Objective: To determine the contribution of specific psychological, social, and mechanical work exposures to the self-reported low level of work ability.

Methods: Employees from 48 organizations were surveyed over a 2-year period (n = 3779). Changes in 16 work exposures and 3 work ability measures—the work ability index score, perceived current, and future work ability—were tested with Spearman rank correlations. Binary logistic regressions were run to determine contribution of work exposures to low work ability. Results: Role conflict, human resource primacy, and positive challenge were the most consistent predictors of low work ability across test designs. Role clarity and fair leadership were less consistent but prominent predictors. Mechanical exposures were not predictive. Conclusions: To protect employee work ability, work place interventions would benefit from focusing on reducing role conflicts and on promoting positive challenges and human resource primacy.
(T1) and at follow-up (T2) 2 years later. A 2-year period has been found to be an appropriate compromise to detect effects of social work exposures on health symptoms. A recent review on time lags supported the use of a 2-year follow-up period although stronger associations between work exposures and health may be detected with even longer follow-up periods.

Several statistical designs were tested to elucidate effects that were consistent across designs. The full-panel design allows analyzing data (1) cross-sectionally at both measurement points, (2) prospectively with baseline exposure as a predictor of the outcome at follow-up, and (3) average exposure across time [(exposure-T1 + exposure-T2)/2] as a predictor of the outcome at follow-up.

Study Population
A cohort of employees recruited from 48 Norwegian-based organizations (31 private and 17 public) comprised the study population. The organizations represented a wide range of occupational sectors including health care, education, government and public administration, engineering, business, and industry. All participating organizations provided a list of employees’ departmental affiliation, home address, and occupational title according to the Norwegian standard classification of the occupations. STYRK, developed by Statistics Norway, is based on the International Classification of Occupation (ISCO-88).

Each employee received a letter containing information about the survey and a personalized code for logging into the web-based questionnaire or a paper version of the questionnaire if requested in advance. Written information specified aims of the survey, the strict confidentiality guidelines, as well as information about the license for data collection granted by the Norwegian Data Inspectorate. The questionnaire contained items on background information, work organization, psychological, social, and mechanical work factors, mastery of work, organizational change, attitudes to work, personality, coping strategies, physical activity, smoking, alcohol use, mental health, work ability, and health complaints. This study was based on parts of this information.

The first cross-sectional sample (T1) included 6774 responders representing 12,603 invited subjects (53.7%) (Fig. 1). Participants were defined as respondents when completing minimum one exposure measure and minimum one of the three work ability measures. At follow-up 6313 of the 12784 invited subjects (49.4%) responded and comprised the second cross-sectional sample (T2). Average follow-up period for respondents was 24 months (range, 17 to 36 months). Subjects not employed in a participating organization (31 private and 17 public) comprised the study population.

Outcome: Work Ability
Work ability was assessed with the work ability index (WAI), which comprises seven items (see Supplemental Digital Content, Appendix 1, http://links.lww.com/JOM/A180). The WAI intends to capture both subjective evaluations to work ability, work impairment, and objectively verifiable information on health status. The WAI has shown adequate test-retest reliability, and classification of scores has been found stable over a 4-week period. Although the WAI is a self-reported inventory, an advantage of the WAI is arguably that responses to certain items (eg, sickness absence during past year) can be verified by objective means (eg, organizational sickness register). The WAI sum score ranges from 7 to 49 points and was originally categorized, on the basis of the lowest 15th percentile, the median, and the highest 15th percentile, into four groups: “poor” (index score <28), “moderate” (28-37), “good” (38-44), and “excellent” (45-49). A substantial number of subsequent studies have classified WAI scores within the same scoring intervals.

To identify subjects with a “low” WAI score, we chose to dichotomize scores on the basis of the distribution of the current prospective sample. Average scores below the average 15th percentile [WAI-T1 + WAI-T2]/2 score ranged from 7 to 36 and were defined as “low.” Scores at 37 points or higher were defined as “moderate-high.” A total of 13.1% at baseline and 13.0% at follow-up scored within the low WAI category. A WAI score below 37 points has previously been found predictive of subsequent work disability and long-term sickness absence.

Items of the WAI may be indirectly related to work ability (eg, number of diagnosis) or consequences of work ability (eg, sickness absence). Therefore, in the prospective analyses, we also determined work ability by two single items from the WAI. Perceived work ability, compared with the lifetime best, has previously shown adequate predictive validity. The average [(PWA-T1 + PWA-T2)/2] 15th percentile score in the present cohort was 7.5 (scale ranging from 0 to 10). On the basis of the 15th percentile score of the current prospective sample, and in line with previous publications, PWA scores were dichotomized into “low” (scores 0 to 7) and “moderate-high” (scores 8 to 10).

Work ability prognosis (WAP) assesses the perceived ability to perform the same work in 2 years (response categories: 1, “unlikely”; 2, “not certain”; and 3, “relatively certain”). WAP was dichotomized into “low” (categories 1 and 2) and “high” (category 3).

Psychological, Social, and Mechanical Work Factors
The psychological and social exposures were measured by a validated comprehensive instrument—the General Nordic Questionnaire for psychological and social factors at work (QPSNordic). Psychometric evaluations of QPSNordic have shown high validity and reliability of the scales included in this study. The reliability analysis has been found consistent across a variety of occupational groups. A full list of scale items has been published elsewhere. Responses to items were given on a five-point Likert scale: 1, “very seldom or never”; 2, “somewhat seldom”; 3, “sometimes”; 4, “sometimes or often”; and 5, “very often or always.”

Mechanical exposure was measured with a three-item scale, physical workload, a single item, working with arms raised to or above shoulder level. Physical workload was assessed by measuring the extent to which subjects were lifting or handling objects that weigh approximately 1 to 5 kg, 6 to 15 kg, and more than approximately 15 kg with own muscular strength. Response categories for both of the mechanical exposure measures were as follows: 1, “seldom or never”; 2, “sometimes”; 3, “daily”; and 4, “many times per day.”

To accommodate nonlinear relationships, categorical levels of exposures were computed before entered into exposure-outcome models. As many of the exposure factors were substantially skewed, categorizing scales scores based on the distribution (tertile or quartile splits) would result in grouping together score levels, which may be differentially related to the level of work ability. For instance, by basing categorization on tertiles, scores reflecting lower exposure to role clarity (ie, 1, “very seldom/never”; and 2, “somewhat seldom”) would be grouped together with scores reflecting higher exposure to the same factor (ie, 3, “sometimes”; and 4, “somewhat often”). Therefore, scale scores were categorized on the basis of the absolute values of the factors rather than on the distribution.

To determine associations between changes in levels of exposure and work ability across time, responses to the psychological and social exposure measures were divided into five levels. Only a limited number of respondents reported “extreme” scores (ie, 1 or 5) on all scale items of any of the factors. Hence, some variation within each score group was allowed for; scale scores from 1.00 through 3.00 were coded into five levels.
FIGURE 1. Flow diagram describing the sampling process. 
† Respondents were defined as having completed minimum one exposure measure and minimum one of the three work ability outcome measures. ‡ Respondents were defined as having completed minimum one exposure measure at T1 and minimum one of the three work ability outcome measures twice (at T1 and T2).

1.80 were defined as 1, 1.81 through 2.60 as 2, 2.61 through 3.40 as 3, 3.41 through 4.20 as 4, and 4.21 through 5.00 as 5. Responses to physical workload were divided into four levels; scale scores from 1.00 through 1.50 were defined as 1, 1.51 through 2.50 as 2, 2.51 through 3.50 as 3, and 3.51 through 4.00 as 4.

To identify the differential impact of exposure levels on low work ability, we chose to trichotomize scale score responses because of statistical power issues. Hence, levels 1 and 2 of the psychological and social factors were collapsed and categorized as “low” exposure, level 3 was labeled “middle” exposure, and levels 4 and 5 were collapsed and categorized as “high” exposure. For the measures of mechanical demands, levels 1 and 2 were collapsed and categorized as “low” exposure, level 3 as “middle” exposure, and level 4 as “high” exposure.

Statistical Analysis

Nonresponse and Attrition Analyses

Univariate logistic regression analyses were conducted to estimate effects of age and sex on baseline participation (a nonresponse effect). Univariate analyses were also carried out to explore if age, sex, occupational group, skill level, baseline low work ability (WAI, PWA, and WAP), and the 16 baseline exposure measures (as continuous) predicted participation at follow-up (attrition effect). Significant variables from univariate analyses were controlled for each other in separate multivariate models to identify predictors with independent effects on follow-up participation.

Associations Between Changes in Exposures and Work Ability

Bivariate associations between changes in exposures and changes in the three work ability outcomes were examined by Spearman rank correlation coefficients. Before computing and entering change variables (score-T1 subtracted from score-T2) into bivariate models, thresholds for “change” were set. This was done to avoid categorizing small variations in raw scores from T1 to T2 as “substantial” increase/decrease in work exposure or work ability. For all exposure measures, change was defined as categorical increase/decrease (≥1) from baseline to follow-up. Change in the WAI score has previously been classified as “substantial” when an increase of 3 points or more/a decrease of 10 points or more occurs.30 Because of a shorter time span between baseline and follow-up (>10 years of the study referred to above), we defined change in the WAI by an increase of three points or more/a decrease of three points or more. Change in PWA was defined as one or more points increase/decrease from baseline to follow-up. Likewise, change in WAP was defined as one or more categories increase/decrease from baseline to follow-up.

Identification of Contributors to Low Work Ability

Binary logistic regression analyses were performed to identify contributors to low work ability. Cross-sectional analyses (with baseline sample, T1; and follow-up sample, T2) were run with low WAI score as outcome. Prospective analyses (with prospective sample, T1 and T2) were run with each of the three work ability measures: low WAI, PWA, and WAP as outcomes.
To determine associations between exposure levels and the occurrence of low work ability (ie, low WAI, PWA, and WAP), odds ratios were calculated. The lowest exposure category was set as a reference. This implies that the odds of low work ability by a given exposure category is estimated on the basis of the odds of low work ability given the lowest exposure category.

To evaluate whether effects of categorical variables were dependent on the cut-off points used, binary logistic regressions with the raw scale scores of all psychological, social, and mechanical measures were also conducted.

Statistically significant spurious associations may occur when investigating a large number of exposure-outcome associations. Thus, odds ratios with 99% confidence intervals were applied in all exposure-outcome analyses (threshold for statistical significance was set to $P < 0.01$). Because of multiple testing, statistical significance was also examined by the use of Bonferroni correction (ie, dividing the overall significance level, 0.01, by the number of tested factors, 16).

**Potential Confounders**

Sex, age, and skill level were controlled for in all exposure-outcome analyses. Skill level was determined by recoding the occupational groups (ISCO-88) in accordance with the International Standard for Classification of Education.

Raw baseline work ability scale scores (WAI, PWA, or WAP) were adjusted for in all prospective analyses. Without adjustment, it would be unclear whether low follow-up work ability resulted from higher baseline exposure or a decline in work ability status, which may have preceded baseline measurement. Employees with “suboptimal” work ability (already before baseline) may experience work exposures as more “demanding,” and consequently, report them as higher at the baseline measure compared with employees with more satisfactory work ability. Thus, adjusting for baseline work ability reduces “reverse” effects as a plausible explanation for identified relationships between exposures and outcomes.

The observed effect of each work exposure on work ability may be confounded by the effects of other work exposures. Nevertheless, controlling for all other work exposures would likely result in overadjustment because the scales are intercorrelated.22,23 A strategy described by Rothman et al31 was used to identify influence by the second model was defined as a confounder.31 This procedure was carried out as follows: (1) in a model controlling for baseline work ability, the effect of an exposure on work ability at follow-up was estimated, (2) in a second model, a second exposure was included, and (3) if the effect estimate of the original exposure changed 10% or more from the first model, the added exposure in the second model was defined as a confounder.31 This procedure was carried out for each of the 16 work exposure measures, whereas the other 15 work exposure measures were included in separate models as potential confounders. All statistical analyses were carried out with SPSS version 20.0 (IBM, Armonk, NY).

**RESULTS**

**Nonresponse and Attrition**

Nonresponse analysis showed that subjects in the three middle age groups (30 to 39, 40 to 49, and 50 to 59 years) had significantly higher odds of responding in comparison to the lowest age group (<30 years) (Table 1). Being in the oldest age group (>59 years) was not predictive of baseline participation. Likewise, sex was not significantly predictive of responding at baseline.

Multivariate analysis revealed that age, occupational group, and skill level were predictive of follow-up participation for baseline respondents (Table 1). Low work ability at baseline (WAI, PWA, or WAP) did not significantly predict follow-up participation. Of the work exposures, higher baseline social climate and physical workload, and lower baseline role clarity were associated with increased odds of follow-up participation.

A decrease in the WAI (≥3 points), PWA (≥1 point), and WAP (≥1 category) from baseline to follow-up was reported by 598 (27.6%), 1090 (29.1%), and 162 (5.2%) subjects, respectively. In contrast, an increase in the WAI (≥3 points), PWA (≥1 point), and WAP (≥1 category) from baseline to follow-up was reported by 375 (17.3%), 1076 (28.7%), and 108 (3.5%) subjects, respectively.

Bivariate rank-correlation analysis showed that changes in 8 of the 16 exposures correlated significantly ($P < 0.01$) with changes in the WAI and PWA (Table 2). Of these, role conflict, support from immediate superior, and fair leadership also correlated significantly with changes in WAP. Changes in mechanical exposures (physical workload, working with arms to/above shoulder level) did not correlate significantly with changes in any of the work ability outcomes ($P > 0.01$).

**Cross-Sectional Associations**

All exposures except control over work intensity, decision demands, and innovative climate were associated with the low WAI in both the baseline and follow-up samples (see Supplemental Digital Content, Appendix 2, http://links.lww.com/JOM/A181). Significant odds ratios (99% confidence interval) ranged from 0.22 (high level of social climate) to 3.09 (high level of role conflict) in the baseline sample and from 0.25 (high level of positive challenge) to 3.07 (high level of role conflict) in the follow-up sample.

With a Bonferroni-corrected significance level, quantitative demands (at both time points), support from immediate superior (at follow-up), and working with arms raised to/above shoulder level (at follow-up) were not found significant ($P > 0.0006$).

**Prospective Associations**

**Work Ability Index**

The low follow-up WAI score was predicted by baseline levels of decision demands, role conflict, and positive challenge ($P < 0.01$) (Table 3). In the analyses with exposures averaged across time [(exposure-T1 + exposure-T2)/2], the above-mentioned exposures as well as role clarity, support from immediate superior, empowering leadership, fair leadership, social climate, and human resource primacy were predictive of the low WAI at follow-up. After Bonferroni correction of the significance level, role conflict (at baseline and averaged across time), role clarity, positive challenge, empowering leadership, fair leadership, and social climate (all averaged across time) remained significant ($P < 0.0006$).

**Perceived Work Ability**

Low follow-up PWA was predicted by baseline and average exposure levels of role clarity, role conflict, and human resource primacy ($P < 0.01$) (Table 4). An average level of positive challenge was also predictive. After Bonferroni correction, all predictors except fair leadership, as baseline exposure, remained significant ($P < 0.0006$).

**Work Ability Prognosis**

In the analyses of low follow-up WAP, higher baseline levels of control over work intensity, and human resource primacy were found predictive ($P < 0.01$) (Table 5). In terms of exposures averaged across time, these two factors, role conflict, positive challenge, and social climate were identified as significant predictors. With the Bonferroni-corrected significance level, only role conflict and human resource primacy (both averaged across time) remained significant.

Overall, the most consistent predictors of any follow-up work ability outcome (WAI, PWA, and WAP) were role conflict, human...
### TABLE 1. Sample Characteristics and Estimated Nonresponse and Attrition Bias

|                              | Invited to the First Survey (N = 12,603) | Invited to the First and Second surveys (N = 9304) |
|------------------------------|--------------------------------------------|---------------------------------------------------|
|                              | Respondents at Baseline<sup>a</sup> (n = 6774) | Nonresponders at Baseline (n = 5829) | Nonresponse Analysis OR (95% CI) | Respondents at the First and Second surveys<sup>b</sup> (n = 3779) | Dropouts (n = 1853) | Attrition Analysis<sup>c</sup> OR (95% CI) |
| **Sex**                      |                                            |                                                  |                              |                                                               |                                                     |
| Male                         | 2648 (39.1)                                | 2035 (34.9)                                     | 1 (reference)                 | 1529 (40.5)                                                    | 675 (36.4)                                            | 1 (reference)                                             |
| Female                       | 4123 (60.9)                                | 3266 (56.0)                                     | 0.97 (0.90–1.04)              | 2250 (59.5)                                                    | 1178 (63.6)                                           | 0.96 (0.82–1.13)                                          |
| Missing data                 | 3 (0.0)                                    | 528 (9.1)                                       | 0.97 (0.90–1.04)              | 2250 (59.5)                                                    | 1178 (63.6)                                           | 0.96 (0.82–1.13)                                          |
| **Age, yrs, mean (SD)**      |                                            |                                                  |                              |                                                               |                                                     |
| <30                          | 44.3 (10.7)                                | 44.0 (11.8)                                     | 1 (reference)                 | 45.1 (4.8)                                                    | 44.4 (10.6)                                           |                                                     |
| 30–39                        | 612 (9.0)                                  | 669 (11.5)                                      | 1 (reference)                 | 239 (6.3)                                                     | 168 (9.1)                                             | 1 (reference)                                             |
| 40–49                        | 1766 (26.1)                                | 1309 (22.5)                                     | 1.47 (1.29–1.68)<sup>*</sup>  | 939 (24.8)                                                    | 474 (25.6)                                            | 1.33 (0.99–1.78)                                          |
| 50–59                        | 2070 (30.6)                                | 1433 (24.6)                                     | 1.58 (1.39–1.80)<sup>*</sup>  | 1242 (32.9)                                                    | 558 (30.1)                                            | 1.54 (1.15–2.06)<sup>*</sup>                             |
| >59                          | 1768 (26.1)                                | 1301 (22.3)                                     | 1.49 (1.30–1.69)<sup>*</sup>  | 1090 (28.8)                                                    | 515 (27.8)                                            | 1.61 (1.20–2.18)<sup>*</sup>                             |
| Missing data                 | 555 (8.2)                                  | 594 (10.2)                                      | 1.02 (0.87–1.20)              | 269 (7.1)                                                     | 138 (7.4)                                             | 1.56 (1.04–2.35)<sup>*</sup>                             |
| **Classification of occupation** |                                            |                                                  |                              |                                                               |                                                     |
| Legislators, senior officials, and managers | 640 (9.4)                                  | –                                                | –                            | 420 (11.1)                                                    | 123 (6.6)                                             | 1 (reference)                                             |
| Professionals                | 1812 (26.7)                                | –                                                | –                            | 1063 (28.1)                                                    | 411 (22.2)                                            | 0.96 (0.70–1.30)                                          |
| Technicians and associate professionals | 2345 (34.6)                                | –                                                | –                            | 1278 (33.8)                                                   | 693 (37.4)                                            | 0.68 (0.50–0.91)<sup>*</sup>                             |
| Clerks                       | 554 (8.2)                                  | –                                                | –                            | 292 (7.7)                                                     | 178 (9.6)                                             | 0.59 (0.41–0.86)<sup>*</sup>                             |
| Service workers and shop and market sales workers | 1146 (16.9)                                | –                                                | –                            | 592 (15.7)                                                    | 347 (18.7)                                            | 0.66 (0.46–0.94)<sup>*</sup>                             |
| Skilled agricultural and fishery workers | 2 (0.0)                                    | –                                                | –                            | 1 (0.0)                                                       | 1 (0.1)                                               | 0.37 (0.02–6.20)                                          |
| Craft and related trades workers | 85 (1.3)                                   | –                                                | –                            | 43 (1.1)                                                      | 24 (1.3)                                              | 0.54 (0.26–1.10)                                          |
| Plant and machine operators and assemblers | 12 (0.2)                                   | –                                                | –                            | 1 (0.0)                                                       | 9 (0.5)                                               | –                                                        |
| Elementary occupations       | 94 (1.4)                                   | –                                                | –                            | 51 (1.3)                                                       | 30 (1.6)                                              | 0.52 (0.26–1.06)                                          |
| Armed forces and unspecified | 3 (0.0)                                    | –                                                | –                            | 2 (0.1)                                                       | 1 (0.1)                                               | –                                                        |
| Missing data                 | 81 (1.2)                                   | –                                                | –                            | 36 (1.0)                                                      | 36 (1.9)                                              | –                                                        |
| **Skill level**              |                                            |                                                  |                              |                                                               |                                                     |
| Competence equivalent to ≥4 yrs of higher education (>15 yrs) | 1812 (26.7) | – | – | 1063 (28.1) | 411 (22.2) | 1 (reference) |
| Competence equivalent to 1–3 yrs of higher education (13–15 yrs) | 2345 (34.6) | – | – | 1278 (33.8) | 693 (37.4) | 0.70 (0.57–0.86)<sup>*</sup> |
| Competence equivalent to high school (10–12 yrs) | 1799 (26.6) | – | – | 929 (24.6) | 559 (30.2) | 0.63 (0.50–0.81)<sup>*</sup> |
| Occupations that do not require high school (<10 yrs) | 94 (1.4) | – | – | 51 (1.3) | 30 (1.6) | 0.54 (0.27–1.06) |
| Occupations with unspecified requirements for competence | 643 (9.5) | – | – | 422 (11.2) | 124 (6.7) | 1.06 (0.78–1.44) |
| Missing data                 | 81 (1.2)                                   | –                                                | –                            | 36 (1.0)                                                      | 36 (1.9)                                              | –                                                        |
| **The work ability index, mean (SD)** | 41.8 (4.9) | – | – | 41.9 (4.8) | 41.5 (5.0) | – |

(continues)
### TABLE 1.  (Continued)

| Invited to the First Survey (N = 12,603) | Invited to the First and Second surveys (N = 9304) |
|----------------------------------------|---------------------------------------------------|
| Respondents at Baseline<sup>a</sup>  (n = 6774) | Nonresponders at Baseline<sup>a</sup> (n = 5829) | Nonresponse Analysis | Respondents at the First and Second surveys<sup>b</sup> (n = 3779) | Dropouts (n = 1853) | Attrition Analysis<sup>c</sup> |
| n (%) | n (%) OR (95% CI) | n (%) OR (95% CI) | n (%) | n (%) OR (95% CI) |
|---|---|---|---|---|
| Low (<37 points) | 645 (9.5) | 340 (9.0) | 204 (11.0) | 1 (reference) |
| Moderate/high (≥37 points) | 4262 (62.9) | 2444 (64.7) | 1101 (59.4) | 1.16 (0.97–1.45) |
| Missing data | 1867 (27.6) | 995 (26.3) | 548 (29.6) |  |
| Perceived work ability, mean (SD) | 8.5 (1.7) | 8.6 (1.6) | 8.5 (1.7) | 1 (reference) |
| Low (<8 points) | 1204 (17.8) | 626 (16.6) | 352 (19.0) | 1 (reference) |
| Moderate/high (≥8 points) | 5545 (81.9) | 3144 (83.2) | 1491 (80.5) | 1.15 (0.97–1.37) |
| Missing data | 25 (0.4) | 9 (0.2) | 10 (0.5) |  |
| Work ability prognosis, mean (SD) | 2.9 (0.3) | 2.9 (0.3) | 2.9 (0.3) |  |
| Low (categories 1 and 2) | 469 (6.9) | 213 (5.6) | 145 (7.8) | 1 (reference) |
| High (category 3) | 5593 (82.6) | 3174 (84.0) | 1504 (81.2) | 1.20 (0.92–1.58) |
| Missing data | 712 (10.5) | 392 (10.4) | 204 (11.0) |  |
| Exposures, mean (SD) | | | | |
| Decision demands | 3.5 (0.7) | 3.5 (0.7) | 3.5 (0.7) | 0.96 (0.85–1.08) |
| Quantitative demands | 3.0 (0.8) | 3.0 (0.7) | 2.9 (0.8) | 0.96 (0.86–1.07) |
| Role clarity | 4.3 (0.7) | 4.3 (0.7) | 4.3 (0.7) | 0.85 (0.75–0.95)* |
| Role conflict | 2.5 (0.8) | 2.4 (0.8) | 2.4 (0.8) | 1.02 (0.91–1.14) |
| Positive challenge | 4.0 (0.8) | 4.0 (0.8) | 4.0 (0.8) | 1.03 (0.91–1.16) |
| Control over work intensity | 3.3 (1.1) | 3.4 (1.0) | 3.2 (1.0) | 1.09 (0.99–1.19) |
| Decision control | 3.0 (0.8) | 3.1 (0.8) | 3.0 (0.8) | 1.10 (0.98–1.25) |
| Predictability during the next month | 4.2 (0.7) | 4.3 (0.7) | 4.2 (0.8) | 1.04 (0.93–1.16) |
| Support from immediate superior | 3.9 (0.9) | 3.9 (0.9) | 3.9 (0.9) | 1.04 (0.91–1.19) |
| Empowering leadership | 3.1 (1.0) | 3.2 (1.0) | 3.1 (1.0) | 1.03 (0.93–1.14) |
| Fair leadership | 3.9 (0.9) | 4.0 (0.8) | 3.9 (0.9) | 1.10 (0.98–1.24) |
| Innovative climate | 3.6 (0.8) | 3.7 (0.7) | 3.6 (0.8) | 0.95 (0.82–1.10) |
| Social climate | 3.8 (0.7) | 3.8 (0.7) | 3.8 (0.8) | 1.17 (1.03–1.34)* |
| Human resource primacy | 3.1 (0.9) | 3.1 (0.9) | 3.1 (0.9) | 0.89 (0.80–1.00) |
| Physical workload | 1.6 (0.8) | 1.6 (0.8) | 1.7 (0.8) | 1.18 (1.05–1.33)* |
| Working with arms raised to or above shoulder level | 1.5 (0.8) | 1.5 (0.8) | 1.5 (0.9) | 0.98 (0.88–1.10) |

<sup>a</sup>Completed minimum one exposure measure and minimum one of the three work ability outcome measures.

<sup>b</sup>Completed minimum one exposure measure at baseline and minimum one of the three work ability outcome measures twice (at baseline and follow-up).

<sup>c</sup>Adjusted for variables found significant (<i>P</i> < 0.05) in univariate attrition analysis.

*<i>P</i> < 0.05.

CI, confidence interval; OR, odds ratio; SD, standard deviation.
resource primacy, and positive challenge, whereas the first two were statistically significant in 5 of the 6, and the latter in 4 of the 6 regression analyses, respectively. Mechanical exposures (physical workload and working with arms to/above shoulder level) were not significant predictors in any of the prospective analyses.

**DISCUSSION**

This study demonstrated that several psychological and social work factors contribute to self-reported work ability. *Role conflict, human resource primacy, and positive challenge* were the most consistent contributors and showed both temporal and longitudinal associations with the level of work ability.

*Role conflict* (conflicting role expectations) was a consistent risk factor to the level of work ability (all three outcomes). To our knowledge, this is the first study to uncover the effects of this specific exposure on work ability. Some studies have implicated conflicting expectations in composite measures of job demands. Of note, a recent cross-sectional study failed to find significant associations between role demands (measured by questions on time constraints and conflicting expectations) and self-reported work ability in different national samples. The occurrence of time constraints (in terms of quantitative demands) was not predictive in any of our analyses. Thus, the present results clearly suggest that levels of time constraints and conflicting expectations have differential impact on work ability.

Independent of estimated confounders (ie, supervisor support and level of social climate), our analysis revealed that *role clarity* (clarity of expectations at work) had a protective role of the WAI score. This is in agreement with Tuomi et al who found that role ambiguity was linked with a decline in the WAI score among aging municipal workers. We also found *role clarity* protective of perceived current work ability (PWA). Nevertheless, this did not pertain to work ability prognosis (WAP). Thus, perceptions of future ability to perform work do not seem to be influenced by clarity of role expectations.

The overall contribution of influence at work, use of special skills, and meaningfulness at work has repeatedly been investigated with single measures. These aspects may have differential impact on work ability. By disentangling the effects of what we would argue to be two different constructs (ie, decision demands and positive challenge), we did not find decision demands significant to all work ability outcomes. Positive challenge on the other hand (ie, usefulness of skills and meaningfulness of work) was a consistent protective factor. The relatively strong relationship between this factor and the level of work ability may not be surprising. In fact, it has been argued that usefulness of skills and knowledge represents an integral part of the ability to perform work.

Supervisory support has not unequivocally shown contributions to work ability in previous studies. For instance, improved supervisor–employee cooperation was only predictive of improvements in the WAI score among municipal workers with physically challenging work. McGonagle et al reported that supervisor support correlated substantially with work ability perceptions in only one of the six examined cross-national samples. This study did not find that *support from immediate superior* was statistically significantly associated with the WAI score in the cross-sectional samples. Nevertheless, the average high level of *support from the immediate superior* over time was predictive of the WAI and PWA at follow-up. Given that the level of support was constant across the 2-year follow-up period, this finding suggests that certain exposure effects are substantive only after a relatively extensive exposure period.

Organizational communicated interest in employee well-being has been found relevant to outcomes such as job satisfaction, long-term sick leave, and health perceptions. In this study, *human resource primacy* was identified as a prominent protective factor of the level of work ability (all three outcomes). Nevertheless, organizational focus on human resources has previously received limited attention in research of self-reported work ability. One notable exception is a cohort study among metal industry workers in Finland.

### TABLE 2. Bivariate Spearman Rank Correlations Between Changes in Exposures* and Changes in Each of the Work Ability Outcomesb (WAI, PWA, and WAP) from Baseline to Follow-Up (n = 92 to 1266)

| Δ Exposure                                      | Δ WAI       | Δ PWA       | Δ WAP       |
|------------------------------------------------|-------------|-------------|-------------|
| Δ Decision demands                             | −0.02       | −0.02       | −0.07       |
| Δ Quantitative demands                         | −0.06       | −0.09*      | −0.21       |
| Δ Role clarity                                 | 0.10        | 0.14*       | 0.10        |
| Δ Role conflict                                | −0.13*      | −0.11*      | −0.24*      |
| Δ Positive challenge                           | 0.17*       | 0.12*       | 0.22        |
| Δ Control over work intensity                  | 0.04        | 0.01        | −0.01       |
| Δ Decision control                             | 0.06        | 0.06        | 0.06        |
| Δ Predictability during the next month         | 0.04        | 0.09        | 0.01        |
| Δ Support from immediate superior              | 0.20*       | 0.18*       | 0.23*       |
| Δ Empowering leadership                        | 0.15*       | 0.16*       | 0.17        |
| Δ Fair leadership                              | 0.22*       | 0.20*       | 0.24*       |
| Δ Innovative climate                           | 0.13*       | 0.17*       | 0.06        |
| Δ Social climate                               | 0.23*       | 0.13*       | 0.19        |
| Δ Human resource primacy                       | 0.17*       | 0.18*       | 0.16        |
| Δ Physical workload°                           | −0.08       | −0.02       | −0.09       |
| Δ Working with arms raised to or above shoulder level° | −0.06       | −0.09       | −0.23       |

*Δ Change was calculated by subtracting the baseline categorical score (1 to 5) from the follow-up categorical score (1 to 5).

*Δ Change was calculated by subtracting the obtained baseline score from the obtained follow-up score. Δ WAI ≥ ±3 points; Δ PWA ≥ ±1 point; Δ WAP ≥ ±1 category.

*P < 0.01.

TWA, perceived work ability; WAI, work ability index; WAP, work ability prognosis.
TABLE 3. Prospective Analysis: Psychological, Social, and Mechanical Factors as Independent Variables and Low WAI (<37 points) at Follow-Up as Outcome—Binary Logistic Regressions, Odds Ratios Adjusted for Baseline WAI

| Work Exposure                  | Confounders Included\(^a\) | Baseline Exposure as Predictor | Average Exposure as Predictor\(^b\) |
|-------------------------------|-----------------------------|--------------------------------|-------------------------------------|
|                               |                             | \(n\) | OR (99% CI) | \(n\) | OR (99% CI) |
| **Decision demands**          |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 165  | 1 (reference) | 159  | 1 (reference) |
| Middle                        |                             | 833  | 0.50 (0.26–0.96)* | 714  | 0.50 (0.26–0.96)* |
| High                          |                             | 1064 | 0.61 (0.32–1.16) | 1120 | 0.62 (0.33–1.16) |
| Continuous                    |                             | 2062 | 0.84 (0.64–1.10) | 1993 | 0.84 (0.62–1.14) |
| **Quantitative demands**      |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 672  | 1 (reference) | 548  | 1 (reference) |
| Middle                        |                             | 817  | 1.37 (0.87–2.17) | 1020 | 0.98 (0.62–1.55) |
| High                          |                             | 627  | 1.55 (0.95–2.53) | 507  | 1.56 (0.93–2.64) |
| Continuous                    |                             | 2116 | 1.25 (0.97–1.61) | 2075 | 1.31 (0.98–1.74) |
| **Role clarity**              |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 61   | 1 (reference) | 42   | 1 (reference) |
| Middle                        |                             | 225  | 0.75 (0.27–2.04) | 173  | 0.50 (0.16–1.49) |
| High                          |                             | 1845 | 0.57 (0.23–1.39) | 1906 | 0.29 (0.11–0.79)* |
| Continuous                    |                             | 2131 | 0.81 (0.64–1.03) | 2121 | 0.68 (0.52–0.90)** |
| **Role conflict**             |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 1124 | 1 (reference) | 1258 | 1 (reference) |
| Middle                        |                             | 818  | 1.38 (0.93–2.07) | 708  | 1.30 (0.87–1.95) |
| High                          |                             | 188  | 2.29 (1.28–4.12)** | 156  | 2.92 (1.59–5.38)** |
| Continuous                    |                             | 2130 | 1.42 (1.12–1.80)** | 2122 | 1.51 (1.15–2.00)** |
| **Positive challenge**        |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 65   | 1 (reference) | 54   | 1 (reference) |
| Middle                        |                             | 298  | 0.42 (0.17–1.04) | 247  | 0.45 (0.17–1.17) |
| High                          |                             | 1658 | 0.35 (0.15–0.80)* | 1639 | 0.26 (0.11–0.64)** |
| Continuous                    |                             | 2021 | 0.75 (0.58–0.96)* | 1940 | 0.58 (0.44–0.78)** |
| **Control over work intensity** |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 525  | 1 (reference) | 494  | 1 (reference) |
| Middle                        |                             | 389  | 0.72 (0.40–1.29) | 450  | 0.74 (0.43–1.30) |
| High                          |                             | 1214 | 0.98 (0.60–1.59) | 1164 | 0.95 (0.57–1.57) |
| Continuous                    |                             | 2128 | 1.01 (0.83–1.22) | 2108 | 0.99 (0.81–1.22) |
| **Decision control**          |                             |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 653  | 1 (reference) | 555  | 1 (reference) |
| Middle                        |                             | 774  | 0.99 (0.63–1.55) | 806  | 0.83 (0.53–1.31) |
| High                          |                             | 615  | 1.14 (0.69–1.89) | 628  | 0.89 (0.52–1.52) |
| Continuous                    |                             | 2042 | 0.97 (0.75–1.26) | 1989 | 0.90 (0.67–1.20) |
| **Predictability during the next month** |                   |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 67   | 1 (reference) | 40   | 1 (reference) |
| Middle                        |                             | 183  | 0.62 (0.20–1.94) | 160  | 0.55 (0.16–1.92) |
| High                          |                             | 1888 | 0.85 (0.32–2.25) | 1926 | 0.44 (0.15–1.33) |
| Continuous                    |                             | 2138 | 0.94 (0.73–1.21) | 2126 | 0.86 (0.64–1.16) |
| **Support from immediate superior** |                          |      |            |      |            |
|                              |                             |      |            |      |            |
| Category                      |                             |      |            |      |            |
| Low                           |                             | 166  | 1 (reference) | 127  | 1 (reference) |

(continues)
| Work Exposure                  | Confounders Included | Baseline Exposure as Predictor | Average Exposure as Predictor |
|-------------------------------|----------------------|--------------------------------|------------------------------|
|                               |                      | n     | OR (99% CI)     | n     | OR (99% CI)     |
| Work exposure                |                      |       |                 |       |                 |
| Middle                        | Social climate       | 401   | 0.91 (0.42–1.95) | 380   | 0.49 (0.23–1.05) |
| High                          | Fair leadership      | 1499  | 0.89 (0.41–1.96) | 1473  | 0.40 (0.18–0.89)* |
| Continuous                    |                      | 2066  | 0.87 (0.65–1.15) | 1980  | 0.72 (0.50–1.02) |
| Empowering leadership         |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 505   | 1 (reference)   | 515   | 1 (reference)   |
| Middle                        |                      | 714   | 0.87 (0.56–1.37) | 688   | 0.69 (0.44–1.08) |
| High                          |                      | 913   | 0.74 (0.46–1.18) | 914   | 0.59 (0.37–0.94)* |
| Continuous                    |                      | 2132  | 0.88 (0.74–1.06) | 2117  | 0.75 (0.61–0.92)** |
| Fair leadership               |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 126   | 1 (reference)   | 101   | 1 (reference)   |
| Middle                        |                      | 398   | 0.61 (0.30–1.26) | 315   | 0.71 (0.32–1.53) |
| High                          |                      | 1596  | 0.54 (0.29–1.02) | 1668  | 0.41 (0.21–0.83)* |
| Continuous                    |                      | 2120  | 0.81 (0.66–1.01) | 2084  | 0.64 (0.50–0.81)** |
| Innovative climate            |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           | Positive challenge   | 125   | 1 (reference)   | 94    | 1 (reference)   |
| Middle                        | Support from immediate superior | 570 | 1.73 (0.77–3.88) | 469 | 1.05 (0.43–2.56) |
| High                          | Fair leadership      | 1211  | 1.58 (0.66–3.82) | 1176  | 1.22 (0.46–3.23) |
| Continuous                    | Social climate       | 1906  | 1.27 (0.87–1.86) | 1739  | 1.55 (0.95–2.54) |
| Social climate                |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 89    | 1 (reference)   | 77    | 1 (reference)   |
| Middle                        |                      | 509   | 0.83 (0.38–1.83) | 395   | 0.83 (0.35–1.94) |
| High                          |                      | 1520  | 0.62 (0.29–1.33) | 1613  | 0.55 (0.25–1.24) |
| Continuous                    |                      | 2118  | 0.89 (0.69–1.15) | 2085  | 0.66 (0.50–0.89)** |
| Human resource primacy        |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 470   | 1 (reference)   | 471   | 1 (reference)   |
| Middle                        |                      | 799   | 0.88 (0.56–1.39) | 742   | 0.62 (0.39–0.99)* |
| High                          |                      | 784   | 0.72 (0.43–1.19) | 784   | 0.57 (0.35–0.93)* |
| Continuous                    |                      | 2053  | 0.84 (0.67–1.04) | 1997  | 0.73 (0.57–0.94)* |
| Physical workload             |                      |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 1268  | 1 (reference)   | 1300  | 1 (reference)   |
| Middle                        |                      | 517   | 1.11 (0.70–1.76) | 483   | 1.32 (0.83–2.10) |
| High                          |                      | 318   | 0.99 (0.54–1.81) | 285   | 1.20 (0.64–2.26) |
| Continuous                    |                      | 2103  | 1.04 (0.80–1.34) | 2068  | 1.13 (0.85–1.49) |
| Working with arms raised to or above shoulder level | |       |                 |       |                 |
| Category                      |                      |       |                 |       |                 |
| Low                           |                      | 1399  | 1 (reference)   | 1553  | 1 (reference)   |
| Middle                        |                      | 486   | 1.38 (0.88–2.15) | 407   | 1.24 (0.78–2.00) |
| High                          |                      | 247   | 0.99 (0.53–1.86) | 160   | 0.98 (0.47–2.04) |
| Continuous                    |                      | 2132  | 1.06 (0.83–1.36) | 2120  | 1.12 (0.84–1.49) |

*aAge, sex, skill level, and baseline WAI adjusted for in all analyses.
*bExposure averaged across time [(T1 + T2)/2].

*P < 0.01.

**P < 0.0006; Bonferroni-corrected significance level (0.01/16).

CI, confidence interval; OR, odds ratio; WAI, work ability index.
### TABLE 4. Prospective Analysis: Psychological, Social, and Mechanical Factors as Independent Variables and Perceived Low Work Ability (PWA, <8 points) at Follow-Up as Outcome—Binary Logistic Regressions, Odds Ratios Adjusted for Baseline PWA

| Work Exposure                  | Baseline Exposure as Predictor | Average Exposure as Predictor<sup>b</sup> |
|-------------------------------|--------------------------------|-----------------------------------------|
|                               | n                              | OR (99% CI)                             | n          | OR (99% CI) |
| **Decision demands**          |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 281                            | 1 (reference)                          | 260        | 1 (reference) |
| Middle Positive challenge     | 1371                           | 1.05 (0.65–1.71)                       | 1130       | 1.10 (0.66–1.84) |
| High                          | 1728                           | 1.04 (0.64–1.71)                       | 1746       | 1.10 (0.66–1.84) |
| Continuous                    | 3380                           | 1.00 (0.82–1.21)                       | 3136       | 1.06 (0.84–1.35) |
| **Quantitative demands**      |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 1110                           | 1 (reference)                          | 910        | 1 (reference) |
| Middle                        | 1457                           | 1.03 (0.76–1.39)                       | 1752       | 0.89 (0.66–1.20) |
| High                          | 1049                           | 1.11 (0.81–1.54)                       | 861        | 1.03 (0.73–1.47) |
| Continuous                    | 3616                           | 1.06 (0.90–1.26)                       | 3523       | 1.07 (0.89–1.30) |
| **Role clarity**              |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 103                            | 1 (reference)                          | 69         | 1 (reference) |
| Middle                        | 393                            | 1.12 (0.55–2.26)                       | 300        | 0.51 (0.23–1.11) |
| High                          | 3183                           | 0.70 (0.36–1.33)                       | 3283       | 0.36 (0.18–0.73)** |
| Continuous                    | 3679                           | 0.77 (0.65–0.91)**                     | 3652       | 0.66 (0.55–0.79)** |
| **Role conflict**             |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 1909                           | 1 (reference)                          | 2135       | 1 (reference) |
| Middle                        | 1462                           | 1.27 (0.98–1.65)                       | 1244       | 1.46 (1.12–1.90)** |
| High                          | 302                            | 2.13 (1.43–3.17)**                     | 254        | 2.45 (1.60–3.74)** |
| Continuous                    | 3673                           | 1.32 (1.12–1.55)**                     | 3633       | 1.49 (1.23–1.79)** |
| **Positive challenge**        |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      | Human resource primacy         |                                        |            |            |
| Low                           | 115                            | 1 (reference)                          | 94         | 1 (reference) |
| Middle                        | 506                            | 0.89 (0.46–1.71)                       | 376        | 0.84 (0.42–1.70) |
| High                          | 2629                           | 0.61 (0.33–1.13)                       | 2504       | 0.45 (0.23–0.88)** |
| Continuous                    | 3250                           | 0.84 (0.70–1.00)                       | 2974       | 0.70 (0.56–0.87)** |
| **Control over work intensity**|                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 918                            | 1 (reference)                          | 845        | 1 (reference) |
| Middle                        | 691                            | 0.78 (0.54–1.12)                       | 786        | 0.73 (0.51–1.05) |
| High                          | 2049                           | 0.78 (0.57–1.06)                       | 1974       | 0.76 (0.55–1.05) |
| Continuous                    | 3658                           | 0.92 (0.81–1.04)                       | 3605       | 0.89 (0.77–1.02) |
| **Decision control**          |                                |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      |                                |                                        |            |            |
| Low                           | 1087                           | 1 (reference)                          | 916        | 1 (reference) |
| Middle                        | 1358                           | 0.98 (0.73–1.31)                       | 1383       | 0.89 (0.65–1.21) |
| High                          | 1015                           | 0.83 (0.59–1.18)                       | 1028       | 0.73 (0.51–1.05) |
| Continuous                    | 3460                           | 0.92 (0.77–1.10)                       | 3327       | 0.83 (0.68–1.02) |
| **Predictability during the next month** |                  |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      | Role conflict                  |                                        |            |            |
| Low                           | 84                             | 1 (reference)                          | 43         | 1 (reference) |
| Middle                        | 275                            | 0.87 (0.34–2.20)                       | 208        | 0.67 (0.21–2.15) |
| High                          | 2828                           | 2.84 (0.54–2.34)                       | 2630       | 1.00 (0.35–2.88) |
| Continuous                    | 3187                           | 1.08 (0.88–1.32)                       | 2881       | 1.10 (0.85–1.42) |
| **Support from immediate superior** |                            |                                        |            |            |
| Confounders Included          |                                |                                        |            |            |
| Category                      | Human resource primacy         |                                        |            |            |
| Low                           | 284                            | 1 (reference)                          | 220        | 1 (reference) |
| Middle                        | 719                            | 0.90 (0.56–1.44)                       | 635        | 0.94 (0.57–1.55)** |

(continues)
| Work Exposure                                      | Confounders Included\(^a\) | Baseline Exposure as Predictor | Average Exposure as Predictor\(^b\) |
|--------------------------------------------------|------------------------------|---------------------------------|--------------------------------------|
|                                                  |                              | \(n\)                           | \(OR (99\% CI)\)                      | \(n\)                           | \(OR (99\% CI)\)                      |
| High                                             |                              | 2417                            | 0.93 (0.59–1.47)                     | 2365                            | 0.69 (0.42–1.14)                     |
| Continuous                                       |                              | 3420                            | 0.97 (0.82–1.14)                     | 3220                            | 0.84 (0.69–1.04)                     |
| Empowering leadership                            |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              | Human resource primacy       | 841                             | 1 (reference)                        | 812                             | 1 (reference)                        |
| Middle                                           |                              | 1182                            | 1.28 (0.92–1.79)                     | 1064                            | 1.01 (0.72–1.41)                     |
| High                                             |                              | 1419                            | 1.09 (0.75–1.58)                     | 1383                            | 0.86 (0.58–1.27)                     |
| Continuous                                       |                              | 3442                            | 1.05 (0.90–1.22)                     | 3259                            | 0.98 (0.81–1.19)                     |
| Fair leadership                                  |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              |                                 | 212                             | 1 (reference)                        | 170                             | 1 (reference)                        |
| Middle                                           |                                 | 683                             | 1.00 (0.59–1.68)                     | 554                             | 0.69 (0.41–1.19)                     |
| High                                             |                                 | 2736                            | 0.84 (0.52–1.35)                     | 2825                            | 0.44 (0.27–0.72)***                  |
| Continuous                                       |                                 | 3631                            | 0.83 (0.72–0.96)*                    | 3549                            | 0.66 (0.56–0.78)****                 |
| Innovative climate                               |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              | Support from immediate superior| 222                             | 1 (reference)                        | 194                             | 1 (reference)                        |
| Middle                                           |                                 | 1087                            | 1.15 (0.69–1.94)                     | 901                             | 1.22 (0.71–2.11)                     |
| High                                             | Human resource primacy        | 2092                            | 1.12 (0.65–1.93)                     | 2084                            | 1.03 (0.58–1.84)                     |
| Continuous                                       |                              | 3401                            | 1.05 (0.84–1.30)                     | 3179                            | 1.00 (0.76–1.30)                     |
| Social climate                                   |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              | Empowering leadership         | 158                             | 1 (reference)                        | 122                             | 1 (reference)                        |
| Middle                                           |                                 | 843                             | 0.83 (0.48–1.46)                     | 645                             | 0.79 (0.43–1.47)                     |
| High                                             |                                 | 2412                            | 0.75 (0.43–1.31)                     | 2444                            | 0.72 (0.39–1.32)                     |
| Continuous                                       |                                 | 3413                            | 0.92 (0.75–1.12)                     | 3211                            | 0.79 (0.62–1.01)                     |
| Human resource primacy                           |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              |                                 | 820                             | 1 (reference)                        | 783                             | 1 (reference)                        |
| Middle                                           |                                 | 1367                            | 0.72 (0.53–0.97)*                    | 1260                            | 0.62 (0.45–0.84)***                 |
| High                                             |                                 | 1288                            | 0.58 (0.42–0.80)**                   | 1272                            | 0.51 (0.36–0.70)**                   |
| Continuous                                       |                                 | 3475                            | 0.78 (0.68–0.90)**                   | 3315                            | 0.69 (0.58–0.81)***                 |
| Physical workload                                 |                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              |                                 | 2252                            | 1 (reference)                        | 2316                            | 1 (reference)                        |
| Middle                                           |                                 | 892                             | 0.97 (0.72–1.32)                     | 802                             | 1.19 (0.88–1.63)                     |
| High                                             |                                 | 487                             | 1.08 (0.72–1.62)                     | 424                             | 1.16 (0.75–1.79)                     |
| Continuous                                       |                                 | 3631                            | 1.03 (0.86–1.23)                     | 3542                            | 1.11 (0.92–1.34)                     |
| Working with arms raised to or above shoulder level|                              |                                 |                                      |                                 |                                 |
| Category                                         |                              |                                 |                                      |                                 |                                 |
| Low                                              |                                 | 2482                            | 1 (reference)                        | 2703                            | 1 (reference)                        |
| Middle                                           |                                 | 783                             | 1.21 (0.89–1.63)                     | 679                             | 1.17 (0.85–1.61)                     |
| High                                             |                                 | 415                             | 1.00 (0.66–1.52)                     | 263                             | 1.09 (0.66–1.80)                     |
| Continuous                                       |                                 | 3680                            | 1.03 (0.88–1.22)                     | 3645                            | 1.09 (0.90–1.33)                     |

\(^a\)Age, sex, skill level, and baseline level of perceived work ability adjusted for in all analysis.

\(^b\)Exposure averaged across time \([T1 + T2]/2\).

\(^*\)P < 0.01.

\(^**\)P < 0.0006; Bonferroni-corrected significance level (0.01/16); the reference exposure category.

CI, confidence interval; OR, odds ratio.
### TABLE 5. Prospective Analysis: Psychological, Social, and Mechanical Factors as Independent Variables and Low Work Ability Prognosis (Categories 1 and 2) at Follow-Up as Outcome—Binary Logistic Regressions, Odds Ratios Adjusted for Baseline WAP

| Work Exposure                  | Confounders Includeda | Baseline Exposure as Predictor | n   | OR (99% CI)     | Average Exposure as Predictor | n   | OR (99% CI)     |
|-------------------------------|-----------------------|--------------------------------|-----|----------------|-------------------------------|-----|----------------|
| **Decision demands**          |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   |                                | 255 | 1 (reference)  | 243                          | 1 (reference)  |
|                               | Middle                |                                | 1185| 1.04 (0.52–2.08)| 1024                        | 0.72 (0.36–1.46)|
|                               | High                  |                                | 1478| 1.00 (0.50–2.01)| 1547                        | 0.89 (0.45–1.77)|
|                               | Continuous            |                                | 2918| 0.94 (0.71–1.24)| 2814                        | 0.97 (0.70–1.33)|
| **Quantitative demands**      |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   |                                | 953 | 1 (reference)  | 780                          | 1 (reference)  |
|                               | Middle                |                                | 1178| 1.19 (0.75–1.90)| 1444                        | 1.24 (0.76–2.02)|
|                               | High                  |                                | 855 | 1.02 (0.59–1.75)| 697                         | 1.42 (0.79–2.56)|
|                               | Continuous            |                                | 2986| 1.03 (0.79–1.36)| 2920                        | 1.10 (0.81–1.49)|
| **Role clarity**              |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   | Support from immediate superior| 83  | 1 (reference)  | 47                           | 1 (reference)  |
|                               | Middle                | Positive challenge             | 298 | 1.38 (0.39–4.85)| 224                         | 0.44 (0.13–1.52)|
|                               | High                  |                                | 2421| 0.93 (0.28–3.07)| 2352                        | 0.35 (0.11–1.09)|
|                               | Continuous            |                                | 2802| 0.95 (0.70–1.29)| 2623                        | 0.93 (0.64–1.34)|
| **Role conflict**             |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   | Human resource primacy         | 1524| 1 (reference)  | 1644                        | 1 (reference)  |
|                               | Middle                |                                | 1115| 1.40 (0.90–2.20)| 914                         | 2.04 (1.28–3.24)**|
|                               | High                  |                                | 238 | 1.37 (0.66–2.87)| 194                         | 2.18 (1.01–4.72)*|
|                               | Continuous            |                                | 2877| 1.18 (0.89–1.57)| 2752                        | 1.40 (1.01–1.95)*|
| **Positive challenge**        |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   | Human resource primacy         | 89  | 1 (reference)  | 75                           | 1 (reference)  |
|                               | Middle                | Social climate                 | 419 | 0.99 (0.34–2.89)| 319                         | 0.34 (0.12–0.95)*|
|                               | High                  |                                | 2186| 0.67 (0.24–1.87)| 2082                        | 0.32 (0.12–0.81)*|
|                               | Continuous            |                                | 2694| 0.80 (0.60–1.07)| 2476                        | 0.65 (0.46–0.92)*|
| **Control over work intensity**|                      |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   |                                | 756 | 1 (reference)  | 708                         | 1 (reference)  |
|                               | Middle                |                                | 576 | 0.56 (0.32–1.00)*| 638                         | 0.76 (0.44–1.31)|
|                               | High                  |                                | 1686| 0.55 (0.34–0.90)*| 1636                        | 0.56 (0.34–0.94)*|
|                               | Continuous            |                                | 3018| 0.81 (0.67–0.99)*| 2982                        | 0.78 (0.63–0.97)*|
| **Decision control**          |                       |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   | Positive challenge             | 806 | 1 (reference)  | 619                         | 1 (reference)  |
|                               | Middle                | Control over work intensity    | 983 | 0.89 (0.52–1.53)| 938                         | 0.80 (0.44–1.44)|
|                               | High                  | Social climate                 | 748 | 0.99 (0.51–1.95)| 712                         | 0.71 (0.33–1.57)|
|                               | Continuous            | Human resource primacy         | 2537| 1.02 (0.71–1.47)| 2269                        | 1.07 (0.67–1.71)|
| **Predictability during the next month** |                      |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   | Support from immediate superior| 79  | 1 (reference)  | 41                           | 1 (reference)  |
|                               | Middle                | Empowering leadership          | 239 | 0.61 (0.17–2.15)| 196                         | 1.42 (0.28–7.24)|
|                               | High                  | Social climate                 | 2465| 0.86 (0.29–2.53)| 2342                        | 1.31 (0.29–5.89)|
|                               | Continuous            | Human resource primacy         | 2783| 0.85 (0.64–1.14)| 2579                        | 0.93 (0.65–1.34)|
| **Support from immediate superior** |                   |                                |     |                |                               |     |                |
|                               | **Category**          |                                |     |                |                               |     |                |
|                               | Low                   |                                | 237 | 1 (reference)  | 193                         | 1 (reference)  |

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| Work Exposure                  | Confounders Included<sup>a</sup> | Baseline Exposure as Predictor | Average Exposure as Predictor<sup>b</sup> |
|-------------------------------|-----------------------------------|--------------------------------|----------------------------------|
|                               |                                   | n  | OR (99% CI)   | n  | OR (99% CI)   |
| Middle                        | Empowering leadership             | 585| 0.56 (0.27–1.18) | 522| 1.33 (0.61–2.93) |
| High                          | Human resource primacy            | 2021| 0.55 (0.25–1.18) | 1970| 0.81 (0.34–1.92) |
| Continuous                    |                                   | 2843| 0.92 (0.67–1.25) | 2685| 0.84 (0.57–1.23) |
| Empowering leadership         |                                   |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           | Human resource primacy            | 708| 1 (reference)  | 693| 1 (reference)  |
| Middle                        |                                   | 981| 0.99 (0.59–1.66) | 900| 0.74 (0.44–1.27) |
| High                          |                                   | 1192| 0.86 (0.48–1.56) | 1162| 0.62 (0.33–1.16) |
| Continuous                    |                                   | 2881| 0.94 (0.74–1.20) | 2755| 0.87 (0.65–1.18) |
| Fair leadership               |                                   |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           | Support from immediate superior   | 169| 1 (reference)  | 126| 1 (reference)  |
| Middle                        | Empowering leadership             | 526| 1.17 (0.48–2.85) | 414| 0.87 (0.34–2.25) |
| High                          | Human resource primacy            | 2117| 0.98 (0.38–2.50) | 2072| 0.74 (0.28–2.01) |
| Continuous                    |                                   | 2812| 1.11 (0.79–1.55) | 2612| 0.93 (0.61–1.42) |
| Innovative climate            | Positive challenge                |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           | Support from immediate superior   | 167| 1 (reference)  | 136| 1 (reference)  |
| Middle                        | Empowering leadership             | 824| 1.20 (0.49–2.93) | 657| 0.97 (0.37–2.56) |
| High                          | Social climate                    | 1644| 1.39 (0.53–3.66) | 1578| 1.55 (0.53–4.54) |
| Continuous                    | Human resource primacy            | 2635| 1.19 (0.78–1.82) | 2371| 1.65 (0.95–2.86) |
| Social climate                |                                   |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           |                                   | 123| 1 (reference)  | 102| 1 (reference)  |
| Middle                        | Empowering leadership             | 703| 0.68 (0.28–1.65) | 543| 0.37 (0.16–0.87)<sup>*</sup> |
| High                          | Human resource primacy            | 2011| 0.56 (0.23–1.38) | 2034| 0.39 (0.17–0.93)<sup>*</sup> |
| Continuous                    |                                   | 2837| 0.87 (0.62–1.21) | 2679| 0.76 (0.51–1.14) |
| Human resource primacy        |                                   |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           |                                   | 694| 1 (reference)  | 680| 1 (reference)  |
| Middle                        |                                   | 1140| 0.93 (0.58–1.49) | 1057| 0.67 (0.42–1.08) |
| High                          |                                   | 1072| 0.55 (0.32–0.96)<sup>*</sup> | 1065| 0.46 (0.27–0.78)<sup>**</sup> |
| Continuous                    |                                   | 2906| 0.78 (0.63–0.98)<sup>*</sup> | 2802| 0.66 (0.51–0.86)<sup>**</sup> |
| Physical workload             | Control over work intensity        |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           |                                   | 1806| 1 (reference)  | 1837| 1 (reference)  |
| Middle                        |                                   | 722| 1.05 (0.63–1.75) | 644| 1.13 (0.66–1.92) |
| High                          |                                   | 424| 1.21 (0.65–2.26) | 374| 1.32 (0.69–2.55) |
| Continuous                    |                                   | 2952| 1.13 (0.86–1.48) | 2855| 1.21 (0.90–1.64) |
| Working with arms raised to or above shoulder level | Control over work intensity |    |                |    |                |
| Category                      |                                   |    |                |    |                |
| Low                           |                                   | 1996| 1 (reference)  | 2159| 1 (reference)  |
| Middle                        |                                   | 649| 1.30 (0.79–2.12) | 560| 1.25 (0.74–2.10) |
| High                          |                                   | 345| 1.14 (0.61–2.11) | 215| 1.69 (0.85–3.36) |
| Continuous                    |                                   | 2990| 1.07 (0.83–1.37) | 2934| 1.31 (0.97–1.76) |

<sup>a</sup>Age, sex, skill level, and baseline work ability prognosis adjusted for in all analysis.

<sup>b</sup>Exposure averaged across time \([T1+T2]/2\).

<sup>*</sup><i>P</i> < 0.01.

<sup>**</sup><i>P</i> < 0.0006. Bonferroni-corrected significance level (0.01/16).

CI, confidence interval; OR, odds ratio.
that found promotion of employee well-being (ie, higher interest in employee well-being and increased attempts to improve employee work conditions) predictive of elevations in the WAI score.14

The job content questionnaire29 is commonly used in research aiming to identify the impact of psychological work exposures on work disability11-13 and sickness absence.6,26-41 Time pressure (a component of the psychological job demand dimension) has not been found significantly important to WAI scoring.11,30 In accordance with earlier cross-sectional findings, quantitative demands was consistently unrelated to all work ability outcomes in this study.

A central component of control of the job content questionnaire is decision authority. A cross-sectional study found a single-item measure on influence of decision making associated with the WAI.11 A prospective study using a measurement scale resembling this study’s decision control (ie, influence on methods, decisions important to own work, and collaboration with colleagues) found positive score change on this scale to be predictive of the elevated WAI score from baseline to follow-up 2 years later.10 Decision control did not predict the level of work ability in any of our prospective analyses. The divergence of findings may be attributable to differences in cohorts. Tuomi et al14 analyzed industry and retail employees, whereas the present results were based on responses from a variety of occupational groups.

The current results did not support the notion that higher mechanical demands (physical workload, working with arms raised) have long-term effects on the level of work ability. The systematic review of van den Berg et al24 concluded that four of the seven studies (with acceptable quality) showed significant associations between mechanical demands and the WAI level. Nevertheless, three of these four positive studies reported from the same cohort of middle-aged employees and two of these had a substantially longer follow-up period than this study. Thus, conflicting results could be due to differences in cohorts and methodological designs. On the basis of a cohort representing a wide range of the working population, it seems relevant for future studies to estimate effects of mechanical demands on work ability over longer periods. It is important to keep in mind, however, that substantial physical exertions at work are not as common as before. Thus, further investigations may also want to consider whether the contribution of mechanical demands to the level of work ability depends on occupational group. Plausibly, mechanical demands may be of particular relevance to the reported level of work ability among employees in occupations, which still implies high biomechanical loads.

Methodological Considerations

There are several known method biases that may threaten the validity of conclusions in epidemiological studies on the basis of self-reported data. Some measures have been taken to mitigate the potential confounding influence of biases on the present results.

Associations between baseline exposure and follow-up work ability may be influenced by the relationship between baseline exposure and baseline work ability. Adjusting for baseline work ability should help diminish this influence. At the same time, adjustment may have underestimated associations. The most consistent predictors were related to the level of work ability at baseline and to the level of work ability at follow-up. Thus, the variation in follow-up work ability explained by baseline work ability may, to some extent, result from baseline exposure. Nevertheless, this study was not designed to provide information about the mechanisms by which work exposures relate to work ability—merely to establish prospective associations.

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