NATIONAL INSTITUTE FOR OCCUPATIONAL HEALTH
Division of the National Health Laboratory Service

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A Human-Centred Approach to Workplace, Equipment and Systems: Designing for Women in Mining

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Date: 20 August 2026

PRESENTATION OVERVIEW

- **Human-centred design** to improve safety, health, productivity, and inclusion.
- **Physiological and anthropometric differences** between men and women and their implications on work.
- **Workplace factors** affecting women's physical and psychological wellbeing.
- Promoting **gender-responsive occupational health** in mine design and operations.

INTRODUCTION

- Historically, mining workplaces were predominantly designed around the "**average male**" worker.
- This influenced the design of **PPE, mining equipment, machinery, workstations and operational systems**.
- As more women entered the mining industry, many existing systems and designs were not sufficiently changed to accommodate a more diverse workforce.
- Women are exposed to various **mechanical, physical, ergonomic, psychological and biological hazards etc**.

(Kunda et al. 2013; McPhee, 2004; Sen et al. 2020; Mokwena et al. 2025)

INTRODUCTION

Traditional Approach: Getting different workforces into mining and working around mine systems.

DIFFERENT WORKFORCES

MINE SYSTEMS

INTERGRATION APPROACH

Integration Approach: With women entering the mining systems there is a need to take a **human factors and ergonomics approach** to accommodate women in mining systems.

INTEGRATION APPROACH:
1. SPECIALISED HFE DOMAINS

Figure 1. Specialised Ergonomics Domains

2. THE ROLE OF ERGONOMICS

= To fit the workplace to the worker.

AND

≠ Not fit the worker to the workplace.

PRINCIPLES OF ERGONOMICS

1.SYSTEMS MODEL

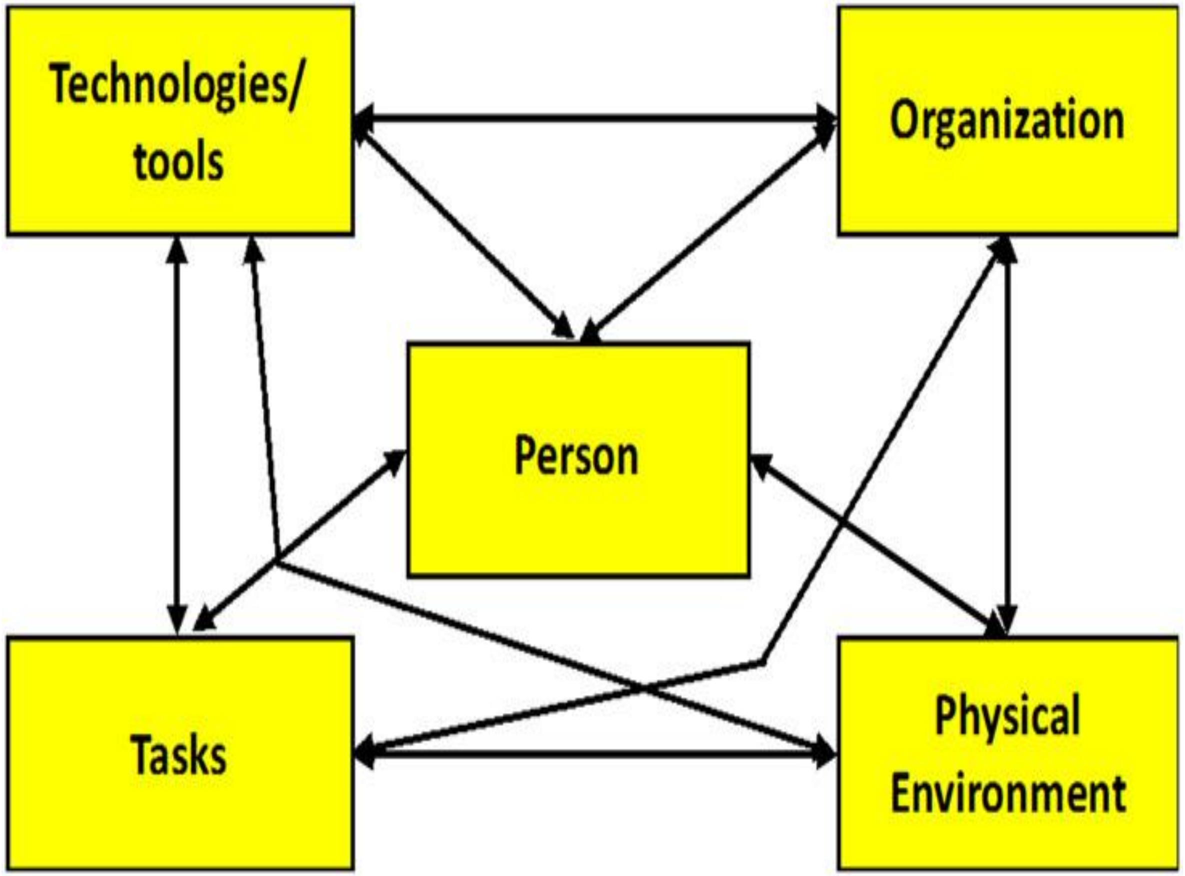


Figure 2. Socio-technical Work System Model, adapted from Smith and Carayon (2009). doi:10.1080/10447310902864928

Person/Worker:
- Education, skills, knowledge, individual factors, physical characteristics

Tasks:
- Type of tasks
- Autonomy, job control
- Job demands

Technology and Tools:
- Devices and tools used
- Human factors characteristics of technologies

Organisation:
- Teamwork, organisational cultures and collaboration, work-schedules

Environment:
- Layout, noise etc.

2. HUMAN-CENTRED APPROACH

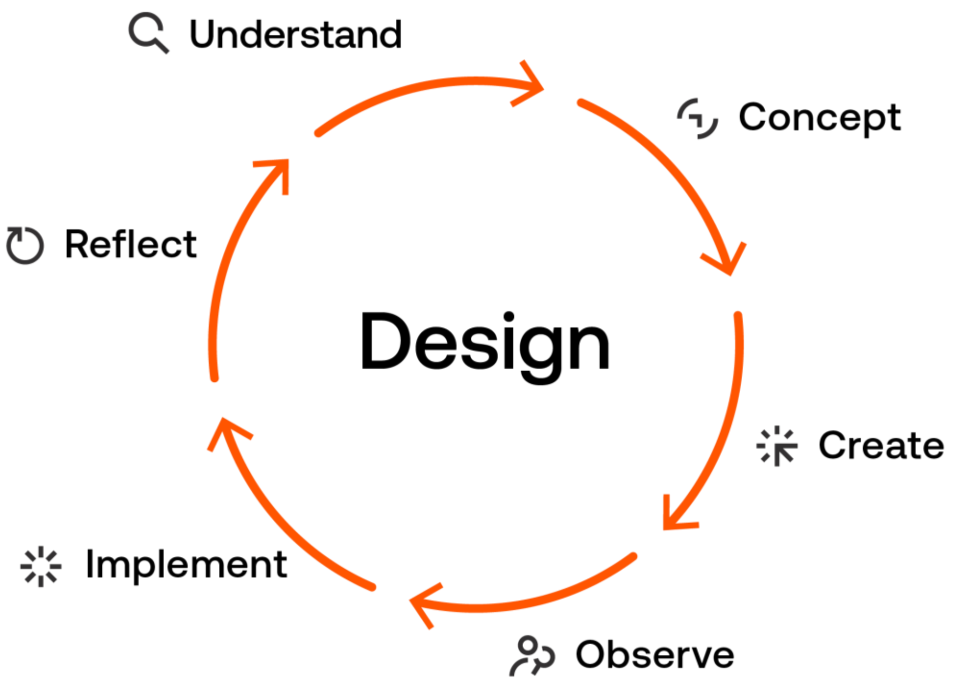
Human centred approach which is an interactive systems aims to make systems usable and useful by focusing on the user

Figure 3. The Balance Theory Model. Carayon (2009). doi:10.1080/1044731090286492

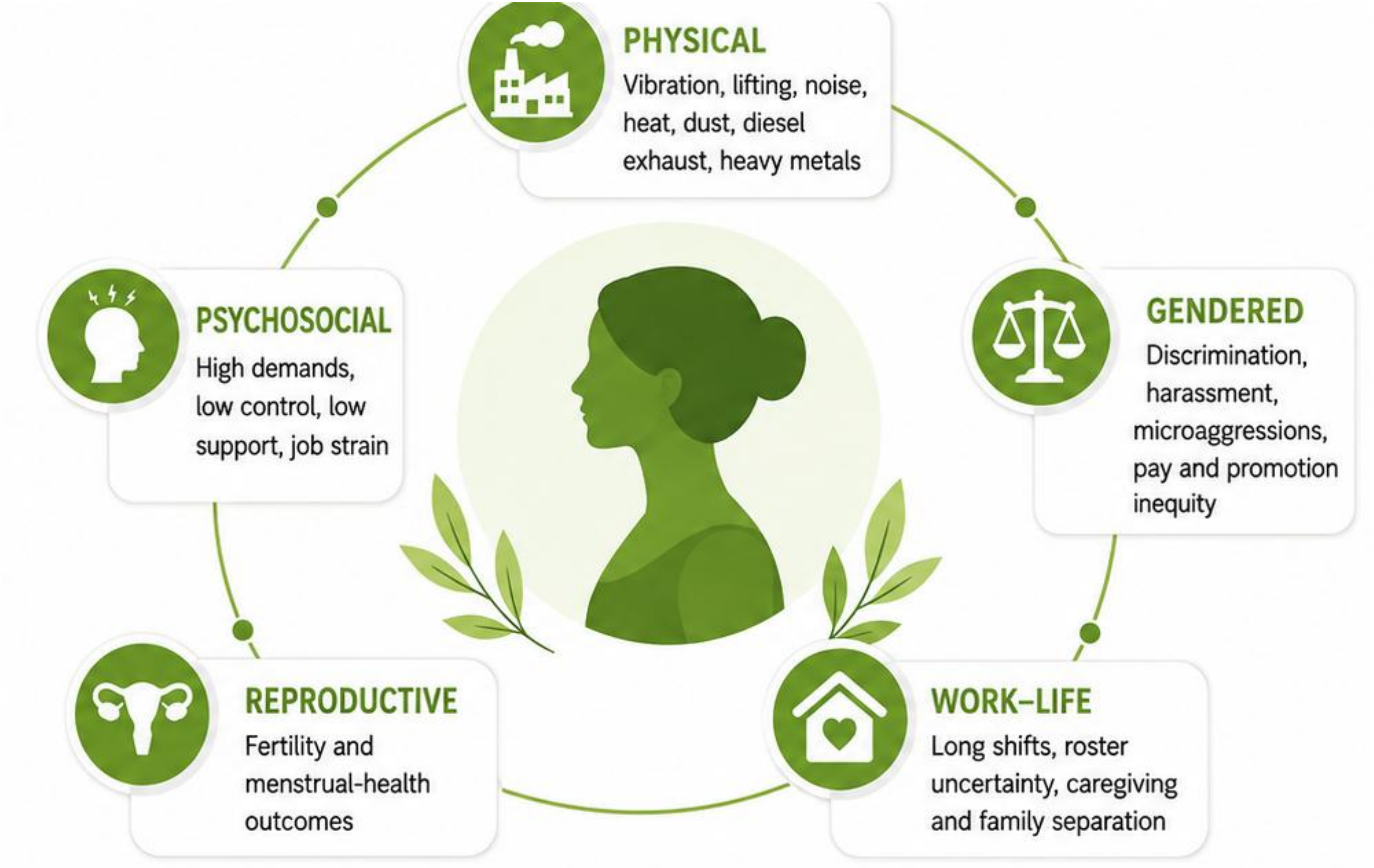
(Carayon, 2009)

3. DESIGN DRIVEN

- Design of products
- Design of tools
- Design of workstations



Workplace Factors That Affect Women's Physical and Psychological Wellbeing



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PHYSICAL FACTORS AND REPRODUCTIVE HEALTH

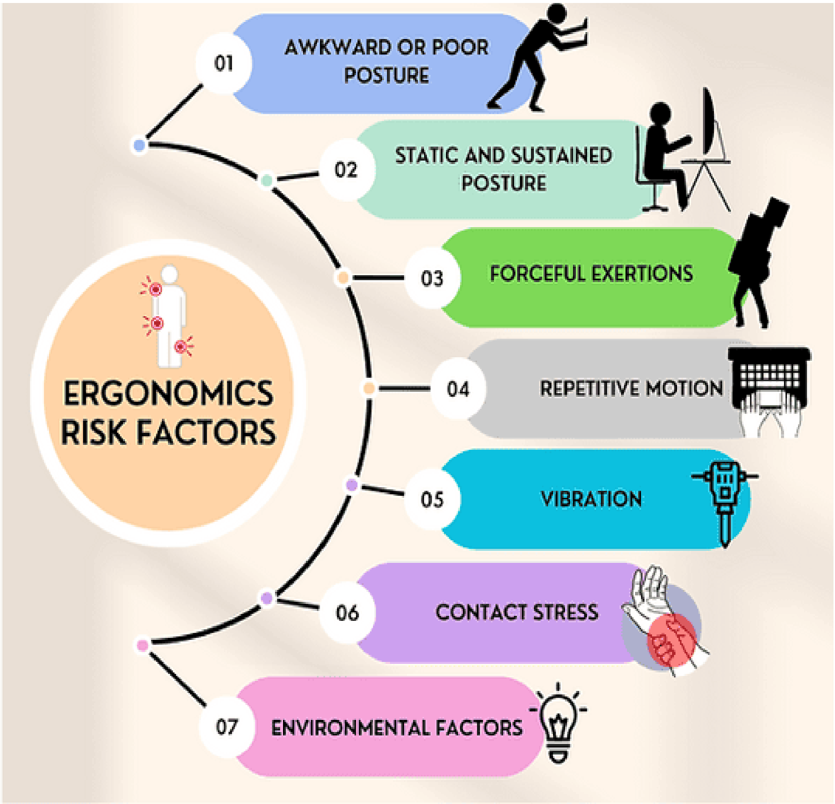


Figure 4. Ergonomics Risk Factors

Physical and health challenges

- **Lifting and bending:** Repetitive, physically demanding work may have implications for reproductive health.
- **Emerging evidence**: identified evidence linking high job demands, low job control, long working hours and heavy lifting with infertility. Sasaki et al. (2025)
- A gender-responsive approach can broaden assessment to physical workload, fatigue, reproductive stage, psychosocial demands and recovery.

(Sasaki et al.2025)

PSYCHOSOCIAL WORK FACTORS: DEMANDS, CONTROL AND SUPPORT

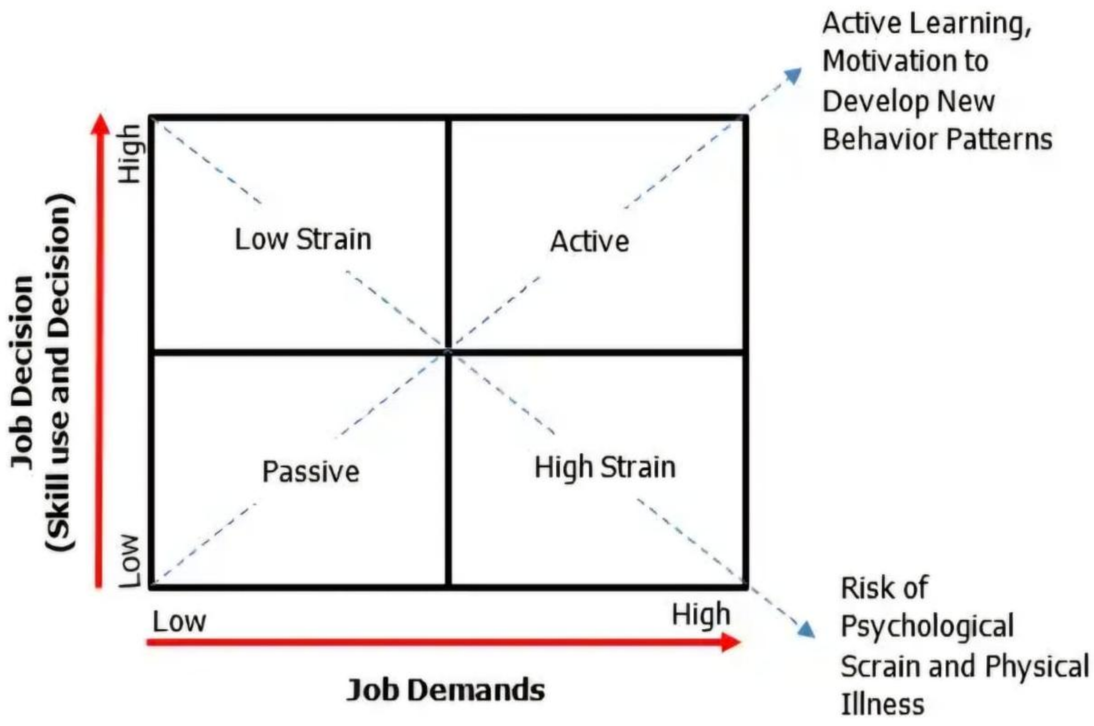


Figure 5. Job Demands-Control model (Chambel et al., 2020)

- High psychological demands combined with low decision control represent a high-strain work configuration (Niedhammer et al., 2021).
- Swanson et al. (2000) found linking high-strain work among women with psychological distress, pain, and reduced physical functioning.
- On the other hand Milner et al. (2021) found that the relationship between work and mental health varies by workplace exposure; long working hours.
- Workplace stress should therefore be considered in relation to the resources and autonomy available to the employee.

LONG WORKING HOURS, WORK–LIFE BALANCE AND RECOVERY

- Long shifts and extended working hours can reduce opportunities for sleep, recovery and family time.
- In mining, long shifts, fly-in/fly-out rosters and remote-site living can intensify caregiving strain, fatigue and family separation.
- Roster uncertainty, call-outs and expectations to be always available can narrow the boundary between work and personal life.
- Recovery should therefore be treated as a system requirement, not simply an individual responsibility or Working-time design therefore becomes a human factors/ergonomics issue i.e., workload must be considered alongside recovery capacity.
- Swanson (2000) highlights the combined demands of employment and family responsibilities as an important source of stress for women.

LONG WORKING HOURS, WORK–LIFE BALANCE AND RECOVERY

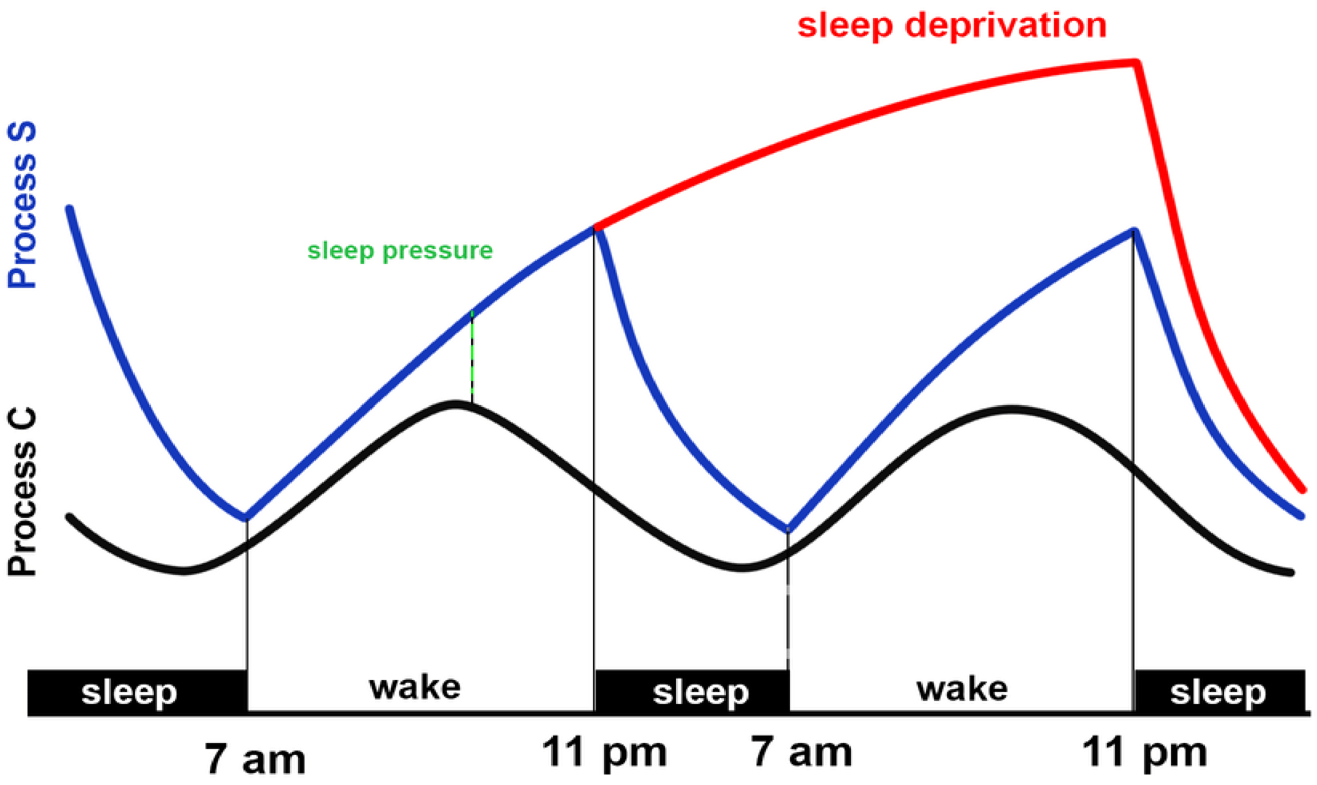
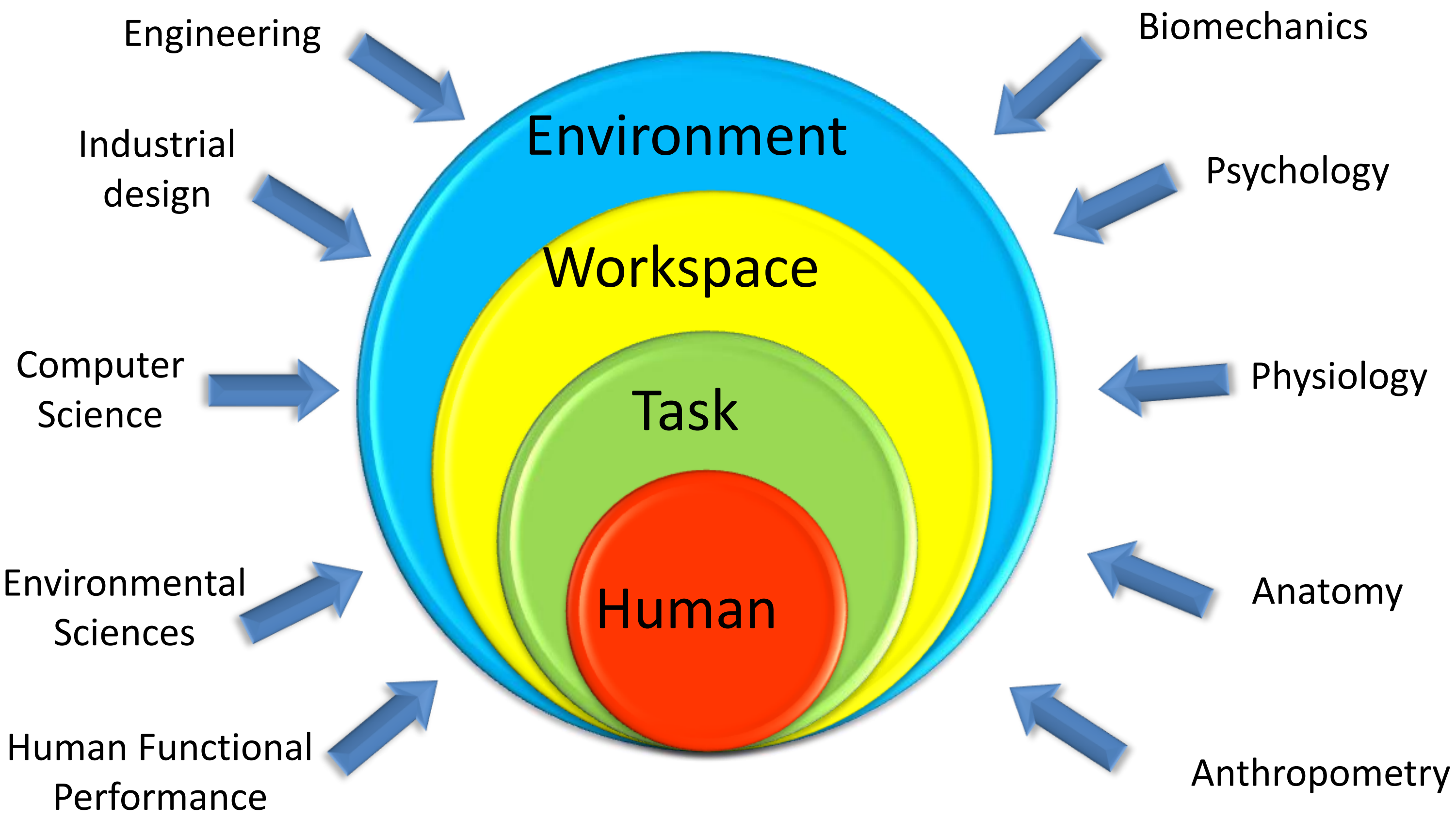


Figure 6. The two-process model for the regulation of sleep. Process C is the circadian arousal drive and Process S is the homeostatic sleep drive (taken from Borbély and Achermann, 1999).

MULTIPLE EXPOSURES: THE WORK ENVIRONMENT IS NOT ONE HAZARD AT A TIME



MULTIPLE EXPOSURES: THE WORK ENVIRONMENT IS NOT ONE HAZARD AT A TIME CONT…

- Women's workplace wellbeing is multidimensional and shaped by the interaction of work design, physical exposures, psychosocial demands and gendered organisational conditions.

- Physical hazards such as WBV can have pregnancy-related implications and warrant exposure-specific controls.

- Psychosocial hazards include high demands, low control, harassment, discrimination, isolation and work-family conflict.

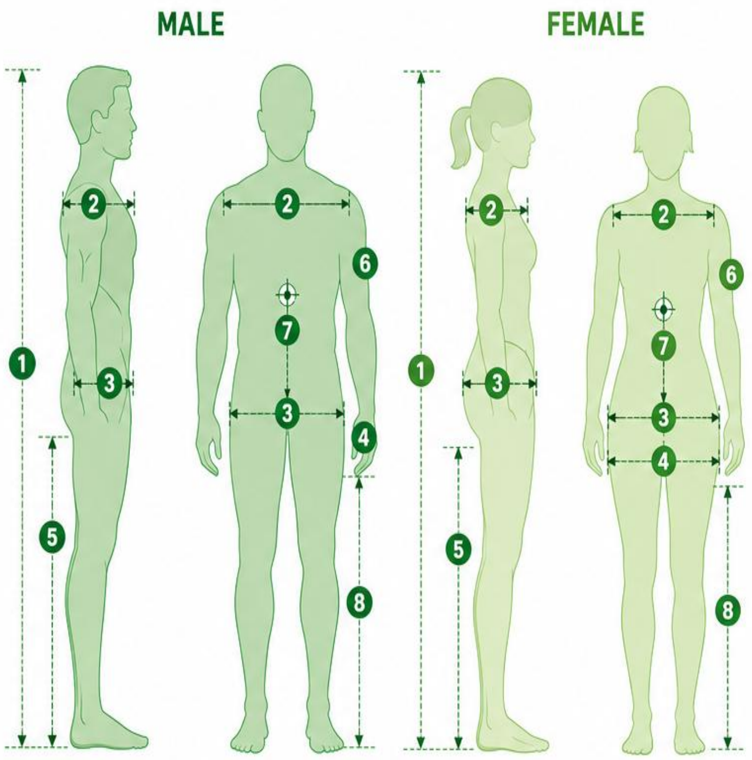
- Mining illustrates how physical, environmental, economic and cultural conditions can accumulate into a broader wellbeing risk.

- **The most sustainable approach is systemic approach!!**

DESIGNING FOR WOMEN
1. ANTHROPOMETRIC DIFFERENCES

Male Characteristics

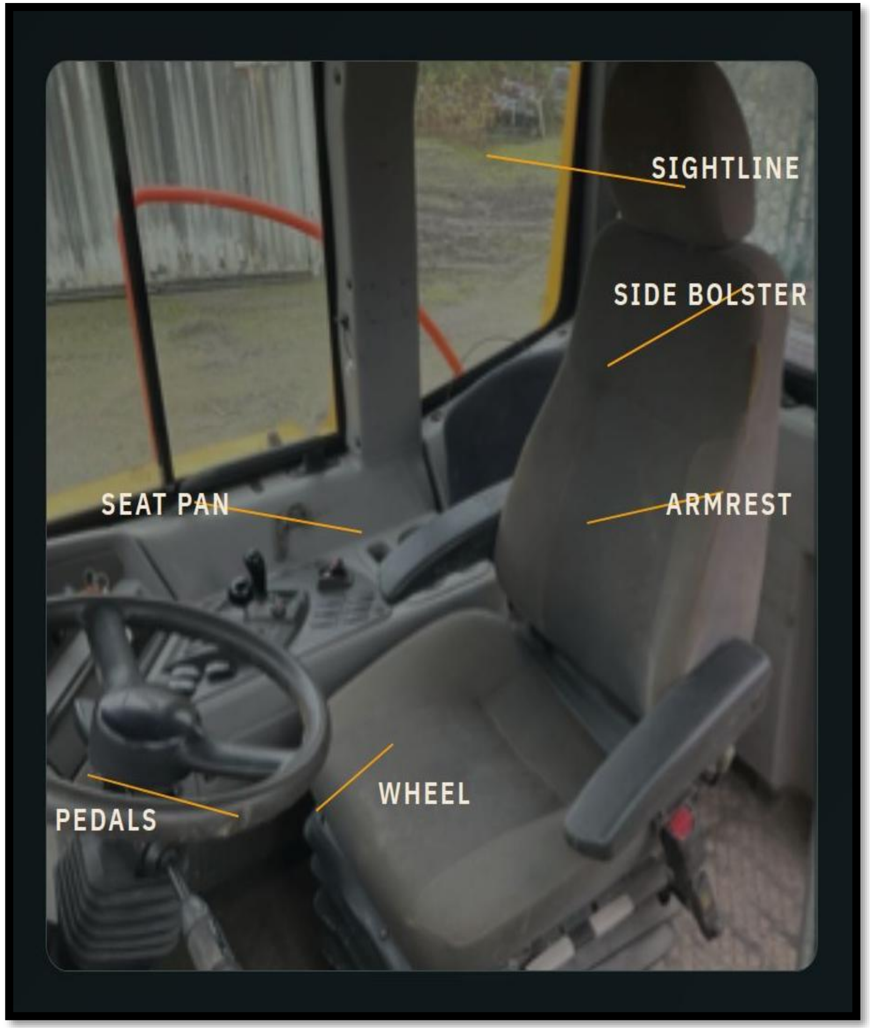
1. Greater stature (height)
2. Broader shoulders
3. Narrow pelvis
4. Smaller hip width
5. Longer limbs
6. Greater muscle mass
7. Different centre of mass
8. Greater body weight



Female Characteristics

1. Shorter stature (height)
2. Narrow shoulders
3. Wider pelvis
4. Wider hip width
5. Shorter limbs
6. Lower muscle mass
7. Different centre of mass
8. Lower body weight

EXAMPLE OF ANTHROPOMETRIC CHALLENGES



ANTHROPOMETRIC MIS-MATCH

POOR FIT

- CONTROLS TOO HIGH OR TOO LOW
- POOR FIT OF SEAT OR HARNESS OR PPE

RESTRICTED MOVEMENT

- OVERREACHING OR STRETCHING
- AWKWARD POSTURES
- LIMITED FREEDOM OF MOVEMENT

INCREASED SAFETY RISK

- HIGH PHYSICAL STRAIN AND FATIGUE
- REDUCED CONTROL AND PRECISION
- GREATER RISK OF INCIDENTS

Ergonomic Solution: Design equipment, tools and workplaces using inclusive anthropometric data and a **human-centred approach**.

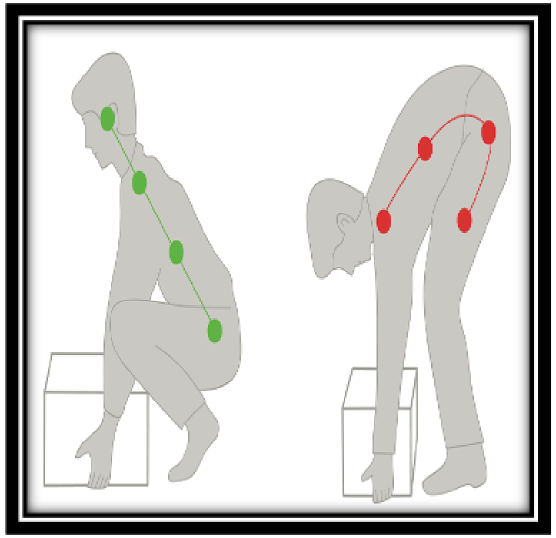
ANTHROPOMETRIC MATCH

Ergonomics: design for diverse body dimensions and capabilities

- **Adjustable controls**, seating and work surfaces can accommodate a wider range of statures and reach dimensions.
- **Right-sized respirators**, harnesses, gloves, boots and other PPE improve fit, mobility and usability.
- **Mechanical assists and load-reduction technologies** can reduce reliance on individual strength.
- **Ergonomic design** should consider anthropometry, biomechanics, task demands and the interaction between worker and equipment.
- **Gender-responsive ergonomics** means designing for variability rather than creating separate 'female' versions of every task.

NOTE: The dimension of similar person in different populations or countries are different. Use population specific data

2. BIOMECHANICS/BIOPHYSICS

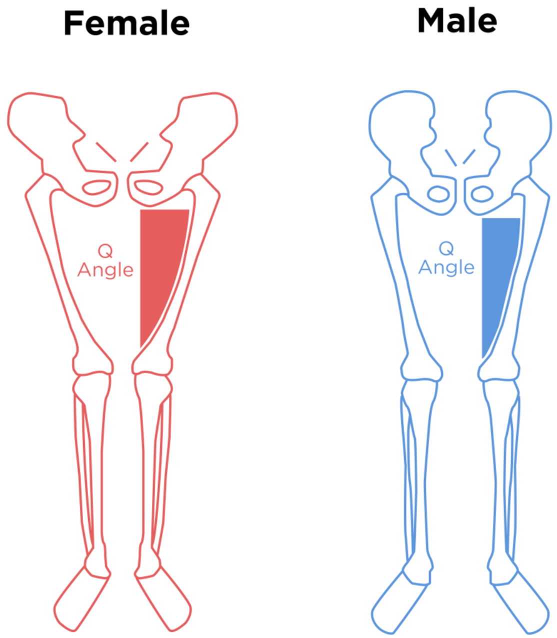


Movement Strategies

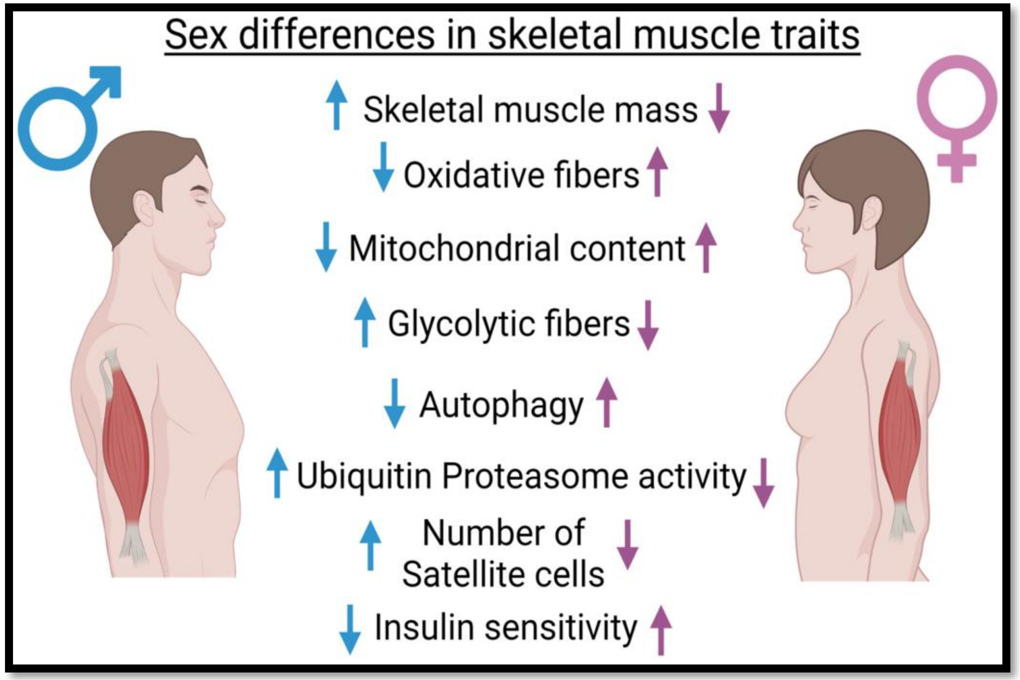
- Biomechanically, men use more upper body and back strategies when lifting compared to females, who rely more on lower body stability

Muscle mass and Body Composition

- Men have a higher lean mass (30-40%)
- Larger muscle sectional area
- Making them able to more force compared to women.



3. PHYSIOLOGICAL AND SKELETAL MUSCLE DIFFERENCES



Physiological Differences
Understanding Human Performance Differences in:
- Muscle strength and endurance
- Fatigue thresholds
- Heat stress response

Impact:
- Increased fatigue under same workload
- Higher risk of musculoskeletal strain

=

- Increased risk to injury
- Degradation in human performance
- Increased MSD
- Compromises safety

EXAMPLE OF HEAT STRESS RESPONSE

HEAT SCREENING TESTS FOR WOMEN IN MINING

- Identify test protocols validated for women
- Different hormonal phases may influence heat responses
- Use results to individualise work/rest cycles and hydration strategies
- Incorporate Heat acclimatisation programmes
- The influence of menstrual phase on thermo-regulation and cardiovascular response

TYPICAL TEST MEASURES

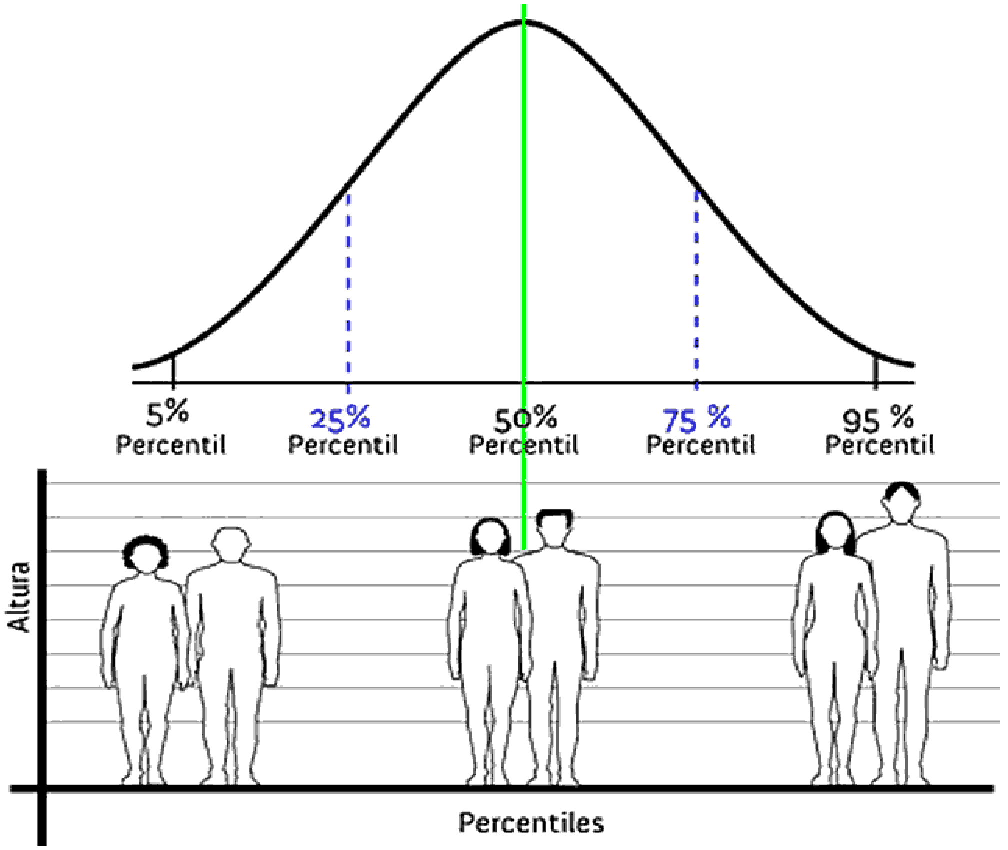
HEART RATE

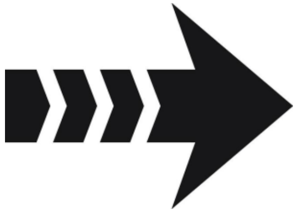
SWEAT RATE

CORE BODY TEMPERATURE

NOT A ONE SIZE FITS ALL

Traditionally, designs were designed for the 50th percentile average





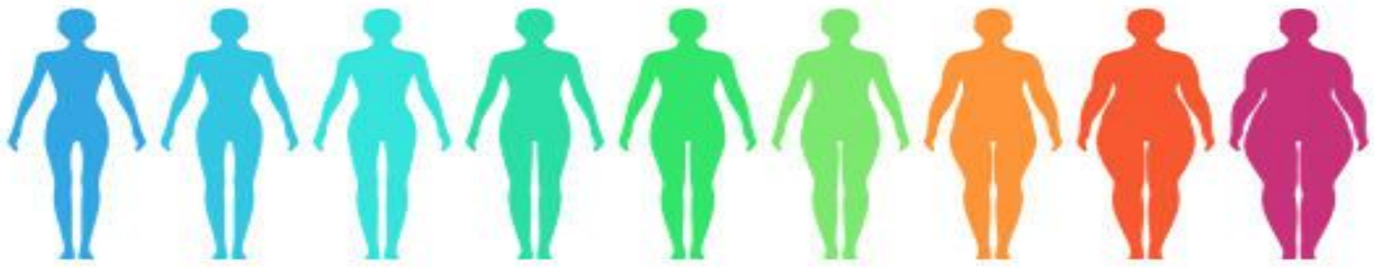
Design for the 95th men and 5th percentile average women

DESIGNING INCLUSIVE WORK ENVIRONMENTS

- **Recognising the role of ergonomics in design:** Influence design, impact usability and enhance safety

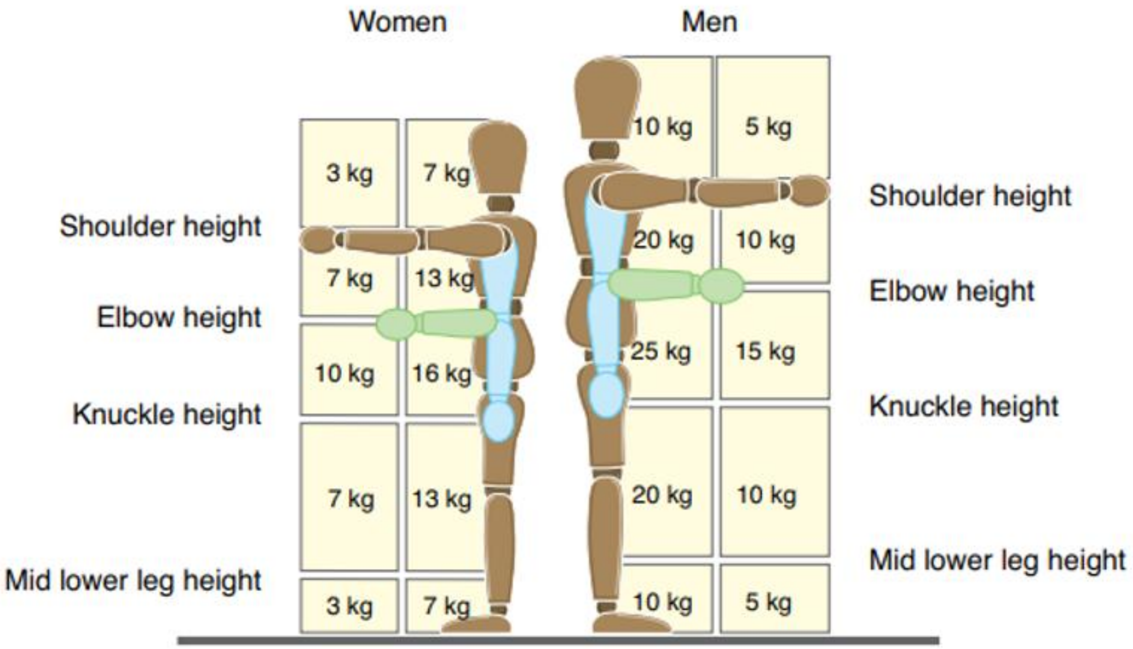
- **Recognise human differences:** Anthropometric, biomechanical and physiological differences between men and women can influence how workers interact with equipment, tasks and the working environment.

- **Consider functional performance:** Poorly matched equipment or excessive physical demands can contribute to **fatigue, discomfort, musculoskeletal strain and reduced functional performance**.



DESIGNING INCLUSIVE WORK ENVIRONMENTS CONT…

- **Lifting and lowering risk guidelines:** Lifting and lowering risk guidelines (Adopted from the Health and Safety Executive, 2020).

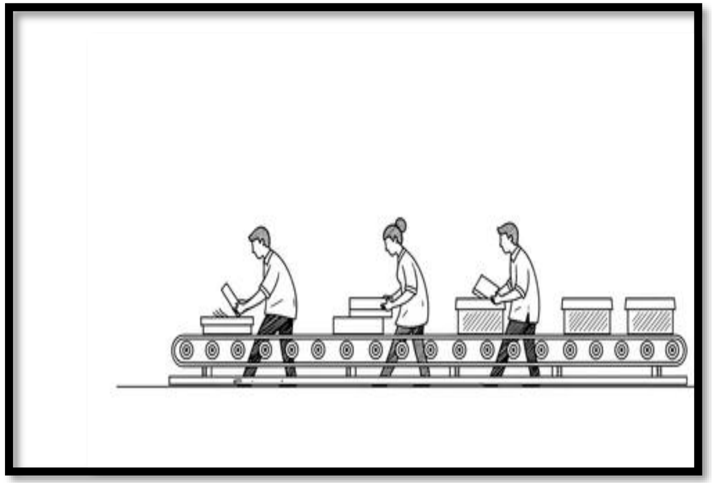


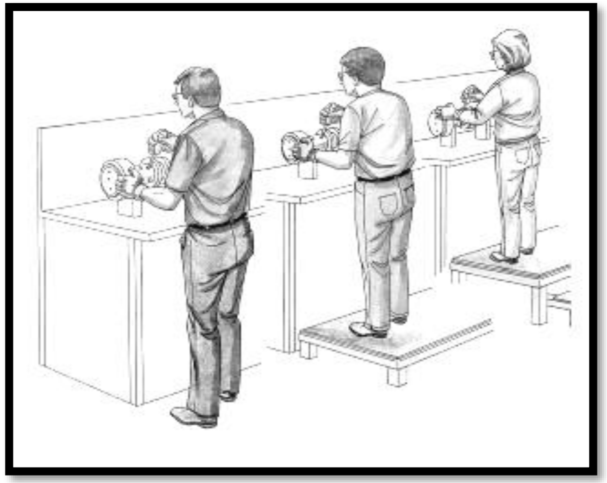
- **Align workloads with human capacity:** ensure physical demands are appropriate for the capabilities required to perform the task safely.

- **Implement fatigue-risk management systems:** identify, monitor and control fatigue associated with workload, shift patterns and insufficient recovery

DESIGNING INCLUSIVE WORK ENVIRONMENTS CONT...

- **Task design:** Minimise force; repetition; awkward posture
- **Equipment design:** Adjustable, lightweight, inclusive; Workstation design; Optimised for reach, posture, visibility
- **Reducing Physical Strain and Fatigue**
- Gender-responsive design should therefore be treated as a systems-engineering and risk-control issue, not only an equity initiative (Milner et al., 2021; Zungu, 2012).





CORE PRINCIPLES OF GENDER-RESPONSIVE MINE DESIGN

INCLUSIVE CONSULTATION	SEX-DISAGGREGATED DATA	ADAPTIVE STANDARDS	LIFECYCLE THINKING
• Women workers involved in design reviews • Participatory risk assessments • Worker input in procurement • Feedback loops after implementation	• Injury and illness • Exposure measurements • Health surveillance • Wellbeing indicators • Retention/absence	• PPE specifications • Ergonomic benchmarks • Exposure controls • Task design • Facility requirements	• Pregnancy • Menopause • Long-term health • Career exposure • Return to work

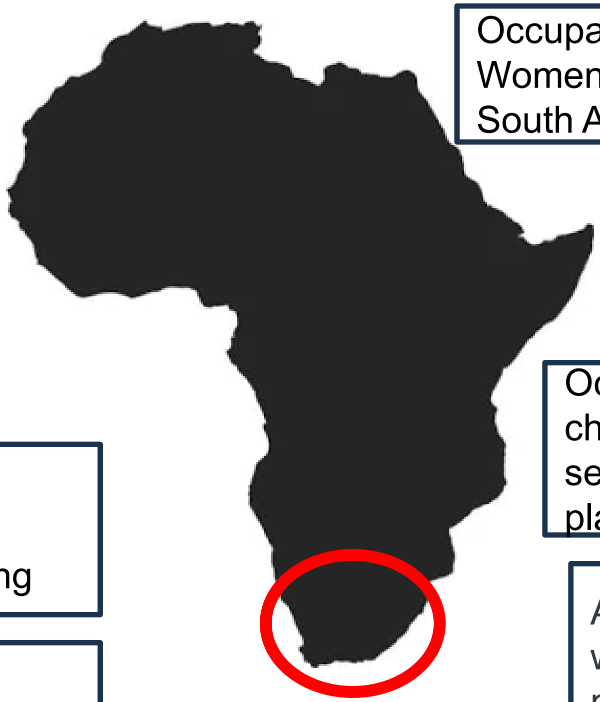
EMERGING RESEARCH IN MINING

Research specifically assessed the ergonomic design and suitability of Self-Contained Self-Rescuers (SCSRs) for women in mining

The physical ability of women in mining: Can they show muscle

South African guideline provision of personal protective equipment for women in mining

A prospective study to assess the prevalence and work-related risk factors in the development of musculoskeletal disorders in the South African mining industry



Occupational Ergonomic Risks Among Women in Underground Coal Mining, South Africa

New bivariate respirator fit test panel representing Black South African respirator users

Occupational health and safety challenges reported by women in selected South African gold and platinum mines

Ergonomics in the South African mining industry; Practical ergonomics in mechanized mining

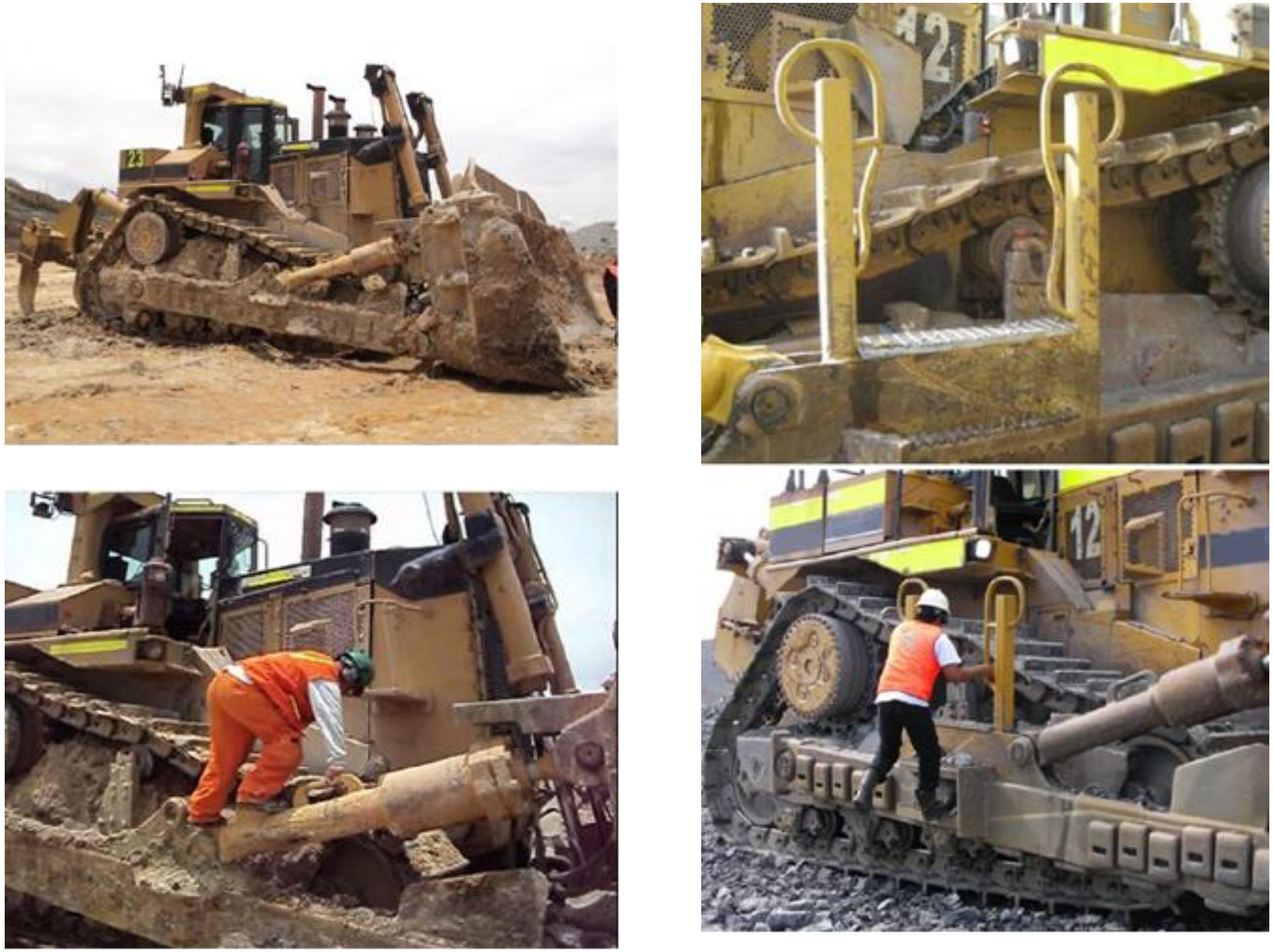
An exploration of the working conditions of women employed in mining operations at a platinum mine in South Africa

Women in mining : a conceptual framework for gender issues in the South African mining sector

Socio-demographic contributors to health and safety of mine workers in South Africa

An exploration of women's workplace experiences in the South African mining industry

ADVANCEMENTS IN RESEARCH DESIGN



(Horberry et al.2016).

GAPS IN RESEARCH

However, despite these contributions there is still a long way to bridge the gaps in designing inclusive mining environments for women.

WAY FORWARD

From Principle → **To Practice**

Implement Systematic Approaches

- Engagement & monitoring: maintain worker participation and use sex-disaggregated indicators to evaluate whether interventions work.
- Capital projects: conduct gender-responsive design reviews before commissioning new shafts, plants, vehicles, workshops, accommodation and facilities.
- Continuous improvement: investigate mismatches, test controls, measure outcomes and revise specifications.

Policy & Governance

- Policy & governance: embed gender-responsive requirements into occupational-health standards, procurement specifications, project design criteria and contractor requirements.

Prioritise Awareness and Training

- Training & capacity: build capability among engineers, occupational hygienists, supervisors, health practitioners and procurement teams.

TAKE HOME MESSAGE

SAFETY

Designs that account for diverse workers can reduce exposure to hazards and improve overall protection.

PERFORMANCE

Better fit, usability and working conditions support comfort, capability and operational effectiveness.

SYSTEMS RESILIENCE

Inclusive systems are better positioned to adapt to changing workforce needs and operational demands.

Inclusive design strengthens the safety, performance and resilience of the entire organisation.

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Thank you

Ms. Thato Malesa

is the Ergonomics Manager at the National Institute for Occupational Health (NIOH) Ergonomics Unit, a Council Member of the Ergonomics Society of South Africa (ESSA), and a Certified Professional Ergonomist (CPE).

She holds a master's degree in human Factors and Ergonomics and is currently pursuing a PhD in Human Factors and Ergonomics at Rhodes University, where her research focuses on the ergonomic challenges faced by women in selected mining operations using a the SEIPs theoretical framework.

With over six years of professional experience in human factors and ergonomics, Ms Malesa has contributed to projects across a diverse range of industries, including mining, retail, automotive, manufacturing, rail, military, and the healthcare sector. Her multidisciplinary experience has enabled her to apply ergonomics principles to enhance worker well-being, optimise system performance, and improve organisational productivity across varied work environments.