Validation of the OCRA Checklist Score as Predictive of the Occurrence of UL-WMSDs in Workers Exposed to Manual Repetitive Tasks

Enrico Occhipinti(✉) and Daniela Colombini

EPM International Ergonomics School, Milan, Italy
epmenrico@tiscali.it

Abstract. ISO 11228–3 and ISO TR 12295 recommend the OCRA Checklist as a useful method for screening exposure to manual repetitive tasks. The aim of this study is to define forecasting models for the expected prevalence of UL-WMSDs in groups of exposed workers based on the OCRA Checklist scores. A database of 11,734 workers divided into 30 groups featuring different exposure levels and different prevalences of UL-WMSDs was analyzed. The association between the independent variable "Checklist score" (CK) and the dependent variable "% of workers with UL-WMSDs" (PA) was researched: a convincing association (R^2 = 0.86) resulted from the linear regression equation PA = 0.742(±0.055) x CK, which may be used (within defined limits) as a model for forecasting the occurrence of UL-WMSDs based on the OCRA Checklist score. By using pre-established OCRA Checklist key-values, macro-groups with different exposure levels were created and the Prevalence Odds Ratio (POR) of each group was computed versus the "non-significant exposure" group. The POR for "borderline", "low", "medium" and "high" exposure groups was respectively 2.18, 2.77, 4.36 and 3.78. These results confirm the overall effectiveness of the current classification of the OCRA Checklist scores, while also suggesting that an OCRA Checklist score of 16 should be the cutoff for identifying low and medium exposure.

Keywords: Repetitive task · Risk assessment · OCRA method · UL-WMSDs

1 Introduction and Aim

The OCRA method for assessing risk associated with repetitive movements of the upper limbs consists of two tools, the OCRA Index and the OCRA Checklist [2, 3, 6, 8], which feature different analytical details and purposes, although both are inspired by the same conceptual model. The OCRA Index is more detailed and was chosen as the reference risk assessment method by international standards relating to high-frequency repetitive manual work [1, 4]; the OCRA Checklist is the simpler one used for the initial screening of workstations, as suggested by ISO TR 12295 [5].

The OCRA Checklist consists of five sections focusing on the four main risk factors (frequency, force, awkward posture/stereotyped movement, lack of recovery periods) and a number of additional risk factors (vibrations, low temperatures, precision work,

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repeated impacts, etc.). It also factors into the final risk estimate the net duration of repetitive jobs. The OCRA Checklist analysis entails using pre-assigned scores (the higher the score, the higher the risk factor) to define the level of exposure associated with each of the aforementioned factors. The sum and product of partial values generate a final score that estimates the overall exposure level (Fig. 1).

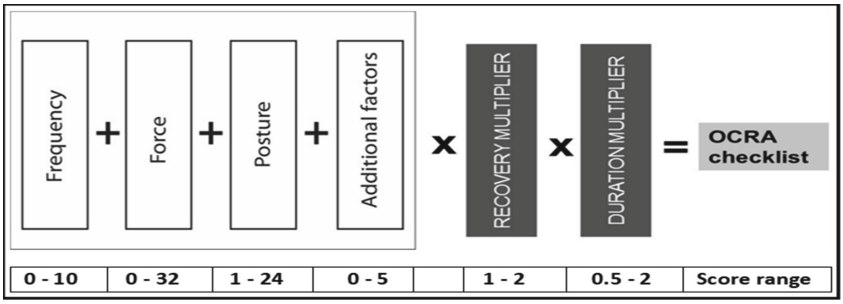

Fig. 1. OCRA Checklist: final score calculation

In the early 2000s, studies involving over 5,000 variously exposed workers found a significant association between exposure levels assessed by the OCRA Index and the overall prevalence of UL-WMSDs (PA) in exposed working populations [7, 9]. A linear regression equation forecasts (within defined limits) the expected PA based on the OCRA Index:

$$PA = 2.39\ (\pm 0.14) \times OCRA\ Index \tag{1}$$

These studies [7, 9], which also considered the overall prevalence of UL-WMSDs (PA) in working populations with non-significant exposure levels, defined OCRA Index "key-values" for classifying exposure as: acceptable (green), borderline (yellow), low-risk (red-low), medium risk (red-medium) and high-risk (red-high or purple). Since a very strong association exists between the OCRA Index and OCRA Checklist values [7], it was possible to obtain "key-values" for classifying OCRA Checklist results and for making "indirect gross estimations" (by linking with OCRA Index values) of the expected prevalence (PA) of workers affected by UL-WMSDs. Table 1 compares the OCRA Index and OCRA Checklist classification systems.

Since the mid-2000s, more data has been added to the existing database. The data regards the OCRA Checklist as an exposure assessment tool and includes matched results for prevalence among workers with one or more clinically diagnosed UL-WMSDs.

The aim of this study is therefore to use the extended database to define a model for forecasting the expected prevalence of UL-WMSDs in groups of exposed workers based directly on the results of the OCRA Checklist.

A secondary aim is to verify the general adequacy of the current classification of OCRA Checklist scores (see Table 1), or determine whether adjustments are necessary.

Table 1. OCRA Index and OCRA Checklist score classification based on key-values.

Zone	Ocra index values	Ocra checklist values	Risk classification
Green	Up to 2.2	Up to 7.5	Acceptable
Yellow	2.3–3.5	7.6–11	Borderline
Red-low	3.6–4.5	11.1–14	Low
Red-medium	4.6–9.0	14.1–22.5	Medium
Red-high	Over 9.0	Over 22.5	High

2 Methods

The study examined over 11,000 workers (including the original reference group used in 2004 and 2007 studies) divided into 30 groups featuring different exposure levels. A representative OCRA Checklist score was calculated for each group and the prevalence of workers affected by one or more clinically diagnosed UL-WMSDs was reported. Figure 2 shows the most significant data in the database used in the study.

The association and regression models between the independent variable "OCRA Checklist score" and the dependent variable "% of workers with UL-WMSDs" (PA) were explored (with SPSS© software). Data was processed by weighting the compared groups based on their numerical size and without considering the constant in the models (i.e. OCRA Checklist = 0; PA ≈ 0).

By using pre-established OCRA Checklist key-values (see Table 1), macro-groups with different exposure levels were aggregated and the Prevalence Odds Ratio (POR) of each "aggregated" group was computed versus the "non-significant exposure" group.

This last procedure was repeated with respect to the preliminary results and considering alternative OCRA Checklist key-values for grouping.

3 Results

The relationship between the OCRA Checklist score and PA (Percentage of workers affected by UL-WMSDs) variables is reported graphically in Fig. 3.

The strength of the association between the two variables was rather high (Pearson correlation coefficient = 0.722; $p < 0.00001$).

A simple linear regression function between the OCRA Checklist Score and PA is expressed by the following general equation:

$$PA = 0.742(\pm 0.055) \times OCRA\,CK \tag{2}$$

This function shows a fairly strong association between the two variables (adjusted $R^2 = 0.86$) and is statistically highly significant ($p < 0.00001$).

Since the regression function (2) can be used as a forecasting model to estimate the number of workers potentially affected by one or more UL-WMSDs based on the OCRA

JOB/TASK	TOTAL	Nr. MALES	Nr. FEMALES	CHECKLIST SCORE	% PERSONS AFFECTED (PA)
Electric motors assembly 1	431	126	305	**15.2**	**11.37**
Electric motors assembly 2	288	173	115	**12.0**	**8.68**
Freezer Assembly	374	264	110	**11.5**	**8.56**
Refrigerator Assembly A	350	270	80	**14.7**	**15.43**
Refrigerator Assembly B	42	32	10	**13.0**	**14.29**
Refrigerator Assembly C	31	31	0	**14.4**	**19.35**
Refrigerator Assembly D	118	63	55	**15.0**	**15.25**
Refrigerator Ass+Cablage	42	22	20	**19.4**	**30.95**
Oven Assembly	650	150	500	**10.2**	**13.23**
Shock-absorber assembly	242	158	83	**19.5**	**23.97**
Meat processing (chickens)	943	0	943	**20.0**	**22.38**
Assembly motor 1	467	355	112	**10.0**	**3.85**
Assembly motor 2	53	37	16	**12.0**	**7.55**
Assembly motor 3	105	42	63	**17.0**	**13.33**
Upholsterers A	783	783	0	**25.0**	**18.60**
Hide cutters A	514	488	26	**21.7**	**8.20**
Stitchers A	840	4	836	**23.2**	**11.30**
Preparers A	205	196	9	**20.6**	**13.20**
Upholsterers B	85	85	0	**24.9**	**20.00**
Hide cutters B	54	50	4	**20.4**	**10.00**
Stitchers B	143	0	143	**24.3**	**8.40**
Preparers B	56	56	0	**20.0**	**7.10**
Upholsterers C	76	76	0	**23.0**	**28.90**
Hide cutters C	25	24	1	**15.2**	**16.00**
Stitchers C	75	1	74	**20.9**	**9.30**
Preparers C	33	33	0	**17.7**	**15.20**
Blue collars not exposed	1383	1306	77	**7.4**	**6.10**
VDU 20-30 hours	577	329	248	**6.2**	**4.33**
VDU >30 hours	1440	792	648	**7.4**	**3.13**
Reference group	749	310	439	**1.5**	**4.41**

Fig. 2. Main features of groups included in the study: breakdown by gender, OCRA Checklist score and prevalence of workers affected by one or more UL-WMSDs (PA).

Checklist value, the 95% confidence interval of the function was computed:

$$\text{Lower } 95\% \text{ limit: } PA = 0.629 * CK \tag{3}$$

$$\text{Upper } 95\% \text{ limit: } PA = 0.856 * CK \tag{4}$$

In order to check PA trends as a function of the OCRA Checklist classification (green; yellow; red-low; red-medium; red-high) the groups of subjects were aggregated based on the "traditional" OCRA Checklist key-scores shown in Table 1.

The results are reported in Table 2 and show a positive incremental trend as exposure shifts from very low to very high, but with no progression from yellow to red-low.

Considering these results, the Prevalence Odds Ratio (POR) and 95% confidence limits were initially computed, further aggregating the red-low and red-medium exposed groups.

Table 3 reports the Prevalence Odds Ratio (POR) and 95% confidence limit relating to this further grouping. PORs were computed in relation to the "green" exposed group (POR = 1).

The results in Table 3 can be considered satisfactory as they show an increasing POR trend when exposure levels shift from borderline to very high.

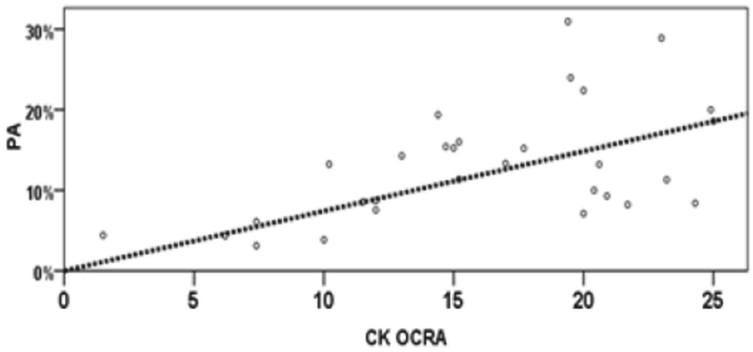

Fig. 3. Association between OCRA Checklist score (CK OCRA) and Percentage of workers Affected by UL-WMSDs (PA)

Table 2. Percentage of workers affected by UL-WMSDs when groups are aggregated based on the "traditional" OCRA Checklist classification (see Table 1)

Checklist scores	Checklist exposure level	Nr. Total	Nr. affected	PA % affected
≤7.5	Green	4,149	187	4.52
7.6–11	Yellow	1,117	104	9.31
11.1–14	Red-low	757	67	8.85
14.1–22.5	Red-medium	3,224	518	16.05
>22.5	Red-high or purple	1,927	292	15.13

However, PORs do not distinguish between low and medium exposure. This differentiation was originally set at an OCRA Checklist score of 14 but was found to be inconsistent; a different cut-off point was consequently sought.

Table 3. Prevalence Odds Ratios (PORs): central values and 95% confidence limits in four groups of workers with different exposure levels (according to OCRA Checklist scores)

CK scores	Exposure level	Total	Nr. affected	PA % affected	POR central value	POR lower 95% CL	POR upper 95% CL
≤7.5	Green	4,149	187	4.52	1.00	=	=
7.6–11	Yellow	1,117	104	9.31	2.18	1.69	2.80
11.1–22.5	Red-low + medium	3,981	585	14.68	3.65	3.08	4.33
>22.5	Red-high	1,927	292	15.13	3.78	3.12	4.59

For this particular purpose, the criteria and procedures used to search for OCRA Index key-values were adopted [7, 9]. These range from estimating the standardized rate (by gender and age) of PAs in a working population with no or very low exposure to biomechanical overload of the upper limbs and initially applying its upper 95% confidence limit and then its multiples (2x, 3x and 4x), to the regression equations associating OCRA Checklist values and PA in the sample.

In previous studies [7, 9], the standardized PA rate for non-exposed populations was equal to 3.7% and the upper 95% confidence limit was equal to 4.8%. In this study, these values were used as driving values and inserted into Eqs. (3) and (2) to find suitable OCRA Checklist key-values for distinguishing different exposure levels.

The application of the procedure, as here briefly reported, confirmed all the "traditional" OCRA Checklist key-values shown in Table 1, with the exception of the key-value of 14 as a cut-off between low and medium exposure levels. This key-value should thus be replaced by a score of 16, the level resulting from using Eqs. (2) and (3), combined with 3 times the standardized rate of PA estimated in the non-exposed reference working population.

Taking the new key-value of 16, the groups in Fig. 2 were re-aggregated according to the updated classification of the OCRA Checklist results, and the Prevalence Odds Ratios (PORs) and 95% confidence limits were computed, this time distinguishing different groups broken down into low and medium exposure.

Table 4 reports the Prevalence Odds Ratios (PORs) and 95% confidence limits for these 5 groups. Again, PORs are computed versus the "green" exposed group (POR = 1).

Table 4. Prevalence Odds Ratios (PORs): central values and 95% confidence limits in five groups of workers with different exposure levels (according to an updated classification of OCRA Checklist scores)

CK scores	Checklist exposure level	Nr. TOTAL	Nr. Affected	PA % Affected	POR central value	POR lower 95% CL	POR upper 95% CL
≤7.5	Green	4,149	187	4.52	1.00	=	=
7.6–11	Yellow	1,117	104	9.31	2.18	1.69	2.80
11.1–16	Red-low	1,712	198	11.57	2.77	2.25	3.41
16.1–22.5	Red-medium	2,269	387	17.04	4.36	3.63	5.24
>22.5	Red-high	1,927	292	15.13	3.78	3.12	4.59

4 Discussion and Conclusions

The results generated by the OCRA Checklist, which is a tool recommended by international standards [4, 5] for quantifying exposure to biomechanical overload of the

upper limbs, show a strong association with the prevalence of UL-WMSDs in groups of exposed workers.

Although the analysis presented here is based exclusively on prevalence studies with intrinsic limits for confirming potential relationships between exposure and corresponding collective health outcomes, the final OCRA Checklist score was found capable of effectively predicting the expected occurrence of UL-WMSDs in exposed working populations.

Forecasts of the expected prevalence of UL-WMSDs should be based on Eq. (2) and its 95% confidence limits (Eqs. (2) and (3)).

The OCRA Checklist predictive model can now be used directly without interpolations with the original OCRA Index classification system.

It should be noted, however, that based on a more detailed analysis of some of the results reported in the present study, when the OCRA Checklist final scores are between 20 and 30 or more, the outcome of the predictive model may be less accurate, but will certainly still be relevant compared with the one for reference populations (no or low exposure).

The OCRA Checklist classification system is substantially confirmed also in relation to the OCRA Index classification. The only significant exception is that the red-light zone now applies to OCRA Checklist scores ranging from 11 to 16. Consequently, the red-medium area ranges from 16 to 22.5. Table 5 shows the updated OCRA Checklist classification system.

It should, however, be emphasized that the classification and key-values reported in Table 5 should be used to better frame the risk assessment and more effectively guide preventative actions, rather than be taken as mere numbers for breaking down results into rigidly defined "risk" levels.

Table 5. Updated OCRA Checklist score classification by key-values.

Zone	Ocra checklist values	Risk classification
Green	Below 7.5	Acceptable
Yellow	7.6–11	Borderline
Red-low	11.1–16	Low
Red-medium	16.1–22.5	Medium
Red-high	Above 22.5	High

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