Final Report

Task Risk Industry Benchmark

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Prepared by
Allison McCombe, Tanya Reid and Marianna Appa – Longitude6

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1.0 Abstract

Musculoskeletal injury is one of the most persistent and costly challenges facing the Australian red meat processing industry, with serious injury claim rates more than three times the national average. Workers perform highly repetitive, physically demanding tasks every shift, yet the industry has lacked a consistent, objective measure of which tasks carry the greatest risk and why. This project established a national ergonomic baseline that facilities can use to prioritise investment, redesign workstations, and reduce injury at scale.

Eleven processing facilities participated between March and May 2026. Wearable sensor technology captured objective postural data across 109 unique tasks across four operational categories and three worker height groups. Key variables were standardised to ensure results reflect the physical design of work rather than task rotation schedules or perceived load.

Hanging Product tasks — where workers access suspended carcases on overhead rails — emerged as the highest risk category, accounting for five of the ten highest-risk tasks. Repetitive spinal flexion is the dominant physical driver across the dataset. Medium and tall workers carry substantially higher back loading in Hanging Product tasks than shorter workers, confirming that height mismatch between the worker and the carcase is the root cause of risk in this category. Tasks performed on height-adjustable platforms returned risk scores 18.1% lower than equivalent tasks on fixed platforms.

Every participating site received a tailored facility report. This project delivers a rigorous, comparable evidence base to guide workstation redesign, direct capital investment, and benchmark musculoskeletal injury reduction across the Australian red meat processing sector.

2.0 Executive summary

2.1 Purpose

Musculoskeletal injuries are among the most common and costly workplace health issues in the Australian red meat processing industry. They cause real harm to workers and significant financial pressure on businesses through compensation claims, lost time, and reduced productivity. Yet despite this, the industry has not had a consistent, objective way to measure physical risk across facilities or to identify where investment in safer work design would make the greatest difference.

The AMPC Task Risk Benchmarking Project was commissioned to address this directly, establishing for the first time a standardised, evidence-based picture of ergonomic risk across Australian red meat processing operations. The findings are intended for processing facility operators, safety managers, equipment designers, and industry bodies, giving them the evidence they need to make informed decisions about workplace design and injury prevention investment.

2.2 Objectives

The project set out to achieve the following, all of which were successfully delivered:

- Objectively measure ergonomic risk across key processing tasks using wearable sensor technology
- Identify the highest-risk tasks and the specific physical factors driving that risk
- Generate industry-wide benchmarking insights across participating facilities

- Provide practical, targeted recommendations to reduce injury risk at the facility level
- Support improved safety outcomes and operational performance across the industry

2.3 Methodology

Eleven volunteer processing facilities participated nationally during April and May 2026. Wearable sensors were used to objectively capture posture and movement data across 109 unique tasks during normal production, without any changes made to how work was performed. Tasks were grouped into four categories: Hanging Product, Fixed Bench, Machine and Equipment Operation, and Logistics, and assessed across three worker height groups. Key variables were standardised across all sites so that findings reflect the physical design of work, not individual worker differences.

2.4 Results and Key Findings

Hanging Product tasks, where workers access suspended carcases, emerged as the clear highest-risk category, accounting for five of the ten highest-risk tasks identified across the industry. Repetitive forward bending of the spine was the dominant physical driver throughout the dataset. Worker height was found to meaningfully influence risk in this category: medium and tall workers carried substantially higher back loading than shorter workers, confirming that the physical mismatch between the worker and the part of the carcase being worked on is the root cause. Importantly, the data also showed that height-adjustable platforms are already making a difference. Tasks performed on adjustable platforms returned risk scores 18.1% lower than equivalent tasks on fixed platforms, providing direct evidence that engineering investment in this area delivers measurable results.

2.5 Benefits to Industry

Every participating site has received an individual facility report with targeted workstation redesign recommendations. At the industry level, this project delivers the first standardised ergonomic risk dataset spanning multiple facilities across the Australian red meat sector, providing a shared evidence base for driving meaningful, sustainable reductions in the human and financial burden of musculoskeletal injury. For AMPC levy payers, this project represents a direct return on investment — translating levy funding into an actionable, evidence-based tool that participating and non-participating facilities alike can use to reduce injury costs and improve worker safety outcomes.

2.6 Future Recommendations

The methodology developed in this project provides a replicable framework for ongoing industry-wide safety benchmarking. Future investment should focus on expanding the number of tasks and facilities assessed with a focus on Machine Operation and Logistics tasks, and identifying key engineering controls for analysis. Repeating the assessment after workstation changes have been made would allow the industry to measure the impact of those changes over time, share learnings and track progress on reducing injury risk across the sector.

3.0 Introduction

Musculoskeletal disorders (MSDs) represent the most significant and costly occupational health challenge facing the Australian red meat processing industry. Driven by the inherently physical nature of processing work — repetitive spinal flexion, overhead reaching, forceful exertions, and high task repetition — body stressing injuries consistently account for the largest share of serious workplace compensation claims across the sector, carrying substantial financial cost to businesses and profound personal impact to the workers affected (McKell et al.; Safe Work Australia, 2019). Despite this, the industry has operated without a standardised, objective measure of ergonomic risk — making it difficult to determine where the greatest risks exist, which workers are most affected, and where investment in safer work design will deliver the greatest return.

While ergonomic risk in meat processing has been examined internationally, existing research is largely site-specific, methodologically inconsistent, and limited in its applicability to active production environments (Tappin et al., 2006). As recently as 2025, slaughterhouse ergonomic assessment internationally has continued to rely predominantly on observational pen-and-paper methods offering only momentary snapshots with high risk of observer bias, with wearable sensor-based assessment still in early adoption (Wolfgang et al., 2025). To the authors' knowledge, no prior study has delivered a comparable, multisite ergonomic baseline across the Australian red meat industry — leaving facility operators, safety managers, and equipment designers without the evidence base needed to make informed, targeted decisions about injury prevention investment.

The central question is straightforward: where does musculoskeletal risk exist across Australian red meat processing operations, how severe is it, and who is most affected? To answer this objectively and at scale, the project deployed Etiscope wearable sensor technology across 11 facilities nationally — capturing quantified postural risk data across key processing tasks in active production environments, free from the subjectivity and variability that limit traditional observational assessment methods. By standardising methodology and exposure variables across all sites, the project generates a dataset that is directly comparable across facilities, task types, and worker height categories for the first time.

The outcomes serve two complementary purposes: equipping individual facilities with localised, actionable remediation guidance; and delivering industry-wide benchmarking insights to identify where engineering and design intervention will have the greatest systemic impact. For levy payers and industry stakeholders, this research represents a shift from reactive injury management to proactive, evidence-based prevention — providing the foundation for smarter capital investment, improved worker health outcomes, and a safer, more sustainable industry.

4.0 Project objectives

The objectives of the AMPC Task Risk Benchmarking Project are to:

- Assess and quantify ergonomic risks across key processing tasks
- Identify high-risk activities and their contributing factors
- Develop benchmarking insights across participating organisations
- Provide targeted, practical recommendations to reduce injury risk
- Support improved safety outcomes and operational performance across the industry

5.0 Methodology

5.1 Study Design

This project used an observational field study conducted across multiple sites. The approach was designed to reflect the real-world scale, geographic spread, and operational diversity of the Australian red meat processing industry. Rather than attempting to assess every task at every site — which would be impractical given the size and remote location of many facilities — the design focused on generating findings that are broadly representative and comparable across the industry. No changes were made to normal work practices at any point during data collection. Everything observed reflects how work is done.

5.2 Participant Recruitment and Site Selection

Eleven red meat processing facilities volunteered to take part, with data collected during April and May 2026. The number of workers assessed at each site varied based on what was operationally feasible on the day and how many workers volunteered. All participants provided informed consent before any assessment took place.

Worker allocation to tasks was not pre-determined — it was driven entirely by what was possible within normal production conditions at each site.

To allow comparison by body size while protecting individual privacy, workers were grouped into three approximate height categories by the assessing practitioner:

Height category	Approximate range
Short	Up to 167cm
Medium	167 to 183cm
Tall	183cm and above

Note on height categorisation

These categories are approximate and based on practitioner observation. In some cases, workers may have self-reported their height. Formal measurement was not used. Findings related to height should be interpreted with this in mind. No individual worker identifiers were recorded at any stage.

5.3 Task Selection and Classification

Each participating site selected up to 60 tasks for assessment from a standardised library of 133 tasks, covering six operational zones. To allow consistent comparison across sites, every task was assigned to one of four categories based on its primary physical demand:

Category	Description
Hanging product	Work performed on suspended carcases on overhead rails or hooks. Primary risk: the height mismatch between the worker and the part of the carcase being worked on.
Fixed bench	Work at non-adjustable waist-height surfaces, tables, or conveyors. Primary risk: sustained forward spinal flexion in a static position.
Machine and equipment operation	Interaction with mechanical controls, panels, or heavy tools. Primary risk: constrained postures and restricted movement.
Logistics	Large-scale material movement including pallets, floor-level lifting, and pushing mobile racks. Primary risk: spinal loading from manual handling.

Where a task spanned more than one category, it was assigned to a single category based on its dominant risk factor, using the following priority order: Hanging Product, then Fixed Bench, then Machine Operation, then Logistics.

5.4 Data Collection

Ergonomic risk was measured using Etiscope (formerly JointAction Solutions/Joint Action Group Pty Ltd) — a wearable sensor system validated for use in industrial environments (JointAction Solutions, 2021; Appendix 1). Five sensors were fitted to each worker, positioned at the head, neck, lower back, and upper arms. These sensors captured posture and movement in real time, generating risk scores for the neck, shoulders, and back, as well as an overall composite risk score and risk grade (JointAction Group Pty Ltd, 2024).

All assessments were conducted during active production. Each task was assessed once per site where possible. Additional assessments were carried out at the assessor's discretion where meaningful variation existed within a task — for example, where the same task was performed in different physical configurations, by workers of notably different height, or with a different cut that changed the actions required.

All captures were reviewed for quality. Any assessment affected by poor sensor set-up, data interruption, or sensor movement was discarded and, where possible, recaptured.

5.5 Variable Standardisation

To ensure that results reflected the physical design of the work rather than individual or administrative differences between sites, two key variables were standardised across all assessments:

Variable	Standardisation applied
Exposure duration	Set to 8 repeats × 60 minutes for all tasks, representing a standard full-day exposure. An exception was applied to loadout tasks, where duration was set to 4 × 60 minutes, reflecting that these tasks are not performed continuously across a full shift at all sites.
Perceived load	Set to zero across all assessments. This removes any influence of individual worker subjectivity and ensures that risk scores reflect workstation geometry and task design only.

Additional optional fields available in the Etiscope system were not used.

5.6 Data Analysis

The dataset included the following variables for each assessment: site, work area, task name, date, time, overall risk score, risk grade, neck score, shoulder score, back score, and captured duration — all automatically generated by the Etiscope system.

Before analysis, risk grades were converted from descriptive categories to a five-point numerical scale:

Risk grade	Numerical value
Low risk	1
Possible risk	2
Substantial risk	3
High risk	4
Very high risk	5

5.6.1 Comparing task categories

Median raw composite risk scores were used as the primary comparison measure, and mean raw score was a secondary measure, used to evaluate the sensitivity of rankings.

5.5.2 Height-related risk analysis

To explore whether worker height was associated with risk, median raw risk scores were compared across the three height groups — Short, Medium, and Tall — within each task category. To ensure reliability, comparisons were only reported as primary findings where each height group contained at least eight assessments. This threshold was set in advance based on the minimum sample size needed to detect a meaningful difference at 80% statistical power. Comparisons involving smaller groups are reported as exploratory findings only.

5.6.3 Body region analysis

To understand which parts of the body were most affected within each category and height group, median neck, shoulder, and back scores were calculated as a proportion of the total composite risk score. This provides practical insight into the physical mechanisms driving risk.

5.6.4 Identifying the top 10 highest-risk tasks

Tasks were ranked to identify the 10 highest risk across the industry. To be included in the ranking, a task needed to have been assessed at least four times across the program. Of 124 unique tasks identified in the dataset, 41 met this threshold and were included in the primary analysis.

Eligible tasks were ranked using a three-step method:

- First, by median risk score — the higher the median, the higher the rank.
- Where tasks were tied on median, by the spread of scores (interquartile range) — a smaller spread indicates more consistent results and was ranked higher.
- Where tasks remained tied, they were ranked by mean raw risk score — preserving the precision of the original data to resolve any remaining ties.

Why these thresholds?

The minimum of four assessments per task was determined using a standard statistical method for estimating proportions with 95% confidence and conservative assumptions. The minimum of eight assessments per group was set to detect a medium-sized difference between groups at 80% power — a standard benchmark in applied research.

6.0 Results

6.1 Dataset Overview

A total of 499 ergonomic risk assessments were completed across 11 red meat processing facilities between March and May 2026. Following quality review, 78 assessments were removed due to sensor issues during capture, and a further 4 were removed for not following the standard task list. The final dataset covers 109 unique work tasks across six operational work areas.

Tasks were grouped into four categories based on their primary physical demands:

Task category	Assessments	Share of dataset
Hanging product	258	52%
Fixed bench	154	31%
Logistics	68	14%
Machine operation	19	4%
Total	499	100

Workers were grouped into three approximate height categories by the assessing practitioner:

Height group	Assessments	Share of dataset
Shortt	87	17%
Medium	269	54%
Tall	135	27%

Note on sample sizes

The number of assessments per task ranged from 1 to 29, with an average of 4.6 per task. This reflects the variation in task coverage across a study of this scale — not all tasks were assessed the same number of times at each site. Tasks with fewer than four assessments were excluded from the task ranking analysis.

6.2 Task Category Risk Profile

All four task categories returned the same overall risk grade of High Risk, making it impossible to separate them on that measure alone. A more detailed comparison using the underlying risk scores revealed a clearer picture of relative risk across categories.

Hanging product ranked as the highest-risk category. Its ranking was consistent and reliable across both statistical measures used in the analysis. No other category achieved this level of certainty in its ranking.

The rankings of the remaining three categories; Machine Operation, Fixed Bench, and Logistics were not consistent across statistical measures and should not be used to prioritise one category over another. These categories should be treated as broadly equivalent in risk level until further data is available.

Task category	Assessments	Median Score	Median Rank	Mean Score	Mean Rank	Risk grade	Confidence in ranking
Hanging product	258	360	1st	379	1st	High Risk	High
Fixed bench	154	292	3rd	317	2nd	High Risk	Low
Logistics	68	272	4th	312	3rd	High Risk	High
Machine operation	19	297	2nd	289	4th	High Risk	Moderate

What the scores mean

The confidence rating reflects how reliable the ranking is; it is lower for machine operation because far fewer assessments were available for that category (19 compared to 258 for hanging product).

Additional data collection is recommended to resolve the uncertainty in category rankings, particularly for Machine Operation where the small sample size (19 assessments) limits the reliability of any conclusions. Until a larger dataset is available for this category, its position relative to Fixed Bench and Logistics cannot be determined with confidence.

While the median scores reflect the typical risk level across each category, some individual tasks within categories reached much higher scores. Extreme scores were identified in fixed bench (highest: 824), hanging product (highest: 961), and logistics (highest: 957). These are single assessments at the upper end of the range and do not change the overall category rankings, which are based on the middle (median) value — not the extreme.

6.3 Does Worker Height Affect Risk?

To explore whether a worker's height influences their level of physical risk, median risk scores were compared across the three height groups — Short, Medium, and Tall — within each task category. Where a height group contained fewer than eight assessments, the comparison is noted as exploratory and cannot be treated as a definitive finding (Cohen, 1988).

Task category	Score range across heights	Disparity level	Sufficient data?	Key finding
Fixed bench	39	Low	Yes	Height makes little difference
Hanging product	91	Moderate	Yes	Taller workers carry notably higher risk
Logistics	154	High	Partial	Short workers appear higher risk — needs more data
Machine operation	48	Low	Partial	Limited data — exploratory only

6.3.1 Fixed bench

Risk scores were broadly similar across all three height groups (Short: 286, Medium: 325, Tall: 292). Worker height does not appear to be a meaningful factor for fixed bench tasks, and no height-specific intervention is indicated for this category.

6.3.2 Hanging product

This is the most significant finding in the height analysis. Medium and Tall workers returned substantially higher risk scores (369 and 373 respectively) compared to Short workers (282) — a gap of 91 points. All three height groups had sufficient data to support this finding.

Taller workers need to bend further down to reach the part of the carcase they are working on, increasing their spinal loading on every cycle. Shorter workers experience less of this mismatch — though they are not without risk.

Key finding: hanging product tasks affect taller workers more

In hanging product tasks, medium and tall workers carry a risk load approximately 90 points higher than short workers. This gap is driven by the height of carcase presentation — taller workers must flex further forward to access the same work point. This finding supports the case for height-adjustable systems as a priority engineering control in this category.

6.4 Which Parts of the Body Are Most Affected

To understand where in the body risk is concentrated, the contribution of the neck, shoulders, and back to the overall risk score was calculated for each category and height group.

The back was the dominant contributor across all categories and all height groups, accounting for between 58% and 71% of total risk score. This is consistent across the dataset and is not surprising given the high proportion of tasks involving forward trunk flexion in red meat processing environments.

Category and height group	Assessments	%Neck	%Shoulder	%Back	Data status
Fixed bench - short	44	17%	22%	60%	Sufficient
Fixed bench – medium	74	18%	22%	60%	Sufficient
Fixed bench - tall	32	18%	22%	60%	Sufficient
Hanging product – short	35	19%	23%	58%	Sufficient
Hanging product – medium	140	16%	21%	63%	Sufficient
Hanging product – tall	79	17%	18%	65%	Sufficient
Logistics – short	6	12%	18%	70%	Exploratory
Logistics – medium	43	12%	16%	71%	Sufficient
Logistics - tall	19	15%	21%	64%	Sufficient
Machine operation - short	2	12%	42%	46%	Exploratory
Machine operation - medium	12	11%	22%	67%	Sufficient
Machine operation - tall	15	17%	25%	58%	Exploratory

6.4.1 Fixed bench

The body region profile was almost identical across all three height groups — back at 60%, shoulders at 22%, and neck at 17–18% in every case. Worker height does not change where the risk sits in the body for fixed bench tasks.

6.4.2 Hanging product

The most notable finding here is that back loading increases progressively with worker height — from 58% in short workers to 63% in medium workers to 65% in tall workers. At the same time, shoulder loading decreases as height increases (23% in short workers, down to 18% in tall workers).

This reinforces the height disparity finding from Section 6.3. Taller workers are not just carrying more overall risk in hanging product tasks — the additional load is concentrated in their back specifically. This further strengthens the case for height-based engineering controls in this category.

6.4.3 Logistics

Back loading dominates in logistics — 71% for medium workers and 70% for short workers (though the short worker finding is exploratory). Tall workers show slightly lower back loading (64%) with a correspondingly higher neck and shoulder contribution. Additional short worker data is required, as worker height may impact risk distribution across the body.

6.4.4 Machine operation

Reliable data is available for medium workers only (back: 67%). Findings for short and tall worker groups in this category are exploratory given limited sample sizes.

6.5 Top 10 Priority Tasks

6.5.1 How tasks were selected and ranked

To be included in the ranking, a task needed to have been assessed at least four times across the program. This threshold ensures the result for each task is based on enough data to be meaningful. Of 109 unique tasks identified in the dataset, 41 met this threshold and were included in the ranking.

The remaining 68 tasks had too few assessments to rank reliably: 35 were assessed only once, 21 twice, and 12 three times. These tasks remain in the full dataset and are recommended as a priority for future data collection.

Eligible tasks were ranked using a three-step method:

1) By risk grade. Tasks rated Very High Risk ranked above those rated High Risk.
2) Risk grade consistency. Tasks with less variation in risk grade ranked higher, reflecting a more reliable finding.
3) Mean risk score, to retain the granularity of the original scoring system.

Confidence levels explained

Tasks assessed 10 or more times are classified as High confidence. Tasks assessed 4 to 9 times are Moderate confidence. Three of the top 10 tasks are High confidence and seven are Moderate confidence. A higher confidence rating means the ranking is based on a larger, more stable set of results.

6.5.3 The Top 10 Results

All 10 tasks returned a risk grade of High Risk or Very High Risk. Six of the 10 reached the maximum grade of Very High Risk. Five of the top 10 tasks belong to the hanging product category, reinforcing this category's dominance in the industry risk profile.

Rank	Task name	Category	n	Risk grade	Mean Risk Score	Confidence
1	2nd Leg	Hanging product	8	Very High	544	Moderate
2	Bunging	Hanging product	7	Very High	471	Moderate
3	Evisceration	Hanging product	7	Very High	419	Moderate
4	Rodding / Clipping	Hanging product	4	Very High	466	Moderate
5	1st Leg / Udder / Pizzle Removal	Hanging product	11	Very High	529	High
6	Floor Person	Logistics	16	Very High	518	High
7	Skin Shed	Fixed bench	4	High / Very High	456	Moderate
8	Restrain	Machine operation	5	High	331	Moderate
9	Lidding / Strapping	Fixed bench	7	High	328	Moderate
10	Bagging	Fixed bench	13	High	308	High

A note on extreme individual scores

Floor Person and 1st Leg/Udder/Pizzle Removal also returned the second and third highest individual assessment scores in the entire dataset (957 and 917 respectively). These are single assessments at the upper end of the range. The rankings are based on the middle (median) value across all assessments for each task, so one extreme result does not determine where a task sits in the list.

6.5.4 A Closer Look at Bunging

Bunging ranked second overall and warrants specific attention because it was performed under different physical conditions across sites. Video review of the assessments revealed that some sites used height-adjustable platforms for this task, while others used fixed platforms.

The table below shows how the Bunging risk profile varied across the six sites where it was assessed, including the primary physical movements driving the risk at each site.

Site	Platform type	n	Median score	Primary movements driving task
Site 1	Adjustable	1	473	Forward bending 20 to 45 degrees, neck flexion
Site 2	Adjustable	2	436	Forward bending 20 to 90 degrees
Site 3	Fixed	1	688	Trunk twist over 60 degrees, combined bend and twist
Site 4	Fixed	1	420	Forward bending 20 to 90 degrees
Site 6	Fixed	1	414	Forward bending 45 to 90 degrees
Site 8	Fixed	1	432	Forward bending 20 to 45 degrees, neck flexion

Forward trunk bending was the consistent primary risk driver across five of the six sites, regardless of platform type. The two adjustable platform sites returned scores of 473 and 436, while three of the four fixed platform sites returned comparable scores of 420, 414, and 432. On this basis, platform adjustability alone does not fully explain the variation in Bunging risk scores across sites.

The exception is Site 3, which recorded the highest Bunging score in the dataset (688). Unlike all other sites, the risk at Site 3 was driven primarily by trunk twisting over 60 degrees and combined bend-and-twist movements rather than straightforward forward bending. This pattern points to a site-specific carcase orientation or working technique rather than a platform height issue and warrants targeted follow-up investigation at that facility.

Why no firm conclusion on platforms from Bunging

With only one assessment per site for most sites in this analysis, there is not enough data to draw a definitive conclusion about the effect of platform type on Bunging risk. The broader question of whether height-adjustable platforms reduce risk across hanging product tasks is addressed in Section 6.5.5, where a larger pooled dataset provides a more reliable basis for comparison.

6.5.5 Do Height-Adjustable Platforms Reduce Risk? A Pooled Comparison

A number of hanging product tasks were identified, through video review of captured assessments, as being performed on height-adjustable platforms at some or all assessed sites. These tasks represent situations where an engineering control has already been put in place to address the physical mismatch between the fixed rail height and workers of varying stature.

The tasks identified as performed on adjustable platforms at one or more sites were: Splitting Saw, Flanking, Hide Puller Upstream, Hide Puller Downstream, Brisket Saw, Carcase Inspection, Carcase Wash, Fat Removal, and Pre-Trim. Three of these (Carcase Inspection, Carcase Wash, and Fat Removal) had fewer than four assessments and were excluded from the comparison. They are recommended as a priority for future data collection.

All six eligible tasks from this group returned High Risk grades and ranked outside the top 10 overall (ranks 18 to 35 among the 41 eligible tasks).

6.5.6 Pooled comparison: adjustable vs fixed platforms

To compare risk between platform types with enough data to be meaningful, assessments from adjustable platform tasks and fixed platform tasks were grouped together for analysis. The adjustable platform group included 29 assessments, and the fixed platform group included 16 assessments. Both groups met the minimum threshold required for a reliable comparison.

Group	Tasks included	n	Median score
Adjustable platforms	Splitting Saw, Flanking (Sites 2, 4, 10), Hide Puller Upstream, Hide Puller Downstream, Pre-Trim (Site 1), Brisket Saw (Sites 1, 2, 9), Bunging (Sites 1 and 2)	29	352
Fixed platforms	Flanking (Sites 6, 7, 8), Brisket Saw (Sites 3, 7, 8), Pre-Trim (Sites 2, 5, 7, 9), Bunging (Sites 3, 4, 6, 8)	16	430
Difference			-78 points

Tasks performed on height-adjustable platforms returned a median risk score of 352, compared to 432 for tasks performed on fixed platforms. This is a difference of 80 points, representing an 18.5% reduction in median risk score associated with the use of height-adjustable platforms.

Within-task comparisons

Three tasks were assessed under both adjustable and fixed platform conditions at different sites: Flanking, Brisket Saw, and Pre-Trim. In every case, the adjustable platform assessments returned lower risk scores than the fixed platform assessments.

Task	Adjustable score	Fixed score	Difference	Data status
Flanking	276 (n=3)	413 (n=3)	137 points lower	Exploratory
Brisket Saw	257 (n=3)	498 (n=3)	241 points lower	Exploratory
Pre-Trim	320 (n=3)	458 (n=8)	138 points lower	Exploratory

Each of these within-task comparisons involved only three assessments in the adjustable platform group, which is below the threshold for a statistically reliable finding. These results are therefore exploratory. However, the fact that all three tasks show the same direction of effect — lower risk scores on adjustable platforms in every case, with differences ranging from 137 to 241 points — adds further weight to the pooled analysis finding.

What this means in practice

Taken together, the pooled analysis and within-task comparisons consistently point in the same direction: height-adjustable platforms are associated with meaningfully lower risk scores in hanging product tasks. An 18.5% reduction in median risk score represents a substantial practical benefit, and the consistency of this finding across different tasks and sites strengthens the case for height-adjustable platforms as a priority engineering control across the hanging product category.

7.0 Discussion

7.1 Overview of Findings

Australian red meat processing has one of the highest rates of musculoskeletal injury of any industry in the country. McKell et al. reported 40.7 serious injury claims per 1,000 workers in the sector — more than three times the national average of 12.6. In Victoria alone, the workers' compensation rate for meat processing (4.869%) is higher than for logging, aged care, and explosives manufacturing (McKell et al.). Nationally, musculoskeletal injuries made up 58% of all serious workers' compensation claims in 2015–16 (Safe Work Australia, 2019).

This study is the first to assess ergonomic risk across the Australian red meat processing industry as a whole. It captured 499 assessments across 109 tasks at 11 facilities, covering four task categories, six work areas, and three worker height groups.

Four key findings emerged:

- Hanging Product was the highest-risk task category, with five of the ten riskiest tasks falling into this group. The core problem is that workers must repeatedly bend forward to reach a carcase suspended at a fixed height — a design issue, not a behaviour issue.
- Worker height matters in Hanging Product tasks. Medium and tall workers had significantly higher risk scores than short workers, with more of the risk concentrated in their backs. This is because taller workers have to bend further down to reach the same fixed point.
- Back loading was the dominant risk across all task categories and all height groups, making up 58–71% of total risk scores. Spinal loading is the sector's primary injury risk, regardless of task type or worker size.
- Height-adjustable platforms reduced median risk scores by 18.1% compared to fixed platforms in Hanging Tasks — a statistically robust finding that supports investment in adjustable-height engineering controls.

Taken together, the evidence points to a clear industry priority: addressing working height in Hanging Product tasks offers the greatest single opportunity to reduce musculoskeletal injury across the sector.

7.2 Task Category Risk

All four task categories scored 4 (High Risk) on the five-point ordinal scale, confirming that elevated musculoskeletal risk is spread across the entire production environment — not confined to any one area. Because all categories hit the same ordinal score, raw risk scores were needed to rank them.

Hanging Product ranked highest under both median and mean raw scores, making it the only category with a reliable ranking. Its large sample size (n=258) and non-overlapping confidence intervals support this result.

Machine Operation, Fixed Bench, and Logistics showed ranking instability depending on which measure was used, due to overlapping confidence intervals. Machine Operation in particular — with only 19 assessments and a very wide confidence interval — cannot be reliably compared to the other categories at this stage. More data is needed before drawing conclusions about these three categories.

Because the strongest risk evidence sits firmly with Hanging Product, industry engineering investment should focus there first while data collection for the other categories is expanded.

7.3 Worker Height as a Risk Modifier

Worker height has a clear and statistically reliable effect on risk in Hanging Product tasks. Median risk scores increased from 282 (short workers) to 369 (medium) to 373 (tall), with back loading rising from 58% to 65% of total risk score across the same range.

The reason is straightforward: in Hanging Product tasks, workers access a carcase at a fixed height. Taller workers must bend further down on every cycle to reach the lower sections of the carcase, placing greater load on the spine. Shorter workers still need to bend, but not as far. This is supported by Alessa & Ning 2018, describing an increase in force on the spine with increasing angle of bending.

This was the strongest height-related finding in the study — all three height groups met the minimum sample size for statistical comparison. The finding supports height-specific engineering controls as the primary intervention for Hanging Product tasks.

Fixed Bench tasks showed no meaningful height effect, with consistent risk scores and body region profiles across all height groups. This suggests that bench and conveyor heights across the assessed facilities are reasonably well matched to the workforce. This does not exclude the possibility that the assessed sites already use informal height-compensation aids, as this was not specifically recorded.

Height findings for Logistics and Machine Operation were exploratory only, as sample sizes were too small for reliable conclusions. The Logistics data showed short workers at higher risk than taller workers — an unexpected pattern — but with only six short worker assessments, no firm conclusions can be drawn. This area warrants further investigation.

7.4 Body Region Loading

Back loading dominated across all task categories and height groups, accounting for 58–71% of total risk scores. This is consistent with WorkSafe Victoria data showing back injuries account for 15% of butchering and boning injuries in the Victorian meat industry. Spinal loading is not specific to one type of task or one group of workers — it is a characteristic of the sector as a whole.

The biomechanical reason is well established: repeated and sustained forward bending increases spinal load progressively, even over short periods, and the Etiscope methodology accounts for this across a full shift of exposure.

In Hanging Product tasks, back loading increased and shoulder loading decreased as worker height increased — exactly what would be expected when taller workers must bend further to reach a fixed working point. This pattern was not seen in Fixed Bench tasks, which reinforces that the Hanging Product result reflects a genuine design problem.

An important note on interpretation: back scores are amplified by the Etiscope consequence weighting system, which assigns greater weight to back injuries based on Australian workers' compensation claims data (JointAction Solutions, 2021). The body region percentages therefore reflect both actual postural loading and the relative cost/frequency of injury types. Neck and shoulder loading may be somewhat underweighted relative to their true biomechanical significance.

7.5 Top 10 Priority Tasks

The ten highest-ranked tasks are the most evidence-supported targets for engineering intervention across the sector. Five of the ten tasks are Hanging Product tasks: 2nd Leg, Bunging, Evisceration, Rodding/Clipping, and 1st Leg/Udder/Pizzle Removal. All five share the same root cause — workers bending forward repeatedly to access a carcase at a fixed height. The fact that five separate tasks with the same underlying mechanism dominate the top 10 is strong evidence that working height is the primary design consideration.

Three tasks — 1st Leg/Udder/Pizzle Removal, Bagging, and Floor Person — have High confidence rankings, supported by larger sample sizes. The remaining seven have Moderate confidence rankings, which means their positions may shift as more data becomes available. This is important context when prioritising tasks for site-level action.

Job rotation is not an effective substitute for engineering controls. A systematic review of 63 manufacturing studies found weak evidence that rotation reduces musculoskeletal disorders regardless of how it is designed (Padula et al., 2017). Rotating workers between Hanging Product tasks does not provide meaningful spinal recovery because all those tasks load the same body region in the same way. Engineering changes to working height are the most effective response.

The Bunging task analysis showed that the same task can have very different risk profiles across sites depending on platform configuration. One fixed-platform site returned a score of 687 — driven by back twisting rather than forward bending — compared to scores of 414–473 at other sites. This highlights that industry-level benchmarks need to be used alongside site-specific assessments.

The platform adjustability analysis provides the clearest evidence in this study that engineering controls work: tasks on height-adjustable platforms scored 18.1% lower than equivalent tasks on fixed platforms, across a statistically sufficient sample. Within-task comparisons for Flanking, Brisket Saw, and Pre-Trim all pointed in the same direction. Matching the working zone height to the individual worker's stature demonstrated a reduction in risk score in this study, and this finding is consistent with the established ergonomic principle that matching working height to worker anthropometry reduces postural loading demands in industrial settings (Castellucci et al., 2020; Pheasant & Haslegrave, 2006), and reducing trunk flexion angle addresses the root cause of injury risk (Hendershot et al. 2013).

7.6 Limitations

Several limitations should be considered when using these findings:

- Sample sizes varied significantly across tasks. Of 109 unique tasks, 68 had fewer than four assessments and were excluded from the ranking analysis. Findings are based on a subset of tasks across the sector, and results may not fully generalise to sites and tasks not represented.
- Worker height was assessed subjectively by the practitioner, not measured formally. Workers near the boundaries between height categories may have been classified inconsistently. Future assessments should use formal anthropometric measurement.
- The n=8 minimum sample size for height comparisons meant that some findings — including the potentially important Logistics short worker result — could only be reported as exploratory. More data collection is needed in these areas.

- Wrist and lower limb loading were not measured by the Etiscope system. These body regions are relevant to the full injury profile of the sector and should be captured in future assessment cycles using supplementary tools.
- The Etiscope consequence weighting is based on Australian manufacturing and shearing claims data, not red meat processing specifically. This may introduce some mismatch when interpreting absolute risk scores and body region breakdowns.
- Assessment reliability (i.e. whether repeat assessments of the same task yield the same score) could not be tested from this dataset, as tasks were generally assessed once per site.
- Platform status data and use of informal height aids (e.g. steps) were not systematically recorded during the assessments. This limits the scope of the platform adjustability analysis and should be addressed in future iterations.
- This is a single point-in-time assessment. A longitudinal program tracking risk scores over time and after engineering changes are made would significantly strengthen the evidence base.

8.0 Conclusions

This study provides the first industry-wide ergonomic risk benchmark for Australian red meat processing, covering 109 tasks across 11 facilities. Four main conclusions can be drawn.

First, musculoskeletal risk is high and consistent across the entire sector. All four task categories returned High Risk scores, confirming that injury risk is not limited to specific tasks or areas — it is built into the way work is done across the industry.

Second, Hanging Product tasks are the highest priority for engineering intervention. They were the only category with a stable, well-supported risk ranking. Five of the ten highest-risk tasks belong to this group, all driven by the same mechanism: workers bending forward to reach a carcase at a fixed height. Height-adjustable platforms reduced risk scores by 18.1% compared to fixed platforms, providing direct evidence that this engineering approach works.

Third, worker height is a meaningful risk factor in Hanging Product tasks. Taller workers carry significantly more spinal loading than shorter workers at fixed working zone heights. Engineering controls should be designed to accommodate the full range of worker heights, not just an average.

Fourth, back loading is the primary risk driver across the whole sector, making up 58–71% of total risk scores across all task types and all height groups. Reducing the amount and angle of forward bending across the production environment is the most impactful thing the sector can do to reduce musculoskeletal injury.

For individual facilities, the top 10 priority tasks provide a practical starting point. High confidence findings can be applied directly; Moderate confidence findings should be weighed alongside site-specific data. The platform adjustability evidence justifies capital investment in height-adjustable engineering controls.

For the broader industry and research community, this study establishes a replicable methodology and baseline dataset for ongoing benchmarking and intervention evaluation.

9.0 Recommendations

The following recommendations are presented in three categories: practical application of project findings for industry, future research and development priorities, and adoption and extension activities.

9.1 Practical Application of Project Findings

Priority Engineering Investment — Hanging Product Tasks

The five Hanging Product tasks in the top 10 — 2nd Leg, Bunging, Evisceration, Rodding/Clipping, and 1st Leg/Udder/Pizzle Removal — should be the first targets for engineering review at all red meat processing facilities. The 18.1% reduction in risk scores associated with height-adjustable platforms provides clear justification for capital investment in this type of engineering control.

Recommended engineering controls, in order of priority:

- Working height adjustment — programmable rail height, height-indexed operator platforms, adjustable transfer zones, or counterbalanced assist arms, depending on facility design.
- Carcase stabilisation systems — to reduce the rotational and multi-directional loading that adds to risk independently of working height.

Medium and tall workers carry disproportionately higher spinal loading in Hanging Product tasks. Where height-adjustable engineering controls have not yet been put in place, facilities should consider worker height when assigning staff to these tasks as an interim measure. This is an administrative control only — it does not replace the need for engineering solutions.

Detailed task-specific recommendations are provided in Appendix 2.

Consideration for Additional Engineering Investment – Floor Person Task

The Floor Person task — ranked third overall with a Very High Risk classification and the second highest individual assessment score in the dataset — warrants specific attention. The Floor Person risk profile is driven by sustained extreme floor-level trunk flexion for waste collection and sweeping under low-clearance infrastructure — a task profile that requires redesign. Automated or semi-automated floor cleaning systems, raised waste collection infrastructure, and long-reach articulated cleaning tools are suggested for consideration.

Site-Level Benchmarking Against Industry Findings

Facilities are encouraged to compare their site-specific risk data against the industry benchmarks in this report. Where site data is available for top 10 tasks, local findings should carry more weight — particularly for Moderate confidence tasks where the industry sample is smaller. Facilities without site data for top 10 tasks should prioritise assessing these tasks.

9.2 Future Research and Development Priorities

Expanded and refined data collection

Findings are limited for Machine Operation tasks and Logistics short workers, so data collection should ensure at least 8 assessments per height group.

Tasks that had less than 4 assessments are also prioritised for collection, specifically Carcase Inspection, Carcase Wash and Fat Removal, as they form part of the platform adjustability analysis.

Height categorisation should be based on actual measurements rather than subjective categorisation.

Wrist and lower limb assessment should be considered alongside wearable data.

Repeating industry-wide assessment across multiple cycles will improve evaluation of engineering control effectiveness and progressive strengthening of sample sizes.

Recording control usage behaviour such as the use of steps or platforms should be recorded, including detail on the specific usage patterns of adjustable platforms within a shift.

Standardised Job Task Analysis Linked to Engineering Control Configurations

The Etiscope platform captures detailed movement data for every assessed task, identifying the specific postures and actions driving risk scores. In this study, this data was only formally analysed for Bunging. Analysing it across all priority tasks would provide clearer insight into what is driving risk for each task, and directly inform the development of standardised job task profiles under specific engineering conditions — for example, comparing Bunging with and without a height-adjustable platform. This would give facilities a practical, evidence-based tool for evaluating their own engineering controls and quantifying the risk reduction associated with specific investments.

9.3 Adoption and Extension Activities

The industry-level benchmark established in this study should be disseminated to all Australian red meat processing facilities through AMPC channels, enabling facilities not represented in the current dataset to assess their own risk profiles against the sector-wide findings. The top 10 priority task list, confidence classifications, and platform adjustability findings represent immediately actionable outputs for facility-level WHS programs.

Industry bodies and equipment suppliers are recommended to develop procurement standards and design guidelines for height-adjustable engineering controls in red meat processing facilities, informed by the working height findings of this study.

Expanding the assessment program to additional red meat processing facilities, species, and operational zones not represented in the current dataset is recommended as a priority for future AMPC investment. Increased facility and species coverage would strengthen the industry-level benchmark, resolve currently under-sampled task and height group findings.

All participating facilities are recommended to systematically document the engineering control configuration — for example platform type, adjustability, and height settings — for all assessed tasks in future assessment cycles.

10.0 Project outputs

Individual Facility Ergonomic Risk Reports — Tailored reports with targeted remediation recommendations distributed to each of the 11 participating processing facilities following data collection and analysis.

Individual Facility Ergonomic Risk Presentations — Each report presented to the site project lead with opportunity for detailed discussion on the findings and content within each report.

Industry Benchmarking Dataset — A standardised, multi-site ergonomic risk dataset covering 499 assessments across 109 tasks and 11 facilities, providing an evidence base for the Australian red meat processing sector provided to AMPC.

Final Technical Report —AMPC Task Risk Benchmarking Project, Project Code 2026-1042 full technical report provided to AMPC.

Final Concise Public Report (this document) — Summarised version of the Final Technical Report, redacted to suit wider distribution outside AMPC.

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12.0 Appendices

12.1 Appendix 1: Etiscope Scoring Methodology

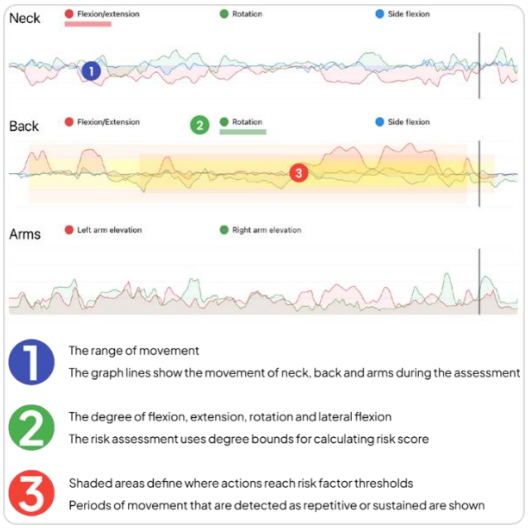
Summary

Risk Analysis Methodology & Scoring:

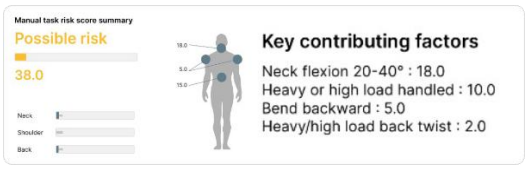
The key information regarding body movements, actions and postures with injury physical risk factor exposure in combination with consequence risk factors are calculated to provide risk scores using inputs from electronic sensors and user questions

Movement, actions and postures

Etiscope uses the exposure intervals and duration definition from the Hazardous Manual Tasks Code(s) of Practice, Safe Work Australia 2026 and 2018 and their predecessor codes and standards. These meet or exceed all comparable international measures and standards.



Consequence



Etiscope uses the Kinney and Wiruth[1] exposure factor standardised consequence categorisation. This is the method most extensively applied to work safety risk management.

Alignment with standardised international risk assessments

Etiscope assess the same or more back, neck and upper limb movements and postures above the wrist addressed by the following risk assessment methods:

- HSE: Upper Limb Disorders (ULD's) in the workplace (HSG60), UK
- HSE: Manual Handling Assessment Charts (MAC) (INDG383), UK
- HSE: Assessment of Repetitive Tasks (ART) (INDG438), UK
- HSE: Risk Assessment of pushing and pulling (RAPP) (INDG478), UK
- Rapid Entire Body Assessment (REBA)
- Rapid Upper Limb Assessment (RULA)

Regarding REBA and RULA, Etiscope does not yet address leg movements or positions.

The revised NIOSH Lifting Equation due to its inter vertebral disc compression based methodology and functional limitations restricting it to two-handed, and symmetrical lifting tasks is not a comparative risk assessment at this stage.

[1]Practical Risk Analysis for Safety Management, G.F. Kinney and A.D. Wiruth, Safety and Security Department U.S. Naval Postgraduate Scho

Risk score

Etiscope risk scoring is a sophisticated risk calculation of:

- Australian and international standardised movement, action and posture risk factors enabled by sensor use
- USA, international and Australian exposure and consequence standardised categories
- Weighting inputs derived from at Australian risk industries multi-year work injury claims degree of harm and cost detailed analysis

Risk grade	Risk score	Numerical value
Low Risk	<20	1
Possible Risk	20–70	2
Substantial Risk	71–200	3
High Risk	201–400	4
Very High Risk	400<	5

12.2 Appendix 2: Control Suggestions

Industry MSK Risk Mitigation Strategies

Top 10 Highest-Risk Tasks

AMPC Industry-Wide MSK Risk Initiative | 11 Participating Sites

Risk mitigation strategies for each of the 10 highest-risk tasks were developed as an integral component of the on-site assessment process conducted across all 11 AMPC member facilities and documented in individual site reports. The following section synthesises those strategies into a consolidated industry-level reference.

The task risk overview describes the primary risk drivers, followed by suggested controls for each task in the Suggested Controls section. Controls mentioned here are limited to Engineering only, which includes design, equipment, and environmental interventions.

Task Risk Overview — All 10 Priority Tasks

The table below summarises the risk range and primary drivers across all 10 tasks, providing a rapid reference for the full section that follows.

#	Task	Sites	Risk range	Primary driver
1	2nd Leg	6 sites	High – Very High	Frequent low carcass working height forces sustained deep trunk flexion on every cycle — the universal root cause across sites.
2	Bunging	5 sites	High – Very High	Beef variant: sustained forward bending with reaching and elevated shoulder/neck loading. Sheep variant: multi-planar rotation and side bending driven by constrained carcass geometry at the bung plug region.
3	Evisceration	5 sites	Very High	Low carcass cavity presentation height forces deep, sustained trunk flexion during organ removal — some sites identified individual cycles of 40+ seconds of continuous deep-range forward bending.
4	Rodding / Clipping	3 sites	Very High	Two distinct profiles by species: beef sites generate marked cervical impacts from between-carcass equipment handling; the sheep variant is dominated by multi-planar trunk rotation from constrained carcass orientation.
5	1st Leg / Udder / Pizzle Removal	6 sites	High – Very High	Working at or approaching knee height on every cycle, with hook alignment under load at changeover sites, drives high cumulative spinal loading.
6	Floor Person	5 sites	Very High	Sustained extreme floor-level bending for waste collection and sweeping under low-clearance infrastructure - continuous end-range spinal loading.

7	Skin Shed	4 sites	Very High	Combines the highest shoulder score in the project with high back loading — the only task with a genuine concurrent dual-region risk profile.
8	Restrain	5 sites	Very High	Accessing a specific anatomical target on a live or recently-restrained animal from a constrained position generates combined forward bending, multi-planar rotation, and moderate upper limb loading — with animal/carcass variability adding postural unpredictability.
9	Lidding / Strapping	3 sites	High – Very High	A side-on pivot-and-rotate handling technique combined with a wide vertical height range creates alternating trunk-dominant (low levels) and shoulder-dominant (overhead levels) impacts, the most technique-sensitive task.
10	Bagging	3 sites	High – Very High	Low product access height drives deep forward trunk flexion on every cycle. Beef variant adds prominent shoulder loading from simultaneous bag manipulation; sheep variant adds elevated neck loading from precision placement demands.

Suggested Controls

Task 1: 2nd Leg

Extreme forward trunk flexion (often exceeding 90°) and combined bend–reach at low carcass working heights, sustained at high repetition. Changeover tasks add hook alignment under load as a compounding factor. Risk is universally driven by working height — the lower carcass zone forces deep spinal flexion regardless of species or facility.

Suggested control	Primary rationale
Working zone height optimisation at 1st and 2nd Leg stations as a coordinated system adjustment	Root cause is low working height. Even partial elevation substantially reduces extreme flexion angles.
Spring-balanced / counterbalanced hook assist arms for leg transfer changeover	Removes sustained load stabilisation under a bent posture — the dominant mechanism noted at several facilities.
Self-guiding funnelled rail interfaces for hook engagement	Eliminates precision alignment demand under load — reduces micro-adjustments in flexed static posture.

Task 2: Bunging

In beef processing: repetitive and prolonged mid to high range bending and high reaching, elevated shoulder and neck loading. Some sites showed a multi-region profile. In sheep processing: multi-planar trunk rotation and side bending rather than forward flexion is the dominant driver, reflecting the different carcass geometry at the bung plug location. Across species, constrained access and carcass geometry at the bung/plug region force non-neutral postures.

Suggested control	Primary rationale
Carcass height optimisation and positioning system at the bunging/bung plug station	Primary driver in beef: deep forward bending. Raising working height reduces trunk flexion across every cycle.
Carcass stabilisation and restraint system to prevent carcass rotation during task	Reduces compensatory rotational and lateral trunk postures. Dominant driver in sheep Bung Plug is twist/side bend contribution.
Counterbalanced or assisted tool system	Reduces repetitive shoulder loading (Notable shoulder score third highest at that site).

Task 3: Evisceration

Extreme forward trunk flexion sustained during organ access and removal, driven by the low position of the carcass cavity relative to the worker's standing height. Several sites identified active evisceration phases of 40+ seconds of sustained deep flexion per cycle. Risk is concentrated in the trunk, with negligible cervical contribution at most sites — supporting this as a working zone height problem.

Suggested control	Primary rationale
Dynamic or operator-controlled height adjustment specific to the evisceration phase	Height adjustment is the highest-impact single intervention — directly eliminates the need to work in a deeply flexed posture.
Carcass stabilisation / spreader system to maintain cavity opening	Some sites identified manual re-adjustment of carcass position as a secondary risk driver. Spreader maintains cavity access, reducing postural variability.
Guided viscera chute or flow assist system	Converts the 40+ second active feed-down manipulation into a guided/monitoring role, reducing both flexion duration and shoulder demand.

Task 4: Rodding / Clipping

Two distinct risk profiles by species: In beef, the primary driver is the very high neck score, driven by repetitive cervical flexion during between-carcass equipment handling - the rod insertion phase itself is moderate risk but the between-carcass preparation generates extreme cervical loading. In sheep, the dominant driver is multi-planar trunk rotation/side bending - driven by constrained carcass orientation at the rodding/clipping point. Across species, carcass stability is a consistent modifiable factor.

Suggested control	Primary rationale
Carcass stabilisation system (guide rails, indexing, stabilisation points)	Freely hanging carcass generates repetitive twisting/side bending across all sites. Reducing carcass movement reduces compensatory posture adoption.

Task 5: 1st Leg / Udder / Pizzle Removal

Driven by the frequent requirement to access the lower carcass at or approaching knee height, generating sustained high range forward trunk flexion with concurrent reaching. At sites with changeover elements, hook handling under load in a deep bent posture is an additional compounding factor. Neck impact is also elevated.

Suggested control	Primary rationale
Dynamic task-phase rail height adjustment specific to leg/udder/pizzle removal	Sites measuring 10–40 second sustained deep flexion periods. Raising the working zone is the only intervention that addresses the root cause: low working height.
Spring-balanced / counterbalanced hook assist arms for changeover components	Load handling under deep bent posture is the dominant mechanism — counterbalanced systems remove both the load and the alignment demand.
Self-guiding funnelled hook interfaces to reduce alignment precision demand	Repeated micro-alignment under load while bent forward is a specific high-risk mechanism at some sites.
Mechanical or semi-automated leg removal assist	Removes the requirement to apply manual force in extreme postural positions — used in progressive facilities as a transition toward further automation.

Task 6: Floor Person

Consistently the highest or near-highest scoring task across all sites where assessed. The task is dominated by sustained extreme floor-level forward trunk flexion to collect waste, combined with trunk rotation during disposal. In the Boning Room variant, the requirement to sweep under fixed low-clearance infrastructure demands end-range spinal loading continuously across the entire task. Neck loading is elevated across all sites from visual tracking demands while deeply bent forward.

Suggested control	Primary rationale
Automated or semi-automated floor cleaning — flush systems, automated scrubbers, conveyor-integrated wash-down	Task substitution — highest level of control. Addresses the Very High risk profiles by eliminating manual floor-level work. Already implemented at leading facilities.
Raised / open-frame workstation design to eliminate low-clearance sweeping zones	Boning Room — the entire task is driven by the requirement to sweep under low-clearance infrastructure. Redesigning access eliminates this at source.
Industrial floor vacuum / suction recovery systems (fixed or mobile)	Eliminates repetitive floor-level bending. Worker operates from upright posture. Used in leading plants for hygiene and ergonomic benefit simultaneously.
Raised waste collection system — elevate crates off floor to waist height	Processing Floor: floor-level crate handling is the primary source of forward bending contribution.
Mechanical bin tipper / bottom-discharge collection bins	Eliminates the high-risk one-arm reach+twist during disposal.
Long-reach articulated cleaning tools (angled squeegees, extended wands)	Practical interim — reduces bending and rotation by 250+ points in Boning Room while infrastructure redesign is planned.

Task 7: Skin Shed

Hide Puller Upstream is the highest individual risk score at that site and one of the highest in the project — the only task with a genuine dual risk profile across back and shoulders simultaneously. Skin Shed task was driven by hide/wool accumulation geometry creating uncontrolled retrieval positions, repetitive offset pulling, and continuous bend/twist. Across all sites, hide pulling combines multi-planar trunk loading, sustained high-force gripping, and significant shoulder demand in a task that is difficult to fully control through administrative means alone.

Suggested control	Primary rationale
Mechanical hide pulling assist system (powered, guided pulling arms, pneumatic assist)	Removes the manual grip-and-pull force generation — the primary driver of concurrent back and shoulder loading.

Hide accumulation and retrieval zone control — prevent uncontrolled pile spread	Variable accumulation positions directly drove repetitive offset pulling and twist. Controlling accumulation geometry removes the root cause of postural variability.
Pull direction and worker alignment improvement — front-on orientation to pull direction	Highest-risk movements occurred during offset pull-and-reposition phases with worker bent and rotated simultaneously.
Carcass stabilisation aids (guide rails, indexing systems)	Reduces carcass movement variability during pulling — eliminates the need for compensatory twisting to maintain grip and control.
Improved grip tooling or mechanical grip assists / hide-gripping clamps	Mechanical grip assists reduce sustained high-force gripping demand.
Working height optimisation at hide engagement zone	Reduces forward bending and reaching demands during hide engagement across all sites.

Task 8: Restrain

Across all sites and task variants, the common mechanism is the requirement to access a specific anatomical point on a live or recently-restrained animal/carcass from a constrained position, generating combined forward bending, multi-planar rotation, and sustained upper limb loading. Sheep Stick was identified as the highest Restrain-category — with the highest rotational/lateral loading recorded across both processing streams. Beef Stick is characterised by combined bend + reach as the primary driver. Stun and Shackle reflect live-animal variability adding postural unpredictability.

Suggested control	Primary rationale
Adjustable carcass / animal positioning system (height and access optimisation)	Consistent primary driver across sites: working zone height relative to the anatomical target. Rail/platform adjustment is the highest-impact single intervention.
Sliding rail alignment system to position carcass directly in front of worker	Trunk rotational loading — the highest twist score identified. Rail alignment eliminates lateral reach and rotation during the incision.
Counterbalanced arm support for sustained upper limb positioning	Sustained bilateral upper limb engagement under trunk flexion creates concurrent multi-region loading.
Integrated knife sterilisation at point-of-work	Ensure In-zone placement eliminates this secondary cervical loading.
Adjustable working platform (Stun/Shackle variants)	Live animal size variability can create worker height mismatch. Platform adjustment allows consistent posture across animal size range.

Task 9: Lidding / Strapping

Multi-planar trunk movements (twist + lateral flexion + forward bending simultaneously) identified as the defining mechanism, driven commonly by a side-on pivot-and-rotate handling technique. Other sites with predominantly forward plane loading and variable height demands. The task is uniquely characterised by a vertical exposure range: low-level stacking (trunk-dominant) and overhead stacking (shoulder-dominant) creating alternating multi-region loading that cannot be addressed by a single postural control. Rotational handling technique is the key behavioural modifier.

Suggested control	Primary rationale
Automated lidding / strapping machine — task substitution	Highest control level. Addresses the entire risk profile at all sites. Viable in high-volume standardised environments.
Height-optimised shelving / staging system — restrict low and overhead tiers	Eliminating the extreme height range removes both the trunk-dominant and shoulder-dominant loading phases.
Pallet lift / height-adjustable staging system	Maintains load at consistent working height across the full task cycle, addressing both the low bending and overhead reaching phases.
Turntable / pivot platform to eliminate trunk rotation under load	Where feasible a turntable removes technique dependence on trunk rotation.
Conveyor or roller transfer system to the lidding/strapping zone	Reduces the forward bending and reaching from manual carrying to the station.

Task 10: Bagging

Consistently driven by deep forward trunk flexion during product access at low working heights, compounded by forward reaching during bag manipulation. The sheep variant shows a proportionally higher neck contribution from precision placement demands. Across all sites, working height is the fundamental risk driver — the task is structurally a height problem, not a technique problem.

Suggested control	Primary rationale
Height-adjustable staging or lift table to bring product to waist-to-chest height	Primary driver across sites is low product access height. Raising the working surface reduces trunk flexion across every bagging cycle — the single most impactful intervention.
Bag opening and holding fixture to eliminate sustained bilateral shoulder elevation	A fixture separates simultaneous bag manipulation and product insertion.
Ensuring that the conveyor or roller transfer system deliver product at working height	Reduces the additional forward bending and reaching from manual product retrieval and transfer to the bagging station.

Angled or tilted product presentation surface	Sheep variant: Angled surface brings the work zone into direct line of sight without compromising placement.
Vacuum assist or mechanical handling for primal cuts	Reduces both spinal and shoulder loading simultaneously.

Summary — Cross-Task Themes

Analysis across all 10 priority tasks and all 11 sites reveals consistent systemic themes that should inform industry-level investment priorities:

- Working height is the dominant modifiable factor across 7 of the 10 tasks. Rail height systems, adjustable platforms, and height-optimised staging are the highest-impact engineering controls available across the sector.
- Carcass / product stability is a universal secondary driver. Stabilisation systems, guide rails, and indexing mechanisms reduce the compensatory multi-planar loading that amplifies risk beyond what working height alone can explain.
- Tool quality and sterilisation positioning are low-cost, high-impact levers. Sharp tools reduce lean-in force compensation; in-zone sterilisers eliminate secondary bending between carcasses.
- The Floor Person role consistently emerges as the highest or near-highest scoring task where assessed. Unlike the other nine tasks, it requires environmental redesign rather than workstation adjustment — waste system engineering, automated cleaning, and infrastructure access are the priority interventions.