Green Ergonomics:
A Global Perspective on the Wind Energy Sector

Does Experience Matter?
Assessment of ladder climbing

UNIVERSITY OF PORTSMOUTH

G+ Global Offshore Wind Health & Safety Organisation

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www.gplusoffshorewind.com

In partnership with the energy institute

The Presenters

Dr Gemma Milligan, PhD, BASES, FHEA, CSci
Senior Lecturer, University of Portsmouth

- Joined the School of Sport, Health and Exercise Science, in 2008
- Completed her PhD in Fitness Standards for the Maritime Coastguard Agency and Oil and Gas Industry, in 2013
- Subsequent research has been in the area of Occupational Physiology, working with companies the military, oil and gas industry, offshore wind and emergency services

Dr Joseph O'Halloran, PhD, CSCS, FHEA
Senior Lecturer, University of Portsmouth

- Joined the School of Sport, Health and Exercise Science, in 2014
- Completed his PhD in Artificial Neural Network analysis of motor skill performance in 2009
- Subsequent research has been in the area of biomechanics, working with companies the offshore wind and emergency services

Bea Hildenbrand,
Manager Offshore Wind, Energy Institute

- Joined the Energy Institute (EI) in 2010
- Manager Offshore Wind, working for G+ (Global Offshore Wind Health and Safety Organisation) and SafetyOn (Onshore Wind Health and Safety Organisation)
- MSc in Environmental Sciences, research associate in atmospheric research and climate modelling at German Aerospace Centre

Health and Safety in Onshore and Offshore Wind

Bea Hildenbrand

Manager Offshore Wind,
Energy Institute

Global Offshore Wind Health and Safety Organisation

Delivering world-class health and safety performance in the offshore wind industry.

https://www.gplusoffshorewind.com/

Health and safety organisation for the onshore wind sector

Providing leadership in health and safety for the dynamic and innovative onshore wind industry.

https://safetyon.com/

G+ and SafetyOn are run in partnership with the Energy Institute (EI), which provides the secretariat and supports its work. The EI is the chartered professional membership body bringing energy expertise together.

https://energyinst.org

Membership

G+

Safety On

Associates

Work programme

Good practice guidelines

- G+ Transfer good practice to be published in Summer 2020
- Medical fitness continues to be worked on
- Human Factors/Mental health and well-being topic on- and offshore

Safe by Design workshops

Latest reports

G+ : Hydraulic torqueing and tensioning systems

SafetyOn: Working under suspended loads

H&S Incident data

Members provide their H&S incident data for all their wind farm sites across the world (G+), from development to decommissioning stage.
The Energy Institute collects, analyses and publishes incident data.

toolbox PUTTING SAFETY IN YOUR HANDS

Sharing incident learnings

- Incident learnings to be shared through Toolbox. Toolbox is an EI web-based app. It is accessible to all, anywhere, any place, any time
- Launched and members and industry are starting to upload learnings

A detailed ergonomic assessment of ladder climbing, published in Nov 2018

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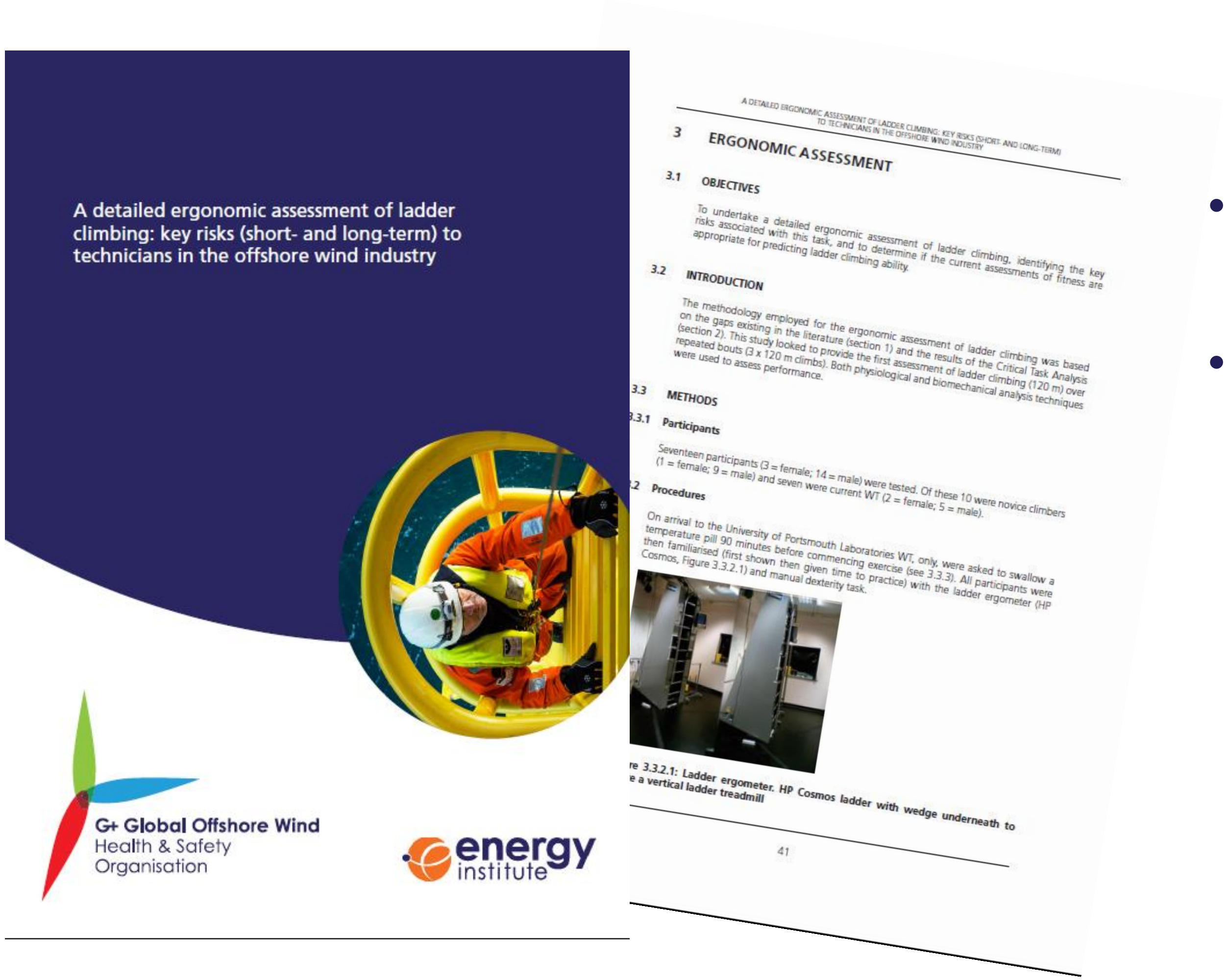
A detailed ergonomic assessment of ladder climbing: key risks (short- and long-term) to technicians in the offshore wind industry

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A DETAILED ERGONOMIC ASSESSMENT OF LADDER CLIMBING: KEY RISKS (SHORT- AND LONG-TERM) TO TECHNICIANS IN THE OFFSHORE WIND INDUSTRY

3 ERGONOMIC ASSESSMENT

3.1 OBJECTIVES

To undertake a detailed ergonomic assessment of ladder climbing, identifying the key risks associated with this task, and to determine if the current assessments of fitness are appropriate for predicting ladder climbing ability.

3.2 INTRODUCTION

The methodology employed for the ergonomic assessment of ladder climbing was based on the gaps existing in the literature (section 1) and the results of the Critical Task Analysis (section 2). This study looked to provide the first assessment of ladder climbing (120 m) over repeated bouts (3 x 120 m climbs). Both physiological and biomechanical analysis techniques were used to assess performance.

3.3 METHODS

3.3.1 Participants

Seventeen participants (3 = female; 14 = male) were tested. Of these 10 were novice climbers (1 = female; 9 = male) and seven were current WT (2 = female; 5 = male).

2 Procedures

On arrival to the University of Portsmouth Laboratories WT, only, were asked to swallow a temperature pill 90 minutes before commencing exercise (see 3.3.3). All participants were then familiarised (first shown then given time to practice) with the ladder ergometer (HP Cosmos, Figure 3.3.2.1) and manual dexterity task.

re 3.3.2.1: Ladder ergometer. HP Cosmos ladder with wedge underneath to e a vertical ladder treadmill

41

- Undertaken by University of Portsmouth
- Aim:
  - identify the risks to technicians
  - determine an ergonomic assessment of repeated ladder climbing
  - assess the effect of experience

Physical capacity/medical requirements and standardisation for OW

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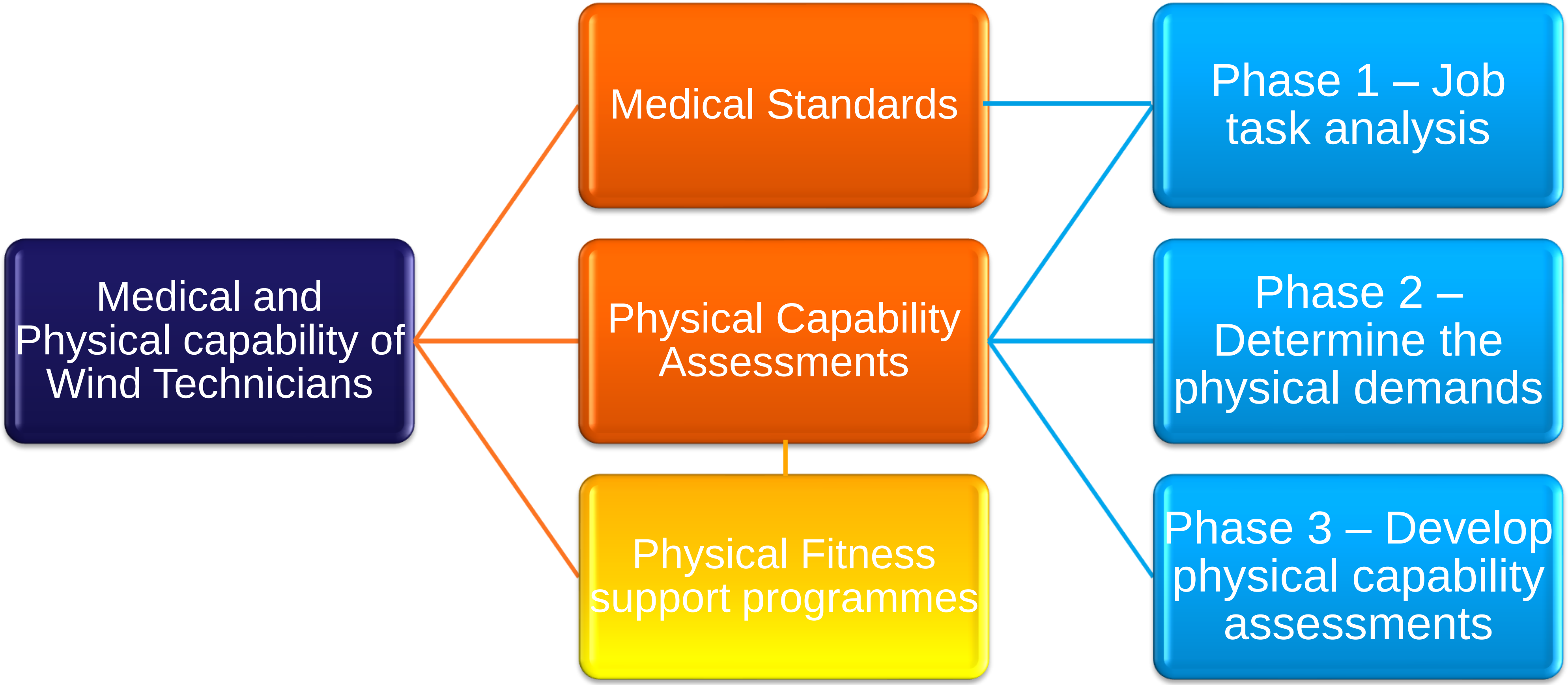

A Job Task Analysis for Technicians in the Offshore Wind Industry

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G+ Global Offshore Wind Health & Safety Organisation

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Phase 1 - A Job Task Analysis

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Purpose

- Gather, organise, analyse & document job information
- Define job specifications

Requirements

- Generic &/or Essential
- Measurable & reliable
- Necessary for safe & successful work
- Unable to be modified

Outcomes

- Identify generic & essential job tasks
- Identify worker requirements
- Define physical abilities involved in job(s)
- Identify ergonomic parameters

Phase 1 - A Job Task Analysis

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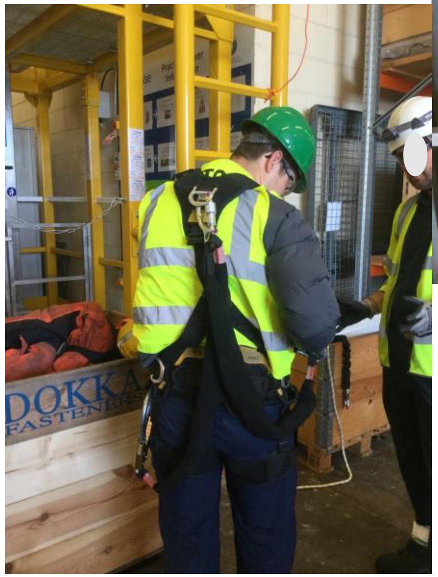
Objective: To determine the most physically demanding tasks undertaken by wind technicians, globally and across different turbines

Methods: The task analysis is being completed through:

- Previous research (Milligan et al., 2019)
- Using a semi-structured interviews & focus groups
- Obtaining technical specifications of turbines
- Reviewing approved working procedures
- Observations of WT performing tasks (video)
- The research team performing the tasks



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Demographic

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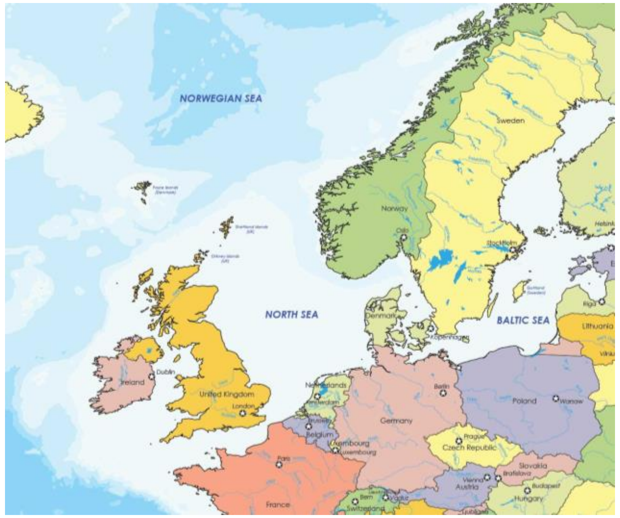
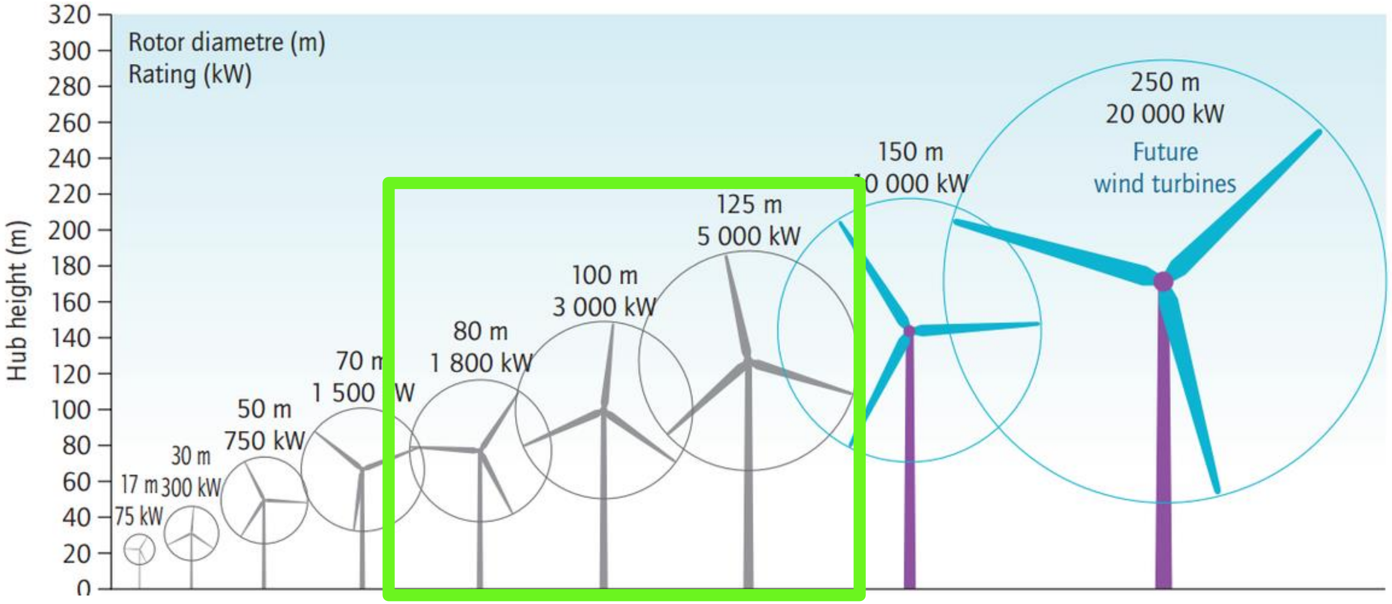
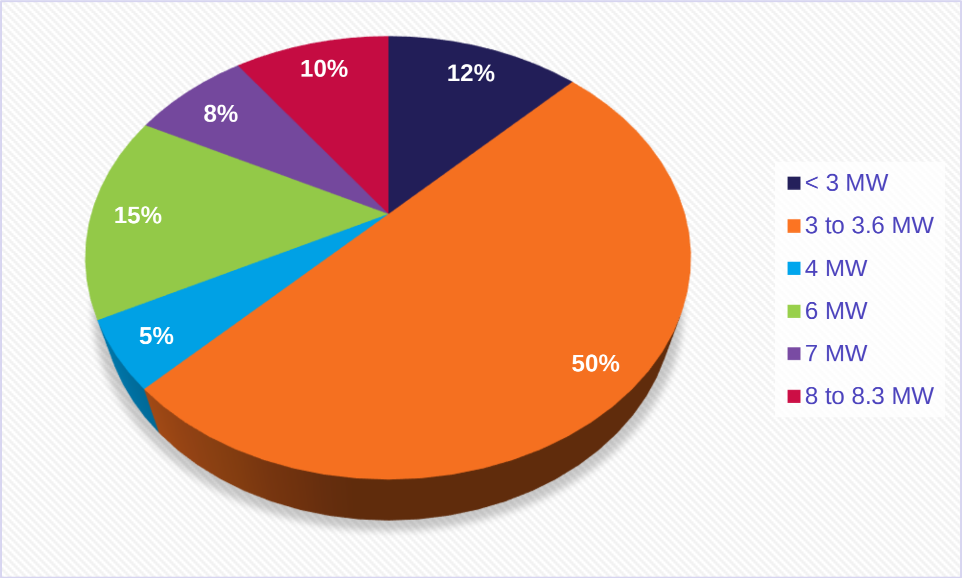
- 6 countries
- 40 sites

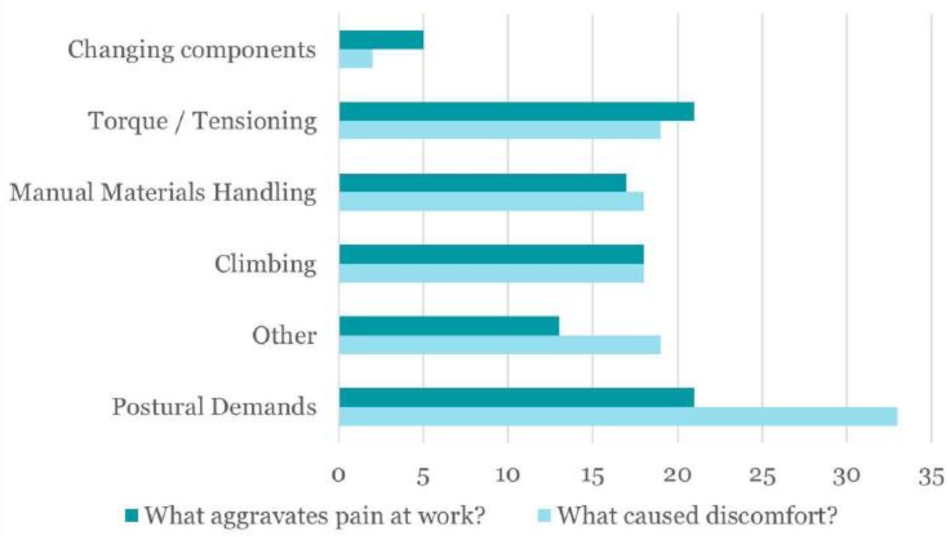




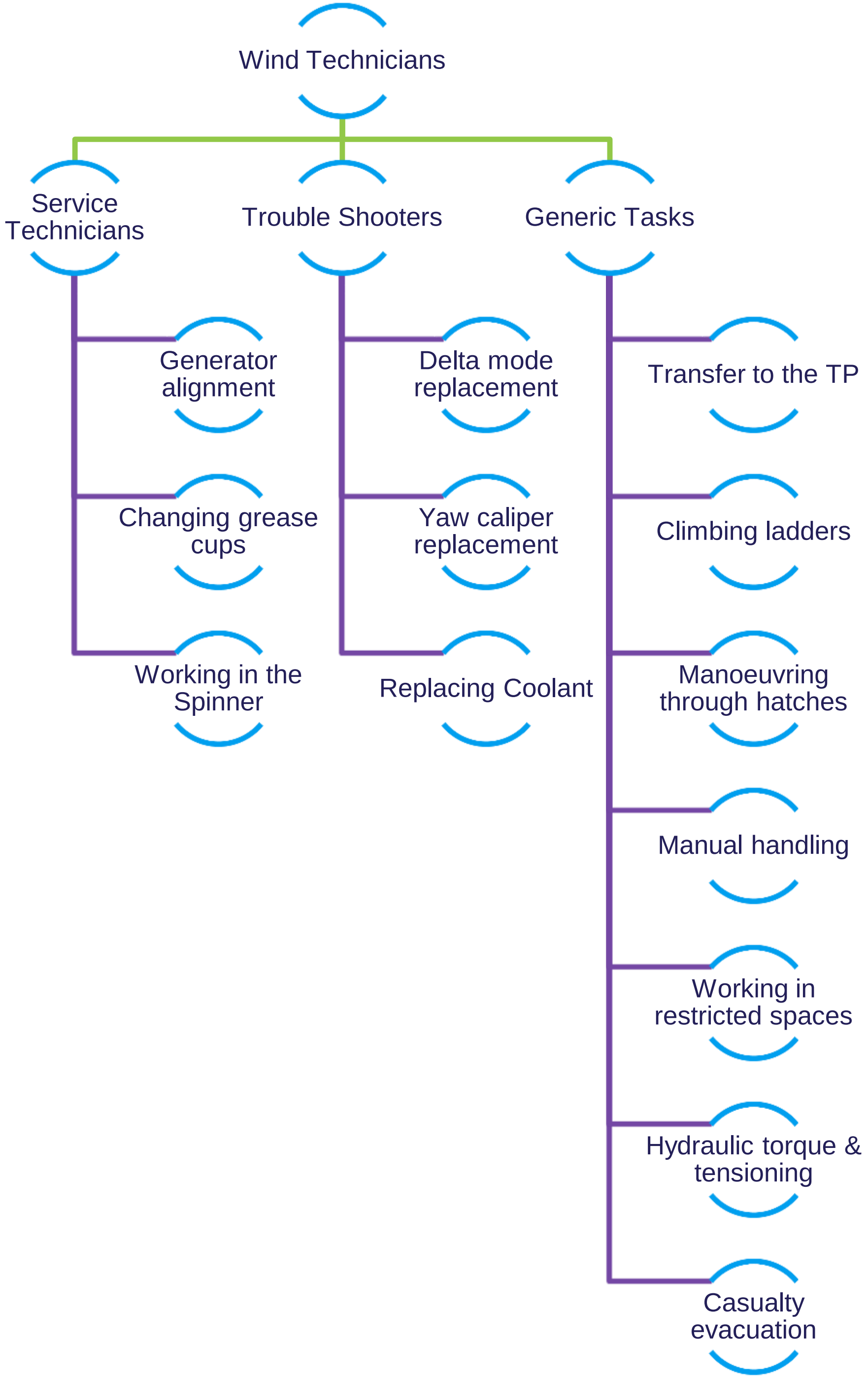


Generic & Essential Tasks

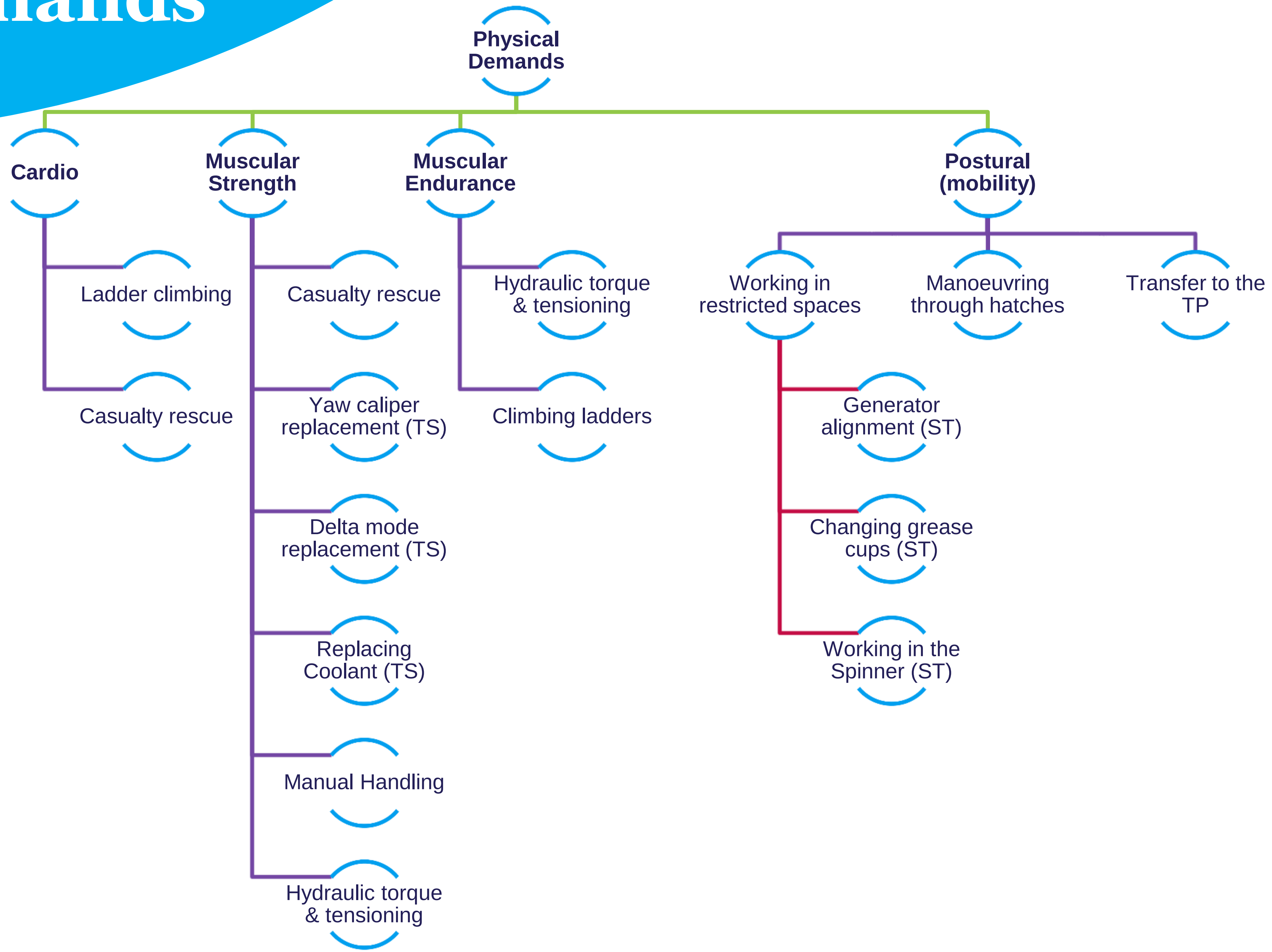
What likely causes or aggravates your discomfort?



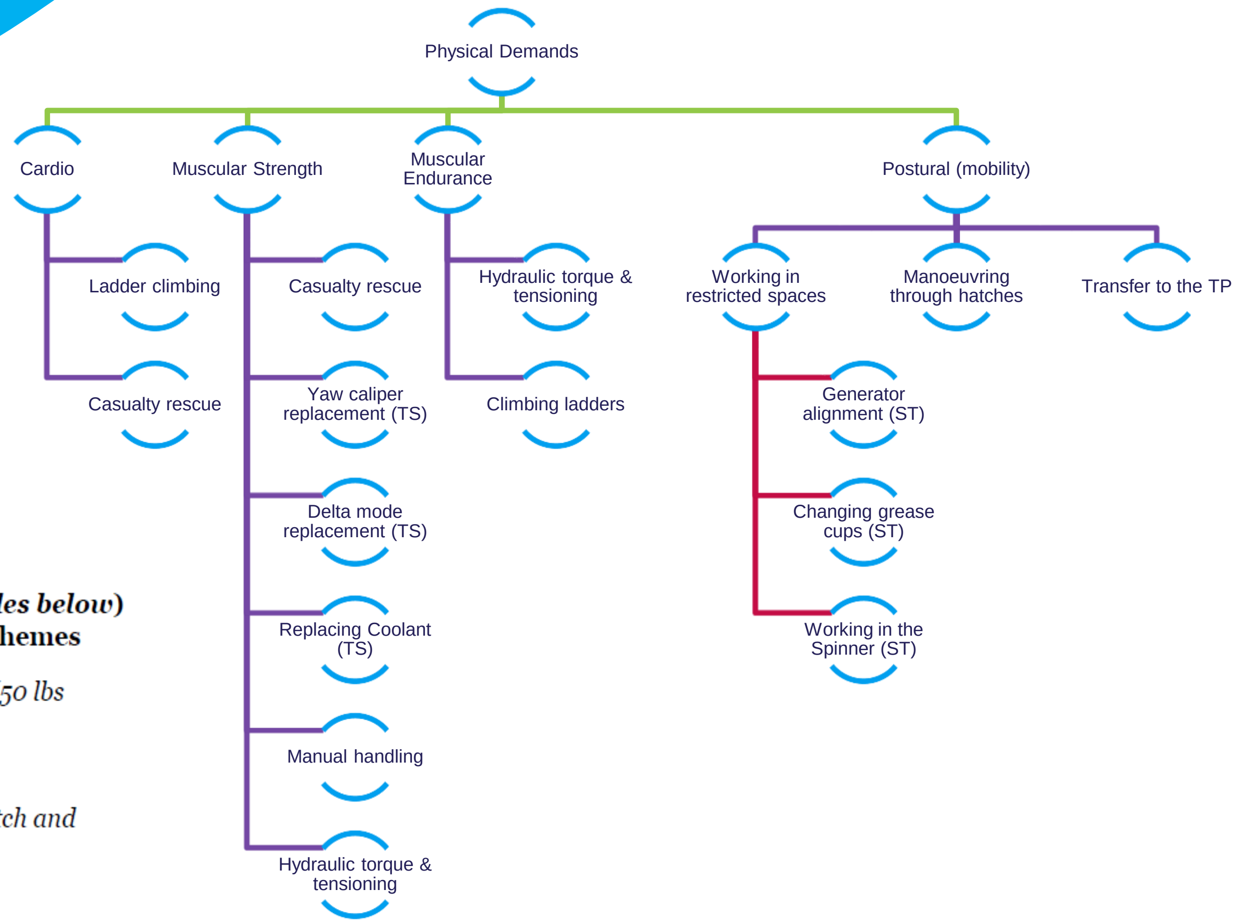
Fischer (2020)

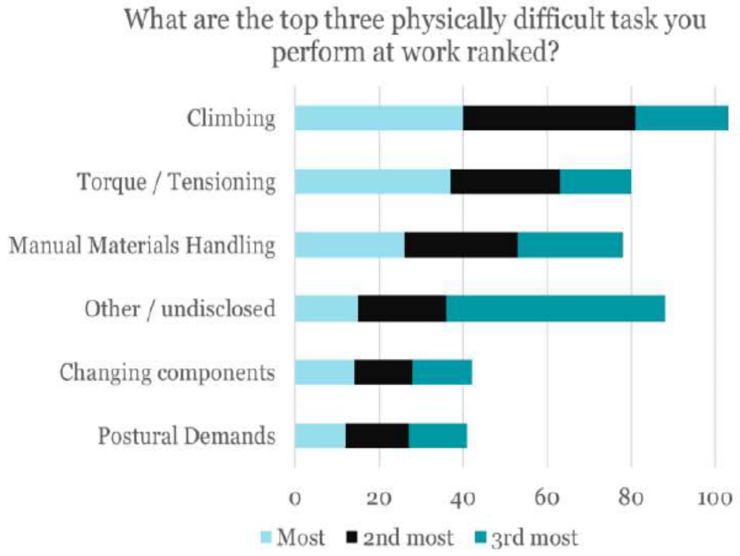


Physical Demands



Physical Demands





Open ended response (*examples below*) were recoded into 1 of six themes

"Climbing with safety gear on (50 lbs of gear)"

"Yaw spring pack torqueing"

"Lifting bags through crane hatch and into the nacelle."

"hub work"

"changing main component gear box, main shaft , blades, blade-bearings"

"working in awkward positions, i.e. above head"

OCCUPATIONAL BIOMECHANICS & ERGONOMICS LAB
Optimizing Human Performance

https://www.msdprevention.com/resource-library/view/staff-feedback-survey.htm

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Fischer (2020)

Next Steps

- Specifications
  - Transfer
  - Tower
  - Nacelle
  - Hub
  - Spinner
- Loads
- Differences
- Validation

Tower	Tower height (total to be climbed)
	Circumference of the tower
	Space between the ladder and the wall of the turbine.
	No. of ladders
	Individual ladder heights
	Rung spacing
	Rung dimensions
	No. of ladder from the lift to the Nacelle
	Ladder heights of those from the lift to the Nacelle
	Angle of ladders from the lift to the Nacelle
	No. of hatches
	Hatch orientation and where they lead to (e.g. directly above the user leading to the Nacelle)
	Hatch dimensions
	Hatch mass (load experienced when opening if known)
	Does the hatch have mechanism to assist in opening (e.g. hydraulics)?
	What is the opening mechanism on the hatch?
	What is the smallest/most awkward space individuals have to get through?
	What are the dimensions of this smallest/ most awkward location?
	Other

Applications of a Job Task Analysis

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- Applications
  - Employee selection
    - Modular
    - Direct task simulations
    - Predictive selection tests
  - Job design
  - Progression testing
  - Training design
  - Training programme placement
  - Job aid & procedure design

Adapted from - Human Performance Technology at Georgia State University
http://hpt2014.weebly.com/job-task-analysis.html

An ergonomics assessment of three simulated 120 m ladder ascents:

A comparison of novice and experienced climbers

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Introduction

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<u>Literature Review:</u> Conduct a review and analysis of existing literature on ladder climbing and the effects of this activity on the human body (long term and short term).

Literature Review

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Results & Practical Application:

- **Hand positioning**
  - Rails vs Rungs
  - Slip risks
  - Force application and climbing technique
- **Toe clearance**
  - Slip risks
  - Current recommendations
- **Physical demands**
  - Ladder pitch
- **Injuries**
  - Risk factors

Methods

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Methods:

- 7 wind turbine technicians (EC) and 10 novice climbers (NC) undertook 3 x 120 m (4 x 30 m climbs separated by a rest to work schedule of 1:1), at a self selected pace, climbs separated by approximately 1.5 hrs

Pre Test
- Height
- Mass
- Anthropometry
- Leg length
- BLa
- Grip Strength
- 30 s grip endurance
- MDT
- Descend the ladder x3

→

Test - Ladder climbing
- VO_2 - Continuous
- HR - Continuous
- EMG - Continuous
- Kinematic - Continuous
- RPE - at rest intervals
- Grip Strength - at rest intervals

→

Post Test
- Grip strength
- Descend the ladder x 3
- BLa - pre and post
- MDT
- Grip strength
- 30 s grip endurance
- MDT

Results – Physical

- Grip Strength and Endurance
  - No significant differences were reported between EC and NC
  - Lower grip strength and endurance scores following each 120 m climb
  - Grip strength and endurance remained significantly lowered at the start of the second and third 120 m climbs compared to the first

- Oxygen consumption
  - Climb 1 - climbers spent significantly less time metabolising energy aerobically than anaerobically
  - Climb 2 - climbers spent significantly less time metabolising energy aerobically than anaerobically
  - Climb 3 - no significant difference in the time spent metabolising energy aerobically and anaerobically

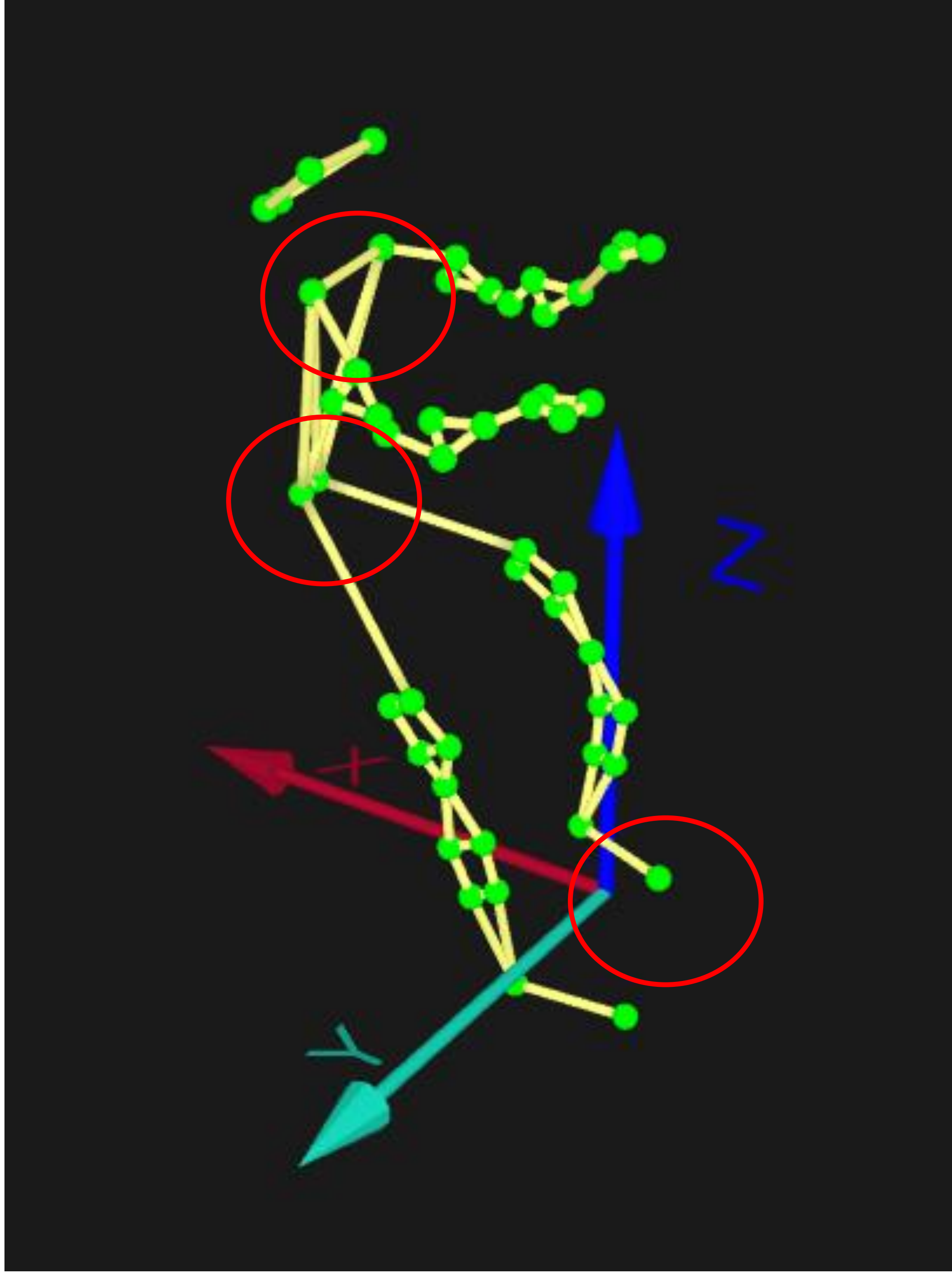
  - There were no significant differences between EC and NC
    - EC tended to work more anaerobically

Results - Movement

- As fatigue increased with multiple climbs, toe clearance on the ladder was reduced

- Changes where observed in the shoulder joint which suggested that as fatigue increased participants changed their technique to reach higher with their arms

- Novices demonstrated less range of movement through the hips, and a higher proportion of muscle activation in the upper body than the WT



Results – Muscle Activation

- **Forearms**
  - A significant difference in forearm muscle activation, irrespective of experience, was found between climbs
  - NC demonstrated significantly higher forearm muscle activation in Climb 2 and Climb 3 compared to the EC

- **Biceps**
  - A significant difference, irrespective of experience, was found between climbs
  - NC showed significantly higher muscle activation in the bicep during Climb 3

- **Anterior Deltoid**
  - A significant difference, irrespective of experience, was found between climbs
  - NC demonstrated a significantly greater anterior deltoid muscle activation than the EC during Climb 1, Climb 2, and Climb 3

- **Calf Muscle**
  - No significant differences were found for the calf muscle group activation across each of the climbs

Practical Application

- Ascending a 120 m vertical ladder was shown to require a high physical demand
  - Minimum climbing speeds recommend for the Oil and Gas Industry (24 rungs.min^{-1} and 34.5 rungs.min-^{1}) may not suitable for use within Wind Power

- Tasks following climbing
  - Reductions in grip strength and endurance of pre and post each climb were approximately 35% and 26% respectively

Practical Application

- Shoulder joint
  - As fatigue increased, due to multiple climbs, participants were changing their technique to reach higher with their arms

- Compare NC to EC
  - EC demonstrated faster climbing speeds, took less rest, had fewer self-selected rest breaks and ultimately took less time

Practical Application

- **Ladder climbing technique and experience improves performance, reduces the physiological burden and maintains optimal movement patterns for longer.**

- **Therefore, it is recommended that future work evaluates:**
  - what constitutes an EC; the role body size plays in climbing ability and efficiency
  - if their is an optimal climbing speed to reduce forearm fatigue, optimise climbing ability and minimise the risk of injury
  - how long it takes to become proficient at prolonged ladder climbing using the minimum acceptable standards
  - if training can improve the time to proficiency

Useful Information

https://www.gplusoffshorewind.com/

https://safetyon.com/

https://energyinst.org

Milligan, Gemma S., O'Halloran, Joseph P., and Tipton, Michael J. (2019) 'A Job Task Analysis for Technicians in the Offshore Wind Industry'. *Work,* 63 (4) 537 – 545. **DOI:** 10.3233/WOR-192961

Milligan, G. S., O'Halloran, J., & Tipton, M. J. (2020). An ergonomics assessment of three simulated 120 m ladder ascents: A comparison of novice and experienced climbers. *Applied Ergonomics*, *85*, 103043 **DOI**: 10.1016/j.apergo.2019.103043

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Thank you for listening

ANY QUESTIONS?

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