well as definite CVD.

in knee and hip OA (Allen *et al.*, 2010). We most likely found no association because of a lack of statistical power; all odds ratios (ORs) were positive. An additional explanation may be that questions on use of force and uncomfortable positions provided insufficiently detailed exposure information to examine associations with OA. Whether use of force and work in an uncomfortable position put demands on knees or hips was unknown. Finally, for OA to develop, activities need to have loaded the joint repeatedly, for longer periods of time, and not too recently, although exposure levels sufficient to cause OA are unknown (Allen *et al.*, 2010). Duration of exposure (i.e. how long individuals have performed their current or former job) and time that elapsed since exposure are unknown in the LASA study. In addition, no information can be derived from our JEM about the variation in intensity of exposure. As a result, our findings may underestimate the effect of use of force and work in uncomfortable positions. In current workers, repetitive movements were associated with functional limitations, but not with SPH. In former workers, repetitive movements were associated with functional limitations and (only in those with high probability of repetitive movements) with SPH. Also, former workers who performed jobs with high probability of repetitive movements were more likely to have definite knee and hip OA, concurrent with previous studies. Former repetitive (or prolonged) kneeling (Cooper *et al.*, 1994; Palmer, 2012) and squatting (Palmer, 2012) results in knee OA and formerly often or always bending, twisting, and reaching results in hip OA (Allen *et al.*, 2010). In contrast to former workers, physical demands were not associated with knee or hip OA in currently employed individuals. The exposure may have been too recent to influence OA onset (Palmer, 2012). In contrast, it can be argued that 55–64 years olds performing physically demanding jobs often have performed those jobs for a longer period of time. Also, individuals suffering from early OA can still be able to work. A recent study showed that work participation rates of individuals with OA were similar to the general Dutch population, although work adaptations were necessary (Bieleman *et al.*, 2013). Again, a lack of statistical power may provide an explanation; positive ORs (in the range of 1.6–6.2) were found.

A few counterintuitive results were found regarding psychosocial demands and resources in former

workers (e.g. higher DBP was found if exposed to high autonomy). Highly demanding jobs may at the same time have high resources, and vice versa, which could have biased these results. Indeed, individuals formerly employed in jobs with high psychosocial demands and low resources (i.e. iso-strain) showed to be more likely to have higher DBP and hypertension than those without iso-strain jobs, supported by previous studies (e.g. Rosenthal and Alter, 2012), suggesting iso-strain was accurately measured in our GPJEM. The pathway through which occupational stress leads to (chronic) high blood pressure is still unclear. Possibly, repeated stress experiences result in repeated elevations of blood pressure, which in turn could result in hypertension. In addition, occupational stress may result in poor life style behaviours (e.g. smoking, inactivity), which in turn are known to be risk factors for high blood pressure (Rosenthal and Alter, 2012). However, no information was available on former life style. Iso-strain jobs were associated with blood pressure only if cognitive demands were not considered. Compared with other psychosocial demands, a relatively high number of occupational classes were classified as having a high probability of cognitive demands, suggesting high consensus within classes and, therefore, accuracy of the classification. Although we can only speculate, cognitive demands are possibly not associated with stress-related health problems. They may even resemble mentally stimulating activities and, according to the use-it-or-lose-it theory (Orrell and Sahakian, 1995), potentially prevent cognitive decline in old age. Further research is needed to explore this.

In contrast to blood pressure, no association was found between iso-strain jobs and CVD. An explanation may be that CVD is only for a small part caused by work stress; a recent meta-analysis including large samples found only a small effect of job strain (i.e. iso-strain excluding social support) on coronary heart disease (Kivimäki *et al.*, 2012). In addition, it is thought that prolonged exposure to stress, for instance from work, may directly be associated with CVD by activation of neuroendocrine responses and, if activated frequently and over a longer period of time, thereby initialize atherosclerosis and damage the cardiovascular system. Although we examined the longest job, the duration and frequency of exposure were unknown, thereby possibly explaining why null results were found (Chandola *et al.*, 2008). Also, as mentioned, whether former life style or other coronary risk factors, such as high cholesterol levels or diabetes, biased our results is unknown.

In current workers, psychosocial demands, psychosocial resources, and iso-strain jobs were not associated with blood pressure, hypertension, and CVD. Nevertheless, a relatively high consensus (up to 71.8%) existed within occupational classes regarding psychosocial demands, suggesting satisfactory accuracy. Also, associations of formerly performed iso-strain jobs with blood pressure and hypertension were found, suggesting there is some merit to our classification. Again, we may have found no association in current workers because of a lack of statistical power. In addition, a healthy worker effect may have biased our results. Individuals with (precursors to) CVD may no longer be employed due to their illness. Measures possibly influenced less by a healthy worker effect may be more appropriate to determine the validity of psychosocial demands and resources in currently employed. For instance, associations have been found with job satisfaction, emotional exhaustion, psychosomatic, and physical health complaints (de Jonge *et al.*, 2000).

Some limitations need to be mentioned. First, a disadvantage of GPJEMs in general is the inability to account for exposure heterogeneity within the job categories. Although occupational classes were found with high consensus on the level of physical demands, psychosocial demands, and resources (up to 59.5, 71.8, and 83.6%, respectively), heterogeneity within NSCO92 occupational classes exists; certain jobs may be less likely to have exposure to a demand or resource compared with other jobs within one class. More research on the within class heterogeneity may provide additional information on the validity of our GPJEM. Still, we chose to systematically provide an estimation of exposure probability for each NSCO92 job title so that population-based studies using this (or an adjacent) occupational classification can apply the GPJEM. An advantage of aggregating self-reported work exposure is that the influence of individual factors (e.g. mood, past experiences, health) may be reduced. Second, for some NWCS job titles, no NSCO92 class was found that perfectly matched. In the NWCS, no data were available on required level of education of the profession, which is needed to properly code the occupations according to the NSCO92. Also, NWCS job titles are less detailed compared with

the NSCO92. NSCO92 occupational classes were consequently classified to have a certain level of work exposure based on fewer job titles than are included in the NSCO92 class, which may have led to misclassification. More research is needed to examine how this has influenced our GPJEM. We chose to first examine whether this linkage is acceptable by studying the relationship with health measures. Associations with health outcomes were found, especially in physical demands, indicating sufficient correct classifications. Third, we used self-defined cut-offs. Although we attempted to use a systematic rationale for the cut-offs, these are evidently up for debate. As mentioned, heterogeneity exists within occupational classes, which is underlined by the fact that no classes were found in which all respondents reported high demands or resources. We feel it is, therefore, a reasonable choice to regard classes in which >50%, a relatively high cut-off, and >NWCS-based total % reports high exposure to demands or resources as high and moderate probability of exposure, respectively. Also, associations were found with health outcomes, showing there is some merit to these cut-offs. Nevertheless, the chosen cut-offs may have influenced the results. The validity of the GPJEM may be further examined by studying more or less stringent cut-offs, or even a continuous proportional measure. Fourth, we based our GPJEM largely on self-reported data because more objective measurements (e.g. systematic observations) were unavailable in large general population samples as used in this study. Still, both subjective and objective methods have drawbacks regarding assessment of physical demands (Stock *et al.*, 2005) and, especially difficult to measure objectively, psychosocial demands and resources (Burdorf and Van der Beek, 1999). Fifth, although a large NWCS study sample was examined ($n = 18\,937$), occupational classes were found to which few respondents belonged (e.g. $n = 31$ performed a job that was classified to belong to 'higher transport occupations'), which may result in less precise exposure estimates. Sixth, due to exclusion of respondents with missing data, the association between physical demands and health measures may have been overestimated in current workers and underestimated in former workers, as excluded current workers had less functional limitations and excluded former workers were older and had more functional limitations. Finally, we were unable to adjust for some potentially confounding variables. It is unknown whether currently employed 55–64 year olds were preparing to retire. As a result, they may experience less stress from their job, possibly explaining null results found in currently employed. Also, life style was not adjusted for. Additional analyses (not tabulated) showed that physical activity and smoking behaviour at baseline in current and former workers did not influence the examined associations. No information was available on former lifestyle. Additionally unknown was the strength and duration of occupational exposure, and the time that elapsed since the occupational exposure, possibly explaining some unexpected or null results. We were able to perform additional analyses in which we adjusted for time elapsed since leaving the labour market (on average 21 years; i.e. not necessarily from their longest job). Results showed that the association of use of force and work in an uncomfortable position with functional limitations disappeared but with hip OA became significant. This shows the latency of exposure may be relevant, although more precise data on the time elapsed since exposure are needed. For future research on our GPJEM, using data with more complete employment histories of individuals (i.e. information on strength and duration of exposure and time since exposure) is warranted to give more insight into its association with the examined health measures.

To date, no GPJEM exists in the Netherlands, including physical and psychosocial work demands as well as psychosocial work resources. Although the application of GPJEM is easy, the construction is a tedious process. We developed such a GPJEM, using self-reported data from 55–64-year-old workers. The GPJEM is linked to the NSCO92, which has often been used to classify jobs in large Dutch population-based studies (T' Mannetje and Kromhout, 2003). Also, the GPJEM may be applied in studies using other occupational classification; the NSCO92 can be linked to other occupational classifications, e.g. the internationally used ISCO08. We took a first step toward validating our GPJEM. We conclude that our GPJEM accurately classified jobs according to probability of exposure to physical demands, which was only partly the case for iso-strain jobs. Iso-strain was associated with DBP and hypertension in former, but not in current workers. This may be explained by a healthy worker effect.

WHAT THIS PAPER ADDS

- This is the first Dutch GPJEM including physical and psychosocial work demands as well as psychosocial work resources.
- The GPJEM developed and validated accurately classified jobs according to physical demands and, although less clearly, iso-strain (i.e. high psychosocial demands and low psychosocial resources).
- This GPJEM can be applied in study populations examining older and retired workers.

SUPPLEMENTARY DATA

Supplementary data can be found at http://annhyg.oxfordjournals.org/.

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