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The TACOs (time-based assessment computerized strategy) approach to evaluating occupational working postures

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ABSTRACT

Many investigations of biomechanical overload concentrate on upper limbs and manual handling: certain jobs require an evaluation on spinal and lower limb postures. While existing methodologies adequately describe postures, they often poorly consider the organisation. This shortcoming prompted the development of TACOs for spinal and lower limb postures, using organisational factors to adjust the risk indexes. The TACOs is set out in steps: task identification, posture assessment, duration, and a final evaluation also for complex cycles. Given the complexity, tools have been devised, free downloadable, to facilitate evaluation. Studies on the TACOs reliability indicate excellent intra-observer and moderate interobserver agreement. TACOs, defining the task as a measurement unit, offers the advantage of assessing postures more easily and, considering duration, provides precise evaluation of the final risk. While the method does not demonstrate predictive validity regarding related diseases, it nonetheless enables the classification of exposure levels, even in complex multitask scenarios.

PRACTITIONER SUMMARY

The development of TACOs strategy for posture analysis stems from the need to modulate the intensity of posture risk factors in relation with duration. It estimates final exposure scores in real work through detailed preliminary organisational studies. This involves identifying tasks, assessing postures for type and duration in work period.

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Awkward postures; time assessment; exposure score; multitask analysis; organisational studies

1. Introduction and aims

Up until the 1970s, there were no standardised methods for describing working postures, or criteria for assessing them, including determining potential risks associated with different postures and exposure times. However, this deficiency began to be addressed subsequently with the development of standard methods for describing and, more recently, assessing working postures.

The earliest posture analysis methods were introduced by Priel (1974), Grieco et al. (1978), and Karhu, Kansi, and Kuorinka (1977), followed by approaches proposed by Corlett, Madeley, and Manenica (1979) and, which advocated for a more comprehensive approach to analysing working postures. In the 1990s, additional methods were introduced, incorporating classification criteria for descriptive analysis (McAtamney and Corlett 1993; Hignett and McAtamney 2000; ISO 2000).

These methods primarily rely on analysing the primary postures, observed during unspecified working periods, to determine the final risk, either based on the posture that persists the longest or on the most unfavourable one regardless of its duration. In our view, this approach lacks proper timing for assessing postural durations, especially in multitasking scenarios, resulting in a questionable evaluation of the final risk, which may often lead to an overestimation of exposure risk. As a result, while these methods adequately describe the postures to be assessed, they do not provide reliable criteria for risk evaluation, especially for complex multitasking activities.

This limitation prevents drawing reliable conclusions about their efficacy in assessing exposure risk or tolerability.

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The Ethical statement is not applicable.

Significant advancements in assessment methods will only occur when there is greater certainty in evaluating postural tolerability. The underlying assumption is that tolerable postures should not cause (Colombini et al. 1985; Colombini and Occhipinti 2018):

- Discomfort in the short term,
- Musculoskeletal disorders or diseases in the long term.

Establishing standard requirements, methods, and criteria for assessing posture tolerability presents challenges due to several factors that must be considered (Colombini and Occhipinti 2018):

a. The significant number of variables comprising a posture,
b. The virtually endless combinations of postures,
c. The non-specific nature of diseases and disorders associated with awkward postures.

In the literature, certain laboratory studies have yielded crucial data and criteria, aiding in better understanding the reasons behind the inadequacy or lack of tolerability of certain postures (Kuok Ho 2020; Popescu-Stelea et al. 2021; Hulme et al. 2022; Santos et al. 2024).

These approaches offer valuable insights into the extent to which muscles, discs, or joints, when considered individually, can tolerate biomechanical loads, and, among them:

- surface electromyograms (Kadefors, Kaiser, and Petersén 1968, Kadefors et al. 1978; Chaffin and Park 1973; Hagberg and Jonsson 1975; Ortengren et al. 1975, Ortengren, Andersson, and Nachemson 1981; Petrofsky et al. 1982; Andersson and Ortengren 1984; Colombini et al. 1986),
- direct and indirect intervertebral disc pressure measurements (Chaffin and Park 1973; Colombini et al. 1985),
- the biomechanics of posture (Seireg and Arvikar 1973; Boccardi and Lissoni 1977; Andersson 1981; Boccardi et al. 1981; Davis 1981; Nachemson 1981; Ortengren, Andersson, and Nachemson 1981; Schultz and Andersson 1981; Schultz et al. 1982; Colombini et al. 1985).
- posture acceptability from the psychophysical standpoint (Ayoub et al. 1979; Garg, Mital, and Asfour 1980; Legg and Myles 1981; Mital 1984).

Furthermore, it is important to note that to comprehensively study biomechanical overload of the upper limbs, it is necessary to employ a method that examines all related risk factors, including those of an organisational nature such as time management, breaks, and task rotation. For example, the OCRA method (Occhipinti and Colombini 1996; Occhipinti 1998; ISO 2007; Colombini and Occhipinti 2017) incorporates the analysis of awkward postures of the upper limbs as one among a spectrum of risk factors as frequency of actions, force, additional factors, recovery duration and distribution, net duration of repetitive task.

The OCRA system examines the primary joint segments of both the left and right arms, identifies significant awkward postures, and assigns varying scores based on the area of the limb involved and the duration of the posture (Figure 1).

Similarly, addressing biomechanical overload of the lower back during manual lifting calls for a multifaceted approach: studying posture alone is inadequate. The Revised NIOSH Lifting Equation (RNLE) method

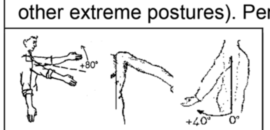
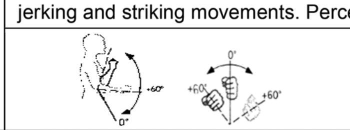
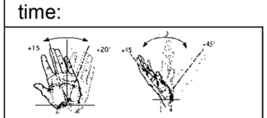
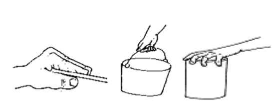
Type of awkward posture and movement	Duration of awkward posture or movement and relative scores	Score	Type of awkward posture and movement	Duration of awkward posture or movement and relative scores	Score
A-Shoulder- Arm at shoulder height, unsupported (or in other extreme postures). Percentage of time:			**B-Elbow-** Elbow executes full flexion-extension, prono-supination, jerking and striking movements. Percentage of time:		
	< 1/3= 10% - 24% 1/3 = 25% - 50% 2/3 = 51% - 80% 3/3 = > 80%	(2) (6) (12) (24)		1/3 = 25% - 50% 2/3 = 51% - 80% 3/3 = >80%	(2) (4) (8)
C-Wrist- Wrist in an extreme position or awkward posture (full flexion/extension lateral deviation). Percentage of time:			**D-Hand-** Hand grasps objects or tools in pinch, hook grip, or other types of grasps. Percentage of time:		
	1/3 = 25% - 50% 2/3 = 51% - 80% 3/3 = >80%	(2) (4) (8)		1/3 = 25% - 50% 2/3 = 51% - 80% 3/3 = >80%	(2) (4) (8)

Figure 1. Awkward postures and movements of the upper limbs using the OCRA checklist.

(Waters et al. 1993) and its extensions (Colombini et al. 2012) consider body postures alongside organisational factors such as the frequency and duration of lifting, in line with the recommendations included in International Standards (ISO 2021).

Both methods also integrate criteria derived from findings in psychophysical, biomechanical, and electromyography (EMG) studies, which have proven useful in proposing the classification of final risk scores.

Furthermore, they offer epidemiological reference data for both exposed and non-exposed workers. These two approaches to evaluating the risk of biomechanical overload for the upper limbs and spine respectively, predict damage at specific exposure/risk levels, thus facilitating assessments of short- and long-term tolerability.

However, the two aforementioned methods have certain limitations and may not address every aspect of biomechanical overload. While the OCRA method is suitable for analysing awkward postures and movements of the upper limbs in many occupations, there are numerous jobs that do not involve lifting or manual handling but still result in biomechanical overload of the spine and lower limbs, often due to prolonged static postures. In such cases, it is imperative to incorporate specific studies of postures, particularly those involving the spine and lower limbs.

Examples of occupations where this is relevant include agricultural workers, kindergarten teachers, physiotherapists, construction site workers, and archaeologists, among others. These professions often require individuals to maintain static positions for extended periods, leading to strain on the spine and lower limbs. In all those cases a comprehensive approach to assessing biomechanical overload should encompass the study of postures beyond just lifting or manual handling activities.

In addition to employing descriptive methods and basic evaluation criteria, reconstructing the organisational framework of the activity, it is essential to define the types and patterns of tasks encompassed in the job, and determine the duration of exposure to awkward postures in order to comprehensively assess overall exposure levels and, consequently, tolerance thresholds.

The innovative methodology presented here aims to analyse awkward postures of the spine and lower limbs, with a focus on accurately timing them to adjust final exposure scores. This involves not only considering the intrinsic awkwardness score of each individual posture but also accounting for its actual duration within each task, both preceding and following the work cycle. Such an approach is particularly vital in highly complex environments where workers engage in multiple tasks over extended periods, such as monthly or annual cycles.

Given the complexity of the data management and exposure score calculations, user-friendly "simple tools" (free-to-download Excel spreadsheets) have been developed. These tools facilitate data collection, input, and automatic processing, thereby enhancing the practicality of the strategy for assessing the risks associated with exposure to awkward postures. This strategy is referred to as the Timing Assessment Computerised strategy for postures, or simply, the TACOs model.

The TACOs strategy was validated by verifying inter- and intra-rater reproducibility. Due to space limitations, this first paper concentrates on the method and application, giving only a preliminary summary of the validation results. Details of validation outcomes will be provided in a following paper.

2. Materials and methods

2.1. The generally recommended process for posture analysis

The TACOs method introduces novel criteria for calculating a synthetic exposure index, even in highly complex scenarios where workers can be engaged in multiple tasks, sometimes spanning cycles lasting longer than one day.

Prior to implementing the TACOs strategy for conducting a comprehensive study of occupational biomechanical overload, it is advisable to adhere to the procedure outlined in Table 1.

Following, the use of the TACOs method requires the following application strategies, summarised in Table 2.

In the following pages (Results), an example is provided to better illustrate how to apply the TACOs method.

2.2. Types of postures, time assessment and relative scores for posture analysis

The lists of postures to be considered and the specific scores assigned, presented in TACOs Strategy, are shown in **Annexe 1** (Forms 1 to 19). The postures were selected from various methods reported in the scientific literature (Karhu, Kansi, and Kuorinka 1977; McAtamney and Corlett 1993; Hignett and McAtamney 2000) and in current standards (ISO 2000; CEN (European Committee for Standardization) 2005).

While the above methods propose the analysis of postures for each body segment, TACOs does not propose individual postures for individual body segments.

Table 1. The complete analysis of occupational biomechanical overload by steps.

1-Identify the exposed people to analyze: the group of workers exposed to the same work risks (homogeneous group for exposure)

2-Deal with the preliminary organizational study: analyze whether the homogeneous group of workers identified is:
- exposed to only one task,
- exposed to multiple tasks in a daily cycle that repeats in a similar way all year round,
- exposed to multiple tasks that are distributed differently over the different days of a month (monthly cycle), which then repeats in a similar way same throughout the year,
- exposed to multiple tasks that are distributed differently over the different months of the year (year cycle).

3a-Study the risk of biomechanical overload of the upper limbs in repetitive work (which also includes the study of postures: the OCRA method (i.e. the OCRA Checklist) is recommended.

3b-Study the risk of biomechanical overload of the spine in manual lifting (loads weighing 3 kg or more): the RNLE method is recommended.

3c Study the risk of exposure in tasks involving awkward postures of the spine and/or lower limbs: the TACOs strategy (Annex 1).

Table 2. The application strategies of the TACOs method by steps.

1.Identify the task/s.

2.Evaluate the specific postures intrinsic risk scores within each task identified (evaluate the intrinsic risk means evaluating the risk as if the task is the only one performed during an 8-hour shift (with a canteen break and two 10-minute breaks).

3. Study the proportion with which each task is performed in the identified period: daily, or monthly or annual cycle (previously identified) and modulation of their intrinsic risk scores through the application of Duration Multipliers (Dm) in Table 3 corresponding to the true duration of the tasks.

4. Application of calculation models for estimating the final exposure score, modulated with respect to the true duration of the tasks in the identified cycle.

4.a Daily monotask: application of DM in table 3 (Duration Multiplier) to the intrinsic risk score.

4.b Daily multitask: calculation of the Weighted Average if the turn-over is less than 90 minutes, otherwise use the original MULTIGEI calculation formula (see below)

4.b Multitask on a monthly or yearly cycle: apply the original MULTIGEI calculation formula (see below).

Instead, it presents images of entire working postures that have been pre-scored, and the scores vary depending on the duration of the task under consideration.

Regarding the scoring criteria, it is important to note that the exposure scores simply rank postures from the most comfortable (typically the "neutral" posture) to the most awkward. For instance, consider the postural scenario outlined in Form 7: when frequent changes of posture occur, such as transitioning from standing to sitting with back support, at least every hour, the risk score will be 0.5 (indicating no risk) for durations comprising 1/3, 2/3, and 3/3 of the time.

Another example pertains to Form 8, where the worker is seated upright, reclining against a backrest. In this scenario, the scores are as follows: 0.5 when the worker spends approximately 1/3 of the time (around 20-40%) in this posture; a score of 1.5 when the worker spends half the time (approximately 40-60%); and a score of 3 when the worker spends most of the entire time (approximately 60-100%). As the discomfort caused by the posture intensifies, the scores escalate accordingly, commencing from a duration of 1/3 of the time. Subsequently, the other scores are doubled or tripled. It is worth noting that a score is assigned to very tiring or uncommon postures even if adopted for as little as 1/10 of the time.

The scores range from 0.5 (lowest score for comfortable positions lasting up to 1/3 of the time) to 14 (most awkward positions lasting 3/3 of the time, for example trunk flexion >60° and/or trunk twisted almost all the time).

In other words, the descriptive exposure scores are adjusted based on the awkwardness and duration of the task.

As a general approach to identifying and describing postures and their duration, the following guidelines have been adhered to:

- all the Forms in Annexe 1 are divided into five main groups: standing postures, sitting postures, postures primarily involving the lower limbs, complex (mixed) postures involving multiple body parts, and postures involving the cervical spine,
- whole-body postures presented are defined using sketches and simple descriptions to aid in their identification,
- postures should be examined task by task, allowing for the measurement of posture duration in each task using pie charts depicting different risk scores. The use of stopwatches is seldom necessary.

Additionally, several unique but commonly encountered postures have also been considered, including carrying loads on the head (Form 18), working on a ladder (e.g. pruning trees or cleaning, Form 17), and positions involving a semi-flexed spine with supported knees (e.g. nurses at the patient's bedside or physiotherapists, Form 16).

Form 19 specifically analyses postures involving the cervical spine. The postures described in this form are examined and scored according to three durations. This form, along with the one addressing the use of pedals (Form 14), is used "in conjunction with the other primary postures": first, it identifies the primary posture (sitting, standing, squatting), then it incorporates the use of a pedal and/or awkward postures of the cervical spine.

Given the great diversity and specialisation of postures analysed in certain work settings, various other "simple tools" have been developed that are tailored to certain tasks and jobs, such as physiotherapists working with brain-damaged children. More special postures may be studied and added in the future.

2.3. TACOs strategy: procedure for analysing postures in a daily single-task job, performed on a full-time or part-time basis

Posture analysis should be conducted for each individual task. In the case of repetitive tasks, the analysis can be performed on a single cycle, typically a short one, or on a representative portion of the cycle if it is longer but characterised by the repetition of the same actions.

In a given task, there may be only one of the postures depicted in **Annexe 1** (one form), or there may be multiple postures (multiple forms). If multiple forms are applicable to a task, the score corresponding to the duration of each posture, represented in the Form in Annexe 1, within the task should be selected. The sum of these scores will provide the intrinsic postural score for that particular task (Figure 2.).

The final intrinsic postural score, specific to a given task, and considering a "standard" task duration of 440-480 minutes in a daily shift, should be adjusted to reflect the actual duration of the task within the shift. For this purpose, we propose using duration multipliers DM, the same adopted in the OCRA Checklist method (Table 3), to adjust the final exposure score based on the real duration of the task, whether on a full-time or part-time (Colombini and Occhipinti 2017; 2018). For a duration of 440-480 minutes, DM equals 1 and thus does not alter the intrinsic score; the shorter the exposure duration, the lower DM, thereby reducing the final exposure score proportionally. Conversely, if the net task duration exceeds 8 hours, DM will lead to an increase in the final exposure score.

The final posture exposure scores will be presented both collectively and individually for the four major anatomical sections: head and neck; spine in the

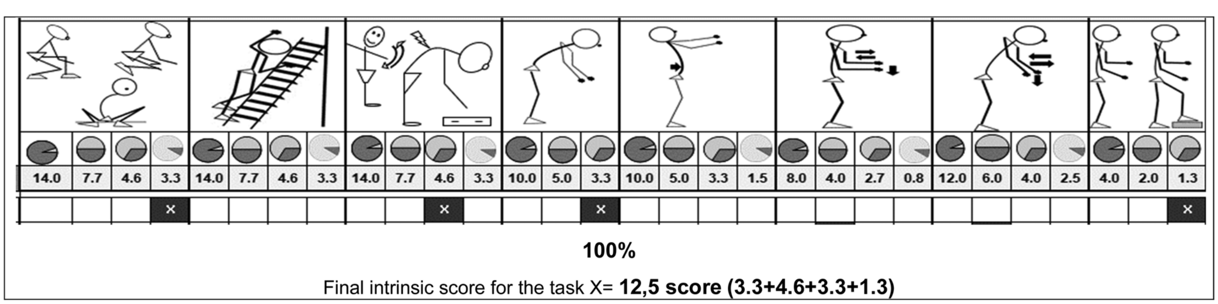


Figure 2. Calculation of the posture intrinsic final score in a single task, with TACOS strategy.

Table 3. OCRA checklist duration multipliers (DM), also utilised in the TACOs strategy, are essential for adjusting the final exposure risk, in function of the net task duration.

Net duration of task (min.)	Duration multiplier	Net duration of task (min)	Duration multiplier	Net duration of task (min.)	Duration multiplier
<1.9	0.007	60 to120	0.5	421 to480	1
1.9 to 3.6	0.018	121 to180	0.65	481 to 540	1.2
3.7 to7.4	0.05	181 to 240	0.75	541 to 600	1.5
7.5 to14	0.1	241 to 300	0.85	601 to 660	2
15 to29	0.2	301 to 360	0.925	661 to 720	2.8
30 to 59	0.35	361 to 420	0.95		

Table 4. The five-exposure score areas are characterised by colours (green, yellow, orange, red and purple), representing different levels of exposure to awkward postures.

Zone	TACOs	Risk classification	Zone	TACOs	Risk classification
Green	<= 0.55	Acceptable	Red-medium	4.00-8.00	Medium
Yellow	0.56-2.00	Borderline or very slight	Purple	>8.00	High
Red-low	2.1-3.9	Slight			

standing position; spine in the sitting position; and lower limbs. The software developed specifically for this purpose automatically extracts the relevant body segments from each Form (complex postures), enabling different exposure levels to be obtained for each of the four body parts.

Since the maximum score is 14, a series of five exposure categories has been arbitrarily defined, each represented by a different colour, indicating different degrees of awkwardness, also considering duration: green, yellow, orange (or red-low), red, and purple (refer to Table 4). This approach is applied both intrinsically to each posture and to the overall outcome of the total individual or multiple task analysis.

2.4. TACOs strategy: all the calculations for timing exposure to multi-task jobs, based on a daily shift

When jobs involve multiple tasks, two mathematical models are utilised to calculate TACOs scores for postures, namely the Time-Weighted Average and the MultiGEI (Colombini and Occhipinti 2014, 2017, 2018; Colombini et al. 2021). These mathematical models are also applied to assess the final risk score for exposure to biomechanical overload of the upper limbs and spine during manual lifting (using the OCRA and RNLE methods) when tasks are rotated in daily, weekly, monthly, or yearly cycles.

a. Time-Weighted Average:
   To compute the final exposure score for jobs involving multiple tasks, this mathematical model assigns a weight to the total duration of the series of tasks performed during the shift. It then allocates specific durations to each individual task performed during the shift, expressed as time fractions. The final exposure levels are adjusted using the Duration Multiplier DM, indicated in Table 3.
b. MultiGEI
   The MultiGEI model is an "incremental" approach based on the concept of identifying the task that generates the most challenging postures ("peak task") and considering its score as the minimum final score. The proportional contribution of the other tasks is then added to this minimum score.

In other words, while the Time-Weighted Average model smooths out exposure peaks, especially when there are both very low- and very high-risk scores, the MultiGEI model tends to retain these peaks.

Currently, due to uncertainties over which is the preferrable model, the software automatically calculates the final exposure level using both mathematical models to allow for a comparison of the results. However, based on physiological considerations, we recommend prioritising the results obtained from the MultiGEI approach. Therefore, only this formula is presented here.

The calculation criteria in the TACOs strategy will now be described based on operational phases, followed by an example in the Results section.

2.4.1. Phase 1: Identifying tasks and calculating intrinsic scores for postures

The first step involves identifying all the tasks undertaken during the shift, along with the associated postures, particularly those that are awkward or tiring.

It is important to revisit the definition of a task: it refers to a clearly defined activity aimed at accomplishing a specific operational outcome (e.g. chopping timber to size, attaching tie wires, laying down parts, plastering walls, etc.).

This entails identifying the intrinsic postures inherent to each task, i.e. the postures that characterise the task as if it is the only one performed for the entire duration of one shift, typically ranging from 440 to 480 minutes (chosen as a constant).

2.4.2. Phase 2: Exposure analysis in task rotations based on a daily cycle

In each shift, the net duration of the tasks to be analysed must be calculated, excluding pauses or irrelevant tasks. Subsequently, the corresponding Duration Multiplier is applied to adjust the exposure scores based on the total duration of all the relevant tasks in the shift.

The MultiGEI model, which calculates the final exposure score, is founded on the concept of the task generating the highest overload (referred to as the 'peak task'). This peak task's effective continuous duration serves as the minimum score, to which the contribution of the other tasks is added in proportion to their intensity and duration. In this case, the procedure is based on Formulas [1] and [2].

$$\textbf{MultiGEI} = E_{\text{I.1eff}} + (\Delta E_{\text{I.1}} \times K) \quad [1]$$

$$K = \left(\left(E_{\text{I.2max}} \times F_{\text{T.2}}\right) + \left(E_{\text{I.3max}} \times F_{\text{T.3}}\right) + \ldots + \left(E_{\text{I.jmax}} \times F_{\text{Tj}}\right)\right) / E_{\text{I1max}} \quad [2]$$

Where:

MultiGEI	Final exposure risk score for multiple rotating manual tasks, using the complex multitask approach;
$E_{I\bullet 1,2,3,\ j\ eff}$	Score for all active tasks, calculated considering D_{mj} (duration multiplier according to the effective duration of each relevant task$_s$ in a working day);
$E_{I\bullet 1,2,3,\ j\ max}$	Score for all active tasks, calculated considering D_{mtot} (duration multiplier for the total duration of all relevant tasks in a working day);
$E_{I.1\ eff}$	Score for task 1, the task with the highest risk score, calculated considering D_{m1} (duration multiplier according to the actual duration of task$_1$ in a working day);
$E_{I1\ max}$	Score for task1, the task with the highest risk score, calculated considering D_{mtot} (duration multiplier for the total duration of all relevant tasks in a working day);
Δ $E_{I.1}$	$E_{I1\ max} - E_{I1\ eff}$;
F_{Tj}	Fraction of time (between 0 and 1) of each task j – except task $_1$ – with respect to total working time minus working time devoted to task$_1$ (in a working day).

2.5. TACOs strategy considering exposure to multi-task jobs based on non-daily cycles: weekly, monthly, yearly

Based on the model for analysing daily task rotations, the next step is to establish a set of procedures and criteria for estimating exposure in more complex situations where workers rotate through several manual tasks with varying levels of exposure distributed over periods longer than a day (referred to as macro-cycles). In such cases, the organisational analysis becomes increasingly important.

The key elements of this procedure include (Colombini and Occhipinti 2018; 2021; ISO/TR 7015 2023; ISO/TR 23476 2021):

Table 5. Exposure time constants.

Hours/day constant	8	Hours/month constant	160
Minutes/day constant	440	Days/month constant	20
Days/week constant	5	Months/year constant	11
Minutes/week (440 min * 5 days) constant	2,200	Days/year constant	220
Weeks/month constant	4	Hours/year constant	1,760

- identifying the period over which the tasks are rotated: this could be a week, month, year, or any other representative period,
- identifying homogeneous groups of workers, defined by their exposure to occupational risks. These groups consist of workers who perform the same rotating tasks, in the same workplace, for similar durations and sequences. A group can also be comprised of only one worker if no one else performs the same job,
- analysing the duration and sequence of all the various manual tasks performed by each homogeneous group over the macro-cycle in questioned,
- calculating the intrinsic exposure score of each task using the TACOs strategy,
- reconstructing an "artificial" working day (in minutes) proportionally with respect to reference time constants (refer to Table 5). This artificial day is used to represent the entire macro-cycle. Each task duration is transformed into representative minutes based on these constants,
- recalculating the intrinsic exposure score for each task, now considering the estimated duration of each task, using duration multipliers (refer to Table 3),
- once the macro-cycle has been transformed into a representative working day, the same formulas [1] and [2] used to analyse daily rotations, can be applied, considering the individual tasks present in the macro-cycle under examination.

3. Results

Several application examples of multitask analyses on daily, weekly, monthly, or annual cycles are available (Colombini and Occhipinti 2018). Due to space constraints, this paper will focus on the results of one of the most complex applications: an annual cycle with the application of calculation criteria using the TACOs strategy for a homogeneous group of construction

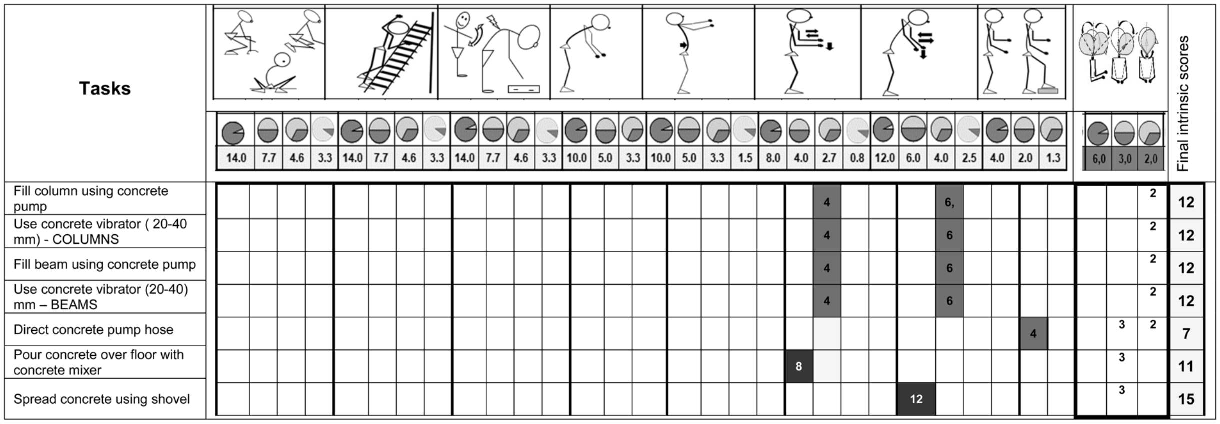


Figure 3. Calculation of intrinsic posture scores for all the identified tasks, using the TACOs method, chousing (along the horizontal line) the timing scores, corresponding to its presence in each posture of that task.

workers laying concrete in the vertical and horizontal structures of a building.

The results are presented in successive phases, obtained using a specific, simple tool – the Excel spreadsheets entitled "VINCI multitask software for annual cycles", which can be downloaded for free at: *free-software-in-english - EPM INTERNATIONAL ERGONOMICS SCHOOL (epmresearch.org).*

3.1. Phase 1 – identifying the tasks performed by the homogeneous group and calculating the intrinsic posture scores within each task

Figure 3 displays both the list of tasks performed by the homogeneous group and the corresponding intrinsic posture scores. The posture scores assigned to each task, illustrated through figures depicting both the type and duration of postures, are obtained by placing an "X" in the relevant box. All scores corresponding to each posture, as well as the final intrinsic value for each task (which is the sum of all the postures included in the task), will appear automatically.

Since each task (described on the horizontal line) may include one or more postures, the individual posture (if only one is present) or set of postures (if multiple) should always amount to 100% of the total duration of the task (with acceptable levels between 90% and 100%).

To complete the biomechanical overload analysis, all identified tasks are also analysed using the OCRA checklist to calculate their intrinsic exposure level, focusing specifically on postures and movements of the upper limbs. This evaluation can be performed using the same software, by completing the specific form for analysing the upper limbs.

3.2. Phase 2 – quantitative exposure time analysis for each homogeneous group

Table 6 presents organisational data regarding the shift, including the number and duration of breaks and non-repetitive tasks present in the shift. This data provides the net duration of the work. However, since the cycle is yearly, the data presented here reflects the data for a representative shift for each month of the year.

Additionally, organisational data is supplemented with the number of hours worked monthly by each worker in the homogeneous group, as shown in Table 7.

To conclude a multitask exposure analysis, it is necessary to obtain a quantitative description of the active tasks, expressed as the percentage duration of each task within the month. The sum of the percentages per month in each column must always add up to 100%, as shown in Table 8. This information quantifies how often the worker performs various tasks and for how long, which is crucial for estimating exposure.

With this information, the software automatically calculates the total time (in hours) spent performing each task per month and per year, as well as the relative proportions with respect to the Constant, which is equal to 1,760 hours per year, as depicted in Table 9.

3.3. Phase 3 – exposure risk analysis for each homogeneous group

Having now acquired both the intrinsic exposure data for postures across different tasks and estimated their durations over the year (in hours and percentages) the MultiGEI formulas [1] and [2] can now be applied to obtain the final exposure levels. The software will

Table 6. Description of representative shift per month over one year for homogeneous group no. 1, to obtain the net duration of work.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Net shift duration (minutes)	-	480	-	480	-	480	480	480	-	480	-	480
Nr. of official breaks (excluding lunch break)	-	2	-	2	-	2	2	2	-	2	-	2
Nr. of breaks with actual duration equal to or longer than 8 minutes (excluding lunch break)	-	2	-	2	-	2	2	2	-	2	-	2
Actual duration of breaks (minutes) (excluding lunch break)	-	30	-	30	-	30	30	30	-	30	-	30
Duration (in minutes) of lunch break if within the shift (paid)	-	60	-	60	-	60	60	60	-	60	-	60
If the shift is interrupted to transfer to a different worksite (or for unpaid lunch breaks) indicate the number of interruptions only if the duration is ≥ 30 min.												
Total duration of actual pauses (minutes)	0	90	0	90	0	90	90	90	0	90	0	90
NON-REPETITIVE TASKS												
Putting on/taking off uniforms (protective gear)	-	10	-	10	-	10	10	10	-	10	-	10
Cleaning	-	15	-	15	-	15	15	15	-	15	-	15
Other: TIME TO REACH WORKSTATION	-	8	-	8	-	8	8	8	-	8	-	8
Others:	-	15	-	15	-	15	15	15	-	15	-	15
Total duration in minutes of non-repetitive tasks In the shift	0	48	0	48	0	48	48	48	0	48	0	48
NET DURATION OF WORKING TIME		342		342		342	342	342		342		342

Table 7. Number of hours worked in each month of the year by homogeneous group no. 1 and each individual worker.

Total working hours per year/ worker	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nr. of hours worked per month (by each worker in the homogeneous group)	–	220	–	200	–	220	220	200	–	195	–	220
% reduction (net duration), considering the net duration versus total duration of the shift	-	71%	-	71%	-	71%	71%	71%	-	71%	-	71%
Nr. of hours spent per month/worker performing the task (net duration)	–	156.8	–	142.5	–	156.8	156.8	142.5	–	138.9	–	156.8
Total working hours/worker/ year	1475											
Constant working hours/ worker/year	1760											

handle the intricate calculations automatically, yielding accurate results.

The TACOs strategy recommends extending posture descriptions to include a comprehensive analysis of biomechanical overload when feasible and necessary. Figure 4 illustrates the comprehensive outcome of such an analysis using the OCRA checklist, encompassing both left and right limbs. The graph also presents a monthly trend for exposure levels, amalgamating disparities in risk levels and task durations.

The total annual exposure score (OCRA checklist = 28 for both right and left upper limbs) and monthly scores are computed using the MultiGEI mathematical model. Table 10, extrapolating data from the OCRA checklist (useful for reference purposes), briefly outlines awkward upper limb postures, indicating their percentages over the specific period. Notably, within this homogeneous group, manual handling of loads is absent.

To complete the study of biomechanical overload, it was necessary here to evaluate back and lower limb

Table 8. Quantitative description of active tasks with the percentage duration of each task within the month.

All tasks	Active tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Breakdown of the task duration for each month of the year											
Fill column using concrete pump	x	-	15%	-	15%	-	15%	15%	15%	-	15%	-	15%
Use concrete with vibrator (20-40 mm) - COLUMNS	x	-	5%	-	5%	-	5%	5%	5%	-	5%	-	5%
Fil beams using concrete pump	x	-	15%	-	15%	-	15%	15%	15%	-	15%	-	15%
Mix concrete with vibrator (20-40mm) - BEAMS	*x*	-	*5%*	-	5%	-	5%	5%	5%	-	5%	-	5%
Direct concrete pump hose	*x*	-	*10%*	-	10%	-	10%	10%	10%	-	10%	-	10%
Pour concrete over floor with concrete mixer	*x*	-	*10%*	-	10%	-	10%	10%	10%	-	10%	-	10%
Spread concrete using shovel	*x*	-	*10%*	-	10%	-	10%	10%	10%	-	10%	-	10%
Mix concrete with vibrator (20-40 mm) - FLOOR	*x*	-	*3%*	-	3%	-	3%	3%	3%	-	3%	-	3%
Manually support vibrator extension	*x*	-	*1%*	-	1%	-	1%	1%	1%	-	1%	-	1%
Pump concrete over floor	*x*	-	*10%*	-	10%	-	10%	10%	10%	-	10%	-	10%
Spread concrete using rake	*x*	-	*10%*	-	10%	-	10%	10%	10%	-	10%	-	10%
Level concrete using with long steel scraper	*x*	--	*5%*	--	5%	--	5%	5%	5%	--	5%	--	5%
Level concrete with laser level (reinforced concrete)	*x*	-	*1%*	-	1%	-	1%	1%	1%	-	1%	-	1%
		%	100		100		100	100	100		100		100

Table 9. Total time spent performing each task per year and percentages with respect to the net duration of tasks per month and constant 1,760 hours per year.

All the tasks performed		% of total hours worked per year	Hours worked per year per task	% vs annual constant of 1760 hours
Fill column using concrete pump	x	15.0%	221	12.6%
Mix concrete with vibrator (20–40 mm) - COLUMN	x	5.0%	74	4.2%
Fill beams using concrete pump	x	15.0%	221	12.6%
Mix concrete with vibrator (20–40 mm)- BEAM	*x*	5.0%	74	4.2%
Direct concrete pump hose	*x*	10.0%	148	8.4%
Pour concrete over floor with concrete mixer	*x*	10.0%	148	8.4%
Spread concrete using shovel	*x*	10.0%	148	8.4%
Mix concrete with vibrator (20-40 mm) - FLOOR	*x*	3.0%	44	2.5%
Manually support vibrator extension	*x*	1.0%	15	0.8%
Pump concrete over floor	*x*	10.0%	148	8.4%
Spread concrete with rake	*x*	10.0%	148	8.4%
Level concrete with long steel scraper	*x*	5.0%	74	4.2%
Level concrete with laser level (reinforced concrete)	*x*	1.0%	15	0.8%
		100%	1475	84%

postures. The software automatically computes exposure scores for these areas, both collectively and broken down into four main categories (Table 11): head-neck, spine/standing, spine/sitting, and lower limbs.

It should be noted that the percentages calculated for the spine and lower limbs are separate from those of the head and neck, as these postures may co-occur.

Subsequently, a valuable perspective on the proportional distributions of various back and leg postures across primary body segments can be gleaned (Figure 5).

We have presented here, due to space constraints, only one application example illustrating a complex organisational situation. This example demonstrates the necessity and feasibility of conducting a comprehensive study of exposure to biomechanical overload risk. Both the data concerning the risk for upper limbs (here no lifting of loads or pulling and pushing occurred) and the values of postural risk for the spine and lower limbs are presented concurrently. These results were automatically processed by software in Excel, yielding easily interpretable outcomes (refer to Figure 6 and Table 11).

Given that work commitments are spread throughout the year on alternate months (as depicted in Figure 5), the study not only reveals persistently high levels of biomechanical overload risk for the upper limbs and spine but also showcases a monthly trend in exposure levels over the year.

Other studies have also been conducted in many other working sectors such as: viticulture, nursery schoolteachers, physiotherapists, archaeologists, civil constructions and are already available (Colombini and Occhipinti 2018).

4. The TACOs strategy: validation results

4.1. Methods to test interrater reliability: the Kappa statistic model

Various methods have been employed to measure interrater reliability, with the Kappa statistic being one of the most commonly used. Interrater reliability refers to the measurement of the degree to which data collectors (raters) assign the same score to the

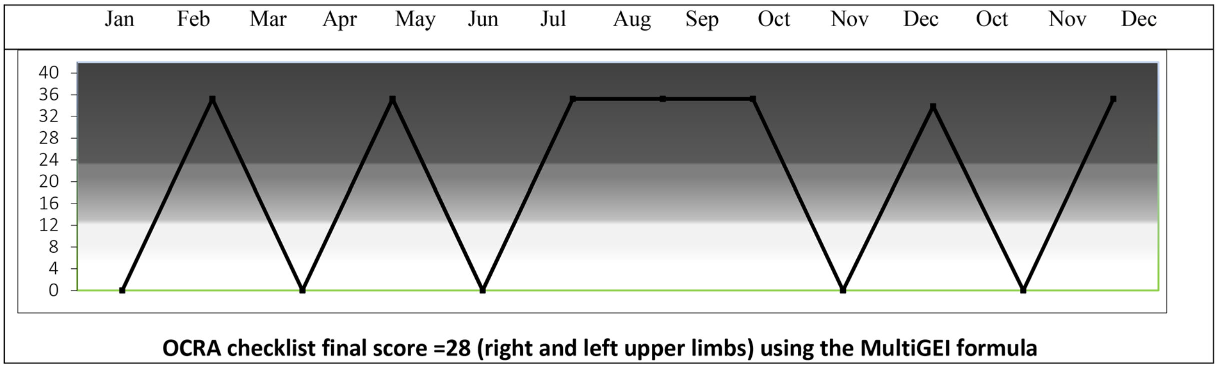


Figure 4. Evaluation of biomechanical overload of the upper limbs using the OCRA checklist. Exposure levels are also provided for each month of the year, showing monthly exposure trends.

Table 10. Awkward upper limb postures, evaluated with the OCRA checklist. Percentages within the cycle (period) for the homogeneous group.

	Right	Left
Arm at shoulder height (>80°) and/or extension	33%	33%
Pinch, palmar or hook grip	10%	10%
Extreme wrist deviations	10%	10%
Elbow prono-supination or full arm-forearm flexion-extension	10%	10%

same variable. Similar to most correlation statistics, Kappa values can range from −1 to +1. Introduced by Jacob Cohen in 1960, Cohen's kappa provides a scale for interpreting Kappa values, as outlined by Landis and Koch (1977): <0 indicates no agreement; 0-20 suggests slight agreement; 21-40 indicates fair agreement; 41-60 suggests moderate agreement; 61-80 indicates substantial agreement; and 81–1.0 indicates perfect agreement."

4.2. Material

The inter- and intra-rater reproducibility of the TACOs Strategy was evaluated by assessing the agreement among the results obtained by 14 observers who analysed six distinct tasks. The tasks varied considerably and encompassed activities such as fruit picking, applying cement to walls, preparing meat sauce in company canteens, making beds in hotels, assembling pizza trays in supermarkets, and arranging pots for transplanting greenhouse plants. Observers completed a dedicated training course in posture analysis. The cycle times for these tasks ranged from 15 to 60 seconds.

For the intra-observer analysis, each posture evaluation was repeated twice by the same observer in two sessions 2-3 weeks apart. Inter-observer evaluations were conducted among different observers.

4.3. Reliability study results

Reliability was assessed using the Kappa statistical methodology according to Landis (Landis and Koch 1977).

The validation results, summarised here for brevity and to be detailed in a separate paper, pertain to the global posture evaluation across the six different tasks using the TACOs method. This includes:

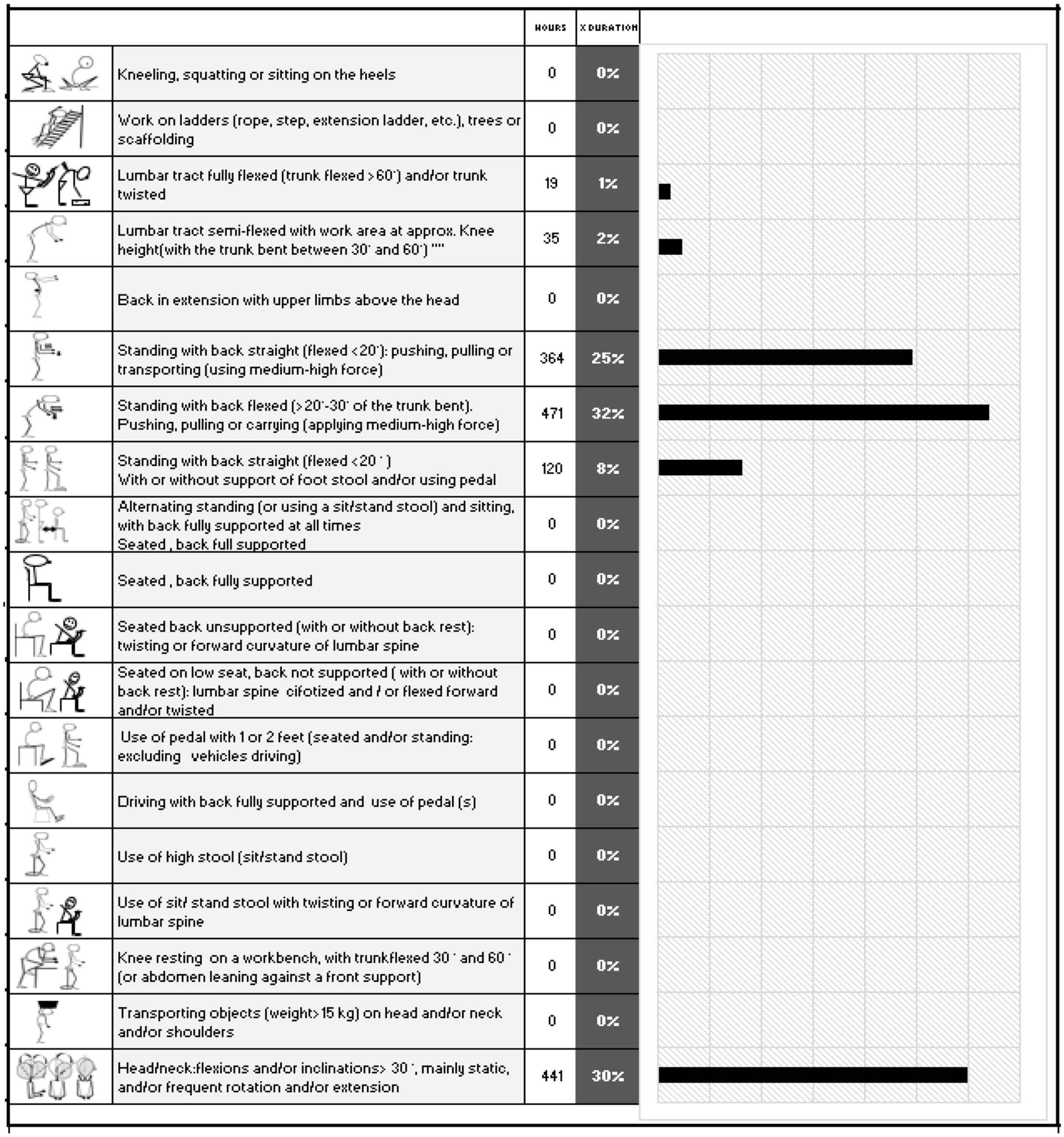
- consistency in repeated posture assessments, yielding the same result,
- instances where evaluations underestimated posture,
- instances where evaluations overestimated posture,
- consistency in identifying postures without risk.

Both intra- and inter-rater analyses demonstrate good validation results: intra-rater reliability shows 'perfect' reproducibility (K = 0.89), while inter-rater reliability indicates 'moderate' reliability (K = 0.50). These results hold statistically significant.

In an upcoming article, currently in preparation, we will present analytical results testing interrater reliability. These results will include assessments for each of the individual posture, outlined in the Tacos method (spinal and lower limb) and in the OCRA method (upper limb). Additionally, we will compare these results with those obtained using other evaluation methods.

4.4. Reliability results discussion

The results, briefly exposed for reasons of space, show that, while for intra-rater, "perfect" reliability appears, for inter-rater the reliability is instead at a "moderate" level. The explanation we obtained, by analytically



	Hours	% Duration
Kneeling, squatting or sitting on the heels	0	0%
Work on ladders (rope, step, extension ladder, etc.), trees or scaffolding	0	0%
Lumbar tract fully flexed (trunk flexed > 60°) and/or trunk twisted	19	1%
Lumbar tract semi-flexed with work area at approx. Knee height(with the trunk bent between 30° and 60°) ""	35	2%
Back in extension with upper limbs above the head	0	0%
Standing with back straight (flexed < 20°): pushing, pulling or transporting (using medium-high force)	364	25%
Standing with back flexed (> 20°-30° of the trunk bent). Pushing, pulling or carrying (applying medium-high force)	471	32%
Standing with back straight (flexed < 20 °) With or without support of foot stool and/or using pedal	120	8%
Alternating standing (or using a sit/stand stool) and sitting, with back fully supported at all times Seated , back full supported	0	0%
Seated , back fully supported	0	0%
Seated back unsupported (with or without back rest): twisting or forward curvature of lumbar spine	0	0%
Seated on low seat, back not supported (with or without back rest): lumbar spine cifotized and / or flexed forward and/or twisted	0	0%
Use of pedal with 1 or 2 feet (seated and/or standing: excluding vehicles driving)	0	0%
Driving with back fully supported and use of pedal (s)	0	0%
Use of high stool (sit/stand stool)	0	0%
Use of sit/ stand stool with twisting or forward curvature of lumbar spine	0	0%
Knee resting on a workbench, with trunkflexed 30 ° and 60 ° (or abdomen leaning against a front support)	0	0%
Transporting objects (weight> 15 kg) on head and/or neck and/or shoulders	0	0%
Head/neck:flexions and/or inclinations> 30 °, mainly static, and/or frequent rotation and/or extension	441	30%

Figure 5. Proportional distributions of the various back and leg postures for the main body parts.

Table 11. Exposure scores relative to back and lower limb postures, total and broken down by the four main posture categories (head-neck, spine/standing, spine/sitting, lower limbs).

Total final annual exposure score	Final annual exposure score for posture category			
	Head and neck	Spine/standing	Spine/sitting	Lower limbs
10.4	30%	68%	0%	0%
	2.2	**8.2**	**0.0**	**0.0**

analysing the reliability posture by posture, is that the recognition of the awkward posture causes identification problems when it presents itself borderline with respect to the beginning of its degree of incongruity. In the intra-observer reading, the evaluator, in the double evaluation, maintains his choice, while in the inter-observer evaluation different interpretative paths can be taken by the different evaluators, in judging the posture at risk or not, precisely in case it is borderline. In the TACOs method, this occurs only when the postures to be evaluated as incongruous are described through angles (cervical and lumbosacral spine in semi-flexion, complete flexion, rotation.). The presence of such postures to be evaluated in a task may be frequent or not. For the majority of other postures, considered in the TACOs method, which describe an entire postural structure (kneeling posture, ladder posture, supported sitting posture, etc.) the problem does not exist. The definition of the durations of each posture in the task resulted less problematic. given that the user has to check, following failure of the software, that the sum of their individual durations in % must always give 100% (Figure 3).

5. Discussion

The development of the TACOs strategy for posture analysis arises from the necessity to adjust the intensity of posture risk factors in accordance with their duration. It is designed to calculate final exposure scores in real work settings, incorporating detailed preliminary organisational studies that are often overlooked in other risk assessment methods. This entails identifying tasks, evaluating postures within each task, and determining posture durations throughout the work period.

Another crucial recommendation is to approach the study of biomechanical overload risk holistically, rather than solely focusing on descriptive analysis of awkward postures. Additionally, the TACOs strategy for posture analysis should be complemented with an assessment of biomechanical overload in the upper limbs, utilising methods like the OCRA Checklist for a comprehensive evaluation. Similarly, for tasks involving manual handling, techniques such as the RNLE or psychophysical tables for carrying, pushing, and pulling should be utilised to evaluate the risk to the lower spine.

Thus, the risk assessment strategy outlined here underscores the importance of simultaneously examining both physical risk factors (e.g., force and posture) and organisational factors (e.g., frequency and duration) when investigating biomechanical overload conditions. It stresses the need to integrate posture analysis with other pertinent factors to gain a comprehensive understanding of occupational risks.

Moreover, the TACOs method, along with the OCRA method (Colombini and Occhipinti 2017) and the RNLE revisited and updated with the VLI method (Colombini et al. 2012), can be applied to studies on both mono-task and multi-task work exposures within daily cycles commonly found in various industries. Furthermore, they can be extended to encompass highly complex cycles (e.g., multi-tasking within monthly and annual cycles) prevalent in sectors such as agriculture, construction, supermarkets, and physiotherapy.

Considering the complexity of these exposure studies and the formulas required to calculate final exposure indices, user-friendly tools have been developed: *free-software-in-english - EPM INTERNATIONAL ERGONOMICS SCHOOL (epmresearch.org)*, They aim to streamline and expedite the investigative process, which can be challenging due to the intricacies of the mathematical models.

These Excel spreadsheets are available for:

- analysing exposures to single or multiple tasks on a daily cycle (TACOs method for posture).
- analysing complex multi-task exposures in monthly or annual cycles (Vinci Multitask Software).

In the manuals published by Colombini et al. (2012), Colombini and Occhipinti (2017), and Colombini and Occhipinti (2018), numerous application examples are provided to illustrate that with the provided criteria and these operational aids (the Excel spreadsheets), it is feasible to address the complete study of biomechanical overload even in complex and often high-risk situations. It can be affirmed that even these seemingly “mission impossible” scenarios become “possible" with these resources.

6. Conclusions

In many industrial settings, the examination of occupational biomechanical overload has traditionally emphasised repetitive movements, upper limb exertions, and manual load handling. Methods like OCRA, RNLE, or psychophysical tables inherently incorporate the assessment of awkward postures alongside other pertinent risk factors, notably organisational aspects such as frequency, duration, and recovery periods. These elements contribute to defining the overall risk of biomechanical overload, particularly for the upper limbs and lower lumbar spine.

However, certain occupations and work environments, both industrial and non-industrial, necessitate a more comprehensive evaluation of biomechanical overload, requiring the inclusion of awkward postures involving the entire spine and lower limbs. For example, jobs in agriculture, building construction, childcare, and physiotherapy frequently involve such postures, along with repetitive upper limb movements and manual load handling.

While the existing literature and international standards offer methods for analysing working postures, these often fall short of addressing relevant organisational aspects, such as exposure time and multitasking (McAtamney and Corlett 1993; Hignett and McAtamney 2000; ISO 2000), as comprehensively as methods like

OCRA or RNLE. Consequently, the final exposure levels are often not correlated with the actual duration of exposure.

It is essential to note that, like many other methods, the scores assigned by the TACOs strategy to various postures are ordinal. They are utilised to classify exposure from the lowest to the highest level. However, these scores cannot currently be considered predictive of the likelihood of developing work-related disorders or diseases. This limitation arises from the absence, not only in TACOs method but in the literature regarding the posture studies, of specific epidemiological studies, preventing them from being regarded as definitive risk indexes. Nevertheless, the ordinal scores proposed by the TACOs strategy will serve as valuable tools for classifying exposure levels in future epidemiological studies: these studies, with some difficulty, are still ongoing and the results will be published as they will be available.

Finally, educational resources on the TACOs method have been developed and implemented, including residential courses in various languages and e-learning courses, available in English: TACOS method to analyse THE awkward POSTUREs of SPINE AND LOWER LIMBS (thinkific.com).

These training activities serve as crucial forums for discussing the comprehensibility and practical application of the TACOs method by prospective users. They also provide authors with invaluable feedback for continuous improvement.

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Annexe 1

Form 1
The work is generally performed below knee level. This posture is particularly tiring for the back and often also entails twisting of the trunk. The scores indicated must be applied even if the back is straight. but the trunk is significantly twisted.

Form.2
A very frequent posture for the back. occurring in numerous types of jobs, which starts with a 30° flexion (trunk visibly bent) then increases to 60°, with the work performed roughly at knee height.

Form 3
It is particularly tiring to work with the spine extended, as this position overloads the structures of the lower back. Eventually, especially if the job also involves manual lifting, this posture can lead to acute lower back pain. The situation is aggravated by working with the arms raised.

Form 4
This posture occurs in a wide range of very different settings: e.g. physiotherapists treating patients with back flexed and pressing downwards, or jobs involving pushing or pulling trolleys with considerable effort. Unless MEDIUM TO HIGH FORCE is used this posture is the same as standing with the spine semi-flexed.

Form 5
As before, but with the back straight. This posture occurs in a wide range of very different settings: e.g. physiotherapists treating patients with back flexed and pressing downwards, or jobs involving pushing or pulling trolleys with considerable effort. Unless MEDIUM TO HIGH FORCE is used this posture is the same as standing.

Form.6
Standing, even with the back straight, becomes tiring after a prolonged period, whether in one spot or moving around. This is the typical posture of assembly line workers…

Form 7
The ideal way to minimise biomechanical overload of the lower back is to alternate between standing and sitting in a chair with a backrest at least every hour. This allows the intervertebral discs to receive nutrients through osmosis.

Form 8
Sitting with the back reclining against a backrest generates constant pressure on the lumbar intervertebral discs of up to 80 kg. These postures are not entirely comfortable if prolonged and stationary: this reduces the elimination of catabolites from the disc, lowers the action of the osmotic pump, and thus prevents nourishment from reaching the lumbar discs.

Form.9
Compared to continuously standing, using a sit/stand stool supports 60% of the bodyweight and facilitates shifting from the sitting to the standing position. The disadvantage is that it can cause localised compression, circulation problems and swelling of the lower limbs. There is no support for the back.

Form 10
Sit-stand stools require sufficient room to accommodate the lower limbs and a narrow work area for the upper limbs: falling is a risk, which is increased if the upper body has to twist and/or turn.

Form 11
Seating that does not provide lumbar support increases the load on the lumbar discs, especially if the lower back is kyphotic, as is often the case. The lumbosacral spine is subject to biomechanical overload. This section should also be used to indicate the presence of frequent significant turning and/or twisting of the trunk.

Form 12
Low chairs provide little or no support for the lower back (whether or not there is a back rest) and the upper body is often bent forward. Loads on the lumbar discs increase and the lumbosacral spine is subject to biomechanical overload. Use this section also to highlight the presence of frequent significant turning and/or twisting of the trunk.

Form 13
This section groups together all the various postures that are adopted when working at ground or floor level i.e. kneeling on one or both knees, squatting or sitting on the heels. The spine and upper limbs are significantly engaged.

Form 14
The presence of a pedal should be specified in this section, along with a description of the relevant sitting or standing posture. First indicate the posture and its duration, then the time spent pressing the pedal(s).

Form 15
Driving vehicles entails sitting in a reclined position in a seat with a backrest and using pedals. Describe here all situations resembling driving.

Form 16
In this position. one knee is resting on a work surface; physiotherapists and hospital staff often adopt this position when treating or moving patients. It helps reduce biomechanical overload of the lower back, transferring part of the load to the knee.

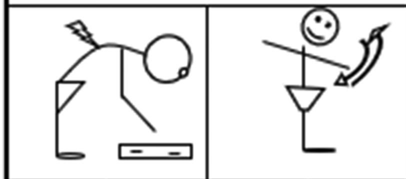
Form 17
A whole section has been devoted to this complex posture, as working on ladders engages virtually all body parts. Scores are invariably high. Included here are jobs that entail working on ladders and climbing trees and scaffolding etc.. and involve adopting uncomfortable positions to retain balance.

Form 18
The study of tiring postures associated with carrying heavy loads on the head, neck and shoulders is as neglected as it is important. This section is compiled when the loads weigh 15 kg or more.

Form 19 Head/neck: flexed and/or tilted >30°. mainly static and/or frequent rotations and/or extensions. Flexing and/or bending of the head is described when the positions are mainly static and the flexion is above 30°. The description also reports frequent turning and/or extension of the head.3/3 = score 6; 1/2 = score 3; 1/3 = score 2.

Annexe 1 Figures from Form 1 to 9

Form 1
Lumbar tract fully flexed (trunk flexed >60°) and/or trunk twisted



Almost all the time	About half the time	One third Of the time	A small part of the time
14	7	4,6	3

Form.2
Lumbar tract semi-flexed with work area at approx. Knee height (with the trunk bent between 30° and 60°) "

Almost all the time	About half the time	One third of the time
10	5	3,3

Form 3
Back extended with upper limbs above head height

Almost all the time	About half the time	One third Of the time	A small part of the time
10	5	3,3	1,5

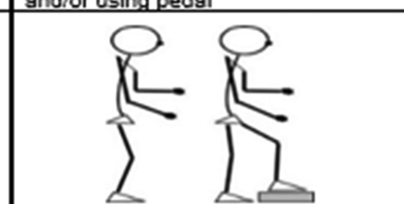
Form 4
Standing with back flexed (>20°-30° of the trunk bent). Pushing, pulling, or transporting (applying medium-high force)

Almost all the time	About half the time	One third Of the time	A small part of the time
12	6	4	2,5

Form 5
Standing with back straight (<20° of trunk bent): pushing, pulling, or transporting (using medium-high force)

Almost all the time	About half the time	One third of the time	A small part of the time
8	4	2,7	0,8

Form.6
Standing with back straight (<20 ° of the trunk bent),
With or without support of foot stool and/or using pedal



Almost all the time	About half the time	One third Of the time
4	2	1,3

Form 7
Alternating standing (or using a sit/stand stool) and sitting, with back fully supported at all times

Almost all the time	About half the time	One third Of the time
0,5	0,5	0,5

Form 8
Seated, back fully supported

Almost all the time	About half the time	One third of the time
3	1,5	0,5

Form.9
Use of high stool (half sitting-half standing)

Almost all the time	About half the time	One third Of the time	A small part of the time
5	2,5	1,7	

Annexe 1 Figures from Form 10 to 19

Form 10
Use of high stool (half sitting-half standing)

Almost all the time	About half the time	One third of the time	A small part of the time
10	5	3,3	1

Form 11
Seated with back unsupported (with or without back rest): lumbar spine kyphotic and/or flexed forward and/or twisted

Almost all the time	About half the time	One third of the time
6	3	2

Form 12
Seated with back unsupported (with or without back rest): lumbar spine kyphotic and/or flexed forward and/or twisted

Almost all the time	About half the time	One third of the time
8	4	2,7

Form 13
Kneeling, squatting, or sitting on the heels

Almost all the time	About half the time	One third Of the time	A small part of the time
14	7	4,6	3

Form 14
Operating a pedal with 1 or 2 feet (seated and/or standing, excluding vehicle driving)

Almost all the time	About half the time	One third of the time
5	2,5	1,7

Form 15
Driving with back fully supported and operating pedal

Almost all the time	About half the time	One third Of the time
3	1,5	0,8

Form 16
Knee resting on work surface with trunk bent forward between 30° and 60° (or belly resting against frontal support)

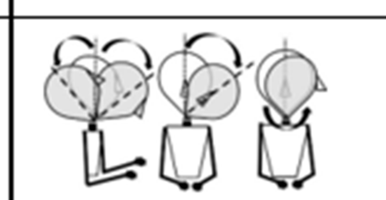
Almost all the time	About half the time	One third of the time	A small part of the time
6	3	2	0,5

Form 17
Work on ladders (rope, step, extension ladder, etc.), trees or scaffolding

Form 18
Transporting objects (weight>15 kg) on head and/or neck and/or shoulders

Almost all the time	About half the time	One third of the time	
14	7	4,6	3

Form 19
Head/neck: flexed and/or tilted >30°, mainly static and/or frequent rotations and/or extensions



Almost all the time	About half the time	One third of the time
6	3	2