# ERGONOMICS AND AGEING – CASE STUDY

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***Abstract:*** *As part of our research, we have produced an overview of various aspects and challenges related to the ageing population. Ergonomics plays a crucial role in addressing the needs and challenges associated with an ageing workforce. As people age, their physical abilities and sensory functions tend to change, which can affect their comfort, safety and productivity in different work environments. A case study is presented that aims to test available new technologies, the Xsens suit and Process Simulate software, during a process of ergonomic workplace design that is also suitable for older people. Applying ergonomic principles to meet the needs of older workers can help maintain their well-being and keep them engaged in the workplace.*

***Key words:*** *ergonomics, aging, ergonomic workplace design*

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## 1. Introduction

The population structure of the world is constantly changing. Increasing life expectancy and declining birth rates are causing global population growth to slow and population ageing to accelerate, often well below replacement levels.

Other demographic changes and rising average life expectancy are affecting the labour market and its demographic structure. Due to the increase in life expectancy in industrialised countries, the proportion of older people in the total population is increasing day by day. The World Health Organisation [WHO, 2011] estimates that the world's population over the age of 60 will triple between 2000 and 2050, rising from 600 to about 2 billion people [Barros et al., 2014]. However, a longer life does not mean a better life [Rennemark 2009]. The changes that occur with ageing in the physiological and psychological functions of the individual affect the quality of life. Although the ageing process is characterised by some changes, there are major differences between people. Even if the individual is healthy, a decline in physiological and cognitive functions is perfectly normal as a prerequisite for normal ageing [Fonad et al. 2006].

Ergonomic workplace design is a systematic approach to creating work environments that focus on the well-being, health and efficiency of employees. It involves designing the spatial layout, equipment and processes to ensure that they meet the needs and capabilities of employees and promote safe and productive work practises. A well-designed ergonomic workplace can improve employee health, reduce the risk of musculoskeletal disorders and increase overall productivity [Vujica Herzog & Buchmeister, 2014 and 2015; Vujica Herzog et al., 2019 and 2022].

Key elements of an ergonomic workplace design include adjustable furniture and equipment, adequate lighting, an optimal room layout, a neutral working posture, optimal screen placement and an optimal work routine with regular breaks and movement. Since long-lasting unfavourable working postures can lead to back pain and even injuries, we should avoid them or eliminate them in time.

For companies, too, the prevention of possible occupational accidents and absenteeism, which are usually associated with high costs, is important and should be methodically taken into account [Genowska et al., 2017; Yang, W. et al., 2018]. The psychosocial work environment plays one of the most important roles in the overall structure of reasons for absenteeism at work. Stress levels, management style, quantitative and qualitative demands of the employer, and time pressures all have an impact on the well-being and attitude of the worker towards their job tasks in younger and older workers. Rehabilitation for injuries and work absences can have high costs, e.g. direct costs related to medical care and indirect costs in terms of lost productivity.

With various approaches and strategies, such as adjustable furniture and equipment, anti-fatigue mats, large print and clear signage, reduction of repetitive movements, more breaks, health and wellness programmes, employers can create a more inclusive and supportive environment for older workers. This not only benefits the workers themselves, but also contributes to higher job satisfaction, productivity and overall employee retention.

An example of computer-based ergonomic analysis using motion capture systems, 3D modelling software and ergonomic assessment software is presented. Computer-aided analyses are very efficient because data collection and analysis can be automated and visualisations are possible. The case shows that both motion capture systems and ergonomics can play an important role in improving the working environment also for older workers in different industries.

## 2. Literature review

In general, the characteristics of an ageing person or worker can be listed as follows.

- Decreased mobility, strength, balance, decreased eyesight
- Decreased reaction time and hearing
- Decreased feedback and dexterity
- Decreased oxygen uptake capacity
- Increased systemic blood pressure
- Faster onset of fatigue
- Increased sensitivity to extreme temperatures
- Different shift preferences
- Like different parenting and learning styles.

Human ageing, like other stages of life (development), is a process of change that is reflected in the physical structures of the organism, the manifestations of cognition and the subjective perception of these changes. In this context, it can be said that ageing is a multidimensional process of change that leads to functional losses in physical, mental and social areas.

All short- and medium-term demographic forecasts point to an ageing world population with a clear preponderance of older workers in the labour market. This ageing poses a workforce management challenge for companies, which means that they need to adopt and develop specific occupational risk prevention measures adapted to their own conditions.

Demographic change is likely to force ageing workers to work at older ages. In the context of more demanding jobs, ageing workers raise questions about the quality of work or their productivity, as well as health risks and safety [Sluiter, 2006].

In the face of an ageing population, longer life expectancy is an important social advance, but it also has significant socio-economic consequences for both companies and society in general. As people work longer and the proportion of this segment of the population increases, many issues related to working life for ageing workers and the management of health and safety in the workplace have become a priority [Araújo-Vila, et al., 2022].

One of these important issues is workplace ergonomics. Ergonomics is about adapting the workplace to the worker, i.e. adapting jobs and tasks to the abilities and limitations of older workers”. The focus of ergonomics is on the interaction between people and the system in which they live, work and carry out their daily activities.

From an ergonomic perspective, maintaining age-related functionality is a priority issue for people [Pamuk et al. 2022]. Ergonomics plays an important role in developing these capabilities and promoting quality of life in older people. In this context, ageing ergonomics is design-oriented and examines age-related changes in physical, cognitive and organisational abilities, with a focus on examining and strengthening the remaining abilities of older people [Cammen, et al. 2019].

Ergonomics is the study of understanding how people interact with other elements of a system to improve human performance and well-being. Proponents of this applied science argue that work tasks, work environment and other organisational factors must be appropriate to the physical, cognitive and psychological qualities of the individual. Therefore, an ergonomic approach makes sense to ensure that ageing workers can continue to contribute to the world of work. At this point, many of the changes that benefit older workers benefit workers of all ages. All workers benefit from better lighting, redesigning unnecessarily complex tasks, avoiding excessive heat, taking adequate breaks, caring for tools and the environment. Implementing holistic ergonomic changes therefore not only allows older workers to continue to contribute to the company, but can also increase overall company performance and employee retention and make the company a more attractive place to work [Fiorini, 2015-2016].

Ergonomics is basically the design of workplaces according to the needs of workers, i.e. all workers. As Campos et al. (2010) stated, the goal of ergonomic design is to minimise problems at this interface. Most guidelines have already been created with older workers in mind, including guidelines for manual material handling, repetitive movements and the selection of controls and screens. Companies concerned with the safety of older workers should continue to assess their losses and focus their prevention efforts on the exposures that cause the highest number, highest cost and highest injury rate [Fox, et al. 2015; Szalma, 2009]. Like everyone, older people have the right to live and work in a comfortable, convenient, safe and healthy environment. In this respect, the equipment and design of the working environment should be adapted to solve or minimise the problems of older people. This is because in designing a suitable workspace and building for older people, the link between the internal and external environment and the facilities provided is of greater importance. Generally, factors such as safety, ergonomics, hygiene and healthy environment are not considered in the design and construction of the workplace.

However, it is clear that the workplace can be used with maximum benefit if it is ergonomically designed and the needs and limitations of older people in the working environment are taken into account. The anthropometric characteristics of the user are important in designing a suitable working environment, but the choices and preferences of the individual should also be taken into account. In this respect, it is extremely important to focus on how to design work environments within the limits of ergonomics, taking into account the mobility and communication of older people, in order to enable older people to perform the movements required by the work and to continue their activities in the most appropriate way.

Considering that the ageing process limits many activities of daily living of older people, optimal design of the living and working environment is important.

Considering the impact of the elderly population on social security systems and solution-oriented alternatives in recent years, it is essential to design accessible and functional living and working environments.

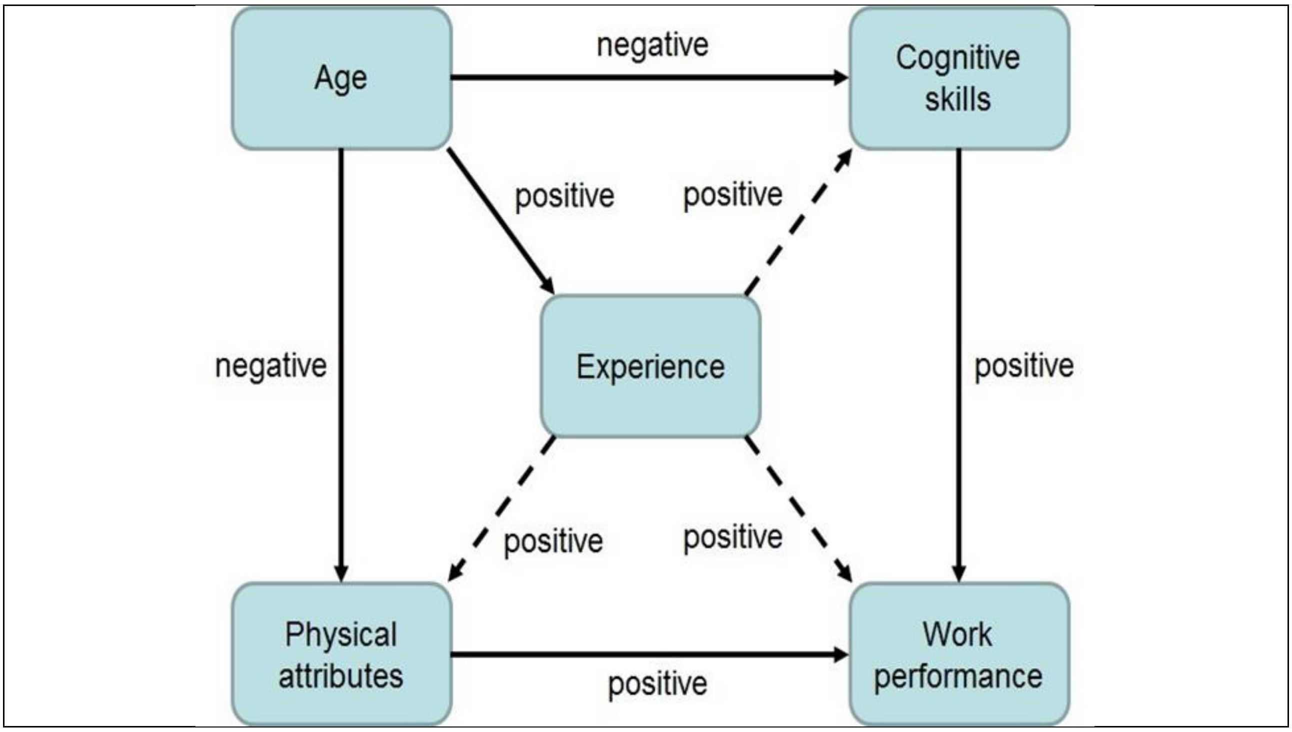


Fig. 1. Age, cognitive skills, physical attributes, experience, and work performance [Stedmon et al., 2012].

In view of the expected ageing of society, the industrialised countries must today develop a strategy aimed at "humanising" work beyond what has been achieved so far and at increasing productivity. But even in developing countries, where the problem of work and ageing is not yet an issue, an industrial infrastructure must be created that will enable society to cope with future ageing in the next decade.

The first step to solving this problem is to fully understand and put into practise the human characteristics that are fundamental to ergonomics. In particular, an "ergonomics in industrial management" strategy should be developed in which the characteristics that cause ageing are objectively understood and the negative and positive effects of ageing on humans are examined in depth.

As the basis of an ergonomics in industrial management strategy for dealing with an ageing workforce, it is essential to diagnose and assess work ability/employability to ensure that there is no mismatch between the work abilities of individual ageing workers and the qualitative and quantitative workloads to which they are exposed.

Therefore, the characteristics of ageing workers need to be fully understood through practical ergonomics research aimed at an older population. The aim is to identify the causes of older workers' work ability from the point of view of the three factors essential for a healthy enterprise (health, safety, environment), and at the same time to plan and implement measures to improve actual productivity.

In summary, the ageing of the population is affecting changes in the labour market. The changes in the workforce lead to organisational challenges that human resource management must be prepared for and address. As a result, companies need to find and implement appropriate HR measures to manage their ageing workforce and ensure smooth performance [Čiutienė and Railaitė, 2014]. Moreover, as Shaw [1986] notes, the needs of ageing people may be similar to those of all people, with some ergonomic measures compensating for physical deficits. The ageing workforce can therefore present challenges for industry. However, these challenges can be overcome by designing a safe, ergonomic and efficient work environment that takes into account the characteristics associated with ageing. In an environment where society is getting older by the day and demographic trends support this, an objective assessment of the extent of this increase is crucial for effective action by ergonomists.

The changes associated with ageing and their significance for work performance can only be achieved through effective action and the involvement of ergonomists. In this context, the role of ergonomics in protecting ageing workers should be addressed like other global demographic trends that may be of interest to future safety and ergonomics professionals.

## 3. Methodology

The aim of our research was to test the latest movement sensing equipment and the possibility of using it to assess movement in workplace design for older workers. The Xsens sensor suit [Xsens Movella, 2023; Xsens MVN, 2021] with 17 wireless motion trackers was used to capture the worker’s movements. The sensors were attached to a Lycra suit and a series of straps to ensure good fixation to the body and minimise skin movement errors.

The motion trackers provide 3D angular velocity using gyroscopes, 3D acceleration using accelerometers, the Earth's 3D magnetic field using magnetometers and atmospheric pressure using a barometer. All this combined with Xsens algorithms ensures drift-free 3D orientation. Sensor calibration is required before starting the tracking procedure.

For data processing, the MVN Analysis Software Engine was used to collect and process the sensor data. The programme combines the data from the individual motion trackers with a biomechanical model of the human body to obtain segment positions and orientations.

Later, the programme Process Simulate [Siemens PLM Software, 2023] was used to simulate the workplace and the worker’s movements. Several ergonomic analyses were performed to evaluate the worker's movements and identify potential health and safety issues.

The OWAS method was used for the ergonomic evaluation. The OWAS method (Ovako Working Posture Analysis System) is an ergonomic assessment tool for identifying and analyzing risks related to working posture. It was developed by Ovako, a Swedish steel company, and is used in various industries to evaluate and improve working conditions. The main objective of the OWAS method is to identify and classify work postures [Diego Mas at all., 2015] that can cause physical stress and injuries to workers. These postures are evaluated based on back strain, arm and leg strain, and trunk rotation.

The method focuses on static postures, which are postures that are held for an extended period of time. The application process of the OWAS method consists of the following steps:

*Observation:* a qualified observer records the work performed by the worker and records the postures assumed during a specified period of time. Each posture is assigned a posture code consisting of four digits. The first digit depends on the back position of the worker in the posture evaluated (Tab. 1), the second on the arm posture (Tab. 2), the third on the leg posture (Tab. 3) and the fourth on the load guided (Tab. 4).

| *Back position* | |
|---|---|
| ***Back straight (1)***<br>*The axis of the worker's trunk is aligned with the hip-leg axis.* |  |
| ***Bent back (2)***<br>*Can be considered to occur for inclinations greater than 20° (Mattila et al., 1999).* |  |
| ***Back with twist (3)***<br>*There is torsion of the trunk or lateral tilt of more than 20°.* |  |
| ***Back bent with twist (4)***<br>*There is simultaneous trunk bending and twisting (or leaning).* |  |

Tab. 1. Coding of back positions

*Recording of postures:* The observer records the various work postures using a specific code that describes the worker's posture. These codes are based on the position of the upper and lower extremities and trunk rotation.

*Evaluation:* after the postures are coded, they are evaluated using a scoring matrix that combines the factors of back strain, arm and leg strain, and trunk rotation. Each posture is classified into one of the risk categories (Tab.5):

- Green - Changes are not required,
- Yellow - changes are required in the near future,
- Orange - changes are required immediately,
- Red - intensive observation required.

| *Position of arms* | |
|---|---|
| ***Both arms low (1)*** <br> *Both arms of the worker are positioned below shoulder level.* |  |
| ***One arm lowered and the other raised (2)*** <br> *One arm of the worker is below shoulder level and the other arm, or part of the other arm, is above shoulder level* |  |
| ***Both arms raised (3)*** <br> *Both arms (or part of the arms) of the worker are above the level of the shoulders* |  |

Tab. 2. Coding of arm positions

| *Leg position* | |
|---|---|
| ***Seated (1)*** <br> *The worker remains seated* |  |
| ***Standing with both legs straight (2)*** <br> *Both legs straight and with the weight balanced between them.* |  |
| ***Standing with one leg straight and the other leg bent (3)*** <br> *Standing with one leg straight and the other bent with the weight unbalanced between the two legs.* |  |
| ***Standing or squatting with both legs bent and the weight balanced between the two legs (4)*** <br> *Can be considered to occur for thigh-calf angles less than or equal to 150° (Mattila et al., 1999). Greater angles will be considered straight legs.* |  |
| ***Standing or squatting with both legs bent and weight unbalanced (5)*** <br> *Can be considered to occur for thigh-calf angles less than or equal to 150° (Mattila et al., 1999). Greater angles will be considered straight legs.* |  |
| ***Kneeling (6)*** <br> *The worker rests one or both knees on the ground.* |  |
| ***Walking (7)*** <br> *The worker walks.* |  |

Tab. 3. Coding of leg positions [20]

| *Load or force* | |
|---|---|
| *Less than 10 kg (1)* |  |
| *Between 10 and 20 kg (2)* |  |
| *More than 20 kg (3)* |  |

Tab. 4. Coding of load and supported forces

| Risk category | Posture effect | Required action |
|---|---|---|
| 1 | Normal and natural posture without harmful effects on the musculoskeletal system. | No action required. |
| 2 | Posture with the possibility of causing damage to the musculoskeletal system. | Corrective actions are required in the near future. |
| 3 | Posture with harmful effects on the musculoskeletal system. | Corrective actions are required as soon as possible. |
| 4 | The load caused by this posture has extremely damaging effects on the musculoskeletal system. | Corrective action is required immediately. |

Tab. 5. Risk Categories and corrective actions.

Table 6 is used to determine the risk category to which each posture belongs. In it, from each digit of the posture code, the risk category to which the posture belongs is indicated.

*Remedial Action:* When unacceptable postures are identified, corrective action must be taken to correct them and reduce the risks to worker health and safety. These corrective actions may include, but are not limited to, changes in workstation design, introduction of ergonomic equipment or tools, task rotation, and staff training.

| | Legs | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Load | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Back | Arms | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 4 |
| | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |
| | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 1 | 1 |
| 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 2 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

Tab. 6. Risk categories according to posture codes.

The OWAS method provides a systematic and standardized process for evaluating work postures and their impact on worker health and well-being. Identifying and correcting unacceptable postures can prevent musculoskeletal injuries, improve comfort and productivity, and promote a safe and healthy work environment.

It is important to note that the OWAS method is only an assessment tool and does not provide definitive solutions to ergonomic problems. It is critical to combine its use with other ergonomic techniques and approaches, and to involve and actively work with workers and management to achieve optimal ergonomic and well-being outcomes in the workplace [Diego Mas, 2015; Gómez-Galán et al., 2017; Prayogo et al., 2018].

## 4. Case study

The study was conducted in the Laboratory of Operations and Production Management at the Faculty of Mechanical Engineering, University of Maribor. The test subject was a 25-year-old student (Fig. 2). We created a simple test environment in which the student performs movements according to the previous plan: She goes to the table, takes the small box, goes to the higher shelf and puts it on the shelf. Then she takes another box, goes to the next target and places it on the floor. Then she chooses a chair, goes to the table with it and pushes it under the table.

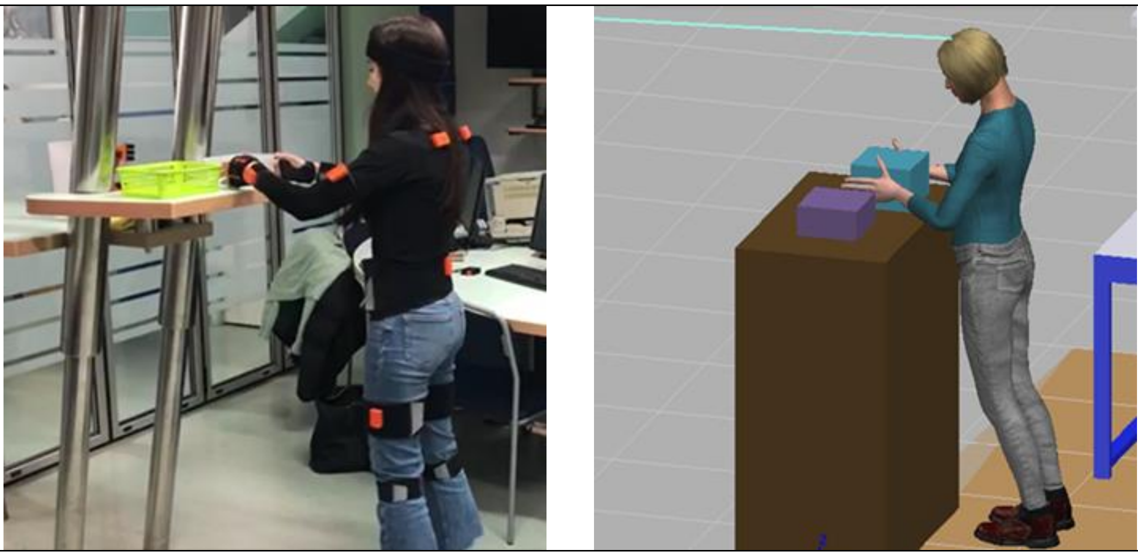

Fig. 2. Human with Xsens suit and human model in Process Simulate

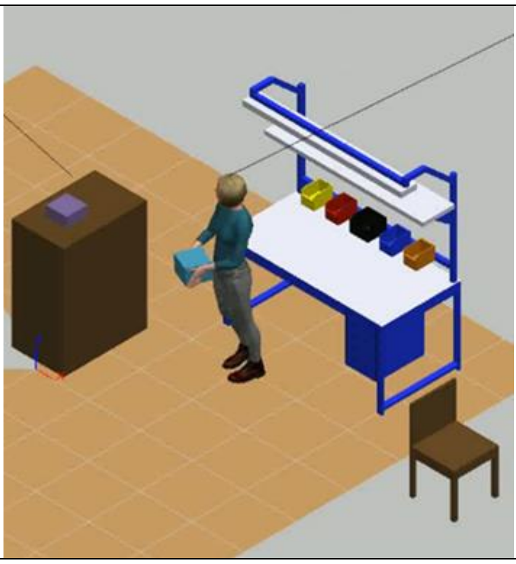

Fig. 3. Workplace created with Process Simulate software

The students' movements were recorded with the Xsens suit and the MVN software and later transferred to the Process simulate software, where the working environment with the required furniture was also created (Fig. 3). Based on the recorded movements, a new simulation was performed for two human models, a 25-year-old and a 60-year-old individual. Some details were corrected using the Task Simulation Builder (TSB) interface.

## 5. Results and discussion

The ergonomic method OWAS was used to evaluate the workers' movements, which were simulated with the Process Simulate software package. Fig. 4 shows the designed work environment with a 25- and 60-year-old human model. The results of the OWAS analysis are shown in colour. Slight differences between the two models can be seen in the movements shown, which are marked with orange and red.

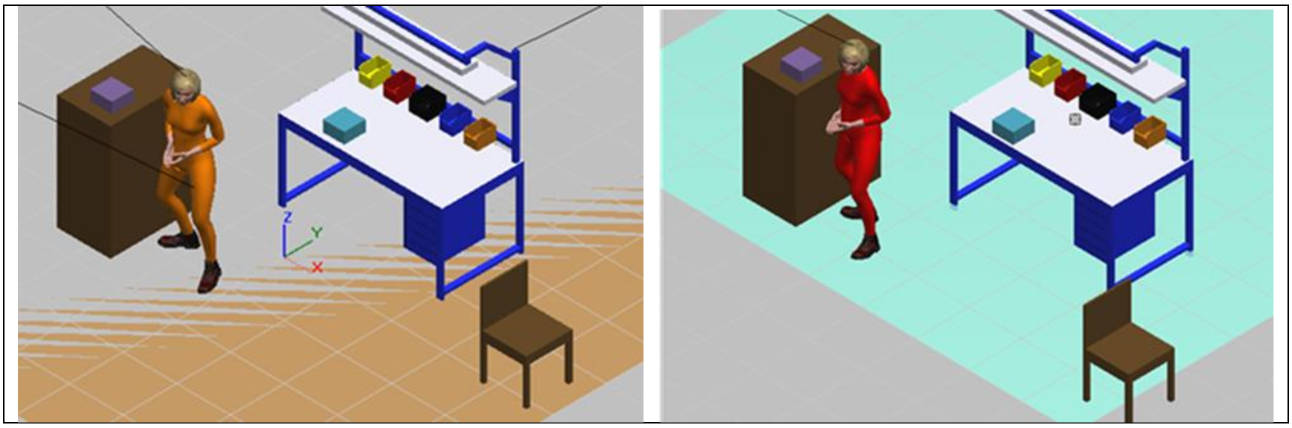


Fig. 4. Working environment for 25- and 60-years old human

The cumulative results of all movements performed with OWAS analyses for 25- and 60-year-old persons are shown in Fig. 5 a, b and 6 a,b.

| Time (Sec) | Operation | Object Weight ( kg) | Action Category | Code Posture Combination | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Back | Arms | Legs | Load | - | Head |
| 0 | Frame 4 | 0 | 1 | 1 | 1 | 2 | 1 | - | 1 |
| 0.2 | | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 8.3 | Frame 88 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 8.7 | Frame 94 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 16.25 | Frame 175 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 16.9 | Frame 181 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 19.2 | Frame 205 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 22.45 | Frame 241 | 0 | 4 | 4 | 1 | 4 | 1 | - | 1 |
| 23.1 | Frame 247 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 23.8 | Frame 253 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 24.2 | Frame 259 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 24.3 | | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 24.5 | Frame 262 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 25.3 | Frame 271 | 0 | 4 | 4 | 1 | 4 | 1 | - | 1 |
| 26.5 | Frame 283 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 27.2 | Frame 289 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 27.5 | Frame 292 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 27.6 | Frame 295 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 28 | Frame 298 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 29 | Frame 310 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 29.1 | | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 29.3 | Frame 313 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 30.9 | Frame 331 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 32.2 | Frame 343 | 0 | 3 | 2 | 1 | 4 | 1 | - | 4 |
| 33.5 | Frame 358 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 36.8 | Frame 394 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |

Fig. 5. OWAS results for 25-year-old person (part a)

The results of the analyses performed are similar for most of the simulated movements. The only significant difference between these two studies is in one of the postures the person adopts when turning around to walk to another point (Fig. 4) and placing the object on the floor. In the case of a 25-year-old person, both actions are marked orange, which means that the risk is moderately high and it is recommended to make a change as soon as possible. In the case of a 60-year-old person, on the other hand, the same actions are shown in red, which means that the risk is very high and immediate change is recommended.

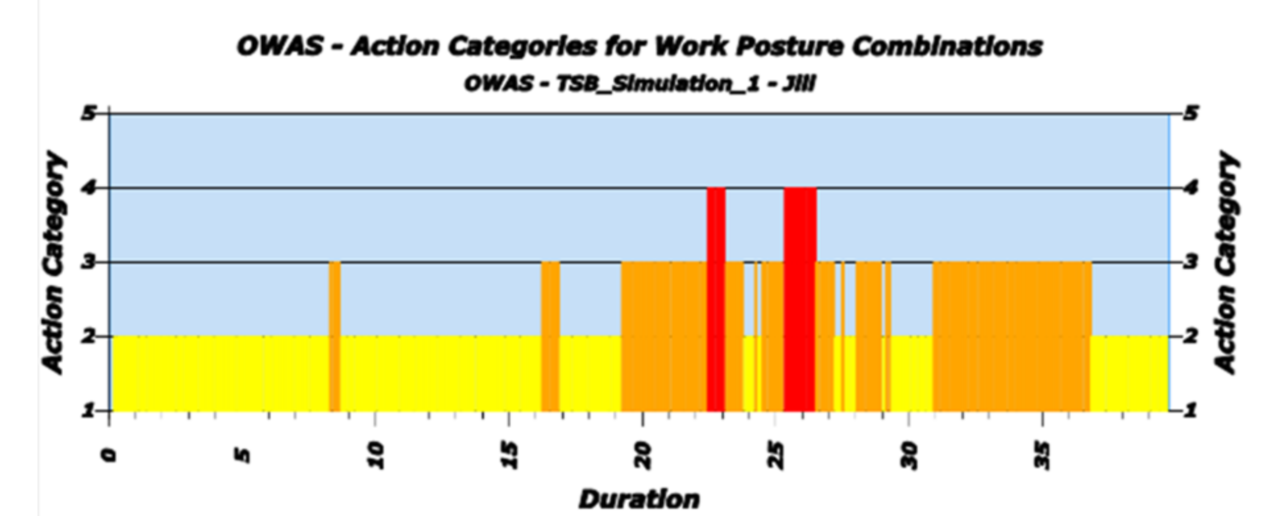


Fig. 6. OWAS results for 25-year-old person (part b)

| Time (Sec) | Operation | Object Weight (kg) | Action Category | Code Posture Combination Back | Arms | Legs | Load | - | Head |
|---|---|---|---|---|---|---|---|---|---|
| 22.2 | Frame 406 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 22.25 | | 0 | 3 | 3 | 1 | 4 | 1 | - | 1 |
| 22.5 | Frame 412 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 22.59 | Frame 415 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 23.38 | Frame 430 | 0 | 3 | 2 | 1 | 4 | 1 | - | 4 |
| 23.5 | | 0 | 4 | 4 | 1 | 4 | 1 | - | 4 |
| 23.6 | Frame 433 | 0 | 3 | 2 | 1 | 4 | 1 | - | 4 |
| 23.85 | Frame 436 | 0 | 4 | 4 | 1 | 4 | 1 | - | 4 |
| 24.15 | Frame 442 | 0 | 3 | 2 | 1 | 4 | 1 | - | 4 |
| 24.34 | Frame 448 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 24.93 | Frame 460 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |
| 29.05 | Frame 535 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 29.55 | Frame 544 | 0 | 3 | 2 | 1 | 4 | 1 | - | 4 |
| 31.65 | Frame 583 | 0 | 3 | 2 | 1 | 4 | 1 | - | 1 |
| 34.55 | Frame 637 | 0 | 2 | 1 | 1 | 4 | 1 | - | 1 |

Fig. 7. OWAS results for 60-year-old person (part a)

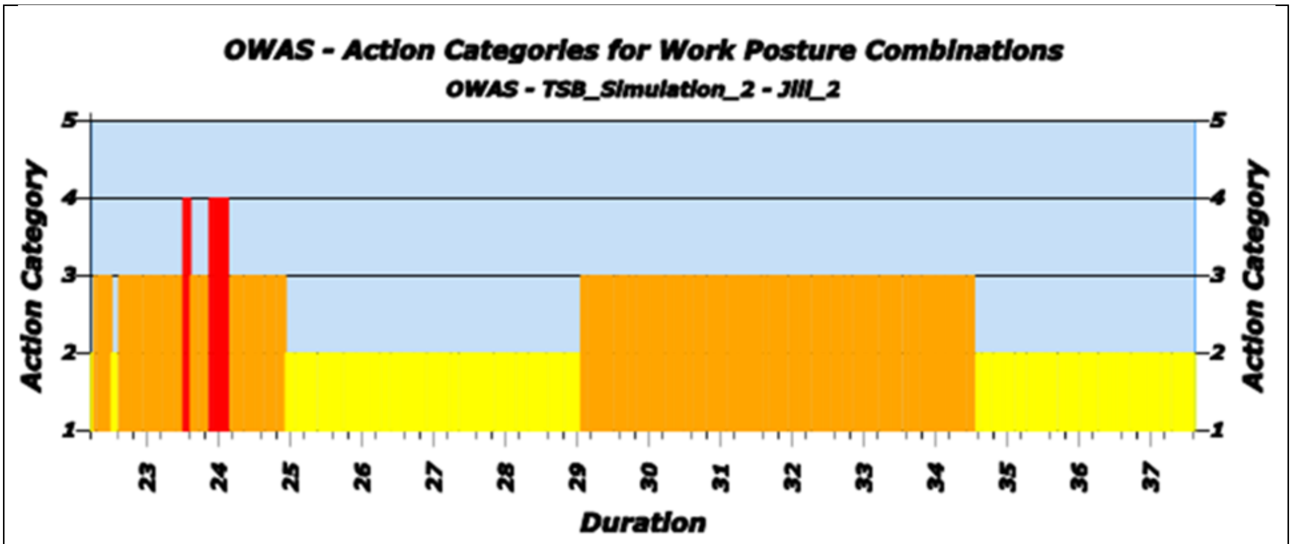


Fig. 8. OWAS results for 60-year-old person (part b)

## 6. Conclusion

In our study, an overview of various aspects and challenges related to the ageing population is given. Various aspects related to the elderly population are discussed and a case study is presented that aims to test available new technologies, the Xsens suit and Process Simulate software, during a process of ergonomic workplace design that is also suitable for the elderly. Considering ergonomics in workplace design is crucial as it has a direct impact on workers' health, well-being and productivity. The application of ergonomic principles aims to adapt the work environment to the needs and abilities of the individual, thus optimising the interaction between the individual, the tasks performed and the environment. This leads to the prevention of injuries and musculoskeletal disorders, the reduction of fatigue and work-related stress, and the enhancement of performance and job satisfaction - all issues that are also important for the safe work of older workers.

The case presented demonstrates the usefulness of motion capture technology for the ergonomic design of workplaces also for older workers. Motion capture technology is used to record and track the movements of people or objects and translate them into a digital format, saving time and effort in the animation process. The data obtained with the Xsens sensor suit was later used for ergonomic analyses with the Process Simulate software. The results show the difference in strain between younger and older people.

Ergonomics and aging are both important fields with increasing relevance as the global population continues to age. Future directions in the field of ergonomics and aging may include:

- age-friendly product and environment design,
- developing and improving assistive technologies,
- cognitive ergonomics,
- preventive healthcare,
- designing and implementing solutions that allow older adults to remain in their own homes and communities comfortably and safely,
- user-centered research,
- age-related disabilities,
- and others.

The field of ergonomics and aging is evolving to meet the challenges and opportunities presented by an aging demographic. It requires a multi-disciplinary approach and a strong focus on user-centered design therefore we can conclude that motion capture technology has several advantages and can significantly support the ergonomic design of workplaces for older workers as well.

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## 8. References

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