

Development and validation of a work-related risk score for upper-extremity musculoskeletal disorders in a French working population¹

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1. Supplementary materials
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Table S1: Comparison of occupational exposures between development and validation samples

| | Development sample (N=2468) | Validation sample (N=1051) | P-value ^(a) |
|---|--------------------------------|-------------------------------|------------------------|
| | N (%) | N (%) | |
| PHYSICAL FACTORS | | | |
| Repetitiveness of tasks (≥4h/day) with/without break | | | 0.071 |
| <i>missing</i> | 15 | 14 | |
| No | 1799 (73.3) | 776 (74.8) | |
| Yes, without break | 499 (20.4) | 216 (20.8) | |
| Yes, with break | 155 (6.3) | 45 (4.4) | |
| High perceived physical exertion (RPE Borg scale) | | | 0.780 |
| <i>missing</i> | 9 | 7 | |
| No | 1216 (49.5) | 525 (50.3) | |
| Yes, 13≤RPE<15 | 715 (29.1) | 291 (27.9) | |
| Yes, RPE≥15 | 528 (21.5) | 227 (21.8) | |
| Use of vibrating hand tools (≥2h/day) | | | 0.666 |
| <i>missing</i> | 6 | 8 | |
| No | 2142 (87) | 913 (87.5) | |
| Yes | 320 (13) | 130 (12.5) | |
| Exposure to cold temperature (≥4h/day) | | | 0.156 |
| <i>missing</i> | 4 | 8 | |
| No | 2303 (93.5) | 988 (94.7) | |
| Yes | 161 (6.5) | 55 (5.3) | |
| Use of computer keyboard or mouse (≥4h/day) | | | 0.541 |
| <i>missing</i> | 3 | 9 | |
| No | 1792 (72.7) | 747 (71.7) | |
| Yes | 673 (27.3) | 295 (28.3) | |
| Arms above shoulder level (≥2h/day) | | | 0.579 |
| <i>missing</i> | 7 | 7 | |
| No | 2128 (86.5) | 910 (87.2) | |
| Yes | 333 (13.5) | 134 (12.8) | |
| Holding hand behind the trunk (≥2h/day) | | | 0.318 |
| <i>missing</i> | 6 | 9 | |
| No | 2331 (94.7) | 995 (95.5) | |
| Yes | 131 (5.3) | 47 (4.5) | |
| Arms abduction (60–90°) (≥2h/day) | | | 0.606 |
| <i>missing</i> | 5 | 7 | |
| No | 2086 (84.7) | 877 (84) | |
| Yes | 377 (15.3) | 167 (16) | |
| Elbow flexion/extension movements (≥2h/day) | | | 0.496 |
| <i>missing</i> | 8 | 9 | |
| No | 1640 (66.7) | 707 (67.8) | |
| Yes | 820 (33.3) | 335 (32.2) | |
| Pronation and supination movements (≥2h/day) | | | 0.460 |

| | | | |
|---|-------------|------------|-------|
| <i>missing</i> | 10 | 8 | |
| No | 2095 (85.2) | 899 (86.2) | |
| Yes | 363 (14.8) | 144 (13.8) | |
| Wrist twisting movements (≥2h/day) | | | 0.005 |
| <i>missing</i> | 22 | 22 | |
| No | 1585 (64.8) | 717 (69.7) | |
| Yes | 861 (35.2) | 312 (30.3) | |
| Use of the pinch grip (≥4h/day) | | | 0.262 |
| <i>missing</i> | 10 | 6 | |
| No | 2254 (91.7) | 970 (92.8) | |
| Yes | 204 (8.3) | 75 (7.2) | |

PSYCHOSOCIAL FACTORS: DECISION LATITUDE

| | | | |
|--------------------------------|-------------|------------|-------|
| Learn new things | | | 0.698 |
| <i>missing</i> | 1 | 3 | |
| Strongly disagree/disagree | 276 (11.2) | 122 (11.6) | |
| Agree/strongly agree | 2191 (88.8) | 926 (88.4) | |
| Repetitive work | | | 0.049 |
| <i>missing</i> | 3 | 6 | |
| Strongly disagree/disagree | 606 (24.6) | 290 (27.8) | |
| Agree/strongly agree | 1859 (75.4) | 755 (72.2) | |
| Requires creativity | | | 0.286 |
| <i>missing</i> | 5 | 3 | |
| Strongly disagree/disagree | 891 (36.2) | 399 (38.1) | |
| Agree/strongly agree | 1572 (63.8) | 649 (61.9) | |
| Allows own decisions | | | 0.616 |
| <i>missing</i> | 6 | 3 | |
| Strongly disagree/disagree | 445 (18.1) | 182 (17.4) | |
| Agree/strongly agree | 2017 (81.9) | 866 (82.6) | |
| High skill level | | | 0.592 |
| <i>missing</i> | 8 | 9 | |
| Strongly disagree/disagree | 855 (34.8) | 372 (35.7) | |
| Agree/strongly agree | 1605 (65.2) | 670 (64.3) | |
| Little decision freedom | | | 0.077 |
| <i>missing</i> | 7 | 4 | |
| Strongly disagree/disagree | 1820 (74.0) | 804 (76.8) | |
| Agree/strongly agree | 641 (26.0) | 243 (23.2) | |
| Variety | | | 0.772 |
| <i>missing</i> | 5 | 2 | |
| Strongly disagree/disagree | 435 (17.7) | 181 (17.3) | |
| Agree/strongly agree | 2028 (82.3) | 868 (82.7) | |
| A lot to say | | | 0.597 |
| <i>missing</i> | 10 | 2 | |
| Strongly disagree/disagree | 623 (25.4) | 257 (24.5) | |
| Agree/strongly agree | 1835 (74.6) | 792 (75.5) | |
| Develop own abilities | | | 0.476 |
| <i>missing</i> | 8 | 4 | |

| | | | |
|--|-------------|------------|-------|
| Strongly disagree/disagree | 546 (22.2) | 221 (21.1) | |
| Agree/strongly agree | 1914 (77.8) | 826 (78.9) | |
| PSYCHOSOCIAL FACTORS: PSYCHOLOGICAL DEMANDS | | | |
| Work fast | | | 0.271 |
| <i>missing</i> | 1 | 2 | |
| Strongly disagree/disagree | 974 (39.5) | 435 (41.5) | |
| Agree/strongly agree | 1493 (60.5) | 614 (58.5) | |
| Work hard | | | 0.045 |
| <i>missing</i> | 9 | 2 | |
| Strongly disagree/disagree | 922 (37.5) | 431 (41.1) | |
| Agree/strongly agree | 1537 (62.5) | 618 (58.9) | |
| No excessive work | | | 0.590 |
| <i>missing</i> | 7 | 2 | |
| Strongly disagree/disagree | 1414 (57.5) | 613 (58.4) | |
| Agree/strongly agree | 1047 (42.5) | 436 (41.6) | |
| Enough time | | | 0.994 |
| <i>missing</i> | 3 | 4 | |
| Strongly disagree/disagree | 633 (25.7) | 269 (25.7) | |
| Agree/strongly agree | 1832 (74.3) | 778 (74.3) | |
| Conflicting demands | | | 0.039 |
| <i>missing</i> | 8 | 4 | |
| Strongly disagree/disagree | 1739 (70.7) | 776 (74.1) | |
| Agree/strongly agree | 721 (29.3) | 271 (25.9) | |
| Intense concentration | | | 0.807 |
| <i>missing</i> | 10 | 3 | |
| Strongly disagree/disagree | 1287 (52.4) | 544 (51.9) | |
| Agree/strongly agree | 1171 (47.6) | 504 (48.1) | |
| Tasks interrupted | | | 0.390 |
| <i>missing</i> | 6 | 2 | |
| Strongly disagree/disagree | 1151 (46.7) | 507 (48.3) | |
| Agree/strongly agree | 1311 (53.3) | 542 (51.7) | |
| Hectic work | | | 0.904 |
| <i>missing</i> | 13 | 1 | |
| Strongly disagree/disagree | 1477 (60.2) | 634 (60.4) | |
| Agree/strongly agree | 978 (39.8) | 416 (39.6) | |
| Wait on others | | | 0.262 |
| <i>missing</i> | 9 | 3 | |
| Strongly disagree/disagree | 1805 (73.4) | 750 (71.6) | |
| Agree/strongly agree | 654 (26.6) | 298 (28.4) | |
| PSYCHOSOCIAL FACTORS : SOCIAL SUPPORT | | | |
| Supervisor concerned | | | 0.440 |
| <i>missing</i> | 25 | 18 | |
| Strongly disagree/disagree | 660 (27) | 266 (25.7) | |
| Agree/strongly agree | 1783 (73) | 767 (74.3) | |
| Supervisor pays attention | | | 0.602 |
| <i>missing</i> | 17 | 14 | |

| | | | |
|--|-------------|------------|-------|
| Strongly disagree/disagree | 458 (18.7) | 186 (17.9) | |
| Agree/strongly agree | 1993 (81.3) | 851 (82.1) | |
| Helpful supervisor | | | 0.871 |
| <i>missing</i> | 17 | 13 | |
| Strongly disagree/disagree | 537 (21.9) | 230 (22.2) | |
| Agree/strongly agree | 1914 (78.1) | 808 (77.8) | |
| Supervisor good organizer | | | 0.370 |
| <i>missing</i> | 33 | 21 | |
| Strongly disagree/disagree | 492 (20.2) | 222 (21.5) | |
| Agree/strongly agree | 1943 (79.8) | 808 (78.5) | |
| Co-workers competent | | | 0.190 |
| <i>missing</i> | 25 | 18 | |
| Strongly disagree/disagree | 181 (7.4) | 90 (8.7) | |
| Agree/strongly agree | 2262 (92.6) | 943 (91.3) | |
| Co-workers interested in me | | | 0.392 |
| <i>missing</i> | 33 | 20 | |
| Strongly disagree/disagree | 277 (11.4) | 107 (10.4) | |
| Agree/strongly agree | 2158 (88.6) | 924 (89.6) | |
| Friendly co-workers | | | 0.802 |
| <i>missing</i> | 28 | 18 | |
| Strongly disagree/disagree | 169 (6.9) | 74 (7.2) | |
| Agree/strongly agree | 2271 (93.1) | 959 (92.8) | |
| Co-workers helpful | | | 0.532 |
| <i>missing</i> | 27 | 17 | |
| Strongly disagree/disagree | 241 (9.9) | 95 (9.2) | |
| Agree/strongly agree | 2200 (90.1) | 939 (90.8) | |
| ORGANIZATIONAL FACTORS | | | |
| Temporary employment | | | 0.093 |
| <i>missing</i> | 8 | 5 | |
| No | 2213 (90) | 960 (91.8) | |
| Yes | 247 (10) | 86 (8.2) | |
| Shift work | | | 0.163 |
| <i>missing</i> | 13 | 11 | |
| No | 2063 (84) | 854 (82.1) | |
| Yes | 392 (16) | 186 (17.9) | |
| Irregular working hours | | | 0.022 |
| <i>missing</i> | 14 | 6 | |
| No | 1632 (66.5) | 653 (62.5) | |
| Yes | 822 (33.5) | 392 (37.5) | |
| Work with temporary workers | | | 0.328 |
| <i>missing</i> | 6 | 5 | |
| No | 1720 (69.9) | 748 (71.5) | |
| Yes | 742 (30.1) | 298 (28.5) | |
| Work pace dependent on automatic rate | | | 0.877 |
| <i>missing</i> | 85 | 8 | |
| No | 2011 (84.4) | 878 (84.2) | |

| | | | |
|---|-------------|------------|--------|
| Yes | 372 (15.6) | 165 (15.8) | |
| Work pace dependent on colleague's work | | | 0.162 |
| <i>missing</i> | 102 | 10 | |
| No | 1659 (70.1) | 705 (67.7) | |
| Yes | 707 (29.9) | 336 (32.3) | |
| Work pace dependent on production standards or deadlines | | | 0.121 |
| <i>missing</i> | 84 | 9 | |
| No | 1256 (52.7) | 519 (49.8) | |
| Yes | 1128 (47.3) | 523 (50.2) | |
| Work pace dependent on external demand | | | <0.001 |
| <i>missing</i> | 56 | 8 | |
| No | 1419 (58.8) | 489 (46.9) | |
| Yes | 993 (41.2) | 554 (53.1) | |
| Work pace imposed by permanent monitoring | | | 0.098 |
| <i>missing</i> | 92 | 10 | |
| No | 1739 (73.2) | 790 (75.9) | |
| Yes | 637 (26.8) | 251 (24.1) | |

RPE Borg scale: Rating perceived exertion Borg scale

^(a) Chi-square test

Table S2: Performance of the risk score for identifying workers with UEMSD diagnosed at inclusion into the cohort. Results from complete case analysis in the validation sample (N=968).

| <i>Global performance</i> | |
|----------------------------------|---------------------------|
| R^2 (Nagelkerke) | 2.1 % |
| Brier score | 0.10 |
| Brier score (scaled) | 1.1 % |
| <i>Discrimination</i> | |
| AUC | 0.59 (0.53-0.65) |
| Discrimination slope | 0.01 |
| <i>Calibration</i> | |
| Calibration intercept | -2.50 |
| Calibration slope | 0.05 |
| Hosmer-Lemeshow | $\chi^2 = 6.53, p = 0.59$ |

Figure S1: Calibration plot showing the prognostic validity of the risk score in the subsample of workers without UEMSD at inclusion and with complete data. The distribution of predicted risks is shown at the bottom of the curve. The triangles indicate the observed frequencies by decile of the predicted risk.

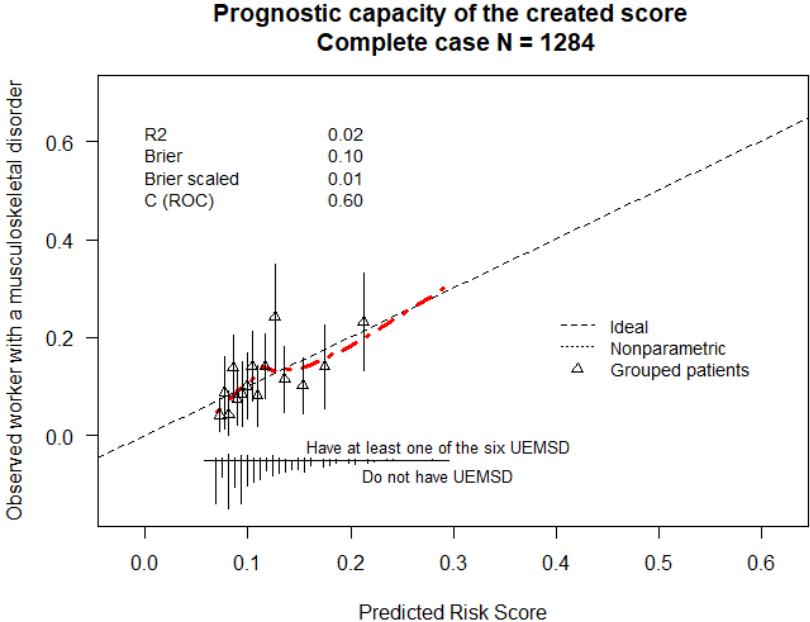
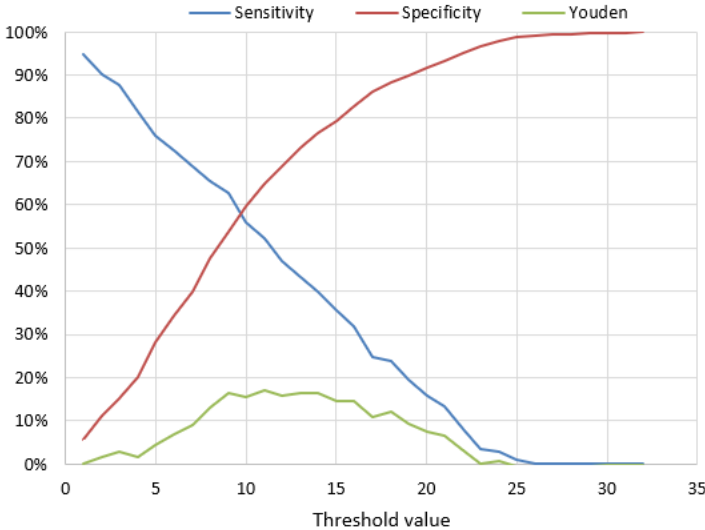


Figure S2: Classification performance of the risk score for identifying workers with UEMSD diagnosed at inclusion into the cohort. Results from complete case analysis in the validation sample (N=968).



| <i>Threshold value</i> | ≥5 | ≥10 | ≥15 | ≥20 |
|------------------------|-----------|------------|------------|------------|
| n | 700 | 408 | 217 | 89 |
| TP | 86 | 63 | 40 | 18 |
| FP | 614 | 345 | 177 | 71 |
| TN | 241 | 510 | 678 | 784 |
| FN | 27 | 50 | 73 | 95 |
| Accuracy (%) | 33.8 | 59.2 | 74.2 | 82.9 |
| Sensitivity (%) | 76.1 | 55.8 | 35.4 | 15.9 |
| Specificity (%) | 28.2 | 59.6 | 79.3 | 91.7 |
| PPV (%) | 12.3 | 15.4 | 18.4 | 20.2 |
| NPV (%) | 89.9 | 91.1 | 90.3 | 89.2 |

TP: true positive, FP: false positive, TN: true negative, FN: false negative, PPV: positive predictive value, NPV: negative predictive value

Youden’s index = Sensitivity + Specificity -1