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Systematic Review

Reliability and Validity of Observational Methods for Postural Load Assessment: An Updated Systematic Review

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Abstract

Context: Defined by several physiological and anatomical contributors, posture is essentially an accurate indicator of health status that is most frequently highlighted by affecting the configuration and operations of internal systems and organs. Quantifying body position has always been highlighted in clinical, academic, and industrial contexts, and various posture analysis approaches have been developed throughout the years.
Objectives: This study aims to establish the reliability and validity of several novel observational approaches to postural load assessment and provide an overall view of related trends.
Methods: This review was designed and conducted following (PRISMA) guidelines and five databases were surveyed, namely PubMed, Science Direct, CINAHL, Ergonomic Abstracts, and EMBASE, utilizing both generic and specific search terms modified for each database. Articles introducing a novel approach to observational postural load analysis and concepts of reliability and validity of the introduced method were included. Cross-sectional, case-control, experimental, and controlled trial designs were considered. Studies were excluded if they were exclusively based on subjective approaches. The methodological quality of the studies was evaluated using the MacDermid checklist. Similarly, reliability, measurement error, content validity, and criterion validity were assessed using consensus-based standards for selecting health measurement instruments (COSMIN) boxes B, C, D, and H, respectively.
Results: Twenty-five articles were selected for the final review. The studies mainly reported intra-class correlation coefficient (ICC) for reliability and r and r^2 for validity. The results on the MacDermid quality evaluation tool varied from 38 to 80%, with a mean of 61.60 ± 11.54%. Regarding the COSMIN checklists, the scores were 61.40 ± 10.39%, 59.16 ± 11.35%, 64 ± 16.07%, and 57.12 ± 15.19% for boxes B, C, D, and H, respectively. Some studies did not obtain high scores for specified inclusion and exclusion criteria and appropriate sample size, leading to a moderate quality rating in checklists.
Conclusions: Drawing comprehensive conclusions by directly comparing and contrasting observational techniques can be challenging due to their unique strengths, limitations, and inconsistencies. Such variations may arise from the methods' characteristics, such as the fields, settings, populations, and the evaluated risk factors.

Keywords: Posture Assessment, Reliability, Measurement Error, Content Validity, Criterion Validity, Systematic Review

1. Context

Posture, by definition, is the angular relationship between body segments in the three-dimensional space (1). It indicates the alignment and shape that the body adopts in static and dynamic physical conditions (2). Posture is not a fixed arrangement of body parts but is a greatly automated motion process that reflects the body's response to gravitational and other external loads (3). Defined by several physiological and anatomical contributors, body position is an accurate indicator of health, most frequently highlighted by affecting the configuration and operations of internal systems and organs (4). Consequently, deviations and irregular body posture are linked to various adverse health conditions, such as discomfort syndromes and overall or localized musculoskeletal diseases (5).

Correct posture is generally perceived as a straight and proportionally aligned posture. However, it is more accurately defined as preserving balance with optimal steadiness, least energy usage, and minimal strain on the physical structures (6). Correct posture is maintained through synchronized contraction of various postural muscles and continuous adjustment of the neuromuscular system.

The importance of quantifying posture has always been highlighted in clinical, academic, and industrial contexts (3, 7), and essentially, a variety of approaches to posture analysis have developed throughout the years. These methods are generally classified into two major groups based on data gathering procedures: direct measurement and observational. Direct measurement methods are considered more accurate and reliable than observational approaches (8). These methods can generally be organized into groups, such as X-ray examination, electro goniometry, photogrammetry and 3D body scanning, motion capture system, machine learning, and smartphone apps. Apart from being costly and sometimes invasive, and not always portable to be employed outside laboratory settings, the abovementioned approaches can analyze the posture quantitatively. In addition, with the advancement of artificial intelligence and machine learning and their integration into medical applications, several advanced approaches to posture analysis have recently been developed (9). These techniques mostly aim to modify the structure of well-known traditional methods and increase the sensitivity of the inputs. Nonetheless, due to the contemporary nature of such methodologies, further studies are required to evaluate the quality of the outcomes.

Observation techniques, on the other hand, rely on the information collected by examining the person and the associated duties, including the well-known REBA (10), RULA (11), and PERA (12). There has been a debate about the precision and accuracy of the outcomes acquired through observational techniques relying on the obtained data. (13, 14). In particular, information gathering is commonly done through personal observation or basic calculation of anticipated angles in photographs or videos. This could result in reduced precision and increased inconsistency among observers (7). Besides, many of these approaches are not standardized concerning the categories used to quantify individual postures or how postures are recorded. Nonetheless, such methods are still commonly used by practitioners as they are feasible, economical, and flexible, especially when gathering the required data in the field (3).

2. Objectives

The current review aimed to establish the reliability and validity of various observational approaches to postural load assessment and provide an overall view of related trends (Appendix 1).

3. Methods

The current review was planned and conducted in compliance with the PRISMA protocols (15) and was mainly focused on observational techniques for postural load assessment.

The study searched five databases, namely PubMed, Science Direct, CINAHL, Ergonomic Abstracts, and EMBASE, by arranging general keywords and specified terminologies for each database to identify relevant publications. The general keywords used were: (“psychometric property” OR “clinimetric property” OR “validity” OR “reliability”) AND (“posture” OR “postural load” OR “static physical workload” OR “sedentary physical workload”) AND (abbreviations of observational postural assessment tools’ titles). The researchers also explored the bibliographical references of the chosen studies to obtain further related publications. The search strategy is presented in Appendix 2 in Supplementary File.

The articles were eligible if they fulfilled the following criteria: (1) reported findings from human participants; (2) involved individuals aged six years or older; (3) presented an innovative technique for observing postures; (4) examined the credibility and accuracy of the new method; and (5) adopted any of the following research designs: Methodological, cross-sectional, case-control, experimental, or controlled trial. Excluded were book chapters, conference abstracts or proceedings, unpublished and non-English papers, and all forms of reviews. Articles that relied exclusively on subjective methods were not considered (Appendix 3).

Titles and abstracts of the categorized studies were assessed separately by two reviewers (R.O. and N.R.) to categorize eligible papers. Preliminary database checking was carried out in June 2022, and an update was performed in November 2022. Finally, both reviewers carried out a complete evaluation of the papers independently. Any inconsistency was solved through a directed meeting, and a third reviewer (M.A.M.B.) was consulted if required.

3.1. Quality Assessment

Included papers were systematically evaluated by two reviewers (RO and NR) via two special quality assessment tools: the critical appraisal tool by MacDermid checklist (16) and consensus-based standards for selecting health measurement instruments (COSMIN) checklist (17). The MacDermid tool was employed to assess the methodological quality (research inquiries, measurements, study purpose, analyses, and suggestions), providing an overall point out of twenty-two. Also, the COSMIN checklist was employed to review the psychometric properties of the introduced observational tool (box B for reliability, box C for measurement error, box D for content validity, and box H for criterion validity).

Utilizing the abovementioned checklists could assist the research team in comprehensively assessing the included studies' overall condition. Initially, two review team members (RO and NR) took part in a preliminary meeting in which all evaluation parameters were debated. Then, they individually evaluated all included papers. In the following meeting, all items from both checklists were freely debated until details were agreed upon. In case of any inconsistencies, the third reviewer (MAMB) evaluated the issue, and a discussion was held to reach a final agreement. For each checklist, the obtained total score was computed into a percentage. Ultimately, the overall score of the checklists was labeled as very low (VLQ) for scores 0 - 25%, low (LQ) for 26 - 50%, moderate (MQ) for 51 - 75%, and high (HQ) for scores 76 - 100% (18).

3.2. Data Extractions

Each reviewer conducted a thorough data extraction of half of the included papers confirmed or completed by the other assessor. Obtained parameters were the number and characteristics of participants/observations, the employed postural load assessment tool, and validity and reliability indices.

Variables considered for validity were r (simple correlation coefficient), r^2 (coefficient of determination), and measurement error between the reference system and the specified observational assessment tool. Also, intra-class correlation coefficient (ICC), weighted Kappa, Kendall's W, and Cronbach's alpha were considered for reliability.

3.3. Data Analysis

As a result of the variation in methodologies employed in the included studies, the findings of this systematic review could not be combined in a meta-analysis. Therefore, simply a descriptive synthesis of results was conducted. In general, five topics of concern were designated to describe the quality of evidence for each observational postural load assessment method: (1) tool metrics; (2) methodological quality of the study; (3) reliability and validity of the employed assessment tool; (4) strengths and weaknesses of the tool; and (5) the context of use.

4. Results

4.1. Characteristics of Studies

Nine hundred and seventy-five papers were found. Twenty-five articles were included after eliminating duplicates, screening titles/abstracts, full-text analysis, and manual source finding (Figure 1).

4.2. Methodological Quality

The results for the MacDermid quality assessment tool ranged from 38 to 80%, with a mean of 61.60 ± 11.54% (Appendix 4). Three articles were categorized as HQ studies, sixteen as MQ, and six as LQ. COSMIN results are presented by box (Appendices 5-8). Scores for box B (reliability) ranged from 44% to 83%, with a mean of 61.40 ± 10.39% (1 HQ, 19 MQ, and 5 LQ articles).

Scores for box C (measurement error) ranged from 43% to 82% with a mean of 59.16 ± 11.35% (3 HQ, 14 MQ, and 8 LQ articles). Scores for box D (content validity) ranged from 30 to 90% with a mean of 64 ± 16.07% (7 HQ, 11 MQ, and 6 LQ articles). Scores for box H (criterion validity) ranged from 29 to 79% with a mean of 57.12 ± 15.19% (3 HQ, 11 MQ, and 10 LQ articles). Some studies did not obtain high scores for specified inclusion and exclusion criteria and appropriate sample size, resulting in a noticeable medium-quality score for MacDermid and COSMIN checklists. The overall quality of evidence is summarized in Table 1.

5. Discussion

The current systematic review of 25 papers evaluated accessible, high-quality publications on the reliability and validity of the observational postural load assessment tools as an update to past reviews by Takala et al. (41) and Sukadarin et al. (42). The research also complements recent reviews by Graben et al. (43) that focused on the assessment tools for the upper extremities and from Kee (44) that precisely compared three of the main observational postural load assessment tools, and also the review by Joshi and Deshpande (45), in which comparative studies of such approaches were thoroughly evaluated. The methodological properties of the articles were evaluated using the MacDermid checklist (16). Similarly, reliability, measurement error, content validity, and criterion validity were appraised via COSMIN boxes B, C, D, and H, respectively (17).

The review by Takala et al. indicated that different examiners would report fairly similar results when measuring wide-ranging body alignments and work activities if they had obtained comparable approaches and skills through enough preparation (41). Similarly, direct

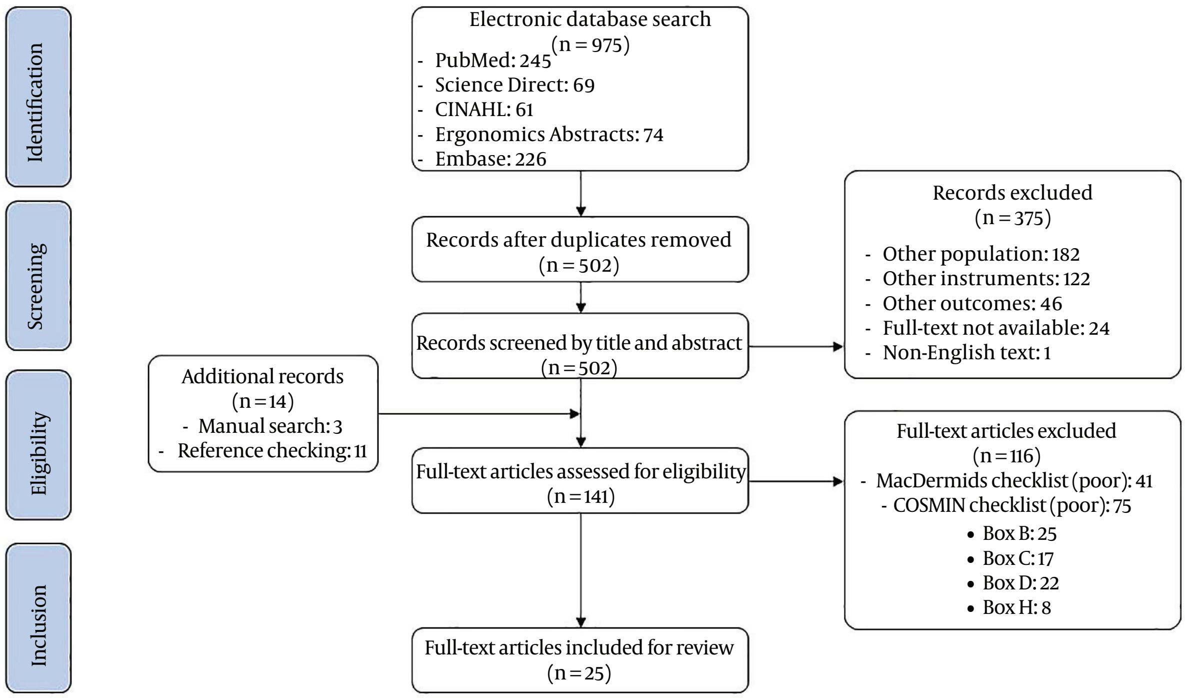

Figure 1. PRISMA flow diagram

examination of smaller body segments and movements appeared more difficult and less reliable. Particularly if the movements were fast, they believed no single tool seemed to have a noticeable advantage compared to the others. More specifically, they reported that when selecting the most appropriate method in a particular setting, the examiners must comprehensively outline their requirements and predict how output would influence the final result. This aligns with the results reported in our study since various high- and medium-quality methods proved to perform differently based on tool metrics and sampling strategy. Most occupations and duties appear to have routine inconsistencies in biomechanical exposures. Consequently, the sampling approach (i.e., the number of participants and examinations per individual) is a key parameter for the accuracy and reliability of the output. Certain methods are developed based on sampling at fixed-time periods (34, 40), while some other approaches utilize constant examination for extended time intervals (19, 37). In both occasions, inconsistencies within and between measurement times and individuals must be considered when devising a high-quality measurement approach.

In addition to the posture that appeared as the dominant contributing factor to the computations, external forces, and the duration and frequency of the task, it was proved to be significant. It is essential to note that posture assessment is theoretically simple since the relative position of body segments in 3D space can be quantified by measuring joint angles (42). Therefore, studying a person's work-related movements can evidently define the angular deviation of a body part from normal posture. Nonetheless, the challenge is to employ a valid and accurate approach, particularly reliable on how measurements for body segments are obtained to verify the risk levels. In other words, miscalculation of the related load is predictable if the body segment's orientation is not properly assessed. Moreover, the influence of the right on the left side of the body while completing work tasks must be considered. Considering the decision on which limb is actively measured, the calculated postural load is not equally distributed between the two sides. Thus, it is essential to utilize an approach that can deal with the left and right sides independently (7, 41). Results from the current review confirm this, as most medium and high-quality tools are designed to measure the postural load separately for each body side. Nonetheless, to the best of the authors' knowledge, no clear-cut solution to combine the results of the sides and estimate the overall postural load for the whole body has been developed hitherto.

Context of use was another important item of interest in the present review. The variety of approaches to developing observational postural assessment tools partly explains the wide range of application contexts for these tools. Some are more applicable in industrial settings (12, 23, 25-27), while some are specifically designed for clinical use (10-12, 23, 37), and the majority of the tools with high quality are of interest to academia. It was not feasible in the current review to conclude the most appropriate available method for each context. Because metrics and application purposes differ among researchers, clinicians, and occupational health and safety specialists, all the domains mentioned above could benefit from general postural load assessment methods and observational approaches. These methods rapidly and efficiently provide valid and reliable data on the risk factors associated with various musculoskeletal disorders. The current systematic review focused on the existing research on healthy adult individuals to minimize possible inconsistencies in the reported data. Nonetheless, observational postural load assessment methods must benefit all other vulnerable groups, such as the sick, children, and aging populations.

There were important limitations to this research that should be noted. Although a sufficient number of articles were evaluated in this review (25 studies), only seventeen scored high for psychometric and methodological designs, resulting in defective conclusions (refer to Table 1). Most studies with other quality levels had comparatively similar limitations, such as being directed at certain reliability or validity parameters, limited sample sizes without justification, and the need to explain inclusion and exclusion criteria. In some measures, the issues mentioned above interfered with study quality but did not affect the accuracy of the generated data. Another important concern was the heterogeneity of metrics for postural load assessment across articles which hindered the research team in further quantitative analyses. Although posture itself was a prominent factor, external forces, duration, as well as task duration and frequency, were the metrics that were not consistently taken into calculation in all studies. The above points underline the importance of developing detailed guidelines and standardization for the risk factors analyzed in postural load assessment methods.

6. Conclusions

Observational methods commonly used for assessing postural load are performed differently based on tool metrics and sampling strategies. Similarly, in addition to the posture that obviously appeared as the dominant contributing factor to the computations, the task's external forces and duration, and frequency appeared to be influential.

Moreover, various approaches to the development of observational postural assessment tools partly explain the extensive range of application settings for these tools. To put it into context, metrics, and functional purposes differ significantly among researchers, clinicians, and occupational health and safety specialists.

In conclusion, although it might be challenging to make direct comparisons and draw general conclusions about observational postural assessment techniques due to their strengths and limitations, being specific on the context of use and the main contributing factors can facilitate appropriate tool selection for each study.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Footnotes

Authors' Contribution: R. O., N. R., and M. A. M. B. conceived and designed the study. R. O., and N. R. searched the databases, extracted data, and performed the study selection. R. O., N. R., and M. A. M. B. interpreted the results and analyzed the data. All authors edited and revised the paper. All authors read and approved the final paper for publication.

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Table 1. Summary of the Overall Quality of Evidence [a]

Study	Year	Tool	Metrics	MacDermid Checklist, Methodological Quality	COSMIN, Checklists		Strengths	Limitations	Context of Use
					Reliability, Measurement Error	Content Validity, Criterion Validity			
Yazdanirad et al. (19)	2022	PRAMUD	Po, Fo, Fr, Mo, Ph	MQ	N/A, N/A	HG, HQ, (n = 300)	It can be utilized to monitor and evaluate the probability of musculoskeletal disorders in people with different personal and occupational qualities.	It has to be validated in the female population and various industries. Also, organizational factors may be required for more accurate estimation.	Ac, Cl, In
Kee (20)	2021	LEBA	Po, Fo, Du, Fr	LQ	MQ, MQ, (n = 12)	MQ, LQ, (n = 148)	Considerable association between the LEBA scores and qualitative (e.g., discomfort) and quantitative estimates.	Not appropriate when tasks are highly diverse. Focuses on work tasks; the examiner must determine which tasks are mostly loaded.	Cl, In
Chander and Cavatorta (12)	2017	PERA	Po, Fo, Du	MQ	N/A, N/A	HQ, MQ, (n = 88)	Conformity with the related standards. The results are implications for verifying how the changes in the work phases affect risk assessment.	Constrained analysis and explanation of the risk levels are essential because of the force and recurring movements.	Cl, In
Savino et al. (21)	2016	OES	Po, Fo, Du	MQ	MQ, MQ, (n = 34)	MQ, MQ, (n = 190)	Suitable for the rapid detection of dangerous postures and is a confirming initial structure, as it is straightforward to employ and appropriate for an early assessment of repetitive duties.	The right and left sides have to be evaluated individually. And, so far, there is no specific approach available to synchronize the obtained scores.	Ac, Cl
Kong et al. (22)	2015	AWBA	Po, Fo	MQ	MQ, MQ, (n = 18)	MQ, LQ, (n = 50)	High levels of usability. The computerized recording is available to the public.	Mainly, Applicable to agricultural domains.	In
Rodríguez et al. (23)	2013	ERIN	Po, Fo, Du	MQ	MQ, MQ, (n = 38)	MQ, MQ, (n = 220)	Easy to be utilized by non-experts, with basic levels of instructions. Usable without the need for any special equipment.	Relatively time-consuming. Accessibility to the software is unknown.	Cl, In
Sanchez-Lite et al. (24)	2013	NERPA	Po, Fo, Fr	LQ	MQ, MQ, (n = 54)	LQ, LQ, (n = 163)	Quick and easy to use. Computerized registration is available.	Different body sides have to be evaluated individually. And, so far, there is no specific approach available to synchronize the obtained scores.	Ac, In
Abd Rahman et al. (25)	2011	WERA	Po, Fo, Du, Fr	MQ	MQ, MQ, (n=18)	MQ, LQ, (n=33)	It considers many physical parameters, including body alignment, force, vibration, physical stress, and task time.	Not precisely applicable when tasks are highly different. Focusses on work tasks; the assessor must determine what duties are more critical.	Ac, Cl
David et al. (26)	2008	QEC	Po, Fo, Du, Fr, Mo	HQ	HQ, HQ, (n=20)	HQ, HQ, (n=35)	Great level of usability. Applicable for a variety of tasks. Considers interaction of different risk factors. Brings together the assessor and the worker.	Subjective estimation, and personal opinions of the individual to be assessed, might reduce the accuracy of the results.	Ac, Cl, In
Choobineh et al. (27)	2004	WEPAS	Po	HQ	HQ, MQ, (n=32)	MQ, MQ, (n=6)	The calibration and set-up process is straightforward to perform.	Preparation, such as dark surfaces and horizontal and vertical orientation lines, should be specified in the evaluated workplace. Applicable to the weaving industry.	Ac, In
Branson et al. (28)	2002	PAI	Po	MQ	MQ, MQ, (n = 14)	MQ, MQ, (n = 25)	Relevant to both photographed and real-time postures.	Designed only for posture evaluation in dental work. Does not consider force, duration, and repetition.	Cl
Chung et al. (29)	2002	CPWE	Po	LQ	LQ, LQ, (n = 30)	LQ, LQ, (n = 42)	Computerized registration. The examiner can recover and evaluate the image of the matching posture using the evaluation.	Relatively dependent on the postural imaging process and quality.	Ac, Cl, In
Neumann et al. (30)	2001	OUBPS	Po	MQ	MQ, MQ, (n = 40	MQ, MQ, (n = 104)	The reliable method with the benefit of not interrupting the individual while obtaining a stable record that can be considered for evaluation of other noticeable risk parameters.	The assessor should video-record the individual while performing the task. Somewhat time-consuming.	Ac, Cl
Kee and Karwowski (31)	2001	LUBA	Po	MQ	N/A, N/A	HQ, MQ, (n = 20)	Effortless and easy to implement. They recorded established physiological parameters. Quantitative results can make the evaluations simpler than a qualitative explanation.	The evaluation does not include force, duration, and repetition of the task.	Ac, In

Continued on next page

Table 1. Summary of the Overall Quality of Evidence [a] (Continued)

Kadefors and Forsman (32)	2000	VIDAR	Po, Fo, Du, Fr, Mo	LQ	N/A, N/A	LQ, MQ, (n = 147)	Minimal and simple. Promotes the contribution of individuals. Explanatory and descriptive results can help the assessor and the individual understand potential complications at the workplace.	Subjective assessment of load parameters relies on the discomfort that might hinder the decision on the mathematical estimation, particularly in group evaluation—typical drawbacks of video recordings.	Ac, Cl
Hignett and McAtamney (10) [b]	2000	REBA	Po, Fo, Fr, SA	MQ	HQ, HQ, (n = 14)	MQ, MQ, (n = 60)	Good coverage of body Parts in the evaluation. They are easily completed with adequate training. Specialized variations are available for different types of tasks and contexts. Popular among experts.	Combining the overall result for both sides of the body is not possible. Task duration is not entered in the calculations.	Ac, Cl, In
Occhipinti (33)	1998	OCRA	Po, Fo, Du, Fr	MQ	N/A, N/A	MQ, MQ, (n = 10)	Appropriately covers details of the tasks (e.g., recovery times). Appraises the individual risk, considering each cyclical duty in a complicated occupation.	Relatively complex and time-consuming to implement. High levels of profession and training are required for the assessment.	Ac, Cl, In
Buchholz et al. (34)	1996	PATH	Po, Fo, WA	MQ	MQ, MQ, (n = 148)	HQ, MQ, (n = 885)	It was essentially developed for effortless application at workplaces. Considers a process for developing task-oriented patterns for assessment. The sampling approach is efficient and well-thought-of. Data are treated and handled on a computer.	The approach only focuses on exposure levels and just in specified periods. Involves extensive instructing.	Ac
Moore and Garg (35)	1995	SI	Po, Fo, Du, Fr	MQ	MQ, LQ, (n = 24)	MQ, LQ, (n = 73)	The method contains critical risk factors regarding upper-limb problems. Considers the interaction between evaluated parameters.	Restricted to hands and distal upper limb assessment in specific tasks. Some subjective assessments of the criteria are not very certain. Vibration and contact stress are not evaluated.	Ac, Cl
Kemmlert (36)	1995	PLIBEL	Po, Fo, Fr, Mo	MQ	MQ, MQ, (n = 14)	HQ, MQ, (n = 25)	Reasonably inclusive and usable screening tool.	The output is not quantitative—moderate reliability because of only dichotomous answering options.	Pr
Fransson-Hall et al. (37)	1995	PEO	Po, Fo, Du, Fr, Mo	MQ	MQ, MQ, (n = 17)	MQ, MQ, (n = 40)	The approach facilitates the recording of body alignment and the related time. The output enables the examiner to carry out further analyses for special objectives.	Accessibility to the related software is not evident. Relatively Inefficient if detailed data is required. If the task needs to be performed quickly, evaluating some exposure types is not feasible.	Ac
McAtamney and Nigel Corlett (11) [b]	1993	RULA	Po, Fo, Fr, SA	HQ	HQ, HQ, (n = 36)	HQ, HQ, (n = 120)	Simple and effective. Popularity among professionals.	Not possible to integrate the scores for both sides of the body. Task duration is not considered in the computation.	Ac, Cl, In
Holzmann (38)	1982	ERGAN (ARBAN)	Po, Du	MQ	LQ, LQ, (n = 53	MQ, MQ, (n = 200)	Provides illustrative and easily understandable output. Has computerized calculations.	Relatively inefficient for some complicated tasks and detailed analyses.	Cl, In
Corlett and Madeley (39)	1979	PT	Po	MQ	MQ, MQ, (n = 16)	MQ, MQ, (n = 50)	Projecting postural parameters in polar coordinate format provides numerical measures on ordinal scales. Suitable for validating other similar postural assessment methods.	Appropriate only for static postures. It might be difficult to monitor all body parts concurrently.	Ac, Cl
Karhu et al. (40) [b]	1977	OWAS	Po, Fo	MQ	N/A, N/A	LQ, MQ, (n = 318)	Widely used and accepted among physical health professionals.	Recurrence and task time are not considered for evaluating repeated postures. Assessment of some upper body segments is not feasible. Moderately time-consuming.	Ac, Cl, In

Abbreviations in Appendix 3.

[a] Metrics: Du, duration; Fo, force; Fr, frequency; Mo, movements; Ph, physical characteristics; Po, posture; SA, static action; WA, work activity. Checklists, HQ: high quality; MQ, moderate quality; LQ, low quality; VLQ, very low quality. Context of use Ac, academia; Cl, clinical; In, industrial.

[b] Machine learning development.