Work evaluation in agriculture – Status quo analysis and future research agenda

Saskia HOHAGEN, Niklas OBERMANN, Uta WILKENS

Institut für Arbeitswissenschaft, Ruhr-Universität Bochum,
Universitätsstraße 150, D-44780 Bochum

Abstract: The digital transformation is accompanied by new forms of workload and work stress for farmers. The use of digital technologies not only changes production on the farm, but also the activities of the farmer, which ultimately leads to new work requirements. This article is dedicated to the evaluation of workload. A systematic literature analysis is used to analyze how the methods and criteria for assessing workload have developed in recent years. The results show that the literature has focused on the investigation of physical ergonomics in agriculture in depth and that the methods have developed only slightly over the years. There has hardly been any broadening of perspective in the assessment of workload. Finally, future research perspectives are derived from the results.

Keywords: work evaluation, ergonomics, agriculture

1. Introduction

The use of new (digital) technologies in agriculture, such as farm management systems, robotic systems for animal feeding (Gabriel & Gandorfer 2022), but also big data, artificial intelligence, and machine learning are influencing agricultural production (Fountas et al. 2020). Agriculture is currently undergoing a transformation that is leading to higher productivity (Himesh et al. 2018). Marinoudi et al. (2019), among others, point out that agriculture is evolving from a traditional, more artisanal industry to a high-tech, automated industry. Farmers ultimately use digital technologies with the aim of making work easier by reducing physical labor, but also to reduce working hours or save on labor in view of the shortage of skilled workers (Goller et al. 2020). Schick (2014) emphasizes that agricultural work processes are becoming increasingly digital. The digital transformation is accompanied by a change in the work activities of farmers; physical activities are decreasing, but symbol-processing activities are increasing. The use of digital technologies can increase the quality of life of farmers with regard to more flexible work in terms of time and location, but at the same time this can also be perceived as a burden if there are disruptions in process flows (Goller et al. 2020). Ultimately, the digital transformation leads to a health-promoting work organization in terms of occupational health management or workplace health promotion (Hasselmann et al. 2017). Still, the question of re-evaluating workload remains open.

In a literature review, Wilkens and Hohagen (2023) emphasize that agricultural literature on digitalization issues focuses primarily on questions of physical ergonomics. In terms of classification according to the Federation of the European Ergonomics Societies (n.d.), there has so far been a lack of focus on cognitive and organizational ergonomics. This reveals an imbalance between the assessment criteria for

workload. Although new (digital) methods are being used to assess workload, the issues analyzed appear to remain similar, particularly with respect to physical ergonomics.

The aim of this study is therefore to use a systematic literature analysis according to Fink (2014) to investigate the extent to which the assessment of workload utilizes new methods, but still does not show any further development regarding the focused methods and workload assessment criteria. Finally, a research perspective can be developed from this status quo to determine the extent to which it would be possible to expand/add to the respective methods and criteria.

2. Work science in agriculture

Following Luczak et al. (1989) work science is about analyzing, organizing and shaping the conditions of work processes. Ergonomics is one of the core areas of work science (Preuschen 1973). The Federation of the European Ergonomics Societies (n.d.) emphasizes three different perspectives on ergonomics, namely physical, cognitive, and organizational ergonomics. Physical ergonomics relates to maintaining physical and mental health (e.g. musculoskeletal disorders caused by work processes), cognitive ergonomics focuses on information processing and human-machine interactions (e.g. the operating safety of technologies) and, finally, organizational ergonomics deals with coordination, cooperation within the team and changed cooperation (e.g. with questions of operational management) (Wilkens & Hohagen 2023). Benos et al. (2020a) point out that ergonomics is a multifaceted topic area in agriculture. Musculoskeletal disorders are the most common. This picture emerges not only for manual activities, but also for mechanical activities (Benos et al. 2020b). In the course of technological change in agriculture, musculoskeletal disorders have not decreased, but have merely changed in their form (Kirkhorn et al. 2010). While bending down was a major risk factor for manual activities (Benos et al. 2020a), the focus for mechanical activities is on vibration from tractors, for example (Benos et al. 2020b).

This strong focus on physical ergonomics was already evident in earlier studies. Seedorf, Ries, Preuschen and Hammer were particularly concerned with ergonomics in agriculture (Hahn 2022). Ries (1952), for example, focused on the backs of farmers and Hammer (1993; 1994) on accidents of farmers on farms. Auernhammer (1989) pointed out that methods for measuring workload in agriculture would fall short of the mark.

3. Methodology

In a systematic literature search according to Fink (2014) the Web of Science and Science Direct databases were searched for relevant German and English literature in December 2023 using the search string “agriculture OR farming AND ergonomics”. This way, 300 publications were identified and screened in two steps.

In the first screening, publications were excluded based on the abstract if (1) they did not focus on agriculture, (2) they did not deal with questions of ergonomics and (3) they did not conduct empirical studies. In addition to these content-related facets, publiccations were also excluded if (1) they were not peer-reviewed and (2) they were

not written in German or English. A total of 172 studies were excluded based on the criteria. Figure 1 provides an overview of the screening process.

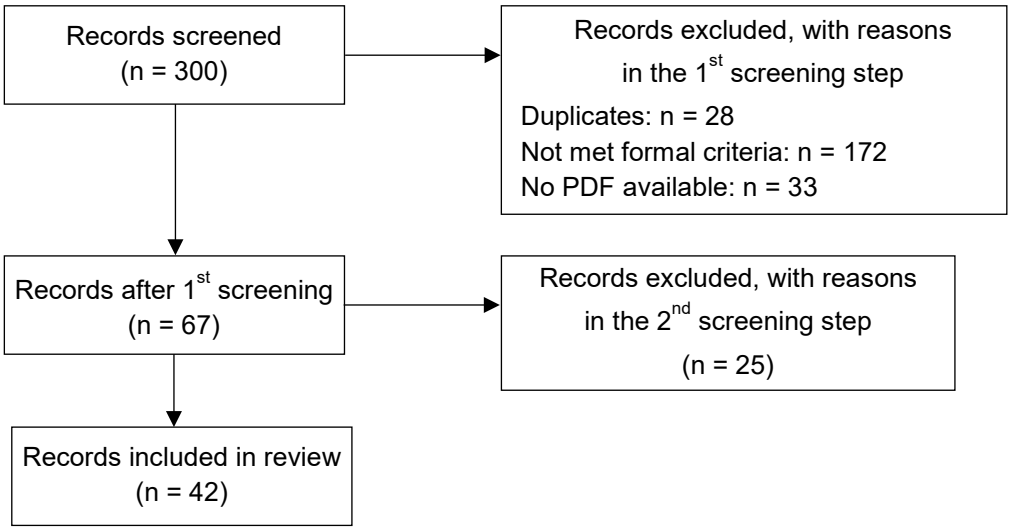

***Figure 1**: Summary of the screening process*

In the second screening, the available full papers were screened based on the content-related criteria. Further 25 studies were excluded. In total, the review is based on 42 studies. The screening was carried out by two authors of this paper with the support of the open-source software Rayyan, which is designed for collaboration on literature reviews (Rayyan 2024). In cases where the reviewers disagreed, a re-evaluation was carried out, which led to an agreement in all cases.

4. Results and discussion

The categorization of the 42 studies (see table 1 for an overview and the references are available under https://ruhr-uni-bochum.sciebo.de/s/TogIN5qyU7jnlhC) according to the Federation of the European Ergonomics Societies (n.d.) showed that almost all studies can be assigned to physical ergonomics. Only a few studies relate to aspects of cognitive ergonomics and no study focuses on organizational ergonomics. The following section therefore focuses on the findings at the level of physical ergonomics, highlighting how the methods and criteria for job evaluation have developed over time.

Studies from 1990 to 2022 were included in the literature review. It is clear that over the course of time, studies were carried out in various work contexts, both in the area of plants (e.g. harvesting, weeding) and with a focus on animal husbandry (e.g. milking with parlors). It is interesting to note that some studies looked specifically at work steps without mechanical support compared to those with mechanical support. Although the work steps and ultimately the work context have changed, for example, due to more mechanized work processes, the method of work evaluation is nevertheless less adapted over time. In particular, the studies analyzed focus heavily on the use of questionnaires (e.g. Borg CR-10 or NMQ/SNQ). This is recognizable both in the very

***Table 1**: Overview of the literature review*

Ergonomic perspective	Literatur	Work Context	Methodology of work evaluation	Workload assessment criteria
Physical ergonomics	Aiello et al. 2022; Boriboonsuksri et al. 2022; Bovenzi & Betta 1994; Burman et al. 2020; Chaturvedi et al. 2012; Cockburn et al. 2015; Das 2022; de Alencar et al. 2009; Douphrate et al. 2012; Douphrate et al. 2014/2016a; Douphrate et al. 2016b; Douphrate et al. 2017; Fethke et al. 2015; Fethke et al. 2020; Gandhi et al. 2012; Ghugare et al. 1991; Gumasing & Robielos 2018; Hasheminejad et al. 2021; Kee 2022; Kee & Haslam 2019; Kim et al. 2018; Kotowski et al. 2014; Kuta et al. 2015; Magri et al. 2021; Mishra & Satapathy 2019; Muzammil et al. 2004; Nag & Pradhan 1992; Nawi et al. 2013; Németh et al. 1990; Nevala-Puranen et al. 1993; Ng et al. 2013; Perkiö-Mäkelä & Hentilä 2005; Pinzke 2003/2016; Pinzke et al. 2001; Pinzke & Lavesson 2018; Putri et al. 2020; Qasim et al. 2021; Swangnetr et al. 2014	operators in harvesting operations (oil, mango; blueberry); weeding in vegetable crop; operators of power tiller; milking (with parlor types); rice farming ; weed threshing; lever-operated knacksack sprayer; poultry layer workers; pistachio farm workers; tractor drivers; hoeing operations; oil palm plantation; broiler farms	Wearble device to collect data; Borg CR-10; SNQ; NMQ; RULA; REBA, FEI; Ergonomic parameters (Heart Rate, Energy Expenditure Rate, Total Cardiac Cost of Work, Physiological Cost of Work, VO2 Max); adapter for measurement of vibration acceleration; computer-assisted recording and long-term analysis; LBP; BPD; full-shift exposures of posture and motion; shoulder elevation and trunk inclination angles; EMG; sensors for kinematics; health problems; human body map; CMDQ; ManTRA; CTD index; NIOSH; video; Job Strain Index method; photographs; OWAS; RPE; interview; BOSS	vibration; musculoskeletal disorders/workload/ symptoms/activity; low back pain; posture and motion of the upper extremity; health problems, musculoskeletal discomfort and overall discomfort score; physical discomfort; posture; physiological and biomechanical strains; physical strain; cardiorespiratory strain; musculoskeletal disorders, functional disability and ergonomic awareness
Physical/Cognitive Ergonomics	Montedo 2012; Smith-Jackson et al. 2010	dairy farms; crop production	Ergonomic Work Analysis (interviews; observation); questionnaires	competencies; safety climate and pesticide risk communication
Organizational Ergonomics	-	-	-	-

early studies and in the current studies. There does not appear to have been any development or expansion of methods, although digital technologies in particular would allow new procedures. Only one study uses new developments such as wearables. The fact that there was hardly any development or expansion of methods is ultimately also reflected in the evaluation criteria. With regard to physical ergonomics, it is noticeable that musculoskeletal disorders were particularly focused on as an assessment criterion. In turn, posture was one of the criteria studies turned their attention to. Apart from that, criteria like vibrations or health problems in general were only partially represented, which does not lead to a clear change in the evaluation criteria. In summary, it can be seen that work activities in agriculture have changed over the years and new, different work contexts have been taken into consideration, but there seems to have been hardly any further development in the area of methods and criteria of work evaluation.

As became clear from the studies, the analysis of ergonomic factors has already been applied to a wide range of activities. Other work contexts have shown that factors at a higher level relating to job identification and job satisfaction can have a similar significance to the job itself. One approach that takes up this consideration is the SMART model of work design by Parker and Knight (2023). The authors identify a total of five higher-order factors that aim to increase the importance of one's own work and improve the general framework conditions. As the nature of work in agriculture changes, and with it the demands placed on farmers, considerations such as these can help maintain the meaningful work of farmers in the age of digitalization. Future research should also take these considerations into account in addition to the aspects of cognitive and organizational ergonomics in order to design appropriate working conditions for the agriculture of tomorrow.

It should be noted that the study was accompanied by some limitations. Workload was defined very narrowly in order to have a clear object of investigation. In addition, the search criteria were restricted with regard to the concept of ergonomics. Both can lead to studies that did not explicitly address these criteria being excluded from the analysis. Furthermore, no German studies were included in the literature review because they were all excluded on the basis of content criteria. In contrast, this form of study design makes it possible to make a concrete statement about the status quo of research in relation to ergonomics perspectives in agriculture. In addition, a similar trend to the study by Wilkens and Hohagen (2023) is emerging, meaning that the selection criteria do not appear to have had too strong an impact on the studies examined.

5. Conclusion and Outlook

The study examines the extent to which the methods and criteria of job evaluation have changed over the years. As with Wilkens and Hohagen (2023), the results showed that the focus in agriculture has been on physical ergonomics. It became clear that the methods or criteria used have hardly changed over time. However, the use of digital technologies or AI in particular could lead to an expansion of methods. So far, subjective questionnaires have been used in many cases, while newer methods with regard to imaging procedures have hardly been addressed. With the advent of digital technologies in agriculture, the framework conditions for agricultural work are changing. With this change, the methods and assessment criteria for workload must also

adapt. It is encouraged to investigate new approaches to evaluation methods. The higher order factors of work design formulated by Parker and Knight (2023) could be a good starting point in this respect.

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Geschäftsstelle der GfA
Simone John, Tel.: +49 (0)30 1300-13003, Alte Heerstraße 111, D-53757 Sankt Augustin
info@gesellschaft-fuer-arbeitswissenschaft.de · www.gesellschaft-fuer-arbeitswissenschaft.de

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