
ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LVIII, 3

SECTIO H

2024

ALEKSANDRA DEWICKA-OLSZEWSKA

aleksandra.dewicka-olszewska@put.poznan.pl

Poznań University of Technology. Faculty of Engineering Management

2 J. Rychlewski St., 60-965 Poznań, Poland

ORCID ID: <https://orcid.org/0000-0003-4683-6519>

Ergonomics in the Polish Business Environment

Keywords: ergonomics; ergonomic activity; entrepreneurship; health and safety at work; quality and productivity at work

JEL: I25; L1; M15

How to quote this paper: Dewicka-Olszewska, A. (2024). Ergonomics in the Polish Business Environment. *Annales Universitatis Mariae Curie-Skłodowska, sectio H – Oeconomia*, 58(3, special issue), 89–102.

Abstract

Theoretical background: Economic processes, the COVID-19 pandemic, evolving technology and aspects of demographic change including, above all, an “ageing population” remaining on the labor market have brought about dynamic changes in many canons, beliefs and areas of activity for businesses and economic organizations. In line with the idea of humanocentrism and nurturing human capital (its knowledge and experience), companies are looking for new organizational and technological solutions, whose main objective is to ensure safety and quality of work. One of the techniques/sciences that integrate the achievements of many sciences humanizing the working and living environment so that it is friendly to the psychophysical and social needs of the user is ergonomics. Ergonomics is the science that deals with the adaptation of technology (machines and tools) and working conditions to the specific needs of the user, and through its multidisciplinary and multifaceted nature has many meanings, roles and characteristics.

Purpose of the article: The aim of this article is to answer questions related to the ergonomic activities of Polish enterprises and its application in practice. What does ergonomics give them? What is the source of inspiration in carrying out ergonomic activities? What is the purpose of conducting ergonomic activities? What is the essence and role of ergonomics in their business operations?

Research methods: In this article, based on literature research conducted by the European Statistical Office (Eurostat), Social Insurance Institution (ZUS), National Labour Inspectorate (PIP) and Statistics Poland (GUS), two authoritative questionnaires were created (under expert supervision) to investigate ergonomic activity in the Polish business arena. The first questionnaire was sent to 15,000 enterprises and searched for ergonomic activity in the business arena. The second questionnaire was sent to a narrower group of ergonomically active enterprises, which provided answers to 100 open and closed questions. The survey was conducted between 2020 and 2022.

Main findings: All three research assumptions were successfully achieved. Businesses were found, investigated and conclusions reached. Selected results from the questionnaire survey are presented in tabular form. The surveyed respondents, representatives of various business sectors of micro, small, medium and large enterprises, unequivocally stated that, in their opinion, ergonomics helps to modernise machinery and technology. In addition, ergonomic activity brings them closer to complying with current standards and legislation, thus, having a positive impact on quality, health and safety aspects. Ergonomic activity also gives entrepreneurs the opportunity to increase productivity, efficiency and work performance. Seeking ergonomic inspiration also contributes to increasing the potential of the knowledge economy.

Introduction

All company activities are directed towards the realisation of specific objectives, which, depending on their concentration, are described as development- or profit-oriented. Every decision taken by an entrepreneur is determined by a management process in which human labour takes on a specific form related to its organisation and protection. The literature distinguishes many forms of definitions of entrepreneurship in which health and safety issues are addressed. Most of the obligations of entrepreneurs in the field of labour protection are determined by legal and regulatory acts, which from the point of view of the effectiveness of the entrepreneurial organisation inform and instruct that inadequate working conditions cause accidents, which generate material and non-material losses.

According to the legal regulations, the proper organisation of working time or its forms, as well as all kinds of improvements in the technical or technological process, should take into account the human-centred element, and the employee should be an equal participant, a partner in the process of adopting these changes in practice. Enterprises are constantly modifying their operating strategies, organisational structures, employee procedures, management methods and the creation of a working environment in line with the idea of fostering economic and social development.

One of the practical sciences directed at society (human beings, consumers, users, employees) is ergonomics. The practical science of ergonomics refers to the direct iteration of the human being with a specific object using social, technical, biotic and also anthropocentric combinations (Butlewski & Tytyk, 2012).

In the present study, on the basis of a questionnaire survey conducted from 2020 to 2022, an attempt was made to identify ergonomic activities in enterprises in the micro, small, medium and large categories. The goals of scientific research assumed:

– to find companies that apply ergonomics or ergonomic measures in the field of correction as well as the concept of measures related to safety and quality of work,

- to identify indicators and guidelines related to the identification of ergonomics in entrepreneurial activities,
- to answer which goals and tasks are prescribed for ergonomic activities in entrepreneurial organisations.

The author has included in the article selected research results related to the verification of the issue of ergonomic activities in Polish enterprises. The results were obtained using research questionnaires that were sent electronically to 15,000 enterprises operating in Poland, of which 3,016 companies were subjected to further research verification of the assumed research goals. The role of ergonomics in economic conditions has been confirmed, thus according to the state institutes supervising occupational health and safety processes, it can be concluded that ergonomic activity contributes to the modernisation of machinery and technology. Ergonomics increases productivity, efficiency and business performance and contributes to compliance with current standards and legislation.

Ergonomics in companies

Ergonomics is an interdisciplinary theoretical and applied discipline dealing with the adaptation of technical facilities (machinery and equipment), organizational conditions and environmental conditions to the psychophysical needs and expectations of the human worker. Ergonomics is dominated by a concern for the diverse health needs and developmental capacities of human beings and, as defined by the International Ergonomic Association (IEA), Ergonomics defines the relationships that arise between human beings and their occupation, equipment and environment in the broadest sense, including situations related to work, play, recreation and travel (Kowal, 2002).

Ergonomics, in its strategy of conceptual and corrective actions, is widely used in diagnostic research, design and organizational studies of work processes and managerial actions (Griffin, 2017), which are an element of the activities of every entrepreneurial organization. The principles and procedures formulated in ergonomics guarantee that enterprises create safe working conditions based on technical and organizational solutions, and their activities are usually related to adapting the environment to the needs and expectations of working people by increasing their effectiveness and work efficiency (Jasiak & Misztal, 2004). This is possible through a set of scientific disciplines of anthropology, work physiology, occupational hygiene, work psychology, pedagogy, praxeology, law, technology, architecture, urban planning, mechanical engineering, response engineering and many others (Dewicka-Olszewska, 2021). The practical application of ergonomics in social and practical activities focuses on the levels:

- ergonomics of mass-consumption products (analytical methods for the control of mass-consumption products),

- ergonomics and job satisfaction (integrating efforts to improve working conditions),
- ergonomics for the elderly (conceptualization of physical characteristics and mental qualities),
- social and economic aspects of ergonomics.

There are three lines of action for ergonomics in adapting the working environment to the psycho-physical capabilities of the human being:

- corrective ergonomics (whose interest is to analyses already existing workstations, products, machines and equipment),
- conceptual ergonomics (aimed at applying ergonomically correct solutions as early as in the design phase of machines, devices, tools, workstations),
- validation of machinery and equipment prototypes (combining conceptual and corrective ergonomics in the introduction of series production of machinery and equipment) (Jasiulewicz-Kaczmarek, 2013).

Elements of ergonomics are:

- dimensions (describing the arrangement of the various elements of the workstation in relation to anthropometric dimensions, as well as sizes),
- shapes of equipment, tools and materials,
- forces (required to operate equipment, move work items),
- factors of the material environment (e.g. lighting, noise, vibration, microclimate, etc.) (Olszewski, 1997).

Entrepreneurial ergonomics is, first and foremost, the purposeful shaping of working conditions (including the working environment) to counteract premature human fatigue and increase interest in work efficiency (Tytyk, 2019). According to the literature research, entrepreneurial ergonomic activity is a multidisciplinary set of creative activities stemming from the social relations that form the basis for the long-term technological development of the enterprise expressed through:

- an increase in the quantity and quality of production or services,
- a decrease in the frequency and severity of accidents at work and near-misses,
- reduction of the risk of occupational diseases,
- decrease in sickness absence,
- decrease in staff turnover,
- decrease in labor costs,
- increased care of tools and equipment,
- reduced potential costs of repairs to plant and machinery, and
- a reduction in direct supervision staff (Dewicka-Olszecka, 2021a).

The activities of corporate ergonomics are primarily concerned with improving working conditions by increasing the safety and efficiency of work tasks in tangible benefits:

- increase motivation at work, by improving the well-being of employees and users,
- increasing interest in work and work tasks,
- adapting to work and coping with possible psychological and physical strain,

– reducing interpersonal conflicts in social relations (Góriska, 2021).

The practical scientific achievements of ergonomics in improving and organising the work of existing technical and organisational solutions can be found in the components of:

- work processes,
- work organisation,
- working methods,
- work tools,
- the physical working environment,
- improvement of work skills,
- and procedures for management action (Olszewski, 2013).

These elements are often referred to in technical terms, simply as:

- ergonomic spatial designs of the (optimal, normal and maximum) movement space of the upper and lower limbs of a human being working standing or sitting,
- ergonomic designs of the movement space of the human body in relation to work surfaces, operating elements of objects, machines and equipment,
- ergonomic design of visual workspace,
- ergonomic functional and communicative spatial designs,
- ergonomic modifications and designs of machines, instruments and equipment used at workstations (Nowacka, 2013).

Ergonomic measures at workstations also include adjustments to the parameters of the material working environment eliminating the negative factors of noise (through hearing protection solutions, machine guards, equipment filters), microclimate (regulating air temperature, radiation temperature, humidity and air flow velocity), dust (ventilation, infiltration, aerobic digestion), vibration (anti-vibration measures), chemical factors (collective and individual protection), and mechanical and biological factors (individual protection), and mechanical and biological factors.

Ergonomic measures eliminate physical and mental burdens on the human being, which are a source of serious danger to life or health. Direct ergonomic solutions involve implementing mechanisation of work, improving working postures, improving conditions for the reception of information and streamlining the organisation of time and content of work (Mrugalska & Dovramadijev, 2023). A practical example of its application in enterprises is the introduction of workstation equipment adapted to the needs of anthropocentric users (seats at work, information elements), as well as organisational solutions shaping workstation rotation and autonomous self-control among work teams.

The application of ergonomic activities in enterprises requires prospective interdisciplinary thinking and the courage to implement non-stereotypical and innovative solutions. Ergonomic activity itself in enterprises is most often expressed in quantitative and qualitative terms (Mrugalska & Karwowski, 2023), as well as in verbal terms using subjective assessments related to the close interaction between people and their environment.

Research methods

Conducting research into ergonomics in Polish business conditions is a difficult and complex element. A supporting element are state institutions such as the Statistics Poland (GUS), the National Labour Inspectorate (PIP), the Central Institute for Labour Protection (CIOP) and the Social Insurance Institution (ZUS), which keep records of accidents, their consequences and corrective actions carried out in enterprises (introduction of technical and organisational elements eliminating occupational risk). These institutions also play the role of motivation, education and training centres for entrepreneurs implementing and complying with the legal requirements set out in the relevant conventions, laws and regulations.

The analysis of ergonomic activity and its identification requires research to be conducted and implemented directly in businesses. Such research has been carried out by the author since 2014 using various types of survey questionnaires and in-depth interviews conducted electronically and by traditional mail.

This paper presents selected research results (and the content of the questions) related to the identification of ergonomic measures from the research year 2020–2022. The two-stage research was carried out electronically using the author's survey questionnaires developed on the basis of ergonomics literature studies. Thanks to the cooperation with business representatives (experts), the factual questions were in a form that was simple and comprehensible for every surveyed company.

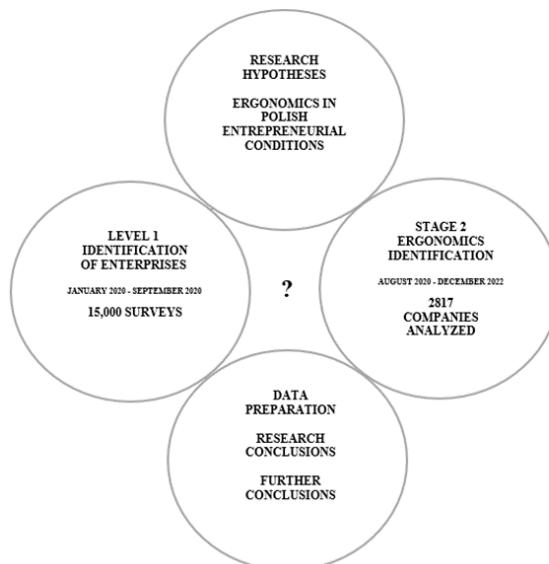


Figure 1. Conducting research on ergonomics in the Polish entrepreneurial environment

Source: Author's own study.

The first stage of the research involved looking for enterprises that carry out ergonomic activities in terms of corrective, conceptual or design activities in their business areas related to improving health, safety and quality at work. The second stage was already directed at the identified companies and contained 100 open and closed questionnaire questions related to the hypothesis of the research on ergonomics in entrepreneurship. The questions in the questionnaire concerned the size of the business and its nature, as well as the results and expectations of ergonomic activities. The stage of the research is included in Figure 1.

The survey questions had a dichotomous scale in which the variables took two values ("yes", "no"), a nominal scale (numerical values), and semi-open questions. The research results obtained were delayed by the COVID-19 pandemic. The further results of the research presented in this paper were also influenced by the reluctance of entrepreneurs to respond to surveys. This was taken into account in the design of the random sample of businesses surveyed.

Results

The first stage of the research was the identification of the number of random operations, which was prepared on the basis of data related to the number of registered business entities on the territory of the Republic of Poland.

At the beginning of 2020, 3,314,947 (GUS data) enterprises were registered in the country, of which approximately 2,066,209 were actively operating entities. The analytical formula used was (minimal research sample) (Babbie, 2003):

$$n_b = \frac{N}{1 + \frac{4d^2(N-1)}{Z^2}} \quad (1)$$

where: n_b – minimum study sample, N – population size, Z – standard value for a given significance level p ($Z = 1.96$ for $p = 0.05$), d – assumed estimation error ($\max 4\% = 0.04$).

Minimum survey sample was calculated. Taking the data N population size of 2,066,209 (active businesses), $Z = 1.96$ and assuming an estimation error within 2% and substituting it into the following equation (minimum survey sample – data substitution) (Babbie, 2003):

$$n_b = \frac{2066209}{1 + \frac{4(0.02)^2(2066209-1)}{1.96^2}} \quad (2)$$

According to the data, a minimum survey sample of approximately 2,398 enterprises was obtained. Considering the problem with the returnability of questionnaire surveys, the electronic version of the survey went to 15,000 enterprises. Table 1 provides data on the actual returnability of the survey data, conducted between 2020 and 2022.

Table 1. Return rate of questionnaire surveys

Surveys 2020–2022		
	Total	15,000
Overall return rate	ro	56%
Return rate of all questionnaires	rw	55%
Actual return rate	rr	47%
Participation rate	ru	46%
Refusal rate	rx	11%

Source: Author's own study based on the 2020–2022 survey.

In 2022, 7,050 completely and correctly completed questionnaires were received and the first question to verify the data in the survey questionnaire was: "Are there activities or tasks in the area of ergonomics in your company?", answer: "yes", "no". Activities in the area of ergonomics in enterprises are shown in Table 2.

Table 2. Ergonomic measures in companies

Ergonomic measures	Number	%
The company operates	3,016	42.78
The company is not active in ergonomics	4,034	57.22
Total	7,050	100

Source: Author's own study based on the 2020–2022 survey.

42.78% of the surveyed enterprises (3,016 companies) confirmed their activity in the area of carrying out corrective or conceptual activities in the field of ergonomics, therefore, in the next part of the research these enterprises played the biggest statistical role in further ergonomics explorations. The results of this study confirmed the research hypothesis that Polish enterprises apply ergonomic activities. These enterprises answered 100 survey questions (open, semi-open and closed) in the next part of the second stage of the research, the aim of which was to identify research gaps related to ergonomic activities (selected questions and their answers are included in the study).

A total of 2,817 companies responded to the second phase of the survey. Surveys are always burdened with a large error in the return of complete answers, which is often due to the reluctance of respondents to provide information and a lack of time in business. 2,817 companies served as a benchmark for research into ergonomic activities in the Polish economy. This population is not large, but it provides an

opportunity to outline teamwork and to realise the research hypotheses. Selected key elements of the research results are presented in descriptive and tabular form.

One of the first survey questions was: "What is the approximate size of employment in your company?". The largest percentage of enterprises surveyed were medium (1,389) and large (984) businesses representing the construction, automotive, manufacturing and service industries. In the semi-open questions, these enterprises were asked to identify the source of inspiration related to carrying out activities directed towards ergonomics. On the basis of the results obtained, it was established that the sources of inspiration of Polish entrepreneurs regarding ergonomic activities are:

- changes in the structure of the industry and the market (in terms of legal and quality requirements),
- demographic changes and the demands of employees and consumers,
- temporary work organization needs (e.g. remote working and the COVID-19 pandemic).

And the predominant source of ideas related to the creation of ergonomic activities in their organizations was:

- shareholders, owners, top management,
- competitors,
- employees,
- media,
- suppliers,
- customers and consumers.

A diverse workforce and its creativity, the Internet, forecasting techniques, docking and training companies and cooperation with similar businesses rotating in the same industry (competition) played an important role in the creation of ergonomic measures in the entrepreneurial area for the interviewees.

As an impetus for the introduction of ergonomic solutions, entrepreneurs largely emphasized changes in legislation (including labor law) to ensure and adapt to safe and hygienic working conditions (resulting from the prevailing COVID-19 pandemic). Respondents emphasized that training and workshops and ongoing technological changes inside and outside the enterprises also played a role in the introduction of ergonomic solutions.

In the next part of the survey, companies were asked to tick answers in closed questions (the aim of which was to identify ergonomic solutions in their structures). One of them was a question regarding the relevance of requirements related to the implementation of ergonomic solutions. The number of most frequent indications is shown in Table 3.

Of particular interest in the identification of ergonomic activities were indications related to the companies' compliance with legal standards and the improvement of health and safety at work. According to the respondents, their ergonomic activities in terms of correction (of a pre-existing work condition) and conception (design of workplaces) are largely based on the elements in Table 4.

Table 3. Requirements/purpose of ergonomic measures

The purpose of ergonomics	Number of indications
Improving health and safety at work	2,102
Compliance with legal standards	1,934
Gaining a competitive edge	892
Adapting to partners' requirements	706
Reduce operating costs	696
Better company image	98

Source: Author's own elaboration based on the 2020–2022 survey.

Table 4. Use of ergonomic solutions

Application of ergonomics	Number of indications
Work organisation	2,561
Machinery and tools	2,397
Working methods (COVID-19 pandemic)	1,902
Forms of work (COVID-19 pandemic)	1,874
Physical work environment	1,653
Optimisation of work	986
Work efficiency	972
Work productivity	953
Fight against competition	951
Satisfaction of consumer needs	341

Source: Author's own study based on the 2020–2022 survey.

The companies surveyed were asked to identify the type of their ergonomic solutions, the results of which are shown in Table 5.

Table 5. Type of ergonomic solutions

Type of ergonomics	Number of indications
Corrective ergonomics	
Improving the material parameters of working conditions	1,459
Elimination of excessive physical workloads	1,230
Elimination of excessive mental stress	1,217
Conceptual ergonomics	
Planning and organising the production process	1,142
Coordinating the production process	782
Regulating the production process	562

Source: Author's own study based on the 2020–2022 survey.

The surveyed entrepreneurs particularly emphasized the shaping of the physical working environment (energy expenditure and psychophysical load), related to the adaptation to occupational health and safety standards and status of noise, vibration, radiation, electromagnetic fields, electricity, industrial dust, and many other dangerous factors that can lead to injuries and health damage. In many aspects,

ergonomics has contributed to the elimination and reduction of occupational risks and consequences related to potential musculoskeletal ailments.

In the opinion of the respondents, ergonomics in Polish business conditions optimizes the functioning of enterprises by directly influencing the forms and organization of work and is also effective through:

- increasing the care of machinery, equipment and tools (including fixed and mobile workstation elements),
- reducing repair costs of machinery, equipment and tools,
- decreasing direct supervision (employee satisfaction with work elements),
- decrease in staff fluctuation (staff turnover),
- decrease in labour costs,
- decrease in sickness absenteeism, as well as accident and near-miss incidents.

The responses to the survey confirmed this problematics, indicating that Polish enterprises are aware of the fact that ergonomics has a protective function in terms of technical and organizational elements that prevent health damage to employees by decreasing sickness absenteeism, decreasing the frequency of accidents and decreasing the number of near misses. This research trend is confirmed by data from the PIP, ZUS and GUS, which carry out direct control and statistical supervision over aspects of safe behaviour and the implementation of ergonomic optimization of work processes in enterprises.

Discussions

The ergonomic activities of Polish enterprises are used in technical and organizational solutions related to the methodology of creating and correcting:

- work processes and organization,
- work methods,
- tools (machinery and equipment) at work,
- the physical work environment,
- improvement of work qualifications, and
- management action procedures.

These elements, in practical terms, are found in the design of work processes, means and methods through anthropocentric, psycho-physiological and biomechanical adjustments to the needs of the user/employee. Ergonomic activities at workplaces also include adjustments related to the parameters of the material working environment, e.g. ergonomic activities at workplaces also include adjustments related to the parameters of the material work environment, e.g. by eliminating the negative factors of noise (proposing individual and collective solutions for hearing protection, machine guards and equipment filters), microclimate (proposing ergonomic solutions for staying within the appropriate air temperature, radiation, humidity and air flow velocity), dust (ventilation, infiltration, oxygen fermentation), vibrations

(organizational and technical measures related to anti-vibration actions), chemical factors (collective and individual protection), and mechanical and biological factors (Jóźwiak, 2020).

This theory was confirmed by a 2020–2022 study in which companies highlighted the importance of ergonomics and its activities in areas that protect human health and life. Ergonomic activities that are helpful to man/worker are related to the elimination of physical, static and psychological human stresses (e.g. reception of information, complexity of information, monotony), which are a source of serious threats to life and health in the present and in the future (bearing in mind the delayed effects of certain undesirable, harmful and burdensome activities). Practical ergonomic solutions in this aspect consist of mechanizing work, improving working postures, improving conditions for the reception and processing of information and improving the organization of time and content of work (elimination of time stress).

Conclusions

Empirical verification of ergonomic activities in Polish entrepreneurial conditions made it possible to develop an outline of the issues and their determinants. The research has confirmed the hypothesis that ergonomics works in enterprises, while it has not exhausted the determination of their problematics and identification in the economy (Rakowska, 2013), which is a serious research gap (to be developed in the future). Currently, there are no measurable indicators of pure ergonomics, there are only figures linking them to absenteeism and accident rates in Polish enterprises.

The results of the questionnaire survey and the analysis of literature sources related to ergonomics gave a clear indication of the qualities that ergonomics should fulfil in entrepreneurship. Ergonomics should:

- minimize individual differences between workers (allowing for the possibility of employing workers with disabilities, but on a non-stigmatizing basis),
- minimize forms of work and methods of working in forced positions (eliminating musculoskeletal complaints),
- reduce stress, uncertainty, apprehension and psychological strain on each recipient and user of its system (human-work equipment system),
- organize work time and space appropriately,
- interact with the norms, regulations, laws and work rules imposed by the company's material and physical working environment (Dewicka et al., 2017).

Irrespective of the size of the enterprise or the sector it represents, the human worker is the most important element in its structure (Penc, 2007). The role of an efficient organizer of work (entrepreneur) is to create such conditions of professional activity with the use of various analytical tools of ergonomics, so that with the obvious aim of maximizing the effectiveness of the organization's activity, the requirement of fulfilling the conditions of safe work (Labor Code, Acts and Decrees), not

endangering (physical) health, i.e. performed at the lowest possible biological cost, giving satisfaction to the employee and the feeling of full psychological well-being, is fulfilled at the same time (Tytyk, 2020).

The processes involved in the ergonomic activities of enterprises require further research. The existence of the concept of ergonomics, its methodology, interactions and conditions has the potential to become a future direction for further developmental research in an economy based on the knowledge of the satisfied and fulfilled employee, user.

References

Babbie, E. (2003). *Badania społeczne w praktyce*. PWN.

Butlewski, M., & Tytyk, E. (2012). The assessment criteria of the ergonomic quality of anthropotechnical mega-systems. In P. Vink (Ed.) *Advances in Social and Organizational Factors* (pp. 298–306). CRC Press, Taylor & Francis.

Dewicka, A., Kalembska, A., & Zywert, A. (2017). The essence of ergonomic innovation in modern manufacturing enterprises. In P.M. Arezes, J.S. Baptista, M.P. Barroso, P. Carneiro, P. Cordeiro, N. Costa, R.B. Melo, M. Sergio, & P. Gonçalo (Eds.), *Occupational Safety and Hygiene V*. CRC Press.

Dewicka-Olszewska, A. (2021a). Application and role of ergonomic innovations in small and medium-sized enterprises. *Procedia – Manufacturing*, 55, 521–526. <https://doi.org/10.1016/j.promfg.2021.10.071>

Dewicka-Olszewska, A. (2021b). Ergonomic innovations and safe operation of machines and devices. In O. Ciszak (Ed.), *Advances in Mechanical Engineering* (pp. 15–22). Wyd. Politechniki Poznańskiej.

Górcka, E. (2021). *Ergonomia. Projektowanie – diagnoza – eksperymenty*. Oficyna Wyd. Politechniki Warszawskiej.

Griffin, R.W. (2017). *Podstawy zarządzania organizacjami*. PWN.

Jasiak, A., & Misztal, A. (2004). *Makroergonomia i projektowanie makroergonomiczne*. Wyd. Politechniki Poznańskiej.

Jasiulewicz-Kaczmarek, M. (2013). The role of ergonomics in implementation of the social aspect of sustainability, illustrated with the example of maintenance. In P. Arezes, J.S. Baptista, M. Barroso, P. Carneiro, P. Lamb, N. Costa, R. Melo, A.S. Miguel, & G. Perestrelo (Eds.), *Occupational Safety and Hygiene* (pp. 47–52). CRC Press, Taylor & Francis. <https://doi.org/10.1201/b14391-11>

Kowal, E. (2002). *Ekonomiczno-społeczne aspekty ergonomii*. PWN.

Mrugalska, B., & Dovramadijev, T. (2023). A human factors perspective on safety culture. *Human Systems Management*, 42(3). <https://doi.org/10.3233/HSM-220041>

Mrugalska, B., & Karwowski, W. (Eds.). (2023). *Anthropometry: Human Body Measurements and How to Use Them*. Routledge. <https://doi.org/10.1201/9781003459767>

Nowacka, W.L. (2013). *Ergonomia i ochrona pracy. Wybrane zagadnienia*. SGGW.

Olszewski, J. (1997). *Podstawy ergonomii i fizjologii pracy*. Wyd. AE w Poznaniu.

Olszewski, J. (2013). *System pracy w warunkach globalnego społeczeństwa informacyjnego*. Wyd. UE w Poznaniu.

Penc, J. (2007). *Nowoczesne kierowanie ludźmi. Wywieranie wpływu i współdziałanie w organizacji*. Difin.

Rakowska, A. (2013). *Kultura bezpieczeństwa w przedsiębiorstwie. Modele, diagnoza i kształtowanie*. CeDeWu.

Tytyk, E. (2019). Współczesne uwarunkowania rozwoju ergonomii w dobie wielkoskalowości i globalizacji działań. In M. Złowodzki, T. Juliszewski, A. Taczalska-Ryniak, & K. Trzyniec (Ed.), *Ergonomia wobec wyzwań masowości i globalizacji*. Wyd. Politechniki Krakowskiej.

Tytyk, E. (2020). Quality management of the human – machine system. Why is worth developing the ergonomic designing? In *Proceedings of the 36th International Business Information Management Association Conference (IBIMA)*. 4–5 November 2020, Granada, Spain. Soliman Khalid S. (Ed.), *Sustainable Economic Development and Advancing Education Excellence in the Era of Global Pandemic* (pp. 4998–5005). <https://doi.org/10.3390/machines1203015>

www1: <https://stat.gov.pl>

www2: <https://www.ciop.pl>

www3: <https://www.zus.pl>