Shearers' Back Aids

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Abstract

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Shearing shares a long history with Australia's agricultural, and economic, development. By observation, shearing is physically demanding and involves non-optimal postures. Some shearers use a *Warrie Back Aid* to apply a tensile vertical force upwards on their upper body. The study undertook to determine the effect of the Back Aid by measures of heart rate and Borg's RPE and by questionnaire.

The Back Aid reduced the working heart rate and the perceived exertion, possibly indicating reduced external demands leading to reduced muscle activity, mainly in the legs and back. Spinal load may reduce in line with the back muscle activity leading to a benefit of reduced injury, and ill health, risk.

A questionnaire revealed that in the shearers' opinions the beneficial effect is to improve the health of the back and to reduce tiredness.

The study did not identify any outstanding adverse effects.

A study of six (nine in total but three did not yield complete data) is insufficient to make definitive statements. However, while the study does not substantiate the opinion that the Back Aid is beneficial, it does offer support to the claim.

The project recommendation is that shearers consider using the Warrie Back Aid, continuing its use based on the individual's opinion and individual professional advice.

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Summary of Conclusions and Recommendations

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The effect of the Back Aid in the study was to reduce the working heart rate and the perceived exertion; that is, the internal response or work strain.

This may indicate a lower level of muscle activity as a result of lower external demands or work load. Much of the reduced muscle activity may be in the back and as a consequence one could conclude that the load on the spine is somewhat lower. The potential benefit of a reduced load on the spine is a reduced risk of injury and ill health.

The questionnaire revealed that in the shearers' opinions the beneficial effect is to improve the health of the back and to reduce tiredness.

Individually some shearers rated some of the effects as adverse, however, overall this was not the case. This is not to say that no adverse effects exist, only that this study did not identify any outstanding adverse effects.

A study of six (effectively since three did not yield complete data) is insufficient to make definitive statements. However, while the study does not substantiate the opinion that the Back Aid is beneficial, it does offer support to the claim.

Based on this project I recommend shearers consider use of the Warrie Back Aid. I recommend continuing use be based upon the individual's opinion and individual professional advice.

Chapter One

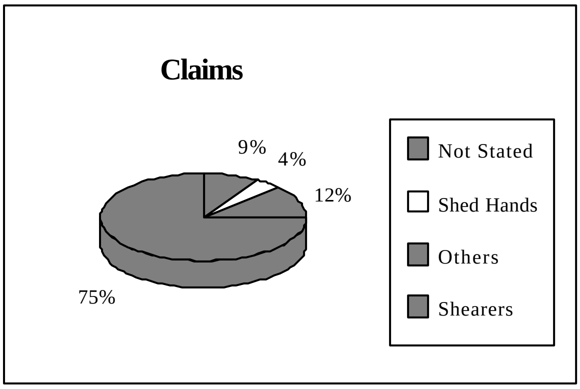
Introduction

1. Introduction

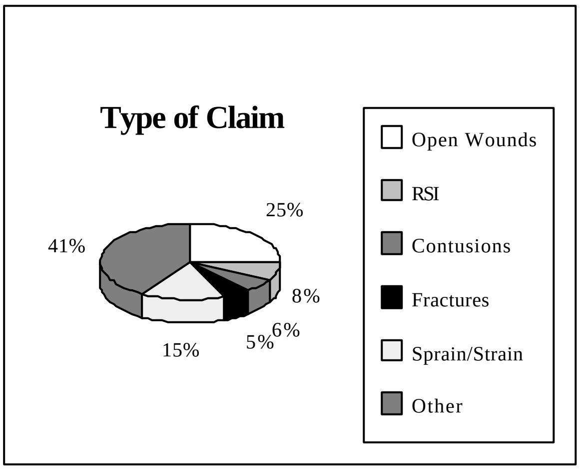
Shearing has a long history in Australia's agricultural, and economic, development. Shearing is, by observation, a physically demanding occupation and involves less than ideal postures. What then is the injury experience?

Data published by the Accident Compensation Commission (1992) (unpublished data obtained by search) for the period September 1985 to March 1993 indicates the following.

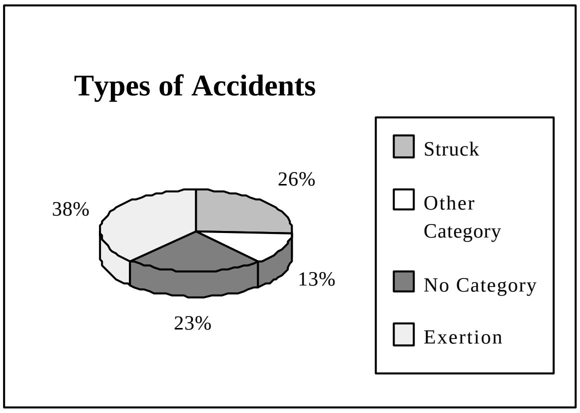
Of the 567 claims for that period, shearers made 75%.



Of the 567 claims 42 % were sprains/strains and 8.1 % RSI. It is not possible from the data available but one could hypothesise that the proportion of sprain/strain in the shearers' group (75%) would be higher than the overall group.



The types of accidents attributed to the claims are as follows:



The 'Warrie Back Aid', developed and marketed by Warrie Shearing Products, has almost complete dominance (in the order of ninety-eight percent) of the Australian market for this type of device. Since development ten years ago sales of the Back Aid have reached forty thousand. (Hambley, W., Warrie Shearing Products) The population of the Australian shearing workforce is difficult to determine; the population includes full time shearers and people who work part time (often only on their own property). In 1986, Gmeinder studied back complaints among shearers in Western Australia. Gmeinder surveyed one hundred and fifty-eight shearers and received thirty-two responses; of the thirty-two, four were using the Warrie Back Aid, which had been on the market at that stage for about three years.

Why use a Back Aid?

Gut feeling or subjectivity on the part of the shearers?

Reports from the manufacturer of the product indicate very positive feedback from the users and thus much of the marketing takes place by word of mouth or shearers trying out Back Aids owned by that their colleagues. I believe that (and if the sales/population ratio is a guide) the use of the Warrie Back Aid is widespread. Gmeinder said that all the users (four of thirty-two respondents) of the Back Aid reported either greatly relieved or abolished pain.

Promotion on the part of the manufacturers?

The promotion of the product appears to have been very inconspicuous; the main methods may be presentation at field-days and word-of-mouth.

Scientific or medical opinion?

Shearer's access to scientific knowledge is probably only through their union (AWU) or other bodies such as the Australian Wool Corporation.

1.1 Aims and objectives

The aim is to determine;
the potential beneficial effects and
the potential adverse effects
of using the Warrie Back Aid.

The objective is to research theory and practice in this field and in similar fields to determine a suitable methodology and then to apply that method to the ergonomic evaluation of the Back Aid.

Chapter Two

Literature Review

2. Literature Review

Research undertaken in this particular proved to be rare, probably due to the devices being a relatively new innovation (approximately ten years). Fraser et al. (1988) and Ormsby and Williams (nd) undertook direct investigations of the Warrie Back Aid; these are the only two pieces of direct research found. Thus the review mainly concentrated on relevant but indirect experiment and theory.

Ergonomics texts that specialise in physically demanding work, posture measurement, physiology, etc, and publications in like areas published in journals formed the basis for review.

A number of sections form the literature review; fundamentally, a review of background theory and research followed by a discussion of the various analytical methods that may serve the aims of the study.

2.1 Physiology

2.1.1 Work Load / Work Strain

The terms *physical stress* and *work load* often describe the external loads upon the body while *physical strain* or *work strain* represent the body's internal response to the imposed stress. (Kilbom 1990; Kuorinka 1986; Rohmert 1987)

Recognising the difference is relevant in ergonomic evaluations. Knowledge of the physical strain experienced by an individual enables design of external demands.

2.1.2 Metabolism

Food breaks down in the intestines until the constituents of the food can pass though the gut wall and into the blood stream. Most of the nutrients store in the liver as glycogen and return to the blood stream as needed in the form of sugars. Various cells in the body convert the sugars to mechanical energy by oxidation. Thus oxygen is necessary. The whole process just described is metabolism. Consumption of oxygen by metabolism has been a common method of ergonomic evaluation (later).

2.1.3 Muscle

Muscle makes up around forty percent of the body's mass. A muscle contains between one hundred thousand and one million fibres that are between 5mm and 140mm long and of around 0.1mm diameter.

A muscle can *contract* to half of its normal length. The longer this contraction length the more work the muscle can do.

The strength of human muscle is between 0.3 and 0.4 N/mm^2; thus the strength of a muscle depends on its cross sectional area and therefore larger muscles are stronger.

While shearing, the muscles of the arms (especially the shearing arm) are mainly contracting dynamically while the muscles of the back and legs are contracting statically.

2.1.4 Energy consumption

2.1.4.1 Energy

Muscles convert chemical energy into mechanical energy. The greatest source of energy is *adenosine triphosphate* (ATP); this compound breaks down to adenosine diphosphate which stores in muscles and other tissues. The other main energy source is *Phosphocreatine* (phosphagen) which breaks down to phosphoric acid and creatine. (Grandjean, 1988)

Kilbom (1990) summarises as follows:

ATP⇔ADP + phosphate + energy

ATP = adenosine triphosphate

ADP = adenosine diphosphate

2.1.4.2 Glucose, Fat and Proteins

The above phosphates convert back into the high energy state with the aid of glucose, fat and proteins. Intensive physical activity such as shearing places demands on glucose while sedentary work makes use of fat and proteins. These products break down into pyruvic acid.

Under oxygen rich circumstances further breakdown of these compounds will be by aerobic glycolysis, the by products being water and carbon dioxide. If oxygen is not present anaerobic glycolysis converts pyruvic acid to lactic acid, a metabolic waste product. This compound releases less energy for reconversion of ATP.

2.1.5 The Cardiovascular System

Kilbom (1990) defines the role of the cardiovascular system as to:

remove heat from the muscles;

supply nutrients from the liver and fatty tissue (glucose and fatty acids) to the muscles;

transport oxygen from the lungs to the muscles;

remove CO_2, H_2O, and lactate from the muscles.

2.1.6 Work Capacity

The capacity to do effective work depends upon the task efficiency (mechanical work done / energy expenditure) and the capacity of the individual in question. (Kilbom 1990)

2.1.6.1 Efficiency

Mechanical efficiency varies between 0 and 50-60%. Holding an object stationary consumes internal energy but does not do any mechanical work, hence the efficiency is zero. Most every day activities are in the 0-20% range. (Kilbom 1990)

2.1.6.2 The Individual

The capacity of people to convert chemical to mechanical energy varies. Oxygen uptake per minute is typically the measure of the maximum an individual can convert. (VO_2, max; indicating the maximum volume uptake of oxygen in a given time)

2.1.6.3 Fatigue

Static work will be more fatiguing on the muscle itself (compared to dynamic work); waste products that are normally 'pumped' out with the blood due to the extension / contraction cycles of dynamic work build up under static loading and cause discomfort. (Grandjean, 1988)

Dynamic work also will be less fatiguing for the same energy consumption than static work. The heart rate for static work at the same energy usage will be higher. (Vanwonterghem 1986)

Chaffin and Andersson (1984) say energy depletion and lactate accumulation greatly influences muscle fatigue. Shearing invoves static and dynamic work; lactate build up may be present.

Karpovich and Sinning (1971) point out energy expenditure causes mental and physical fatigue; excluding energy expenditure results in no fatigue; this is rest. The chemical nature of fatigue may be; a reduction in the store of energy producing substances, the build up of waste products in the muscle, or the alteration of the physiochemical state (a change in homeostasis).

2.1.7 The Skeletal System

2.1.7.1 Structure of the Spine

A description of the lumbar spine is hardly a sufficient description of the structure of the spine, however with the limitations of space and the fact that this region is responsible for many injuries it will be focussed upon.

2.1.7.2 Intervertebral Discs

The intervertebral disc consists of a central watery gel (the nucleus pulposus) surrounded by layers of hyaline fibres (the annulus fibrosus). This disc forms a type of cushion; it separates the vertebrae giving shock absorption and flexibility to the system.

2.1.7.3 Disc degeneration

Under certain conditions the disc may become flattened, tend to squeeze out the rear of the spine and in sever cases rupture whereby the fluid escapes from the nucleus. The factors usually implicated in the degeneration are; inappropriate posture both seated standing and working and handling loads. (Grandjean 1988) Shearing is a task that intuitively would be harmful for the spine; claims figures support this to a certain degree. Measurement of the effect of the Back-Aid on the spine is of prime interest.

2.2 Methods

A discussion of the history, and current opinion, of various methods of work assessment follows.

2.2.1 Oxygen Uptake

Metabolism, described earlier, involves the uptake of oxygen.

One litre of oxygen consumed relates to a turnover of around twenty kilojoules of energy. (Grandjean 1988)

2.2.1.1 Basal metabolism

A resting person has a consumption of energy depending on their size, weight and sex. Lying down with the stomach empty represents the basal condition. A man weighing seventy kilograms has a basal metabolism of about 7000 kJ per 24 hours; for a woman of sixty kilograms the metabolism is about 5900 kJ. An understanding of the basal metabolism is often necessary to use oxygen consumption as a workload measure (below).

2.2.1.2 Energy consumption at work

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The term *work joules* describes energy-consumption increase due to physical work. (Grandjean 1988)
Work joules is a measure of the difficulty of work and can assess different methods. This will not measure mental stress, heat load or extra demands from static work.

Postural aspects of work receive more attention than in the past, hence measuring energy consumption for assessment of occupational tasks is not now as popular.

Grandjean (1988) suggests adopting an upper limit of 10500 occupational kj energy consumption per working day; he makes the important point that there must be adjustment to reflect individual variations.

The calorific equivalent of a litre of oxygen varies between 4686 and 5040 calories depending on the foodstuff being consumed by the oxidation process; carbohydrate, fat, protein or a combination. (Karpovich & Sinning 1971)

Withey (1982) says that the basal metabolic rate is around 0.25 l/min of oxygen which equates to about 1.2 kcal/min (indicating a calorific value of 5000 cal / litre of oxygen).

Oxygen uptake or a ratio between the work metabolic rate and the basal metabolic rate are among many measures to express work that is being done. The ratio measure gives some indication of the work rate in comparison to the individual. Karpovich & Sinning (1971) consider the work *easy* if the ratio is less than three and *hard* if the ratio reaches eight; although maintainable for eight hours.

An individual's VO_2max refers to their maximum oxygen uptake. A muscular demand for oxygen beyond this rate will lead to anaerobic metabolism will occur leading to an 'oxygen debt' to be 'repaid' later.

Monitoring changes in the heat content of the water in a laboratory atmosphere that the subject is working is a direct measurement of energy transfer. Devices such as Douglas air bags and Oxylogs indirectly measure oxygen uptake. The main inconvenience is that they tend to impinge heavily on the wearer. Although heart-rate is two variables distant from energy consumption, it is a practical technique to employ.

Once exercise begins oxygen uptake rises to a steady state where the oxygen uptake corresponds to the demands of the muscles. Once exercise ceases, and the oxygen debt paid off, oxygen uptake gradually falls to the resting level (Troup & Edwards 1985).

Some of the limitations of the oxygen uptake method are as follows.

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Mouthpiece and airways of the apparatus provide some resistance to airflow (that is, as with most measurements, the measurement tends to influence the phenomena).

The tubes, etc, impose mechanical restraints upon the subject.

Expressing the oxygen uptake as a percentage of the individual's maximum is a measure of their capacity; the problem is determining the maximum. The maximum an individual can uptake depends on the activity and the manner of performance (Troup & Edwards 1985).

Troup and Edwards (1985) also highlight some problems with the method in relation to the general physiological principles; these are as follows.

VO_2 for dynamic work varies widely over the population

VO_2 in lifting tasks varies with the load lifted frequency of the lift and the technique

VO_2 is greater for crouch lifts rather than stoop

Habes, Carlson and Badger (1985) investigated fatigue during upper body work by EMG, oxygen uptake and heart rate. They also measured strength decrement and perceived fatigue. The hypothesis of their study was that the load locations, vertically and horizontally, were as important in the onset of fatigue as the magnitude of the load. They considered that EMG was a measure of the upper body fatigue while heart rate and oxygen uptake were accurate measures of whole body fatigue. The Back-Aid must reduce the load on the legs (it is unlikely that all the force in the spings translates to a reduced force applied to the sheep via the hands) and hence EMG may be a less appropriate measure than the other two.

2.2.2 Heart Rate

Vokac et al. (1975) studied the effect of leg and arm exercise (shearing is a leg and arm exercise) on energy output and several cardiorespiratory measures (heart rate, pulmonary ventilation and respiratory frequency). One of their aims was to evaluate the reliability of using heart rate for estimating the circulatory strain and work load in field studies. They found that heart rate overestimates the energy consumption found by other means. The intermittent nature of some occupational tasks diminishes the differences. They say that this point can make transfer of techniques from the laboratory to the field difficult, although in field studies one can compare the working heart rate, over a period of time, with the heart rate reserve described by Astrand & Rodahl (1986).

Louhevaara et al. (1990) investigated muscle and circulatory strain. They concluded that EMG was a time consuming and practically difficult technique for field studies although it had the potential to yield valuable information. They found heart rate to be very easy to measure in the field and blood pressure somewhat inappropriate as it was could not be measured during the work itself.

Bobet and Norman (1984) investigated different methods of carrying a load; they used EMG and heart rate by telemetry.

Their study was, in a sense a repeat of a study by Winsmann and Goldman (described in Bobet & Norman 1984) who investigated carrying two types of back pack; one that beared weight mostly at the shoulder level and one that distributed weight more evenly between the shoulders and the hips (either way an increased static load). They concluded that there were no appreciable differences between the two methods. Bobet and Norman (1984) considered that not all *physiological penalties* manifest themselves in physiological measures; these measures reflect the total workrate of the body but give no insight into loading of specific body areas. Hence they used EMG to measure the activity of the erector spinae and trapezius muscles to investigate differences in the carriage methods.

They found that EMG actually decreased or remained the same when carrying the load; explained by the biomechanically in that the moment due to the weight of the load tended to balance that of the upper body. The moment produced by the two different positions were approximately the same hence differences between the two techniques did not explain this. Comparison of the two techniques showed that the high load position caused increased EMG in both muscle groups.

They conclude that specific muscle loads can change appreciably while measures such as heart rate may not alter significantly and thus caution against broad physiological measures if specific sites are of interest.

From the above study, one can also say that it would be unwise to only use a measure such as EMG which in this case held carrying the load to be easier (or at least no worse) than no load. (Could this be true? Intuitively not.) The message is that while measuring EMG may give insight into the change in load on a particular muscle while shearing with a Back-Aid it does not indicate anything about another muscle.

Gallagher and Unger (1990) studied the psychophysical, physiological and biomechanical effects of working in restricted positions; while shearing the hand-piece and the sheep's location on the floor (the sheep is manipulated but not moved as such) restricts the range of movement.

They analysed miners working with headroom restricted to somewhat less than 1.2 m (typical mine height); postures were; a stooped position and a kneeling position (shearers exhibit significant stoop and some kneeling). The psychophysical measure was a subjective measure of the maximum acceptable weight of lift. The physiological measures were; heart rate, oxygen uptake, minute ventilation and respiratory exchange. EMG was the biomechanical measure of the task.

They found the kneeling posture to be costlier in terms of the physiological measures including EMG of the major back muscles (erectores spinae) and the subjective maximum load was also lower. Despite this finding they were reluctant to recommend adoption of the stooped posture due to the likelihood that the reduced EMG of the erectores spinae was due to transfer of load to ligaments; resulting in no lower (or even higher loads on the intervertebral discs). The higher physiological cost of the kneeling posture (despite lower load being lifted) was probably due to the use of smaller muscle groups. The conclusion that they made, despite disagreeing with their findings, may indeed make sense; it may be preferable to transfer risk from the musculo skeletal system to the cardiovascular system, if indeed this trade off arises. With reference to shearers this may mean that while an intervention increases heart rate due to increased use of small muscles it may be desirable if it simultaneously reduces the load on the spine.

2.2.3 EMG

Electromyography (EMG) is the recording of electrical changes occurring in the muscle during contraction. (Karpovich & Sinning 1971)

Rapidly fluctuating potentials exist within the tissues and on the surface of the skin when nerves activate their muscles. Needle electrodes into the tissue are a method of obtaining EMG but surface electrodes are more practical. The skin is sandpapered and conductive jelly applied. In occupational settings the period of analysis is typically relatively long (compared to clinical studies); this creates difficulties with the storage of the data. (Corlett 1990)

EMG reflects local muscle activity in the region of the electrodes. Equating EMG and mechanical force is common although erroneous; tight control of conditions can reveal a close relationship between the EMG and the physical performance (Grieve & Pheasant 1982). Andersson et al. (1980) found that the correlation with muscle force was good under highly controlled seated conditions. Some factors to control are: posture; temperature; use of muscle groups; location of the electrodes; and fatigue.

Electromyography does not provide a method of determining tension unless information on muscle length is also available; postural adjustments will alter the muscle length. There are also problems with detecting transition of activity from one fibre type to another and with changes that take place as the muscles fatigue. However EMG can monitor the onset of fatigue assess muscle back tension. (Troup & Edwards 1985; Corlett & Manenica 1980)

Bigland-Ritchie and Woods (1974) found that EMG, and oxygen uptake, both correlated well (linear) with submaximal force exerted on a bicycle ergometer.

Electromyography can detect fatigue (a state when the muscle is unable to continue to contract at a given force). EMG and muscular force are highly correlated, both in dynamic and static work. The correlation, once thought to be linear, appears exponential. Occupational EMG is a useful tool for determining which muscles a task places demands upon and to examine changes in the muscle activity over time. (Corlett 1990)

Chaffin and Andersson identify the following factors that affect the EMG to muscle force-levels relationship.

Some Common Factors Affecting Ratio of Myoelectric Activity to Muscle Force Levels

Measurement Factors	**General Effect of Ratio (EMG/Load)**
Large electrode	Increase
Close electrode proximity to muscle	Increase
High electrode impedance	Decrease
Surface electrode (versus indwelling)	Varied
Bipolar electrode (versus monopolar)	Varied
Bipolar electrode spacing increase	Varied
Physiological Factors	
Prolonged contraction	Increase
High muscle temperature	Decrease
Specific muscle tested	Varied
Highly strength trained muscle	Decrease
Muscle length	Varied
High speed of shortening	Increase

(from Chaffin & Andersson, 1984)

Chaffin and Andersson (1984) go on to say that the reason for measuring EMG is to determine muscle tension. The relationship between the two depend on several factors, some of which are above. The relationship does appear to generally positive, in that increasing EMG corresponds to increasing muscle tension. The main point is that under many circumstances the relationship is non-linear. The validity of the relationships under dynamic conditions is very uncertain. They also mention, as others have, that slight alterations in posture or motions will alter the force / muscle relationship.

While mentioning deficiencies of the method they recognise EMG use on many occasions to measure relative magnitude of muscle force in various activities.

Grandjean (1988) only goes as far as saying that an increase in EMG corresponds to an increase in force and that results are only valid for one set of electrodes in one particular setting.

Dul (1986) makes mention that several authors have expressed scepticism about the use of EMG in work involving non-isometric contractions. He, however quotes Bouisset as saying "it seems reasonable to envisage that in future it may be possible to use the value of instantaneous surface EMG signal as an indirect complex indication of the force developed by the muscle." That time is not yet here.

Khalil (1973) offer an electromyographic methodology for the evaluation of industrial design. He offers methodologies where EMG from groups of muscles combine to form an index of total muscular effort expended in an industrial task. The EMG positively correlates with muscular activity although the exact relationship is unclear and indeed variable.

The EMG parallels the muscular activity while the muscle contacts isometrically (not allowed to shorten).

Khalil (1973) presented a method known as the TIMA (Total Integrated Muscular Activity) method. The TIMA method involves measuring the EMG over an area of the body being examined. The numerical sum of activity over these muscles is serves as an indicator of the muscular effort expended in undertaking the task, overcoming the problem of migration of load between muscles due to postural change during the task. The method is more reliable with greater the number of muscles monitored.

Khalil (1973) found that under both static and dynamic conditions the TIMA was sensitive to changes in load time and rate of work.

Schultz et al (1982) considered expanding upon previous investigations that attempted to correlate the results of mathematical biomechanical predictions of forces with myoelectric activity. The 'improvement' that they made to the experiment was to investigate tasks that involved twisting and lateral bending of the trunk; closer to 'real world' postures.

They concluded that the biomechanical models available could predict the myoelectric activity moderately well, but not nearly as well as when the task includes only sagittally symmetrical tasks that tend to only flex the trunk. The explanation for this lies in the inadequacy of knowledge as to the recruitment of muscle groups as posture changes occur. Shearing involves much twisting and lateral bending.

2.2.3.1 Flexion, Relaxation and EMG

Schultz et al (1985) investigated the so-called flexion-relaxation phenomenon of the lower back.

They confirmed previous findings that myoelectric activity increased moderately with flexion. At 40^0 flexion the activity was beginning to exhibit the flexion-relaxation phenomenon and when the flexion reached the maximum the activity was actually much lower than in the upright posture.
The subjects performed a maximum upward pull with various degrees of flexion. Under these conditions the authors found that in all postures myoelectric activity increased compared to the no load state. That is, although the activity in the full flexed position was almost zero, it increased with application of external loads. However, the activity was still considerably lower than when the subject carried the same load in the upright position.

Thus, upon full flexion, contraction of the erector spinae muscles virtually ceases, this is despite the biomechanical models indicating a high force requirement; concluding that these forces transfer passively to ligaments.

But, load application causes contraction of the erectores spinae and further more the force/activity relationship is similar for all degrees of flexion.

A point to note here; despite the added load causing activity in proportion it does not construct a basis for comparison. Meaning that if one was to compare the loaded activity with the unloaded activity one would conclude that it was (almost) infinitely worse (due to the activity being near zero under no load) when this is improbable.

Lee, et al (1986), investigating isometric pushing and pulling tasks by biomechanical and electromyographic means, found some poor correlations between the two and explained this by interaction with other muscle groups and ligamentous contributions of a flexed torso. This comment is noteworthy as the experiments undertaken did not involve extreme flexion.

2.2.4 Other Methods

2.2.4.1 Subjective

Habes, Carlson and Badger (1985) measured fatigue during upper body work by various methods including perceived fatigue. The subjective measures that they used were the 'Feeling Tone Checklist' (from Pearson 1957, mentioned in Habes, Carlson & Badger

1985) and Borg's RPE scale. They found that the RPE was superior in terms of the subjects understanding of the terms, the invariability of understanding between the subjects and repeatability of the results.

2.2.4.2 Blood Pressure

Grandjean (1988) states that under physical work conditions blood pressure will rise.

Kilbom et al (1983) found blood pressure the measure best parallelling psychological responses. The exercise was submaximal (25% MVC) and static. EMG did not correlate well.

2.2.4.3 Posture measurement

2.2.4.3.1 OWAS

Karhu et al (1981) discuss the OWAS (Ovako Working Posture Analysing System) system of posture measurement. They use two examples to investigate the system. The examples tend to show that using the OWAS system can lead to 'improved' postures, actually showing an effect is difficult without a long term follow up study. In either case study of the shearers' Back Aids by this method may lead to the conclusion action is appropriate considering the undesirable postures, however the method will not be able to evaluate the intervention.

2.2.4.3.2 ARBAN

Holzmann (1982) presented the ARBAN method of posture analysis; it involves filming the work, coding frames of the film and subsequent evaluation. The system uses categories of the body to rate the 'ergonomic' stress. Ergonomic stress consists of: posture; dynamic and isometric muscle stress; and vibration and shock. The ratings follow the work of Borg. As with the OWAS system this may be useful for identifying shearing as 'ergonomically' unsuitable it does little to evaluate the intervention. There is some ability of the system to reflect a lowering of the muscle stresses.

2.2.4.3.3 Ariel

Ariel Life Systems (California) market the Ariel Performance Analysis System (APAS) for biomechanical analysis of human motion; the system uses input information from video, electromyography or force platforms. No reference to this system appears in the searched literature; I understand that it is relatively recent onto the market and there is currently only one in Australia (Ballarat University College).

2.2.4.3.4 RULA

McAtamney and Corlett presented The Rapid Upper Limb Assessment (RULA) technique (1992, in press).

RULA is a formalised method of identifying 'undesirable' postures. Such as: extreme flexion of the trunk or neck; side bending or twisting of the neck; extension of either the trunk or neck; arms outreached, above head height, extended, abducted, or working to the side or across the mid-line; raising of the shoulders; extension, flexion, side bending or twisting of the wrist; and unbalanced postures.

2.2.4.3.4 Biomechanical Models

The University of Michigan's two, and three, dimensional models determine the forces throughout the body using the forces applied at the hands (and also by default at the feet). The models have application in occupational task evaluation (Anderson & Chaffin 1984). Garg et al. (1980) used biomechanical modelling to explain the difference they noted between isometric and dynamic lifting capacity. The computerised models would have application to the shearing task if ability existed to apply a force at another location, that is, apply a force at the location of the 'Back Aid'. Without this feature it is difficult to see how these models would have any useful application in such a problem. Modelling by hand is possible (Fraser, et al. 1988) however the limited sophistication would yield largely predictable results.

2.2.4.4 Intra-abdominal Pressure

Davis (1981) detailed the use of intra-abdominal pressure as a measure of spinal stress and also conducted an experiment in its use.

He used a 'radio pill' to transmit pressure information from a transducer and concluded that the method may have clinical applications in discriminating back disorders.

There appears to be little consensus on the relevance of intra abdominal pressure in the analysis of the forces on the lumbar spine. Especially for shearers who maintain posture extended periods of time.

2.2.5 Previous Studies of the Warrie Back Aid

Fraser et al. (1988) investigated the effects on the lumbar spine of using the Back Aid.

Investigation involved kinematic analysis, electromyographic analysis and torque estimation.

The kinematic analysis involved viewing video of shearing at a particular point in the process and measuring the body angles at those points to detect differences posture when using the back against not using the Back Aid. Although they conclude that there are differences it is rather difficult to see this when looking at their data.

They measured EMG of the hamstring and erector spinae and found no significant difference between using the Back Aid to that found without. There seems to be little point repeating this type of experiment.

A load cell placed between the Back Aid and the ceiling measured the force applied by the Back Aid. Alternatively the extension of the spring could indicate the force.

The force measurements enabled calculation of the torque reduction about the lumbar region. Ormsby and Williams (nd) concluded similarly following calculations of torque about the hip.

Chapter Three

Literature Summary

3. Literature Summary

3.1 Why this project should be done

The use of the Back Aid is extensive (based on sales). While user support appears to be good there is little analytic information available to support the use of such an intervention in an occupation obvious as 'physically demanding'.

3.2 Previous studies

Two studies specifically investigated Back Aids; one of these used EMG. Fraser et al. (1988) used EMG and biomechanical modelling to evaluate use of the device versus non-use. The study concluded that use of the device lowers the torque about the lumbar spine but the EMG was insignificantly different.

The subject of EMG divides literary opinion; many researchers have said that the force / EMG relationship is linear for isometric, submaximal, work and uncertain beyond. However, many continued to use this method for other tasks; perhaps on the premise that any method was better than none some information would be useful providing interpretation of the results included limitations of the method.

3.3 Methods

It seems clear that 'whole body strain' indicators such as oxygen uptake or heart rate would be more appropriate measures for a task such as shearing (especially taking into account some of the problems with ligamentous force uptake in stooped postures). Given that in field measurements are to be studied, heart rate is more practical than oxygen uptake. The intrusion of wearing the heart rate measurement device upon the shearer would be minimal compared to the major inconvenience of the oxylog apparatus.

'Subjective' measures will supplement the 'objective' measure of heart rate. Two possibilities are; Borg's Rating of Perceived Exertion (Wilson & Corlett 1990) and Corlett and Bishop's Body Part Discomfort (Wilson & Corlett 1990). RPE is easier and quicker to record but its focus is on dynamic activity; shearing includes dynamic and static activity. Shearers place themselves under great time pressure and I do not believe the would appresiate coding the Body Part Discomfort system and hence would prefer the RPE system.

The method thus chosen for evaluation of the Back Aid is heart rate together with the RPE scale.

Chapter Four

Experimental Design

4. Experimental Design

4.1 Ideally...

The following would be ideal.

- A large sample of shearers.
- A sample of shearers representative of the population of shearers.
- A meaningful measure of the effect of the Back-Aid.
- Elimination of confounding factors during the measurement of the effect of the Back-Aid.

4.2 Discussion of the Ideals Above

4.2.1 A Large Sample

A large sample would be ideal. The problems with obtaining a large sample are as follows.

4.2.1.1 Time

Measuring the effect of the Back-Aid takes a whole day (from about 7am to 6pm). Three shearers at the one shed, if they were: willing; experienced; and able to shear without the Back Aid, could have been tested in one day. This was possible only once. Obviously with this type of experimental design it is not possible to measure, for example, thirty shearers.

4.2.1.2 Subject Availability

Shearers and the owners of the farm have to be willing to participate in the program. The testing takes place at a workplace, not in a laboratory, and subject to weather conditions. The testing involves a number of different workplaces throughout a regional area. The experimenter practically has to be present the whole day (certainly a large part of the day). These points reduce the ready availability of subjects and suitable convenient times to undertake the testing.

4.2.2 A Representative Sample

If this project were comparing the measured characteristics of a sample of a population with that of another population then it would be necessary to obtain a sample representative of that which it represents (!) This project is measuring the effect of an intervention where a single individual within the experimental sample is the control and also the experiment. The measurement does not depend upon a representative sample although the ability to extrapolate the results to the population certainly does.

What is an average shearer? A profile of the Australian shearing population does not appear to exist. If it did exist then one could form a representative sample; if those people were available. I suggest that a sample consisting primarily of males aged between twenty and fifty years of age would not be unrepresentative of the shearing population.

Christopher Culvenor approached shearers in the local area (Campbelltown, Victoria) and asked them to participate. Ideally subjects would be representative of the shearing population, however, a method of measuring subject's representativeness is unavailable (there appears no evidence supporting the claim that they are not representative).

4.2.3 A Meaningful Measure

The main purpose of the Back-Aid appears to be 'Back Aid' with particular reference to the spine. A measure of the aid given to the spine would be useful. Measurement of the intradiscal pressure is very difficult. Measurement of muscle force in the back is of little use due to ligamentous uptake of the force in a stooped posture. Measurement of force in ligaments is practically impossible. Physiological measures such as oxygen uptake and heart rate appear the only alternatives. Between these two, heart-rate is the only suitable one given the industrial setting and task. Shearers assessed themselves using a psychological method of assessment, Borg's Rating of Perceived Exertion.

4.2.4 Elimination of Confounding Factors

The aim is to measure the effect of the Back-Aid not the effect of something else such as: temperature; psychological stress; varying task demand, such as a different type of sheep; or a variation of heart rate over a run, or day, unrelated to the use or non-use of the Back-Aid.

Shearers removed the Back-Aid for a twenty minute period in each two hour 'run'. Thus similar conditions with respect to; temperature, task demands and psychological stress applied to the shearing with and without the Back-Aid.

The experimental design outlined in Figure 4.1, controls the effect of some inherent variation of heart rate over a day or a 'run' this compares to a design such as Figure 4.2 that would not control these factors as well.

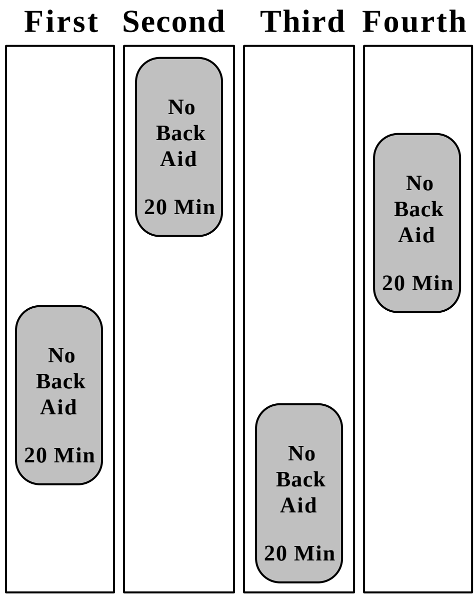

Figure 4.1 Experimental Design

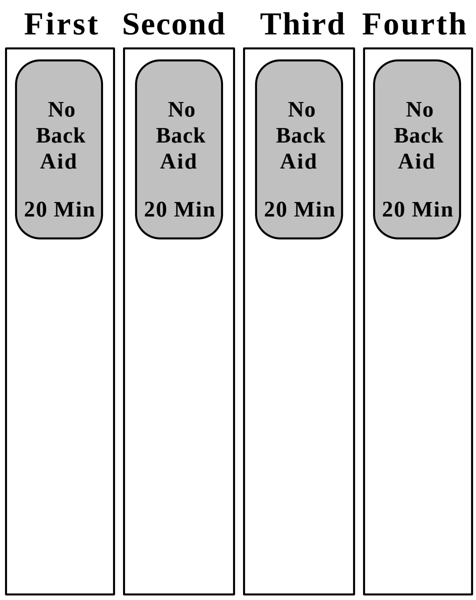

Figure 4.2 Alternative Design

4.3 Experimental Design

Figure 4.1, above, outlines the timing of the 'No Back Aid' periods.

4.3.1 Experiment and Control

Each shearer is to be an experiment and control. Each subject worked with, and without, a Back-Aid while being tested.

Some shearers shear most of the time with the Back-Aid while others use it off-and-on to a lesser extent. It seemed logical for the test to involve half the time using the Back-Aid and half not. This would have been possible with some shearers but not with others. Restricting the time without the Back-Aid to twenty minutes allowed the experiment to be the same for all subjects.

4.3.2 Measurement

Heart rate is the objective measure. The aim is to measure the effect of the Back-Aid. Raw heart rate data include the basal metabolic activity as well as the work. As a work strain measure Astrand and Rodahl (1986) suggest a method known as *Heart Rate Reserve;* they express the working heart rate as a percentage of the reserve.

Maximum Heart Rate:	M
Resting Heart Rate:	R
Working Heart Rate:	W
Reserve:	Res = M-R
Reserve Used:	Ru = (W-R)/Res

Grandjean (1988) proposed the *Working Pulse* as a measure of work strain.

Working Pulse: $Wp = W-R$

Astrand and Rodahl's measure takes into account a variety of maximum heart rates, which is useful for measuring the work strain on an individual, however the aim here is not to do that but rather to compare to working methods, in this light the two methods are the same. To compare an intervention to the control the 'before' divides the 'after'.

For example:

$Ru_{bef} = (W_{bef}-R)/Res$

$Ru_{aft} = (W_{aft}-R)/Res$

Effect $= Ru_{aft}/Ru_{bef}$

Effect $= (W_{aft}-R)/(W_{bef}-R)$

Using Granjean's (1988) *Working Pulse* this would be exactly the same, for example:

$Wp_{bef} = W_{bef}-R$

$Wp_{aft} = W_{aft}-R$

Effect $= (W_{aft}-R)/(W_{bef}-R)$

This result is as before, hence for comparisons of this type there is no purpose in knowing the subject's maximum heart rate. This would not be the case if the purpose were to compare the work load to the individual's capacity to perform it. There is some latitude available in the definition of *Resting Pulse* (Grandjean 1988); I suggest that for the purposes of a comparison or two work methods (rather than a workload assessment for an individual) that providing the same conditions apply to each subject the actual definition is not very important. In this case the definition will be *Resting Pulse: The pulse rate measured in the morning prior to work after one minute sitting* (there is not really time for more interruption to the subjects preparation to begin work). The same method will determine The *Resting RPE*.

Working Pulse or *Work Pulses* will form the basis of analysis. Use of *Work RPE* (that is RPE from rest similar to heart rate measured from the resting rate) seems reasonable if Borg's RPE correlates with heart rate, however there is no history of that process hence raw RPE will be the basis for analysis.

4.3.3 Measurement Tools

The methods used are heart-rate and Borg's RPE scale.

4.3.3.1 Heart Rate

A 'Polar Sport-Tester' measured and recorded the heart-rate. This device consists of an electrode and transmitter, wrist-watch receiver and recorder, down-loading interface and computer software.

4.3.3.1.1 Hardware

The electrode straps to the subject's chest, records ECG and transmits the signal to the wrist-watch recorder.

The wrist-watch receives the signal from the signal and displays the heart rate. The watch records the heart rate at a pre-set interval. A one minute interval allows sufficient memory to record the whole day's data.

The data from the watch downloads to a computer using an interface.

4.3.3.1.2 Software; POLAR

The POLAR software package, in conjunction with the interface, reads the data from the watch into an IBM compatible computer. Statistical measures of the data are easy to obtain, that is averages over any period and peaks.

4.3.3.2 Borg's RPE Scale

The form for the shearers to record their perceived exertion (Appendix A) incorporates Borg's RPE Scale (Wilson and Corlett 1990).

Chapter Five

Experiment Report

5. Experiment Report

Nine shearers participated in the study. Six of the subjects yielded complete information. Subject number one was willing to remove the Back Aid but was not suitable for inclusion as he would be very uncomfortable. Subject number two participated until the fourth run and then indicated he did not want to remove the Back Aid. Subject number four participated fully, however the Sport Tester stopwatch somehow stopped half way during the day (which I nor he noticed); hence that data was incomplete.

The six complete data are as follows (a copy also exist in Appendix B).

		Heart Rate			Work Pulses			Borg's RPE			Work RPE		
Subject	**Run**	**BA**	**No BA**	**Rest HR**	**BA**	**No BA**	**Change**	**BA**	**No BA**	**Rest RPE**	**BA**	**No BA**	**Change**
3	1	110	111	70	40	41	3%	12	13	9	3	4	33%
	2	112	110	70	42	40	-5%	11	9	9	2	0	-100%
	3	113	112	70	43	42	-2%	8	8	9	-1	-1	0%
	4	118	126	70	48	56	17%	11	13	9	2	4	100%
5	1	104	109	54	50	55	10%	11	13	8	3	5	67%
	2	108	118	54	54	64	19%	15	13	8	7	5	-29%
	3	109	118	54	55	64	16%	14	17	8	6	9	50%
	4	118	130	54	64	76	19%	16	17	8	8	9	13%
6	1	104	110	60	44	50	14%	10	12	6	4	6	50%
	2	117	110	60	57	50	-12%	12	12	6	6	6	0%
	3	119	124	60	59	64	8%	12	13	6	6	7	17%
	4	104	120	60	44	60	36%	12	12	6	6	6	0%
7	1	117	125	70	47	55	17%	9	10	7	2	3	50%
	2	119	116	70	49	46	-6%	9	10	7	2	3	50%
	3	138	137	70	68	67	-1%	12	13	7	5	6	20%
	4	142	141	70	72	71	-1%	12	13	7	5	6	20%
8	1	103	106	75	28	31	11%	11	12	8	3	4	33%
	2	107	99	75	32	24	-25%	12	12	8	4	4	0%
	3	95	103	75	20	28	40%	12	13	8	4	5	25%
	4	109	124	75	34	49	44%	15	16	8	7	8	14%
9	1	103	102	83	20	19	-5%	13	13	8	5	5	0%
	2	101	106	83	18	23	28%	12	11	8	4	3	-25%
	3	93	103	83	10	20	100%	12	14	8	4	6	50%
	4	100	104	83	17	21	24%	12	14	8	4	6	50%
		BA	**No BA**	**Rest HR**	**BA**	**No BA**	**Change**	**BA**	**No BA**	**Rest RPE**	**BA**	**No BA**	**Change**
Means →		111	115	69	42	47	14%	12	13	8	4	5	20%

Table 5.1 All Complete Data

Chapter Six

Data Analysis and Discussion

6. Data Analysis

Analysis of the data is in separate sections, the first and perhaps the most meaningful is the analysis of each run separately. Please find the full data presentation in Appendix B.

6.1 Individual Runs (PTO)

See Tables 6.1.1 to 6.1.4, Appendix B for full data presentation.

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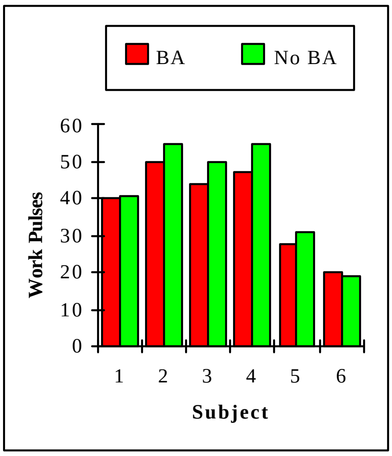
6.1.1 Run Number One

The 'No Back Aid' period of twenty minutes was during the first run nearer the end than the beginning.

6.1.1.1 Work Pulses - Data and Test

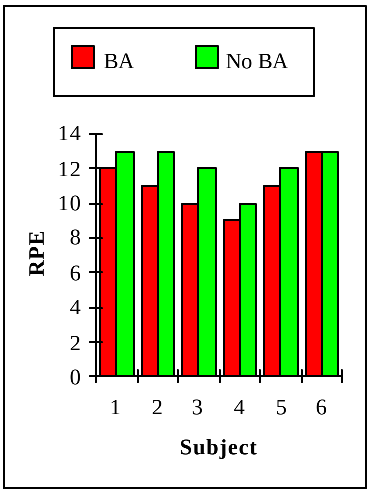


t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	38.17	41.83
Variance	137.77	210.57
Observations	6	6
df	5	
t	-2.70	
P(T<=t) one-tail	0.02	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.1.1.2 RPE - Data and Test



t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	11.00	12.17
Variance	2.00	1.37
Observations	6	6
df	5	
t	-3.80	
P(T<=t) one-tail	0.01	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.1.1.3 Discussion

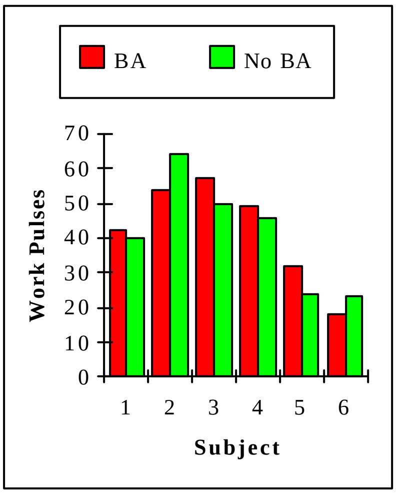
The means of the shearers shows a difference in the work pulses of about three and a half work pulses (about ten percent) and about one RPE point (about ten percent also) between the Back Aid and No Back Aid conditions.

Statistical analysis (at 5%) of both the work pulses and the raw RPE rejected the null hypothesis that the conditions are the same.

6.1.2 Run Number Two

The 'No Back Aid' period was at the very beginning of the run.

6.1.2.1 Work Pulses - Data and Test

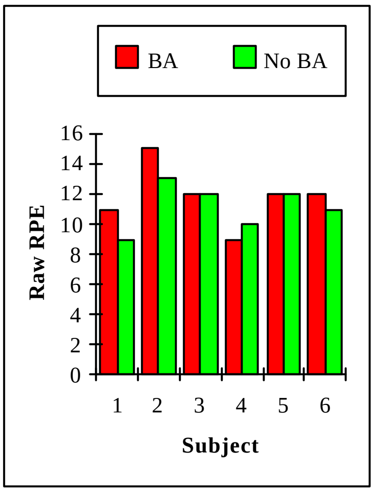


t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	42.00	41.17
Variance	218.80	249.77
Observations	6	6
df	5	
t	0.29	
P(T<=t) one-tail	0.39	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Do Not Reject Null Hypothesis

6.1.2.2 RPE - Data and Test



t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	11.83	11.17
Variance	3.77	2.17
Observations	6	6
df	5	
t	1.35	
P(T<=t) one-tail	0.12	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Do Not Reject Null Hypothesis

6.1.2.3 Discussions

The means of the shearers shows a difference in the work pulses of about negative one pulse (about negative two and a half percent) and negative one half of an RPE point (about negative five percent) between the Back Aid and No Back Aid conditions. Statistical analysis (at 5%) of both the work pulses and the raw RPE did not reject the null hypothesis that the conditions are the same (fairly obviously since the data exhibits an opposite direction to that expected for the one tail test).

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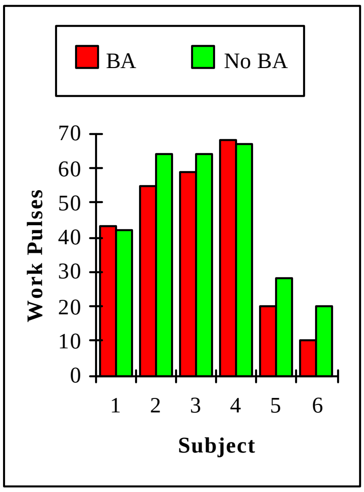
6.1.3 Run Number Three

The 'No Back Aid' period was at the very end of the third run.

6.1.3.1 Work Pulses - Data and Test

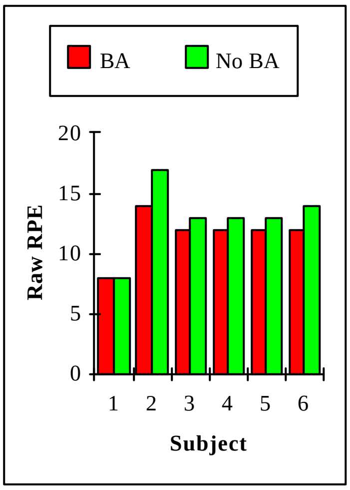


t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	42.50	47.50
Variance	528.30	418.30
Observations	6	6
df	5	
t	-2.48	
P(T<=t) one-tail	0.03	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude:Reject Null Hypothesis

6.1.3.2 RPE - Data and Test



t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	11.67	13.00
Variance	3.87	8.40
Observations	6	6
df	5	
t	-3.16	
P(T<=t) one-tail	0.01	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude:Reject Null Hypothesis

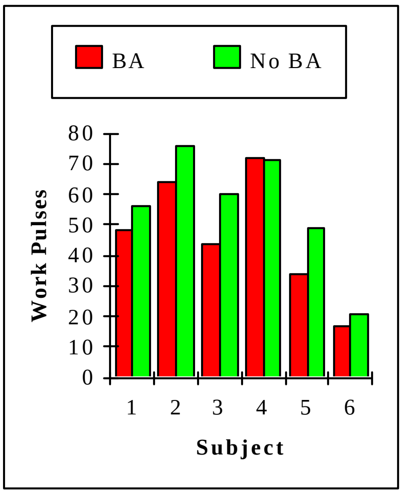
6.1.3.3 Discussion

The means of the shearers shows a difference in the work pulses of five work pulses (about ten percent) and about one and a half RPE points (about ten percent also) between the Back Aid and No Back Aid conditions. Statistical analysis (at 5%) of both the work pulses and the raw RPE rejected the null hypothesis that the conditions are the same.

6.1.4 Run Number Four

The 'No Back Aid' period was during the fourth run nearer the beginning than the end.

6.1.4.1 Work Pulses - Data and Test

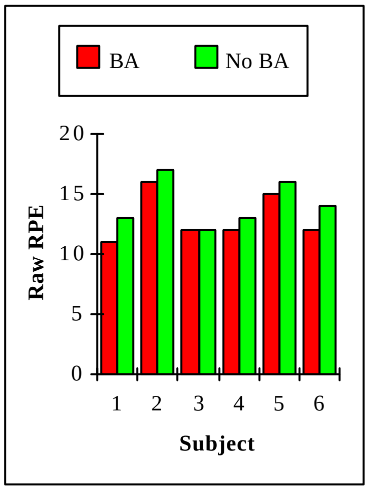


t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	46.50	55.50
Variance	398.30	382.70
Observations	6	6
df	5	
t	-3.32	
P(T<=t) one-tail	0.01	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.1.4.2 RPE - Data and Test



t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	13	14.1667
Variance	4	3.76667
Observations	6	6
df	5	
t	-3.7963	
P(T<=t) one-tail	0.00634	
t Critical one-tail	2.01505	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.1.4.3 Discussion

The means of the shearers shows a difference in the work pulses of nine work pulses (about twenty percent) and about one RPE point (about ten percent) between the Back Aid and No Back Aid conditions. Statistical analysis (at 5%) of both the work pulses and the raw RPE rejected the null hypothesis that the conditions are the same.

6.1.5 Discussion

Statistical analysis of three of the four runs rejected the hypothesis that the conditions are the same. These three runs compared the work pulses and RPE of shearing without the Back Aid for twenty minutes some time during or at the end of a run with shearing with the Back Aid for the remainder of the time. One could claim that the work pulses increase over the run and thus measurement of No Back Aid near the end of the run will yield a difference. This is the reason for the different sample times. Although different sample times made an analysis of variance to test all the data meaningless it did allow reasonable certainty that a measured effect was a true effect rather than an underlying trend caused by something else.

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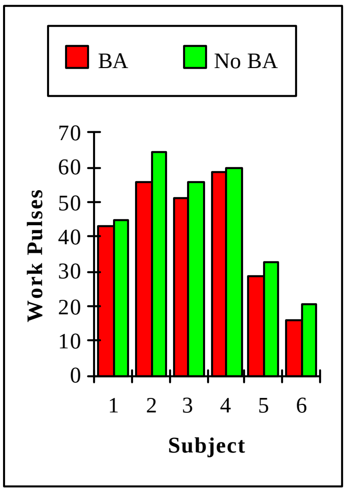
6.2 The Whole Day

6.2.1 By Subject (Table 6.2.1, Appendix B)

6.2.1.1 Work Pulses - Data and Test

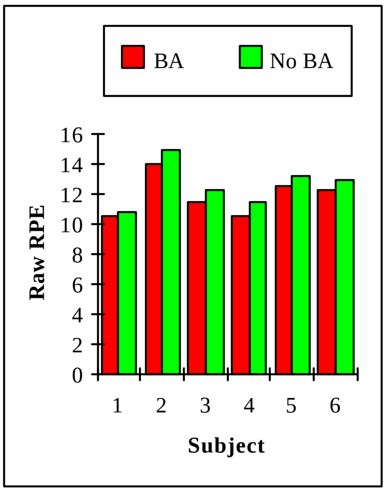


t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	42.29	46.50
Variance	281.09	289.45
Observations	6	6
df	5	
t	-3.51	
P(T<=t) one-tail	0.01	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.2.1.2 RPE - Data and Test



t-Test: Paired Two-Sample for Means

	BA	*No BA*
Mean	11.88	12.63
Variance	1.79	2.22
Observations	6	6
df	5	
t	-6.71	
P(T<=t) one-tail	0.00	
t Critical one-tail	2.02	

Ho: BA = No BA
H1: BA < No BA
Conclude: Reject Null Hypothesis

6.2.1.3 Discussion

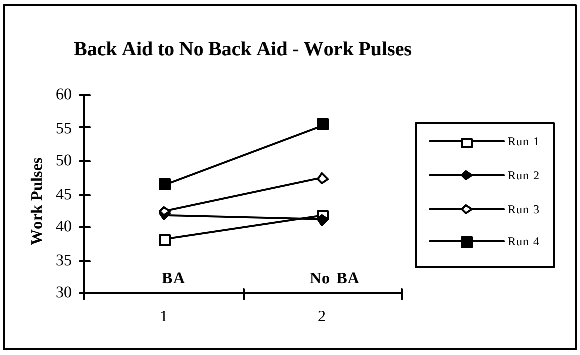
Each sample combines a subject's four runs. The result is a difference in the mean work pulses of about four (about ten percent) and a difference of about one RPE point (just less than ten percent). The t-test (at 5%) rejects the null hypothesis for both the work pulses and the RPE that the conditions are the same.

6.2.2 By Run (Table 6.2.2, Appendix B)

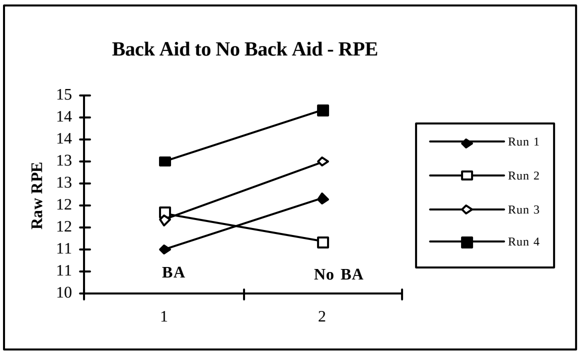
Figures for each run are the mean of data from each subject. A statistical test on the is data is not meaningful however the graphical presentation yields some information.

Run numbers One, Three and Four exhibit a 'parallel' tendency indicating much the same change in condition from the Back Aid to the No Back Aid. An increase in heart rate and RPE over the day causes the vertical separation of the lines. Run two, however, is quite different the effect of the Back Aid is near to nothing (a slight worsening of condition).

6.2.2.1 Work Pulses - Data



6.2.2.2 RPE - Data



6.2.3 Discussion

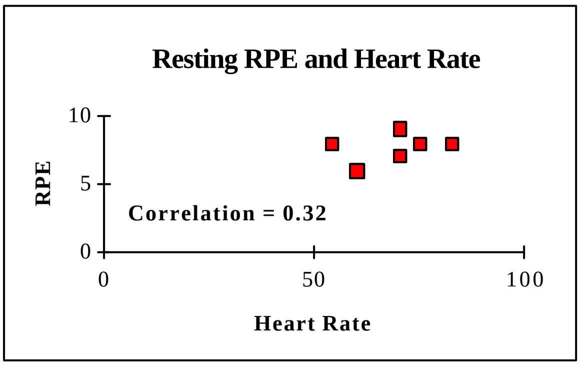
Over the whole day there appears an advantage in using the Back Aid. There appears little difference in the effect of the Back Aid in relation to different runs. Three runs recorded much the same effect even though the removal of the Back Aid occurred at different times (twice during the run and once right at the end). Removing the Back Aid at the beginning of the run resulted in that period recording similar work pulses and RPE as the remainder. Whether there is an increase in heart rate over duration of a run is matter of speculation; raw heart rate profiles (not presented) tended to support this claim for some subjects and not for others.

6.3 Correlation Between Heart Rate and RPE

See Table 6.3, Appendix B.

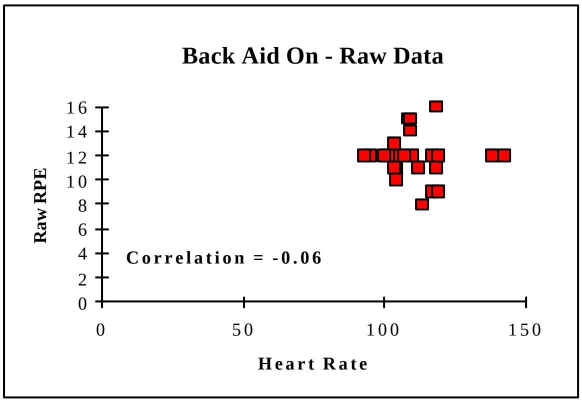
Correlation figures for the subjects while at rest and shearing with and without the Back Aid based on raw heart rate and RPE and the heart rate and RPE measured from rest. None of the relationships correlate well. The correlation figures range between -0.06 to 0.38.

6.3.1 Correlation at Rest

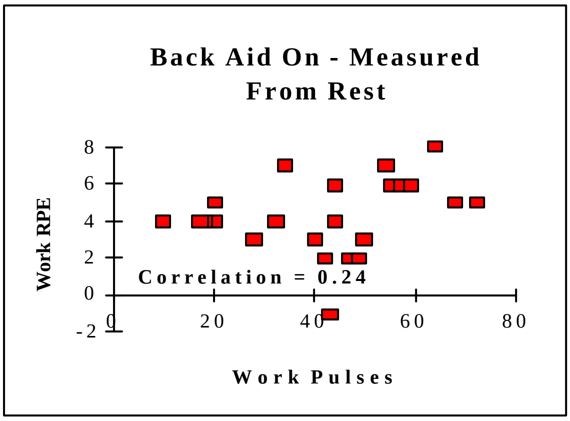


6.3.2 Correlation While using the Back Aid

6.3.2.1 Raw Heart Rate and RPE

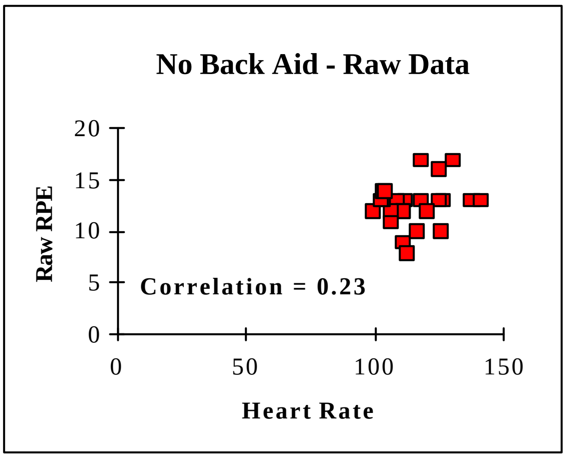


6.3.2.2 Work Pulses and RPE from Rest

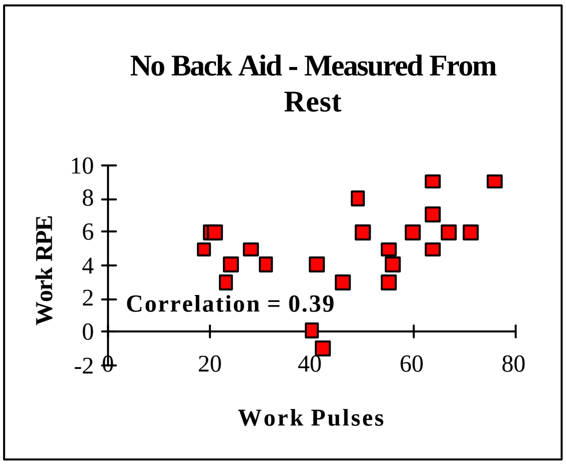


6.3.3 Correlation While not using the Back Aid

6.3.3.1 Raw Heart Rate and RPE



6.3.3.2 Work Pulses and RPE from Rest



6.3.4 Discussion

The correlations are poor. The reporting form was as simple and least time consuming as possible because the number of sheep shorn determines the shearer's income (time is money). The RPE recording only took place at the end of a run or at the removal or replacement of the Back Aid. RPE estimated exertion over a time ranging from twenty to one hundred minutes while the heart rate recorded continuously. It would be unreasonable to say that RPE and heart rate do not correlate well in other circumstances.

6.4 Questionnaire

The shearers filled out a questionnaire; see questionnaire, Appendix A.

Subject	1	2	3	4	5	6	7	8	9	Mean
Days shearing last year	80	55	140	120	180	50	120	85	125	106
% of time using Back Aid	75%	100%	0%	100%	50%	25%	100%	50%	80%	64%
Why Use a Warrie Back Aid										
PainRelief	50%	100%	25%	75%	50%	50%	100%	100%	50%	67%
Injury Prevention	50%	0%	0%	75%	100%	75%	50%	25%	50%	47%
It seems like a good idea	50%	100%	25%	50%	75%	50%	100%	0%	25%	53%
Comfort	75%	75%	25%	100%	25%	25%	75%	0%	50%	50%
Advice from other shearers	0%	50%	50%	50%	0%	25%	50%	25%	0%	28%
Advice from a medical practitioner	0%	0%	25%	75%	0%	50%	0%	0%	0%	17%
Are you dependant on the WBA?	25%	100%	50%	75%	0%	25%	75%	25%	25%	44%
The Effects of the Warrie Back Aid										
Back Health	0%	50%	0%	100%	50%	50%	100%	50%	50%	50%
Tiredness	50%	50%	0%	100%	50%	0%	50%	50%	50%	44%
Shearing Speed	0%	0%	50%	50%	50%	-50%	0%	0%	0%	11%
Ability to control the sheep	0%	0%	0%	0%	-50%	-50%	50%	0%	0%	-6%
Finished quality (sheep and fleece)	0%	0%	50%	0%	0%	0%	50%	0%	0%	11%
Comfort	50%	50%	50%	50%	-50%	50%	50%	50%	-50%	28%

0%	**Not at all Important**
25%	**Slightly or Sometimes Important**
50%	**Moderately Important**
75%	**Very Important**
100%	**Extremely Important**

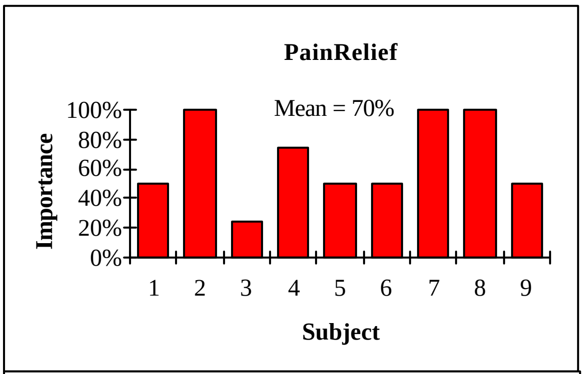
-100%	**Extremely Worse**
-50%	**Moderately Worse**
0%	**No Change**
50%	**Moderately Improved**
100%	**Extremely Improved**

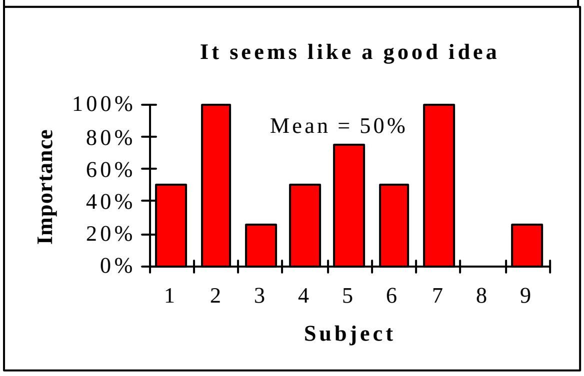
Table 6.4.1 Questionnaire Data

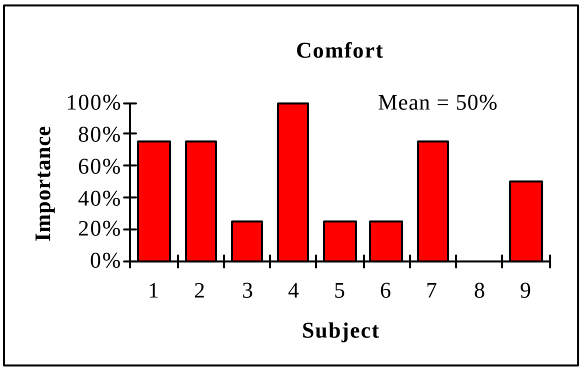
6.4.1 Why Use a Back Aid

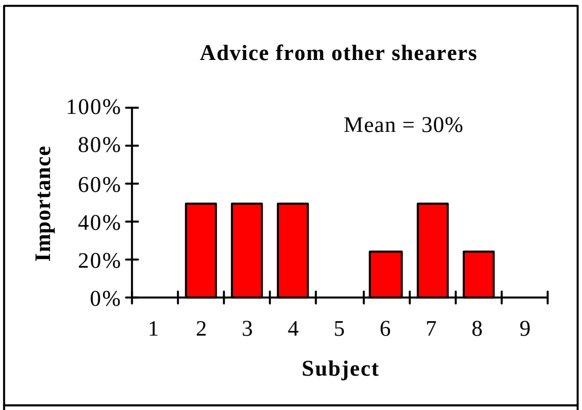
The results of the questionnaire are outlined in Table 6.4.1, above, and presented graphically as follows.

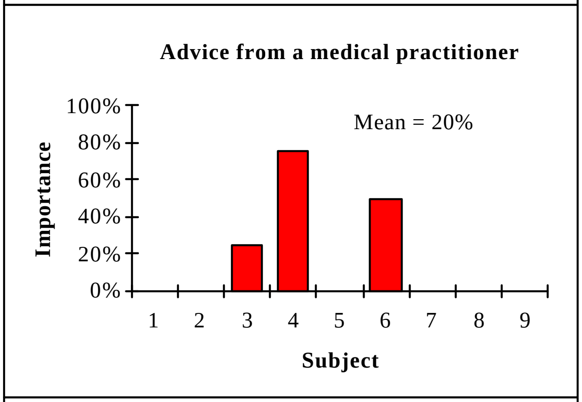
6.4.1.1 Individual Reasons

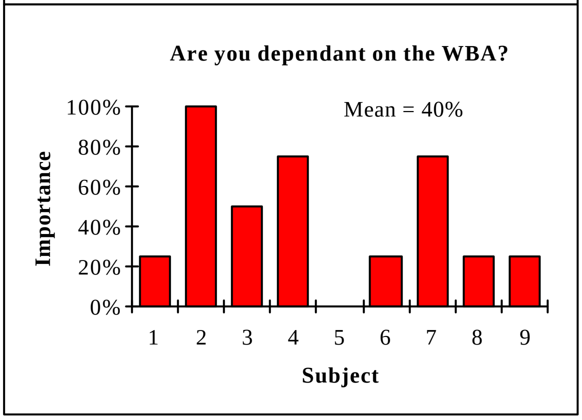




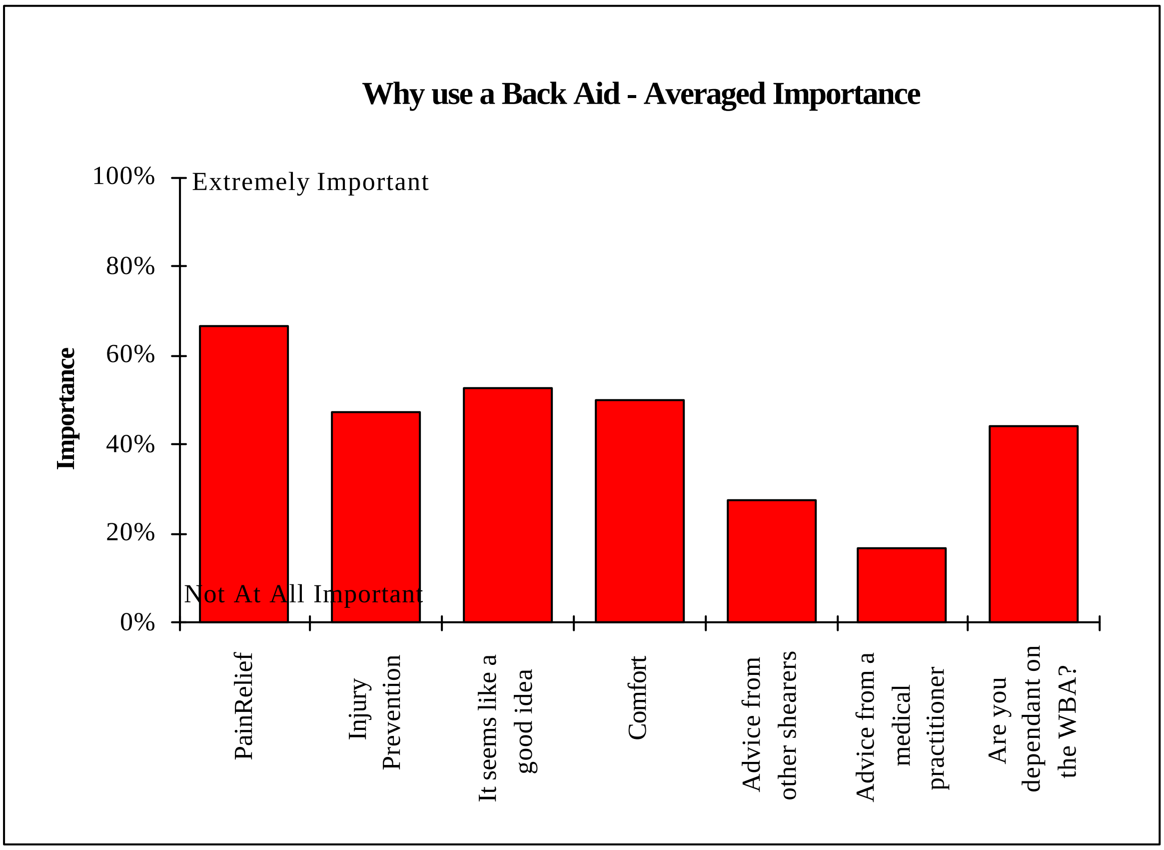








6.4.1.2 Averaged Reasons



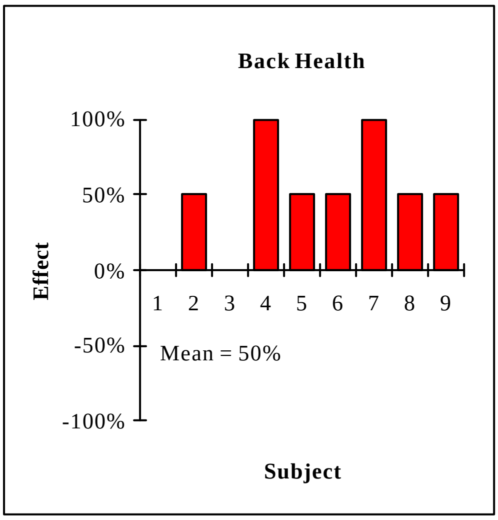
6.4.1.3 Discussion

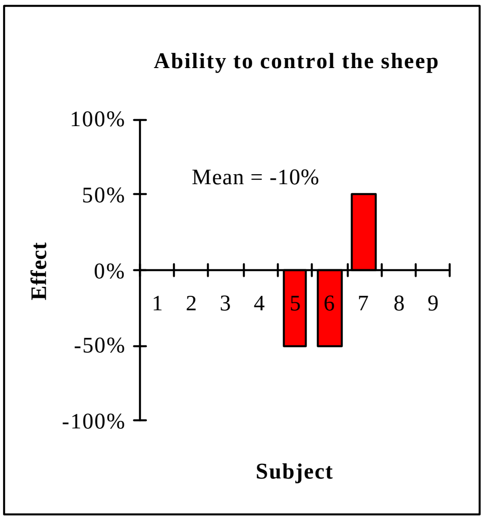
The questionnaire asked the subjects to rate their reasons for using the Back Aid. The most important reason is *Pain Relief.* Fifty percent (see above) equates to the response 'Moderately Important'. The reasons that approximately equal this are; *It Seems Like a Good Idea* and *Comfort*. *Injury Prevention* and *Dependence on the Back Aid* rate slightly below the 'Moderately Important' level while *Advice from other shearers or from medical practitioners* is not really important at all.

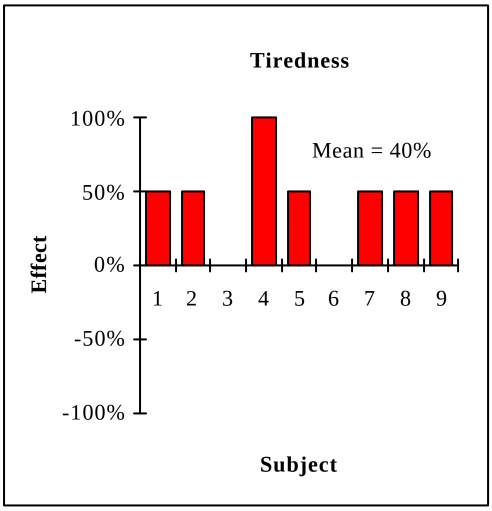
Some other questions such as experience and number of days spent shearing in the past year; these served only as a check on the experience and 'professionalism' of the sample. Note; one subject claimed not to use the Back Aid at all suggesting a lack of experience; this is not so but he has now ceased to use the Back Aid.

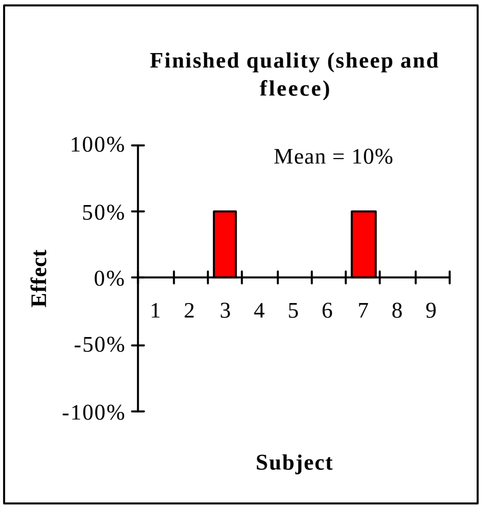
6.4.2 Effects of the Back Aid

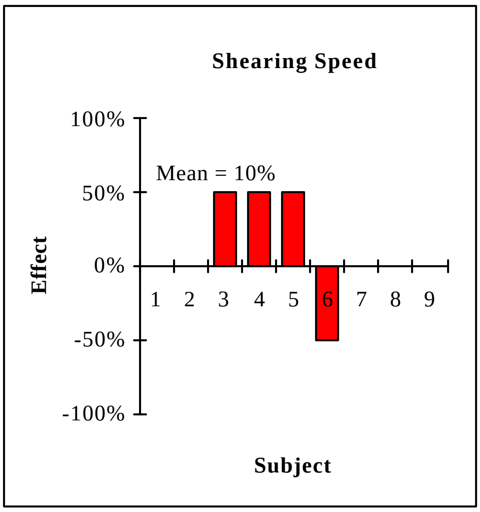
6.4.2.1 Individual Reasons

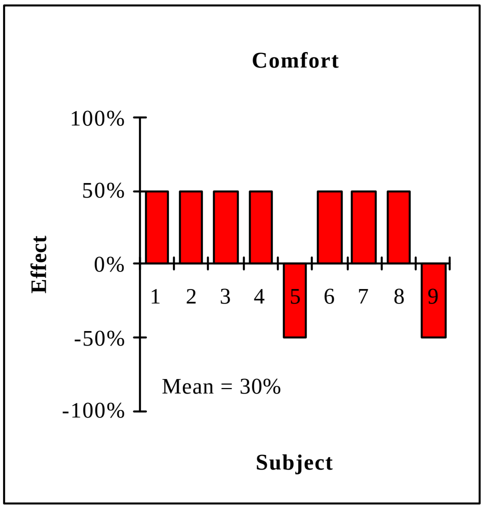




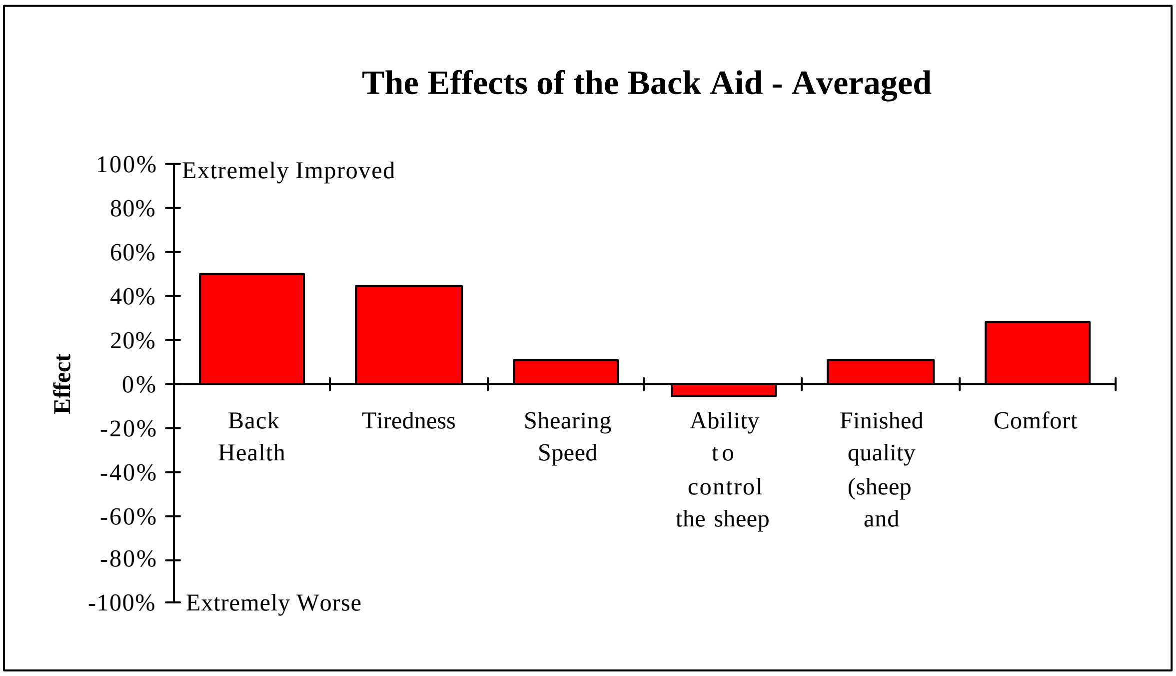








6.4.2.2 Effects of the Back Aid - Averaged



6.4.2.3 Discussion

The subjects rated the effect of the Back Aid on a scale from 'Extremely Worse' to 'Extremely Improved'. The positive effects reported are; *Back Health* and *Tiredness*. Subjects reported minor improvement in comfort and little or no change in *Shearing Speed*, *Ability to Control the Sheep* or the *Finished Quality*.

6.4.3 Discussion

Relief of pain and injury prevention are the main reasons for using a Back Aid while improving the health of the back and reducing tiredness are the main effects.

Chapter Seven

Discussion

7. Discussion

The Analysis section includes the discussion where suitable. Discussion material better suited to a separate section follows.

7.1 Arranging Workplaces and Subjects

The project ran relatively smoothly (although timed somewhat later than expected due to the seasonal conditions); thanks in great part to the help Christopher Culvenor provided by arranging the subjects and workplaces. I also knew most of the owners and shearers. It is very helpful to have someone 'inside' the industry (or where ever the project is taking place) on side and available to help explain the project and encourage participants. I believe the project would have been very difficult if I did not know and of the people involved and worse still if there was no one available to arrange the subjects.

7.2 Technical Issues

On one occasion the Sport-Tester ceased recording while still displaying the heart rate; about half a day's data was lost as no one noticed. The button on the stop-watch most probably became pressed. Closer observation of the stop-watches followed; no problems occurred. To prevent this type of occurrence I wonder if a system whereby pressing two, rather than one, buttons would stop recording would be a good idea?

One transmitter ceased to operate as one day had just ended (fortunately no half way through); it appears this is due to a flat battery. It would be wise to have a spare battery on hand when undertaking field work. Two shearers instead of a possible three took part on the last day; an opportunity lost.

Interference occurred on a number of occasions when the subjects were close to each other; fortunately this was only at break times.

From previous experience with the equipment I knew that two stroke engines interfere extremely with the transmission. There appeared no problem with the equipment in the shearing sheds. The equipment operates on two, and three, phase electric power.

Once the data is downloaded to the computer the time displayed is 'stop-watch' time; thus it is critical to record the time of starting the stop-watch so as to be able to relate the stop watch time with real time. If relation to real time is important I strongly advise starting the stop watch on the hour (not possible since a signal must be present for the stop watch to operate and the shearers' case as they were not in the shed until after 7am and must begin at 7:30) or at least on the half hour (what I did). Even starting on the half hour make the time conversion confusing. I suggest that the manufacturers alter the system such that both real time and stop-watch time are available on the computer (this would appear relatively simple).

7.3 Methodology

The 'No Back Aid' times varied accross the four runs. This was to avoid detecting a change in the conditions that was actually due to some other cyclic effect. This was successul in that three different times of removal yielded similar effects; it was not successful in that analysis of variance of the day as a whole was not possible due to the variation in No Back Aid Times. The change in effect from the beginning of the day to the end could be tested by a design which measured the No Back Aid condition at the same time each run. I do believe that measuring the effect was more important.

7.4 Correlation Between Heart Rate and Borg's RPE

Measurement of the correlation between heart rate and Borg's RPE was a side issue and not tested properly. Correlations between heart rate recorded every one minute and RPE recordings that represent a lengthy time (between twenty and one-hundred minutes) can not lead to definitive conclusions; a more frequent recording of RPE would have impinged too greatly on the subjects work. One could design a far more suitable experiment if the aim were to correlate the two measures.

7.5 The Effect

The effect of the Back Aid on the work pulses and the RPE appears to be about ten percent. A worthwhile change considering that the shearers are working at about forty pulses per minute above their resting rate compared to Grandjean's (1988) recommendation of thirty-five. Although the project aimed to determine the effects of the Back Aid rather than evaluate shearing as an occupation it is worth noting that the working heart rates are above that recommended by Grandjean (1988). The weather during all the tests was mild, or even cool. Without having measured the atmospheric conditions it suffices to say that frequently significantly less favourable thermal conditions prevail during which the heart rates will elevate further.

7.6 Improvements

Lower price was the only improvement suggested. The variability of tension in spring is an issue I believe is of concern. There could be simple changes to the design to allow adjustable but constant tension. Given the large proportion of shearers using the Back Aid, it may be possible to build the constant tension device into workplace.

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Telephone 053-27-9154 Facsimile 053-27-9151: 12 June, 2000

Chapter Eight

Conclusions and Recommendations

8. Conclusions and Recommendations

8.1 Conclusions

8.1.1 The Potential Beneficial Effects of the Back Aid

The effect of the Back Aid in the study was to reduce the working heart rate and the perceived exertion; that is, the internal response or work strain.

This may indicate a lower level of muscle activity as a result of lower external demands or work load. Much of the reduced muscle activity may be in the back and as a consequence one could conclude that the load on the spine is somewhat lower. The potential benefit of a reduced load on the spine is a reduced risk of injury and ill health.

The questionnaire revealed that in the shearers' opinions the beneficial effect is to improve the health of the back and to reduce tiredness.

8.1.2 The Potential Adverse Effects of using the Back Aid

Individually some shearers rated some of the effects as adverse, however, overall this was not the case. This is not to say that no adverse effects exist, only that this study did not identify any outstanding adverse effects.

8.2 Recommendations

A study of six (effectively since three did not yield complete data) is insufficient to make definitive statements. However, while the study does not substantiate the opinion that the Back Aid is beneficial, it does offer support to the claim.

Based on this project I recommend shearers consider use of the Warrie Back Aid. I recommend continuing use be based upon the individual's opinion and individual professional advice.

Appendices

Appendix A
Reporting Form and Questionnaire

Appendix B
Data Presentation

Acknowledgements

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Dr Owen Evans for supervising this project. Ms Elizabeth Pratt for assisting with the practical aspects of the project. Mr Warren Payne for assisting with equipment. Ms Lyn Roberts for assisting with statistics. Mr Christopher Culvenor for arranging the workplaces and subjects for the project.

Thankyou to the kind people who volunteered to take part in the project who must remain anonymous and thankyou to those who allowed the project in their premises who must also remain anonymous.

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