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THE IMPACT OF SPIKED BOOTS ON THE SAFETY, WORKLOAD AND PRODUCTIVITY OF BREAKING OUT

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Figure 1 - Breakerouts working in the study area

ABSTRACT

A study was undertaken to determine the effect of wearing spiked boots on the safety, productivity and physiological workload of a breakerout who was part of a highlead Skagit hauler operation.

Results showed that the wearing of spiked boots resulted in a significant reduction in slipping hazards with no detrimental effect to productivity or physiological workload.

INTRODUCTION

Analysis of the LIRO Accident Reporting Scheme reveals that breakerouts receive a significant proportion of slip, trip and fall lost time injuries. Such injuries accounted for 14.5% (46) of all breakerout lost time injuries from 1985 to 1992, with the average number of days lost being 9.4 days.

Previous research has shown that the wearing of spiked boots by fallers significantly increased their safety without decreasing productivity or increasing the physiological workload of the worker (Kirk & Parker, 1992a, 1992b).

As part of a product development trial involving LIRO, Tasman Forestry Limited (Bay of Plenty District) and New Zealand Safety Limited, the opportunity arose to evaluate the impact of spiked boots on a breakerout operating in a hauler crew. Although only involving one breakerout, this study presented a valuable opportunity to investigate the impacts on the breakerout of wearing spiked boots in terms of safety, productivity and workload. The value of such a case study was reinforced by the fact that previous spiked boot research had centred on fallers.

ACKNOWLEDGMENTS

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STUDY AREA

The study occurred in Compartment 60/1 of Tarawera Forest. The prime extraction machine was a Skagit SJ7 hauler, working in conjunction with a Cat 518 skidder, operating a two stage extraction system from the hauler to the landing. The terrain consisted of steep short faces, covered by heavy slash and containing a high degree of windblow. The breakerout was 19 years old and normally worked as head breakerout for the operation.

STUDY METHOD

Project Design

	Day 1	Day 2	Day 3	Day 4
AM	Spikes	No Spikes	Spikes	No Spikes
PM	No Spikes	Spikes	No Spikes	Spikes

Table 1 - Study design

The study used a split-day design in order to reduce the influence of temperature and slope variations on heart rate throughout the day. This meant that the subject wore both normal and spiked boots during the same day, changing boots exactly halfway through the working day. The following day the reverse arrangement was used (Table 1). This method made it possible to identify slope and temperature effects and account for their influences during data analysis. This design also enabled a replication of the study as day 1 and 2 were later replicated in days 3 and 4. This allowed the comparison of results of days 1 and 2 to those of days 3 and 4, to see if they were caused by the spiked boots, or occurred purely by chance.

Worker Productivity and Safety

As in previous studies (Kirk & Parker 1992a, 1992b), the breakerout's work cycle was broken down into twelve elements and recorded using a continuous time study method. As the terrain for all four days of data collection was comparable, any significant increase/decrease in work element times could be attributed to the wearing of spiked boots. The number of times the breakerout slipped, tripped or fell on each morning and afternoon session was also recorded.

Physiological Workload

Heart rate data was used to estimate the physiological workload of the breakerout during each session of each day (Åstrand & Rodahl, 1977). The breakerout's heart rate was recorded at fifteen second intervals using a Polar Electro Sport Tester PE 3000 portable heart rate monitor. At the same time, the breakerout's activities such as walk in, strop up, walk out, etc. were also recorded at the same fifteen second interval using activity sampling methods. These two sets of information were then merged together in a spreadsheet format and average heart rates for each session's work elements were calculated.

Since high temperatures increase both workload and heart rate (Rodahl, 1989), ambient temperature data was collected on the cutover and the wet bulb globe temperatures (WBGT) calculated for each session. This data enabled accurate workload comparisons to be made between each session.

RESULTS AND DISCUSSION

Productivity and Safety

Analysis of the data shown in Table 2 revealed that by using the split-day design, day 1 could be compared against day 2, and day 3 against day 4. Ground slopes for each individual session were similar as were temperatures. Consequently, heart rate comparisons between each session could be more reliably undertaken. Unfortunately, day 4's heart rate data was influenced when the breakerout became ill and was not representative of the study as a whole. Therefore, no valid heart rate comparisons could be made for day 4.

As with previous spiked boot research, a significant reduction ($p<0.05$) in the number of slips was observed when spiked boots were worn (Table 3). Statistical analysis of trips and falls though showed no significant difference ($p<0.05$) between spiked and normal boots.

The productivity of the breakerout was unaltered by the wearing of spiked boots, with the productive work element times showing no significant change ($p<0.05$). This can be attributed to the self-pacing mechanism present in all human bodies which compensates for any external influences affecting a person's workload (Levine et al, 1982, Myles et al, 1979). For instance, while the breakerout may initially work faster due to the spiked boots, the increase in workload associated with this faster work will prompt the self-

Element		Day 1	Day 2	▿	Day 3	Day 4	▿
Slope (Degrees) (± S.E.)	AM	28 (2.1)	29 (1.9)	NO	27 (1.0)	26 (1.0)	NO
	PM	23 (1.9)	19 (0.9)	NO	30 (1.4)	23 (0.7)	YES
Temperature °C (± S.E.)	AM	17 (3.6)	14 (2.5)	NO	15 (1.3)	15 (2.0)	NO
	PM	22 (3.7)	18 (1.2)	YES	16 (1.5)	18 (1.1)	NO
Heart Rate (beats/minute) (± S.E.)	AM	114 (3.7)	117 (4.1)	NO	107 (2.8)	117 (2.9)	YES
	PM	117 (0.5)	116 (3.4)	NO	112 (3.5)	120 (3.5)	YES

▿ = significant difference (95% Level)

Table 2 - Mean slope, temperature and heart rate values

	Day 1	Day 2	Day 3	Day 4
AM	Spikes Slips = 5 Trips = 1 Falls = 1	No Spikes Slips = 17 Trips = 0 Falls = 1	Spikes Slips = 2 Trips = 2 Falls = 1	No Spikes Slips = 14 Trip = 1 Falls = 0
PM	No Spikes Slips = 12 Trips = 0 Falls = 1	Spikes Slips = 2 Trips = 1 Falls = 0	No Spikes Slips = 7 Trips = 1 Falls = 0	Spikes Slips = 3 Trips = 1 Falls =0

Table 3 - Slips, trips and falls per four hour work period

pacing mechanism into action. This, in turn, slows the body down back to its regular sustainable working pace.

Physiological Workload

In order for a person to carry out heavy physical work, oxygen is needed to transform the chemicals contained in food eaten into energy. If the body can obtain enough oxygen from breathing to meet its energy demands, the person is said to be operating within their aerobic limit. When breathing cannot supply all the required oxygen, such as during very heavy work, the process becomes anaerobic. That is, an oxygen debt situation develops within the body, which rapidly induces muscle fatigue. Therefore, workers in such situations cannot work at this level for long periods of time.

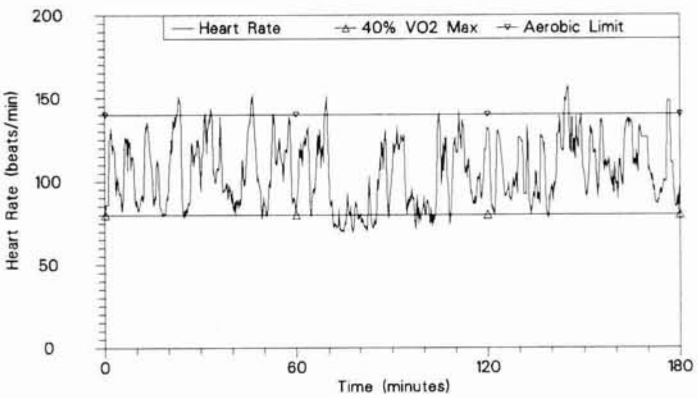

Figure 2 - Breakerout heart rate distribution - three hour morning work period

The ability to be able to convert oxygen into energy is called maximal oxygen uptake (VO_2 max). If a person works at a rate equal to 40% VO_2 max, they will be able to work at that rate all day without becoming fatigued (Åstrand & Rodahl, 1977). Ideally, a worker should work at or below this 40% VO_2 max level, but in reality this rarely is the case with forestry work. Figure 2 shows the heart rate of the breaker-out for a three hour period. The only time he actually obtains the desired 40% VO_2 max level is when he is standing still waiting for the return of the rigging, or during operational delays at the 70, 80 and 90 minute marks.

If the worker is unable to work at the 40% VO_2 max level, the next best option is to work within his aerobic limit. In this case, that is 140 beats per minute (bpm) or lower. It appears that this particular breaker-out is able to achieve this desired level, only experiencing very short periods outside his aerobic limit (Figure 2). This does not mean that the breakerout is not working hard. Internationally recognised workload ratings (Rodahl, 1989), place the breakerout's working heart rate at levels between the moderate to very heavy workload levels. Maximal exercise testing using a bicycle ergometer (Arstila et al, 1984) revealed that the breakerout possessed a high degree of physical fitness as seen by an estimated VO_2 max of 4.6 litres/minute compared to the VO_2 max of the average male of 3.0 litres/minute. This enabled him to rapidly and efficiently convert oxygen to energy when the demand required. Figure 3 gives a more detailed half hour breakdown of the breakerout's heart rate, detailing the corresponding heart rates for each work element.

Initially, it was considered that wearing spiked boots could actually increase workload levels experienced by the breakerout if he was able to move more quickly over the cutover, but as with earlier work this did not occur

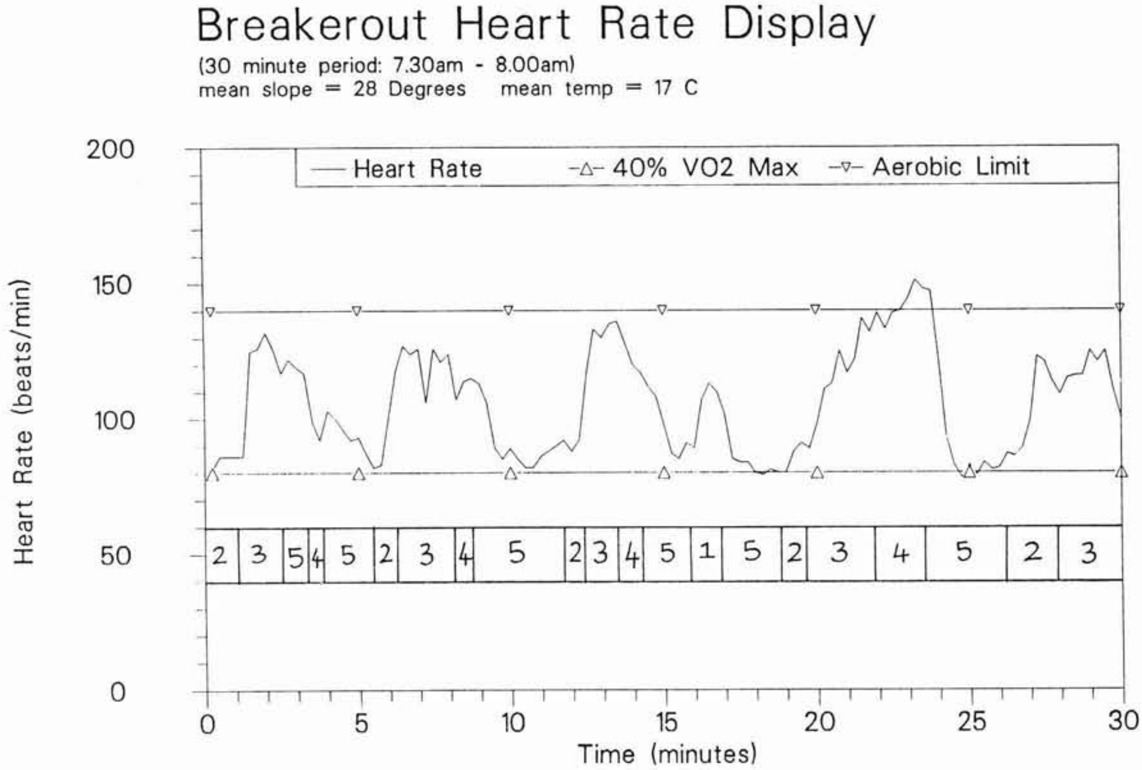

Figure 3 - Breakerout heart rate - detailed half hour

Key To Numbers:

1 = WALK TO NEW POSITION
2 = WALK IN TO ATTACH DRAG
3 = ATTACH DRAG
4 = WALK OUT AFTER ATTACHING DRAG
5 = WAIT

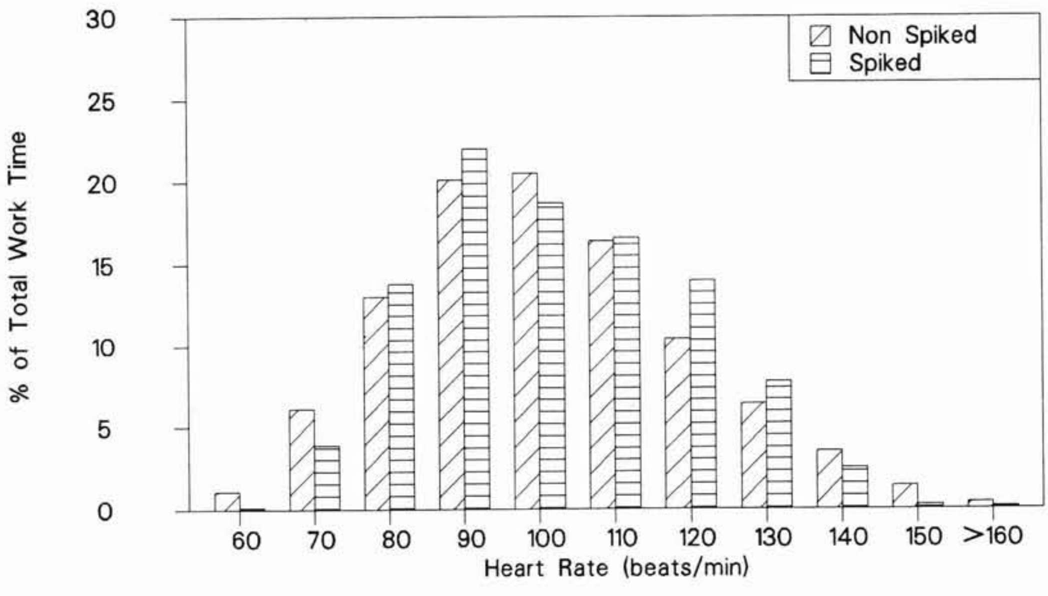

Figure 4 - Heart rate distribution - spiked versus non-spiked boots (all days combined)

(Kirk & Parker 1992a, 1992b). This has been largely attributed to the self-pacing mechanism previously mentioned. The heart rate distributions shown in Figure 4 strongly support this theory, as no significant difference ($p<0.05$) could be found between wearing spiked versus non-spiked boots.

Regarding the comfort aspects of the spiked boots, the breakerout considered them to be unsatisfactory due to the lack of sole flexibility and padding, and consequently stopped wearing the spiked boots shortly after the completion of the study. This comment, combined with similar comments gained from previous work (Kirk & Parker, 1992a), indicates that further development work needs to be undertaked by various local spiked boot manufacturers.

CONCLUSIONS

The wearing of spiked boots significantly reduced the occurrence of slipping by the breakerout. There was no detrimental effect on productivity, or increase in physiological workload, as a result of wearing the spiked boots.

Spiked boots are a relatively cheap and simple means of increasing a breakerout's safety and can be introduced with minimal disruption to the existing work routine.

Further development work needs to be undertaken by various local spiked boot manufacturers to improve the comfort and durability aspect of spiked boots .

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