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Introduction

Shearing has a strong identity in Australian history. Shearers have played an integral role in the nation-building industry that engendered the Australian colloquialism; "riding on the sheep's back". We now know that it is the shearers' backs that take the hard knocks. Scanning through the National Code of Practice for Manual Handling, shearing is a good example of almost everything that represents an injury risk. Heavy, live, hot, and often unwilling objects, must be caught, restrained and dragged to the workstation. Then the shearer must control the animal while applying high forces in a stooped posture; all the while remaining cognisant of removing the fleece cleanly and efficiently. Once the fleece and sheep have parted ways, often a struggle ensues to get the sheep out the chute before it runs amok on the shearing board.

Shearing might be coloured with the romance often nostalgically splashed all over supposedly idyllic rural lifestyles, but the truth is that shearing is still one of the toughest jobs in the world. There's hope that mechanical assistance may be eventually possible but macroscopic change appears distant. Therefore, exposure to traditional shearing and the consequential injury levels are expected to continue for some time. To extend knowledge about the prevention of shearing injuries within the confines of traditional shearing, the National Occupational Health and Safety Commission funded the University of Ballarat's Shearing Research Team to study potential ergonomic improvements to shearing shed design. The team draws its members from the University of Ballarat, the University of South Australia, the Wimmera Health Care Group, and from the shearing industry throughout Australia. The project began in February 1995 and will conclude in December 1997. This paper describes the progress to date and the methodology of the work to be completed.

The Risk of Shearing Injuries

Shearers have a high incidence of injury and disease claims. Worksafe Australia's (1995) analysis of compensation data for 1992-93 show that shearers (Australian Standard Classification of Occupations 4929) suffer injuries at six times the average over all industries. Shearers made 150 claims per 1000 workers per year (*incidence*), compared with the average of 26 claims. The comparison of *claims frequency* shows a similar relative magnitude; shearers made 100 claims per million hours whereas the average was 17 claims.

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While greater in relative number, shearing injuries also take longer to rehabilitate and are therefore more costly. Data reported by Worksafe Australia (1995) indicate an average cost of shearing injuries of $9500; 70 percent higher than the average of $5600. Recently obtained data from the Victorian WorkCover Authority detailing 1098 injuries to shearers (occupation code 322) between September 1985 and August 1997 show an average cost of $26,000; 140 percent greater than the overall mean of $11,000 (September 1985 to December 1996). The greater cost of shearing injuries seems mainly due to the lengthier rehabilitation. Victorian data show that shearing injuries averaged 180 days rehabilitation whereas the all-industry average is about 90 days.

Shearing injuries are confined to a few areas of the body. Both the national and Victorian data show that about 50 percent of shearing injuries affect the arms (shoulder, upper arm, elbow, forearm, wrists, hands and fingers), 20 percent the back, and 10 percent the knee. The data for days compensated and cost are different as back injuries involve lengthy rehabilitation. The average period of rehabilitation for a back injury (which constitute 44 percent of days compensated) as shown by the Victorian data is approximately one year. Back injuries constitute about 50 percent of the cost, arm injuries about 25 percent and knee injuries about 10 percent. Injuries to the back, arm and knee therefore constitute 80 percent of claims, days lost and cost.

Three-Phase Study

The three-phase study aimed specifically at back injuries and energy demand and employed the *identification, assessment and control* methodology. The first phase, *identification*, involved consultation; asking Australian shearing industry representatives, "what are the shed design issues that contribute to injury?". Focus groups were conducted in Ballarat (Victoria), Armidale (New South Wales) and Kojonup (Western Australia). These localities covered a reasonable range of farming conditions, especially encompassing a variation in sheep-sizes. Each focus group included woolgrowers, shearers, a shearing contractor, a Farmers' Federation representative, a union representative, and a local health care provider with significant contact with injured shearers.

The second phase, *assessment*, involved observing the problems in working environments. This took the team to sheds in Victoria, New South Wales, and South Australia to observe and document the issues raised by the focus groups. Eighteen sheds were audited. Shearing was in progress at 13 of the sheds at the time. The sheds ranged in size from one to twelve stands with the most common being four stands. The physical conditions of the sheds were noted with special attention given to the issues put forward in the focus groups. Shearers were interviewed on-site about their experience of shearing and associated injuries. The shearing tasks were timed and videotaped. The workload was assessed by measuring heart rate and by assessing perceived workload using a modified version of Borg’s (1982) *Rating of Perceived Exertion* (RPE) scale.

Shed Design Issues

The third phase, *control*, is due for completion in December 1997 and involves replicating and investigating potential shed changes in a laboratory setting. The potential changes listed below arose from the focus groups and were subsequently observed and documented during the shearing shed audits.

- The texture and orientation of catching-pen floor surfaces.
- The slope of catching-pen floor surfaces.
- The path of drag from the catching-pen to the shearing position.
- The size, position and design of the sheep release chute.

The Catch to Catching a Sheep

Two-thirds of the sheds audited had battens oriented perpendicular to the direction of the drag. Battens orientated in this way are traditional but shearers commented that these battens make the sheep more difficult to upturn. Video evidence was collected at working sheds during the audits showing shearers catching and tipping sheep. When a sheep is able to grip the floor with hind legs during the tipping it is able to fully extend and cause an unexpected, large increase in the moments required of the shearer to complete the task. The centre of mass of an unshorn merino sheep was determined to enable a calculation of this moment.

The Best Surface and Slope for Dragging Sheep

Once the sheep has been upturned, the type of surface was thought to impact on the difficulty of dragging the sheep. In addition it was expressed that a small favourable slope would probably be an advantage. An experiment was conducted to estimate the forces involved with dragging a sheep across five different textures (wooden battens oriented both parallel and perpendicular to the direction of drag, plastic battens oriented in both directions, and steel mesh flooring) and on two slopes. The two slopes were horizontal and a downward slope of gradient 1:10. The five textures combined with the two slopes gave a total of 10 experimental conditions. Subjects were eight experienced shearers, four who shear full-time, and four who shear part-time. Each subject dragged each sheep over each of the ten floors. The sheep were merinos with about eight months growth of wool. Each sheep weighed between 51 and 58 kilograms. The floors were built over a three-dimensional force platform. Preliminary analysis indicates differences between textures and slopes on a number of variables including the average dragging force and the coefficient of friction for each surface.

Twisting and Turning on the way to the Workstation

The path that a shearer must take between the catching-pen door and the shearing workstation is dictated by the arrangement of the shed. The focus groups indicated that some paths of drag may contribute to risk. Assessment of the drag paths during the shearing shed audits revealed five classes of drag. An across-the-board shed can impose three types of drag as the shearing workstation can be positioned in front of the door, to the left, or to the right. A same-side shearing board can impose two types of drag as the shearing workstation can be either to the left or right of the door. The dimensions of examples of these five drag types were drawn from data collected during shed visits. The five drags were then replicated in a laboratory-based experiment to measure the energy consumption while dragging sheep on these paths. As above, subjects were eight experienced shearers. Portable devices were used to measure oxygen uptake. Each subject worked for three minutes to establish a steady state and rested for five minutes between trials. The task consisted of dragging sheep along each path from the catching-pen door to the shearing position. Three sheep were used in a rotating fashion. At the catching-pen door the sheep were presented upturned. Once at the shearing position the sheep was handed to an assistant. The sheep were merinos with about twelve months growth of wool. The sheep weighed between 69 and 74 kilograms. A number of variables will be derived from the measurement of oxygen consumption by relating this quantity to; the subject's body weight; the subject's predicted maximum uptake; and to the number of sheep dragged in the three-minute period.

The Sheep Release

When shearing is complete the sheep must be let out a release door or chute. The ideal situation is that the shed is designed to encourage the sheep to simply stand up and walk away. Unfortunately this is not always the case and the sheep frequently resist. Two-thirds of the sheds audited had under-shed sheep release chutes (sheep tend to be apprehensive about walking downhill). This, and other factors, contribute to the likelihood of a sheep resisting. If a sheep does resist then it must be forced out of the chute by the shearer. Any toe-hold the sheep can access would seem to increase the force required to push the sheep out the door. Obstructions that serve as toe-holds for the sheep were noted across the front of the chutes in one quarter of the sheds. In addition to this problem, 80 percent of the sheds had release arrangements that poorly accommodated a left-handed shearer. A chute with an obstruction has been constructed at the university and an experiment undertaken to estimate the forces involved with handling a sheep that is discouraged from exiting and has a toe-hold upon which to resist. Again the subjects were eight experienced shearers. The sheep were five recently shorn merinos weighing between 57 and 64 kilograms. Subjects pushed the sheep out the chute while the sheep were discouraged from entering the chute. Forces were measured using two three-dimensional force platforms as described above.

Discussion of Work Measurement Techniques

Several work measurement techniques have been employed in this research; perceived measures of workload, oxygen uptake, heart rate, and biomechanical modelling.

Oxygen Consumption

Direct assessment of oxygen consumption is the best method of determining energy expenditure. Traditional gas analysis equipment is extremely bulky and interferes with tasks such as shearing that involve substantial movement. Portable equipment used for this study is a relatively new development and the equipment trialed were the *Aerosport* and *Cosmed* systems. Subjects wear a variety of equipment that involves some inconvenience, especially in a hot environment. However, the portable devices allow the subject to continue working with little change to normal work patterns. The portable units transmit to a base unit and computer via telemetry and allow natural metabolic data to be obtained. A disadvantage of oxygen consumption is that a steady-state of work must be established (several minutes) and so the method does not lend itself to the analysis of activities where the task of interest is intense. Furthermore, measuring oxygen consumption requires a high level of physiological knowledge and can be time-consuming allowing for calibration and time between subjects while parts of the units are sterilised. The portable equipment seems to be in development phase and some problems occurred with its use. A further disadvantage is the high cost of the equipment.

Heart Rate

Compared with oxygen uptake, heart rate can be used to make a less direct measure of energy expenditure, however under most conditions there is a reasonable correlation. Furthermore, heart rate in its own right is a measure of work intensity. The sensitivity of heart rate to short duration changes in workload is better that oxygen consumption. The equipment required to measure heart rate is compact, unobtrusive and reliable. Heart rate is a useful and simple measure where the task of interest can be sampled for a reasonable time.

Biomechanical Modelling

Biomechanical modelling is a technique to estimate forces and moments within the human body. The models do not consider dynamic effects. The technique has been used widely for static analysis and the most common application is to estimate compression force at the L5/S1 segment of the spine. The National Institute for Occupational Safety and Health (NIOSH) limits for spine compression are one benchmark for this variable. A biomechanical model is a snap-shot of an activity and thus not time-dependent. The disadvantage is that a biomechanical model therefore gives no indication of a risk of injury due to repetitive motion. Biomechanical modelling tends to be useful where the critical tasks are "heavy" involving significant risk of injury due to single exertions. The biomechanical software employed in this project was the University of Michigan 3D Static Strength Prediction Program. As the name implies the model allows for posture modelling, and force application, in three dimensions. The program estimates spine compression and estimates moments at many locations in the body comparing these moments to population strengths. A disadvantage of the model is that it relies on measurements of forces applied by the hands only. Overall, biomechanical modelling employing the Michigan software seems appropriate for low acceleration, short duration, heavy tasks where the hands exert the force on the object and the feet are grounded. In some aspects of the shearing task this seems appropriate, for instance the drag and the push out the chute at the completion of shearing.

Perceived Measures of Workload

Borg's RPE scale is a common measure of perceived workload. In this project there was an attempt to use the scale to isolate the demand in different aspects of the work (for example; catching, tipping, dragging, shearing, releasing). This proved to be problematic. The subjects were unable to estimate the workload for components of the activity. While subjective tools like Borg's scale have been shown to correlate well with other measures they are likely to be less accurate if the estimation is not made soon after the activity. In addition, the terminology of the scale and the instructions given must be meaningful to the subjects.

Reaching the Target Audience

Throughout this study, the progress of the research team has been promoted to the wool-growing industry. The ideas and methods have been reported in numerous newspaper articles, radio interviews, television interviews, and conference presentations. The outcomes of this research must reach woolgrowers; a widespread group of small-business operators. Awareness of the research, and shed design issues have been promoted with the aim of creating a climate more receptive to changes recommended at the conclusion. In the interim, some woolgrowers contacted either as part of the research, or who have made contact following publicity about the research, have expressed an intention to modify their shed layouts.

Conclusion

The injury experience of shearers is severe. While the shearing industry explores options for innovation, traditional shearing continues much as it has for decades. With shearing sheds used for a small proportion of the year and the wool industry having been under financial pressure for some time, large investments in changes could not be predicted for the near future. This research is focussed on opportunities to improve the work environment for traditional shearing and has explored options through consultation, observation and currently, experimentation. The study will lead to a range of simple and low-cost recommended improvements to shearing shed design that are supported by experimental evidence.

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