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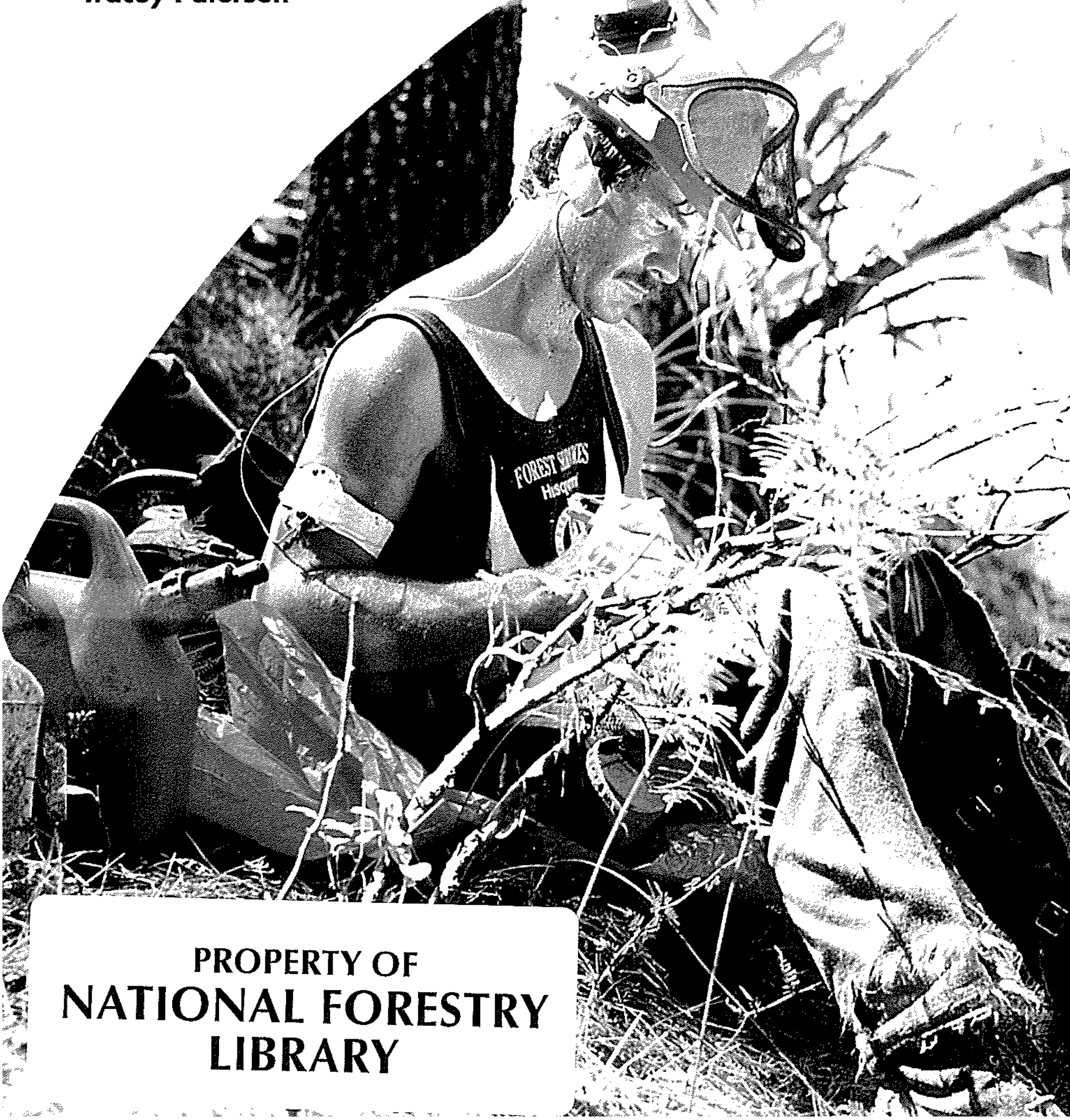
PROJECT REPORT

PR - 66
1997

EFFECT OF FLUID INTAKE ON THE PHYSICAL AND MENTAL PERFORMANCE OF FOREST WORKERS

Tracey Paterson



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EXECUTIVE SUMMARY

- A *regular fluid regime* allowed subjects to work at a lower heart rate and a lower relative work load while maintaining production.

- Psychologically, subjects reported feeling fresher, stronger, more vigorous and more wide awake when fluid was taken regularly.

- Dehydration occurred during *ad lib* drinking (no fluid condition) indicating that fluid intake was not adequate to replace sweat loss under these conditions.

- Subjects reported mean sweat rates of 3.5 litres/day and 3.1 litres/day, for fluid and no fluid conditions respectively, with a range of 0.1 to 6.2 litres/day. The variation was explained by individual difference, and more importantly, environmental conditions.

- When temperature exceeded 17°C sweat rate was greater than 3 litres/day, with an exceptional 6.2 litres/day reported during the hottest day (WBGT of 21.9°C).

- The physical work load of fallers, under summer conditions, can be classified as heavy to moderate.

In conclusion, a regular fluid regime will prevent dehydration, reduce physiological work load and maintain production in fallers during mild environmental conditions.

Recommendations

Forest work is physically and mentally demanding. However, a regular fluid intake is one strategy which has the potential to reduce work load and ensure that health, fitness and nutrition remain optimal. Those who fail to recognise the benefit of an appropriate and regular fluid intake during work risk early fatigue, injury, and the potential for ill health.

- **A fluid intake of at least 0.5 litre per hour is recommended under mild conditions work conditions(<18°C), while up to 1 litre per hour may be required during hot conditions (>22°C)**

INTRODUCTION

Forest harvesting is performed throughout the year without exception or accommodation for the environmental conditions. To date much attention locally and internationally has centred on motor-manual felling. This work is physically strenuous, demanding 'heavy to moderate work loads' (Parker, 1992a, Kirk and Parker 1994, Kirk 1996, Smith and Sirois 1982, Staal Wasterlund and Kerfakwandi 1993, Hagen et al 1993, Kukkonen and Rauramaa 1984, Malinofski et al 1988), is performed in challenging, hazardous and ever-changing environmental conditions (Kawachi et al 1994, Slappendel et al 1993, Vik 1984, Poschen 1993) and most critically, the work demands accurate mental capacity for decision making, information processing, and perception (Slappendel et al 1993). As a consequence, it is hardly surprising that the New Zealand Forest Owners' Association accident reporting scheme (ARS) consistently reports felling and delimbing as having the highest rates of injury of all forest work (Parker 1996, Gaskin and Parker 1993). This is undoubtably the combined response of a strenuous task, an uncompromising physical environment, and workers with personal health, fitness and nutrition that is frequently rated as less than ideal (Smith and Sirois 1982) .

Although the 'physiological load of forest work' and the 'thermoregulatory response' to physical activity in heat are well documented, the degree of physical strain in the New Zealand forest environment has not been clearly defined. However the reports of high injury and lost production time are well defined and consistently an issue in the harvesting workforce (Parker 1996). This suggests a need to identify: 1. whether physiological work load is high under New Zealand environmental conditions (particularly during summer where high temperatures risk exposure to extremes in heat and humidity) and 2. whether intervention can reduce physiological load to promote worker health and safety and maintain work output and productivity.

Sweating is the most effective cooling mechanism during physical activity. However, it has the potential to cause dehydration if fluid intake does not fully replace fluid loss, particularly during situations that demand prolonged physical activity (Sawka et al 1983). Sweat rate has been reported to depend not only on the environmental conditions, but also on clothing, state of acclamation, physical conditioning, gender and body size, varying greatly from one individual to another (Adolph 1947). The consequences of inadequate hydration include discomfort, restlessness, lethargy, and drowsiness (Adolph 1947) with the most reliable indicators being an increasing heart rate and body temperature and a reduction in peripheral blood flow and sweat rate, not to mention a reduced work output. The combination of heat stress and dehydration has a more significant effect on performance than dehydration alone (Craig and Cummings 1965, Buskirk 1958, Saltin 1964). Part of the mechanism responsible for reduced aerobic power in dehydration is the inability to achieve maximal cardiac output and hence maintain appropriate oxygen delivery to muscles.

The specific effects of dehydration on physical and mental performance are well documented. A fluid loss of as little as 1% body mass is reported to increase body temperature (Claremont et al 1975, Drinkwater et al 1976), while for each litre of fluid lost heart rate increases approximately eight beats per minute and cardiac output decreases by 1 litre/min (Coyle and Montain 1992). One study reported that a 2% reduction in body weight; increased heart rate by 10 beats per minute and core temperature by 0.5 degrees C, while a 3% reduction in body weight; decreased sweat rate (as well as) maximal power (by 22%) and work capacity (by 10%) (Craig and Cummings 1965). It is hardly surprising then that 4 to 5% dehydration can result in a very significant increase in both core temperature and heart rate, with a reduction in sweat rate, oxygen uptake (VO_2) and endurance (Sawka et al 1983, Saltin 1964, Burge et al 1993, Nadel et al 1980). During dehydration physical work capacity is reduced (Sawka 1992), the thermoregulatory benefit of fitness and acclimation are negated (Buskirk et al 1958) and cognitive performance is adversely affected (Adolph and Associates 1947). This provides three good reasons for prioritising fluid regimes and fluid balance as important considerations in workers exposed to prolonged conditions of heat and strenuous activity.

Although we know that physical work capacity is reduced during dehydration, and the greater the water deficit the greater the impact (Sawka 1992), there remain few studies on hydration and prolonged submaximal activity. The work that has been reported suggests that dehydration does increase the incidence of exhaustion from heat strain (Adolph 1947, Sawka et al 1983, Claremont et al 1976, Costill and Fink 1974). Much research has been performed in industry and the sporting arena in particular to identify appropriate strategies for coping with conditions of prolonged physical activity, and especially during exposure to heat and humidity. The most powerful technique to maintain performance under such conditions is that of hydration (regular fluid intake). Ideally fluid intake should match sweat production. However, sweat rate amongst forest workers remains unknown and hence specific guidelines remain limited.

Fluid should be ingested before, during and after work on a regular basis to minimise the impact of heat and humidity on performance. The composition of the fluid may also have a bearing on performance. The prolonged nature of felling may give reason to include both carbohydrate and sodium. Carbohydrate may enhance energy intake for muscle fuel and sodium may enhance fluid absorption and replace losses due to sweating. Fatigue during prolonged exercise is generally a result of depletion of the body's limited carbohydrate reserves or dehydration (Maughan and Rehrer 1993).

The effect of working in conditions of heat is one of the most extensively researched topics in physiology reflecting its importance to health, safety and productivity of workers. Clearly it is important that not only is the physiological work load of fallers employed in New Zeland accurately determined but also that strategies should be developed aimed at reducing work (particularly thermal) stress, promoting work performance and minimising injury risk.

Although in general three avenues exist for the reduction of work load: modifying the task, increasing the physical conditioning of the worker, or changing the environmental stress, maintaining appropriate fluid balance through an appropriate hydration regime may be an even simpler strategy for reducing thermoregulatory stress. Because it is now widely accepted that a regular fluid intake can reduce work load and delay physical and mental fatigue the objectives of this investigation were to:

- Identify the physiological work load demanded for the task of felling during Summer
- Perform a task analysis to identify the specific activities, duration and intensity
- Identify the environmental conditions under which the task is performed
- Investigate the effects of a regular fluid regime on physical and mental performance
- Identify an appropriate fluid regime to reduce thermoregulatory stress in forest workers

METHOD

2.0 : Subjects

Eight professional male fallers undertaking clearfell operations in ground-based crews were recruited. Each was required to complete a written informed consent (Appendix I) prior to participation. Ethical approval for the study was obtained from the University of Otago Ethics Committee.

2.1 : Design

A *repeated measures research design* was used whereby each forest worker acted as his own control and participated in all test conditions. Prior to commencing the study all subjects completed a medical screening questionnaire to ensure that they were injury free and in good health (Appendix A). Following this each underwent laboratory testing to determine descriptive physiological characteristics.

The study itself was field-based with all subjects assigned two work conditions to be performed on consecutive days, in a balanced order (Table 1). Condition 'A' was a control condition of normal work practice, while condition 'B' involved following a fluid regime (Table 2). Subjects performed each condition for one working day during which a number of physiological variables were monitored along with productivity and environmental conditions.

Work Day

To accommodate the possibility of workers starting early or finishing late, each work condition was defined as a seven hour period, from 8am to 3pm.

Table 1: Order for Work Conditions by Subject

Subject	1	2	3	4	5	6	7	8
Day 1	A	B	A	B	A	B	A	B
Day 2	B	A	B	A	B	A	B	A

A=Control, B=Fluid Regime

Table 2: Subject Work Conditions

	Control	**Fluid Regime**
Condition	A	B
Intervention	None	Fluid Intake 200ml sport drink each 15 minutes

2.2 : Preliminary Physical Assessment

All subjects performed a series of tests (Table 3) in the week prior to the field work to identify physical characteristics and to allow relative work intensities to be determined based on maximum work capacity.

Table 3: Preliminary physical assessment

Assessment	**Procedure**
Medical Screening	• Health and Injury Questionnaire
Body Composition	• Body Mass Index • Adiposity Rating • Somatotype
Aerobic Power	• Treadmill VO2max

Body Composition

Body Mass Index

Body mass index was determined for each subject by recording subject height in metres, and weight, in kilograms. Body weight was then divided by the height squared to calculate BMI, in kilogram per metres squared. Formula: BMI (kg/m^2) = weight (kg)/height^2 (m)

Sum of Skinfolds

Skinfold, height and weight measures were collected to identify body composition. Skinfold measurements were taken at the following sites; triceps, biceps, subscapular, suprailiac, abdominal, front thigh (seated) and medial calf (foot on chair). Each site was measured to the nearest 0.5mm and scores from all seven sites were totalled to give a sum of skinfolds for each subject (Ross and Marfell-Jones 1985).

Somatotype

Somatotyping was used to classify body build with respect to endomorphy (fat component), mesomorphy (muscle component), and ectomorphy (lean component) using the Heath-Carter classification system. The endomorph component was determined using the sum of: tricep, subscapular, and supra iliac skinfolds, mesomorph component determined from measures of height, bone girths (humerus and femur) and muscle circumferences (with skinfold measures subtracted), while the ectomorph component was derived from height divided by the cube root of the weight (Ross and Marfell-Jones 1991).

Maximum Rate of Oxygen Consumption (VO_2max)

A portable gas analysis system (Metamax metabolic test system) was used to determine individual VO_2max prior to field work. Oxygen uptake (VO_2), and carbon dioxide production (VCO_2) were determined using oxygen and carbon dioxide analysers calibrated with known gas concentrations and the flow metre calibrated using a three litre syringe. The Bruce protocol (Astrand and Rodahl 1986) outlined in Table 4 was used. Workers performed a graded exercise test on a motor driven treadmill. The highest rate of oxygen consumption was recorded in each case to reflect VO_2max.

Resting Heart Rate

Resting heart rate was determined prior to VO_2 max testing. A heart rate monitor was attached and workers requested to sit for a period of 15 minutes (rest condition) at the end of which heart rate was recorded to determine resting heart rate.

Table 4: Bruce Protocol for Determination of Maximal Oxygen Uptake (VO2max)

Stage	Speed-mph (kmph)	Grade % (degrees)	Duration (min)
I	1.7 (2.7)	10 (5.7)	3
II	2.5 (4.0)	12 (6.9)	3
III	3.4 (5.5)	14 (8.0)	3
IV	4.2 (6.8)	16 (9.1)	3
V	5 (8.0)	18 (10.3)	3
VI	5.5 (9.3)	20 (11.4)	3
VII	6 (11)	22 (12.5)	3

(Robert Bruce Treadmill protocol 1971, in Astrand and Rodahl 1986)

Exercise Heart Rate

It is known that there is a linear relationship between heart rate and rate of oxygen consumption (VO_2). For this reason workers wore heart rate monitors throughout the VO_2max test to allow HR:VO_2 relationships to be determined for each individual. This information was then used to predict oxygen consumption during work based on heart rate response.

2.3 : Physiological Assessment of Work

Work Heart Rate (HRwork)

To estimate the percentage of maximum oxygen consumption (%VO_2max) at which workers were operating during each felling task, heart rate was recorded continuously throughout work and used to predict oxygen consumption based on individual VO_2:HR relationships.

Heart rate was recorded using a portable Polar Electro Pe3000 heart rate monitor, wired with shielded coaxial cable between the sensor unit and the receiver unit, to prevent chainsaw interference (Parker 1992b). Work heart rate was recorded at one minute intervals. Monitors were placed in waterproof plastic containers with a clear plastic lid to ensure full protection from the environment yet allow operating function to be checked regularly. The monitor was then secured in an army issue ammunition pouch, attached to workers' felling belts at their waist and finally set in the small of their back to minimise interruption to either work pattern or intensity.

Body Temperature

An auditory canal thermistor was placed inside the ear to monitor body temperature during work. Temperature was taken at one minute intervals and recorded onto a data logger (Squirrel) located in a pouch attached to the workers belt.

Sweat Rate

Total body sweat rate was determined by changes in body weight. Subject body weight was identified at the start and end of each work condition using Wedderburn scales accurate to the nearest 50g. Weight increase due to food and fluid, and weight loss due to faeces and urine was recorded during each day and used to correct final body weights.

Skin Temperature

Skin temperature was monitored as an indication of general heat stress or thermal balance using uncovered thermistors attached to the skin at four sites: upper chest, bicep, thigh and calf. Data was recorded onto a data logger (Squirrel). Mean skin temperature was calculated using the appropriate area weighting factors developed by Ramanathan (1964) where: T_{skin} (°C)=0.3 (chest+upper arm temperature) + 0.2 (thigh+calf temperature).

2.4 : Psychological Response to Work

Rate of Perceived Exertion (RPE)

Subjective assessment of physical strain or perceived exertion has been consistently found to mirror heart rate (Astrand and Rodahl 1986). Borg (1982) has devised a new 10 point Likert scale which extends from 0 (nothing at all) to 10 (very very strong) to determine individual ratings of perceived exertion (Appendix C). Each hour workers were asked to subjectively rate their level of exertion for each condition.

Thermal Comfort and Thermal Sensation

Thermal comfort can be defined as a lack of discomfort or that condition of mind that expresses satisfaction with the thermal environment. It is clearly subjective and comfort range is typically as little as two or three degrees Celsius, with temperature, humidity and air velocity the three major determinants. A questionnaire was administered hourly throughout each work condition to determine thermal comfort level (Appendix D) with perceived thermal comfort rated on a five point Likert scale of 1 (comfortable) to 5 (extremely uncomfortable) (Cotter 1991).

Thermal sensation was determined by asking workers how hot or cold they felt using a nine point scale: 1(very hot) to 9 (very cold) (Kirk 1996) (Appendix D).

Fatigue, Thermal Regulation and Skin Wetness

A self-assessment of fatigue, thermal regulation, and skin wetness was requested at hourly intervals. This required subjects to answer a series of related questions to determine perceived fatigue on a seven point Likert scale (Appendix E) and perceived thermal regulation and skin wetness, on scales of 1 (vigorously shivering) to 7 (heavily sweating) and 1 (more dry than normal) to 7 (sweat running off in many places) respectively (Appendix F).

Body Part Discomfort

Perceived body part discomfort was also determined hourly based on a technique developed by Corlett and Bishop (1976) and modified for forest workers (Ford 1995). Workers viewed a body part diagram and identified whether they felt any discomfort in any of the body part segments identified in the diagram and the level of discomfort (Appendix G).

Mental Fatigue

A digit symbol substitution test (DSS) (Kirk 1996, Kirk & Sullman 1995, Legg et al 1991) was performed by workers each hour as a measure of mental fatigue. The test comprised a page with rows of 15 randomly ordered symbols. Each has a blank row below. At the top of the page is a key that codes each symbol to a number (Appendix H). Workers had five minutes to work sequentially and match as many of the symbols as possible to their correct number. The results measured were the number of matches attempted per trial and the percentage of correct digit symbols matched from the total number attempted. Workers were given an individual familiarization period during their preliminary physical assessment to ensure they understood the requirements of the task.

Eighteen variations of the test sheets were developed using random number tables (Eton 1992) to determine the order of the digit symbols. This should have reduced the risk of subject learning affecting performance on subsequent tests.

2.5 : Time and Motion Analysis

A Husky Hunter field computer programmed with a continuous time study program (Siwork3) was used to determine time and motion data for each worker under each condition. Siwork 3 is a Turbo/Pascal language system specifically designed for work study and data collection (Rolev 1990). Each time a worker performed a pre-determined task it was recorded along with the length of time it took to complete the task.

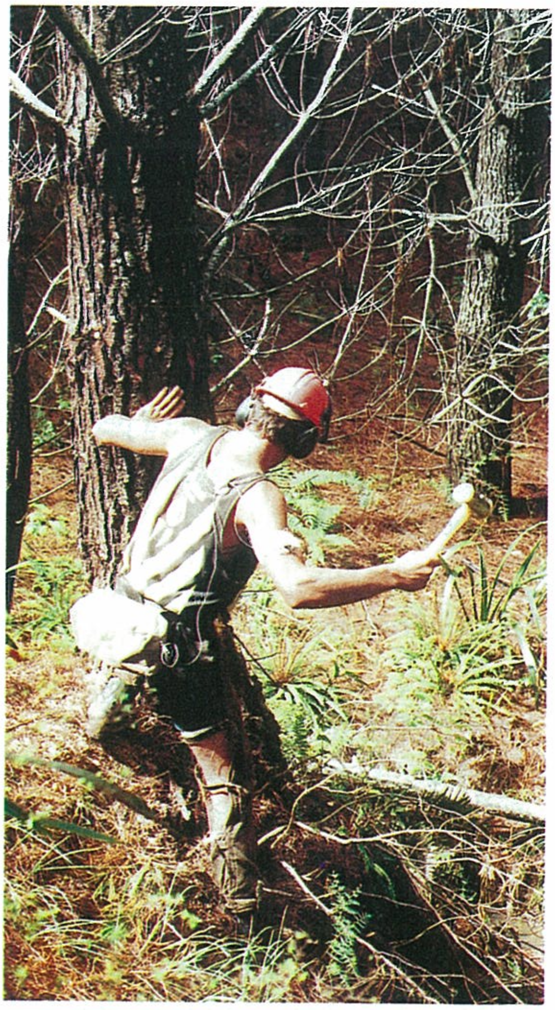


Figure 1: Logger wedging a tree while wearing senors for heart rate and body temperature

Task Analysis

Task analysis during felling and delimbing was based on the following protocol.

Activity	*Description*
Walk In	Walk from the crew vehicle to the work site
Select	Clear path to and around tree and prepare escape route
Fell	Scarf, back cut, sloven
Trim	Trim any branches from stem
Refuel	Refuel chainsaw with petrol and oil
Maintain	Sharpen and tighten saw chain and other related parts
Odel	Delays attributed to operational interference
Pdel	Delays caused by the subject themselves
Mdel	Delays caused by machinery breakdowns and machines in way
Walk Out	Walk from work site to crew vehicle
Smoko	Main meal breaks during the working day

Percentage Time per Task

Time and motion data was used to determine the percentage of time per day spent on each task and hence the relative work load per task.

Volume per Day

The total number of trees felled per day per worker was recorded as an indicator of work performed.

2.6 : Environment

Ambient Thermal Environment

As felling is a field-based task workers must endure a range of environmental conditions some of which may impact on work. A Questemp 15 area heat stress monitor was set up 30 minutes prior to the start of each work day at a location as close as possible to the falling site in order to ensure that the probes were acclimatised and data accurate. Dry bulb (air temperature), wet bulb (relative humidity) and globe bulb (radiant temperature) temperatures were recorded and used to determine wet bulb globe temperature (WBGT) and relative humidity (RH) for each work day.

WBGT was calculated based on the formula devised by Botsford (1971) for outdoor application: WBGT = 0.7(twb) + 0.2(tg) + 0.1(ta); where (twb) is the natural wet bulb temperature, (tg) is the globe temperature and (ta) is the dry bulb temperature.

3.8 Statistics

All data is described using mean and standard deviation. A two-way analysis of variance with repeated measures was utilised to determine whether any significant differences exist within each subject or between conditions. If any significant effects were found then paired t-tests were used to test for specific difference. For all statistics significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

3.0 : Worker Characteristics

The mean (SD) age of the fallers was 27.8 (7.1) years and their mean (SD) physical characteristics of height, weight, body composition and maximum aerobic power (VO_2max) are reported in Table 5. To identify workers' body type subjects were ranked on a scale of 1(minimum) to 7(maximum) for each of the following: fatness, muscularity, and leanness, a ranking more commonly referred to as a somatotype. Mean (SD) rankings are reported in Table 6.

Mean VO_2max was 4.4 ± 0.5 litres per minute (l/min), or 57.5 ± 6.5 millilitres per kilogram per minute (ml/kg/min) when corrected for body weight. This was higher than reported by: Abeli and Malisa (1994), Hagen et al (1993) and Henderson (1984), but lower than that of local fallers (Kirk 1996). It is worth noting that all of the above were predicted values based on sub-maximal testing procedures, results often less accurate than the maximal test procedures employed in this study. Kukkonen-Harjula and Rauramaa (1984) used a testing schedule close to that employed here and reported very similar results (VO_2max of 3.9 l/min or 53.3 ± 6.4 ml/kg/min).

The VO_2max range of 51 to 64 ml/kg/min rates workers at the top of the occupational rankings for aerobic power (Astrand and Rodahl 1986) and compares favourably with what we would expect of an elite athlete, particularly those involved in endurance events. Importantly for tasks such as felling, a positive relationship exists between VO_2max and work output: the higher the VO_2max of an individual: the higher the potential work output (Astrand and Rodahl 1986). Workers in heavy manual tasks (such as felling) generally set their own pace at a level less than about 40% of their individual maximal aerobic power (Astrand 1967).

Subjects were predominantly lean muscular individuals with low levels of body fat and high levels of endurance.

Table 5 : Means and SD for height, weight, skinfolds, BMI and maximum oxygen uptake for forestry workers (n=8)

Height (metres)	Weight (kg)	Skinfolds Sum (mm)	BMI (kg/m^2)	VO2max	
Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1.8 ± 0.2	76.0 ± 7.1	54.2 ± 14.1	23.1 ± 2.8	4.4 ± 0.5 (l/min)	57.5 ± 6.5 (ml/kg/min)

Table 6: Mean (SD) Somatotype Scores for forestry workers (n=8)

Endomorph Component	Mesomorph Component	Ectomorph Component
Mean ± SD	Mean ± SD	Mean ± SD
2.3 ± 0.7	3.0 ± 1.8	2.9 ± 1.5

3.1 : Physiological Response to Work

Heart Rate

There was a significant difference in the heart rate response to work between fluid and no fluid conditions. Providing a regular fluid intake (fluid condition) produced a significantly lower working heart rate than working without a regular fluid intake (no fluid condition) (Figure 2). Although work heart rate decreased from morning to afternoon for fluid, and increased for no fluid the changes were not significant.

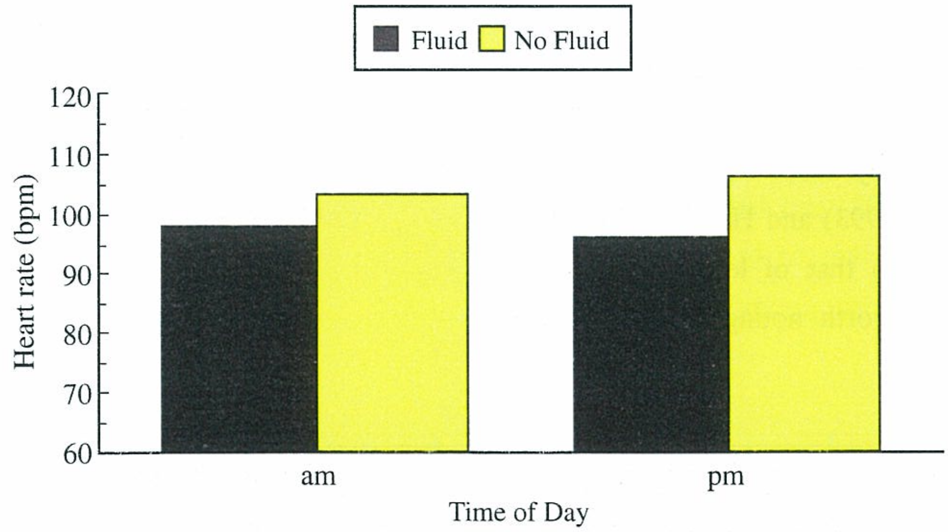


Figure 2: Mean work heart rate during fluid and no fluid conditions (all fallers combined)

Similar results were reported for percentage of maximum heart rate. Subjects worked at a lower percentage of their maximum heart rate during the fluid condition compared to the no fluid condition (Figure 3), and although the percentage increased and decreased (as the day progressed) for no fluid and fluid respectively, these changes were not significant.

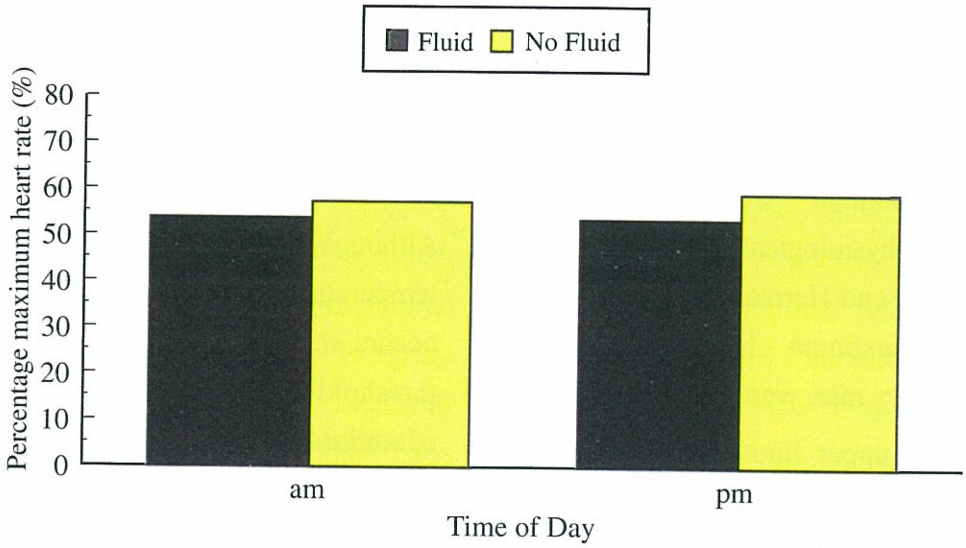


Figure 3: Mean percentage maximum heart rate during fluid and no fluid conditions (all fallers combined)

Work heart rate is an integral part of task analysis providing an objective measure of work load during continuous work. To date results have consistently reported a moderate to heavy physiological load for felling (Astrand and Rodahl 1986) with heart rate typically in the range of 100 to 140 beats per minute (Fibiger and Henderson 1982, Hagen et al 1993, Kirk and Parker 1994, Kirk 1996, Kukkonen-Harjula and Rauamaa 1984). Figure 2 reports mean heart rates of 96 to 106 bpm, reaffirming the high physical demands of this task within New Zealand. The no fluid (or control) results in particular compare favourably with the 107.3 ± 5.5 bpm mean heart rate reported in local fallers by Kirk (1996). In comparing these results to other forest related studies, we must consider that because no standard exists for 'work heart rate' there is obvious variation in each case as to what tasks constitute work heart rate. While we used work heart rate to represent all activity performed, many investigators partition work heart rate into specific tasks. Hagen et al (1993) for example, excluded all rest or meal breaks from 'work heart rate' data, which produced comparatively higher mean heart rates than that of Kirk (1996), where 'work heart rate' was representative of all activity performed, including rest breaks, and that of this particular study.

Drinking fluid at regular intervals throughout the day reduced work heart rate. This suggests that 'a regular fluid intake can reduce work stress'.

Percentage Maximum Heart Rate

Because it is the relative workload rather than the maximal work load that determines physiological response to activity (Saltin and Hermansen 1966) both percentage maximum heart rate and percentage VO_2 max were identified. The recommended upper limit for continuous physical activity of up to eight hours is 50% maximum heart rate (Apud et al 1989). The results in Figure 3 are higher than this, particularly in the no fluid where mean afternoon heart rate was 59.4 ± 8.6 % of maximum. Kukkonen-Harjula and Rauramaa (1984) reported even higher results with a mean heart rate of 123 bpm, which equated to 66 ± 5% of maximum, however other studies have reported significantly lower results, for example; 31.7 ± 4.4% (Kirk 1996) and 50.1% (Abeli and Malisa 1994).

Although heart rate is reported to rise as temperature increases, this generally only occurs at WBGTs greater than 26°C, the threshold for 'hot environmental conditions'. Smith and Sirois (1982) investigated the effects of heat on forest work and reported relative work loads between 61 to 70% of maximum heart rate, based on heart rates of 110 to130 bpm. As the mean WBGT range was 10.4 ±1.0 to 21.8 ±2.1°C, conditions were well below the 26°C threshold, and it is unlikely that temperature would not have had a significant impact on heart rate in this study.

When workers drank fluid regularly throughout the day they were able to operate at a lower percentage of their maximum heart rate, that is, less effort was required to perform the job when workers were well hydrated.

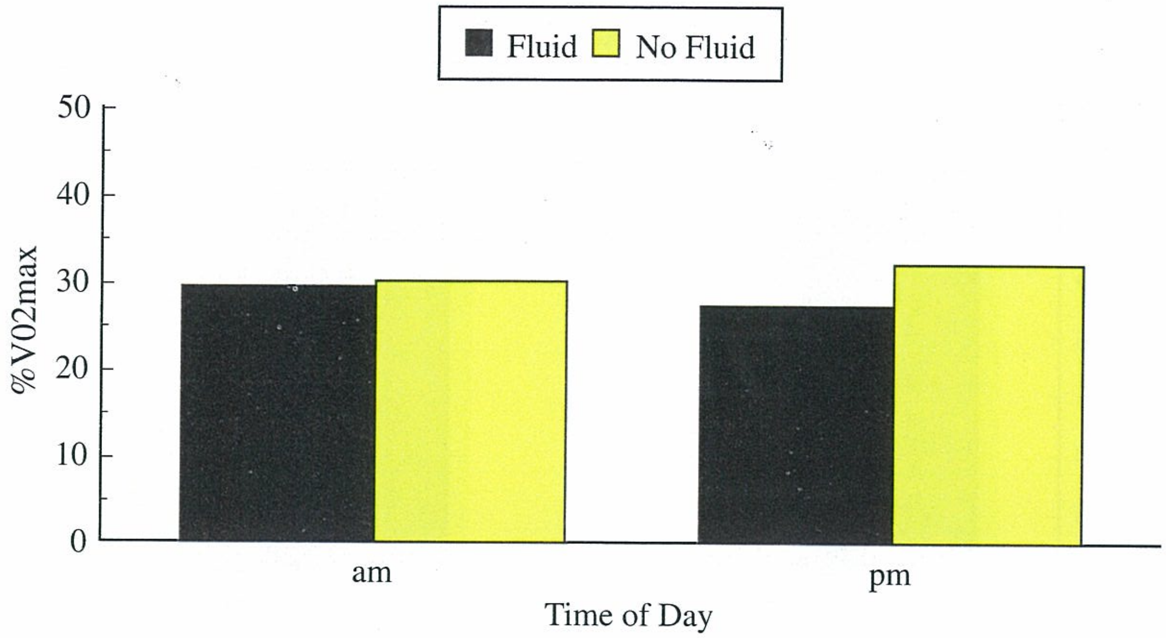


Figure 4: Mean percentage VO_2max during fluid and no fluid conditions

Oxygen Uptake

Using the VO_2:HR relationship established during the maximum aerobic test, predicted oxygen consumption during work was not significantly different between conditions (Figure3). Subjects elected to work at 29% (1.3 l/min) and 32% (1.4 l/min) of their VO_2 max during fluid and no fluid conditions respectively. The percentage of maximum uptake required to perform a task characterises the ability to use maximum capacity over a prolonged period of time (Bunc and Heller 1994) and current consensus is that hard physical labour should not exceed an average of 40%VO_2 max for an eight hour shift (Apud et al 1989, Evans et al 1980). Results here are consistent with this, being lower in both conditions, with little difference between conditions. The lower results could possibly be explained by the fact that the activities of felling and delimbing are predominantly upperbody tasks utilising a lower percentage of total muscle mass than lower body tasks.

Body Temperature and Skin Temperature

Body temperature (Figure 5) and skin temperature (Figure 6) responses were not significantly different between conditions. Although body temperature was lower during the afternoon compared to the morning when fluid was provided, and higher during the afternoon when fluid was not provided, the afternoon responses were not significantly different from the morning responses for either condition.

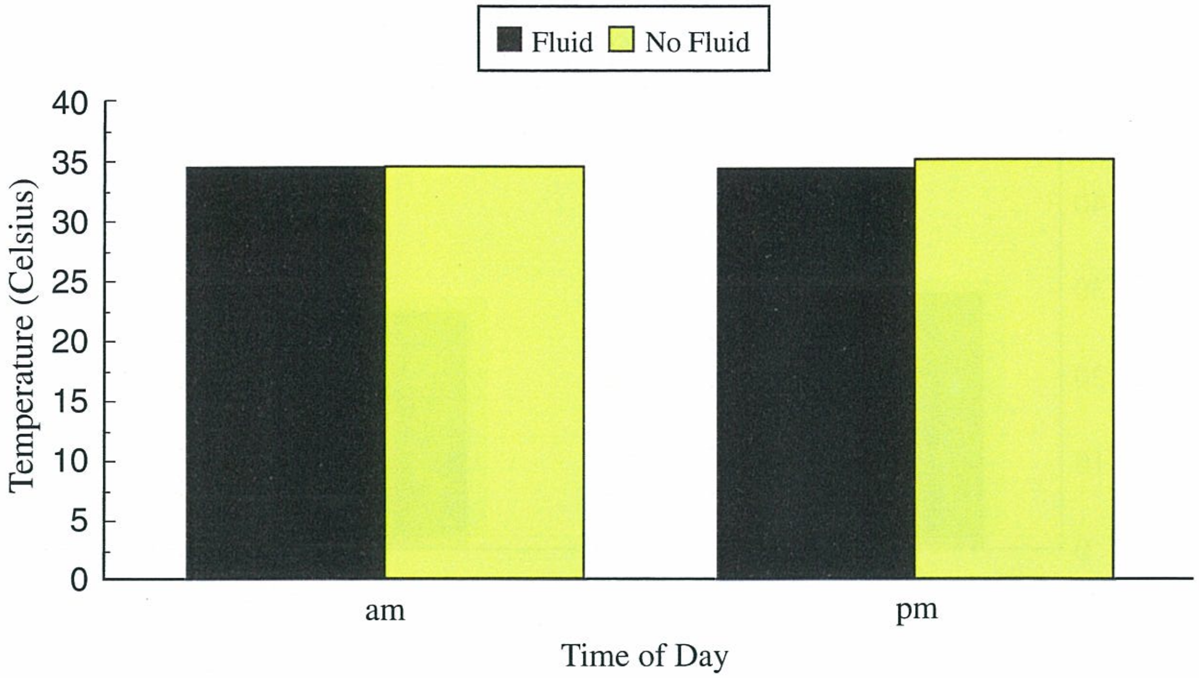


Figure 5: Mean body temperature during fluid and no fluid conditions

There was a significantly greater skin temperature during the afternoon versus morning but there was no difference between the two conditions despite lower temperatures reported both morning and afternoon during fluid.

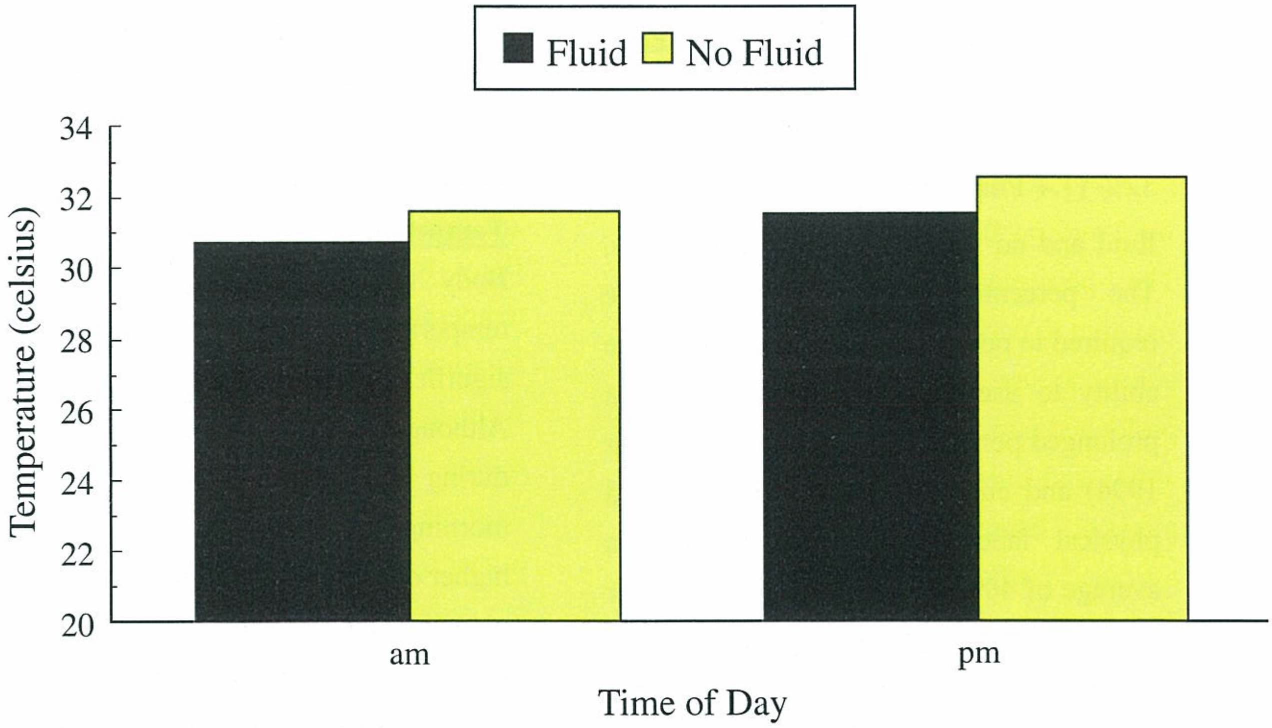


Figure 6: Mean skin temperature during fluid and no fluid conditions

The channels for heat dissipation are the same regardless of whether thermal load is imposed externally (environmental heat) or internally (muscular work). In this case the external heat load would have been minimal, with WBGT considerably less than 26 degrees, however as the task is physically demanding there would still be considerable heat produced as muscles work continuously to provide the energy to meet the demands of the task and maintain the work load. This internal heat load explains the increase in skin temperature in both conditions. Heat was transferred continuously to the skin and dissipated, to ensure that body temperature variation was minimal and thermal balance maintained.

It has been reported that body temperature is directly related to relative work load (Saltin and Hermansen 1966), with increases in heart rate positively correlated to increases in body temperature (Ekelund 1967). This may explain the effect of a higher afternoon body temperature during the no fluid condition in comparison to fluid (although not significantly higher), remembering from above that the relative work load was significantly higher during no fluid compared to fluid.

There was no significant difference in body temperature or skin temperature between conditions due to the mild environmental conditions experienced during this study.

Fluid Volume, Sweat Rate and Dehydration

Individual worker; fluid consumption, sweat rate and level of dehydration are reported in Figures 6, 7 and 8 respectively.

The mean volume of fluid consumed during the 'fluid' condition (5.5 ± 1.3 litres) was significantly higher than that chosen by workers during 'no fluid' (2.7 ± 1.2 litres).

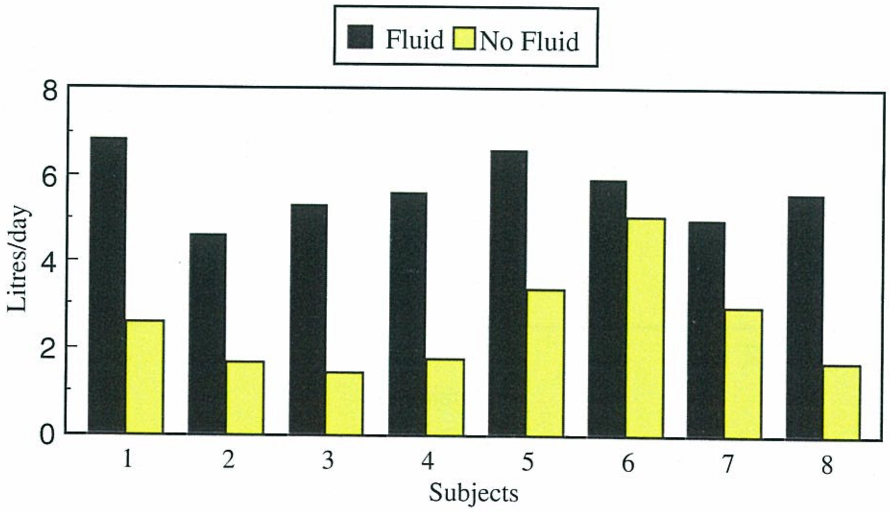


Figure 7: Mean volume of fluid drunk per day by subject, during fluid and no fluid condition

Although there was little difference in sweat rate between the fluid and no fluid conditions, subjects had greater difficulty maintaining body weight when fluid was not consumed regularly, losing on average 1.2 ±1.3 % body weight, compared to a 0.7±1.0 % gain when fluid was provided. This suggests that the volume of fluid consumed when subjects drank *ad lib* (no fluid condition) is not always adequate to counter the effects of sweat loss and, as a consequence, subjects became dehydrated.

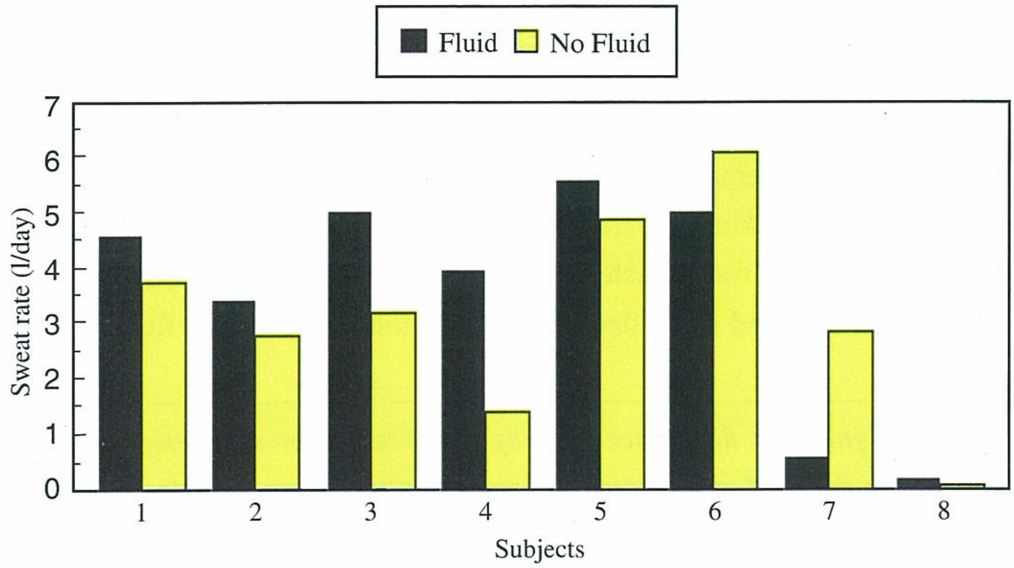


Figure 8: Mean sweat rate by subject during fluid and no fluid conditions

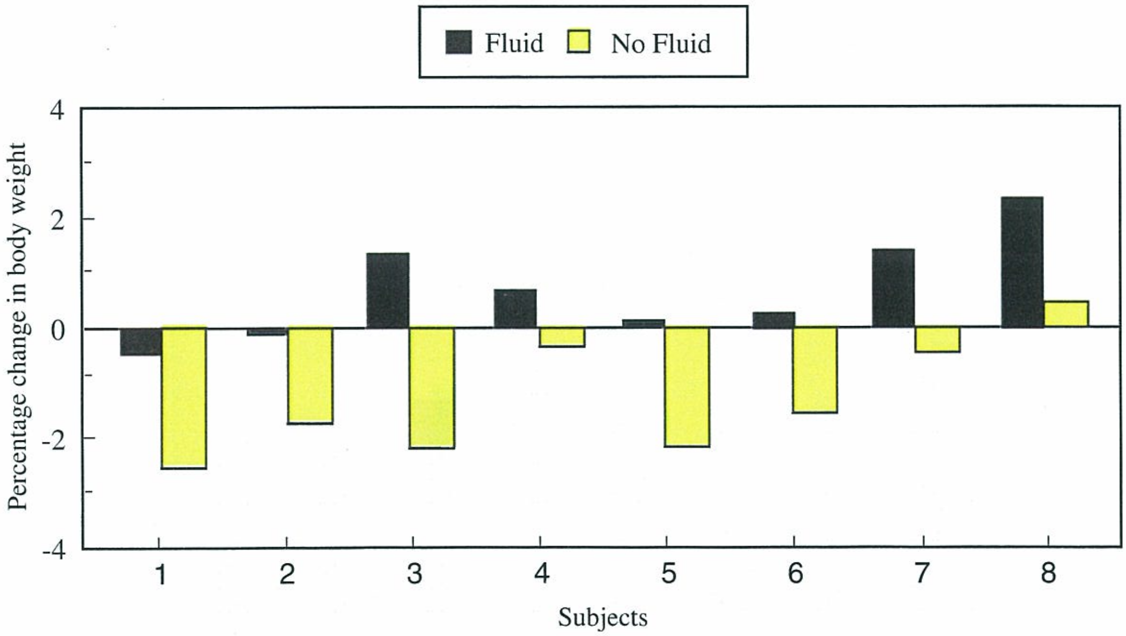


Figure 9: Mean percentage change in body weight by subject, during fluid and no fluid conditions

Dehydration by as little as 1% body weight promotes early mental and physical fatigue and hence every attempt must be made to avoid such conditions, particularly during forest work where concentration, accuracy, and physical endurance are critical to performance. Individual sweat rate is dependent on: environmental conditions, clothing, body size and physical fitness, varying greatly from one person to another (Adolph and Associates 1947). To date there has been no record of sweat rates in forest workers, with predicted rates adopted from occupations with similar physical demands, or more often from the sporting arena. In identifying a mean sweat rate of 3.5 ± 2.1 l/day (during the fluid condition) or 0.5 l/hour we can now recognize the need for not only a regular fluid intake but one that will more accurately ensure that sweat rate is matched and dehydration prevented.

Sweat rate varies significantly from one individual to another, and there is evidence of this within this study. Subject seven (Figure 8) lost very small volumes of sweat, less than 0.5 litre/day, resulting in a weight gain, and this was regardless of the work condition, temperature and level of activity At the other end of the scale one worker, number 6 (Figure 8) lost more than 5 litres/day during both conditions.

It should also be noted that these results occurred in atypical Summer conditions, conditions perhaps more consistent with the cooler seasons, and regions of New Zealand. Further then, if such work was performed in conditions of heat, we would predict that sweat rates would increase (to maintain thermal balance) and hence the fluid requirements to maintain body weight and prevent dehydration would be somewhat greater than those reported above. In fact the highest sweat rate recorded was in excess of 6 litres/day and this occurred on the hottest day (21.9 ± 2.1 °C) (Figure 10) reinforcing the need to increase fluid intake for physical work during conditions of heat.

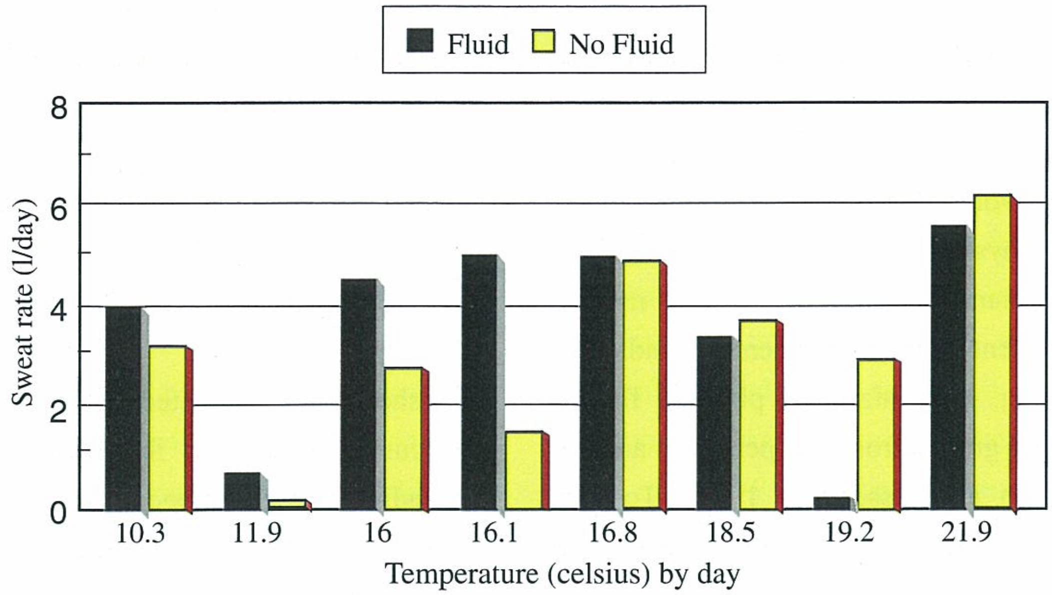


Figure 10: Mean sweat rates by temperature

Table 7: Mean (SD) fluid intake, sweat rate, and change in body weight by condition

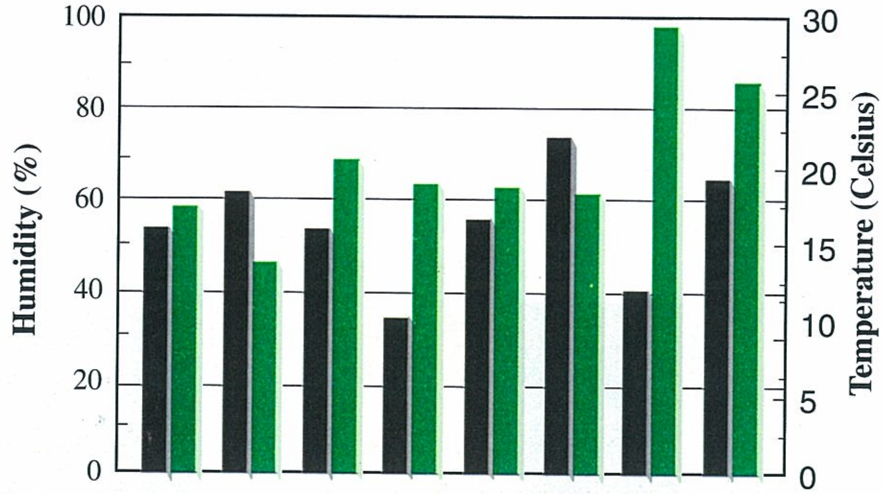
	Fluid Intake (l/day)	Sweat Rate (l/day)	Bodyweight (%/day)
	Mean ± SD	Mean ± SD	Mean ± SD
Fluid	*5.5 ± 1.3	3.5 ± 2.1	0.7 ± 1.0
No Fluid	2.7 ± 1.2	3.13 ± 1.9	# -1.2 ± 1.3
Significant Difference	Yes	No	Yes

(* $p < 0.05$ significantly greater than no fluid) ,(# $p < 0.05$ significantly greater loss in body weight than fluid)

Workers become dehydrated (lost body weight) when fluid intake did not match sweat loss. Sweat rates averaged 3 to 3.5 litres per day, with a maximum of 6.2 litres reported. Workers therefore need to drink at least 3 to 3.5 litres of fluid per day to prevent dehydration under such mild conditions, while in warmer conditions this may need to be as high as 4 to 6 litres per day.

3.2 : Ambient Thermal Environment

The wet bulb globe temperatures (WBGT) and relative humidities are presented in Figure 11 respectively. The WBGT increased from morning to afternoon with significant variation day to day. However, the mean temperature and relative humidity was equal between conditions due to the balanced order in which conditions were performed.



Day Number	1	2	3	4	5	6	7	8
WBGT (celsius)	16.00	18.50	16.10	10.30	16.82	22.00	11.90	19.20
Relative Humidity (%)	59.00	47.00	69.00	64.00	63.00	61.00	98.00	86.00

Figure 11 : Mean daily WBGT and relative humidity by day

Environmental conditions during this study were mild compared to those normally experienced during summer in the Hawkes Bay; however workers still became dehydrated. Hence, in warmer conditions, particularly where temperatures are >26 degrees, fluid intake will be critical to maintaining work performance.

3.3 : Production

Tree Number

There was no significant difference in work output between fluid and no fluid conditions as determined by the number of trees felled (Figure 12).Therefore despite working at a higher relative work load, and in a state of dehydration during the no fluid condition, workers were able to maintain work output. When competition arises for blood flow between the muscles for physical work and the skin for heat dissipation, muscles always win and, as a consequence, although work can be maintained, workers place themselves under risk of heat injury due to the reduced ability to remove heat.

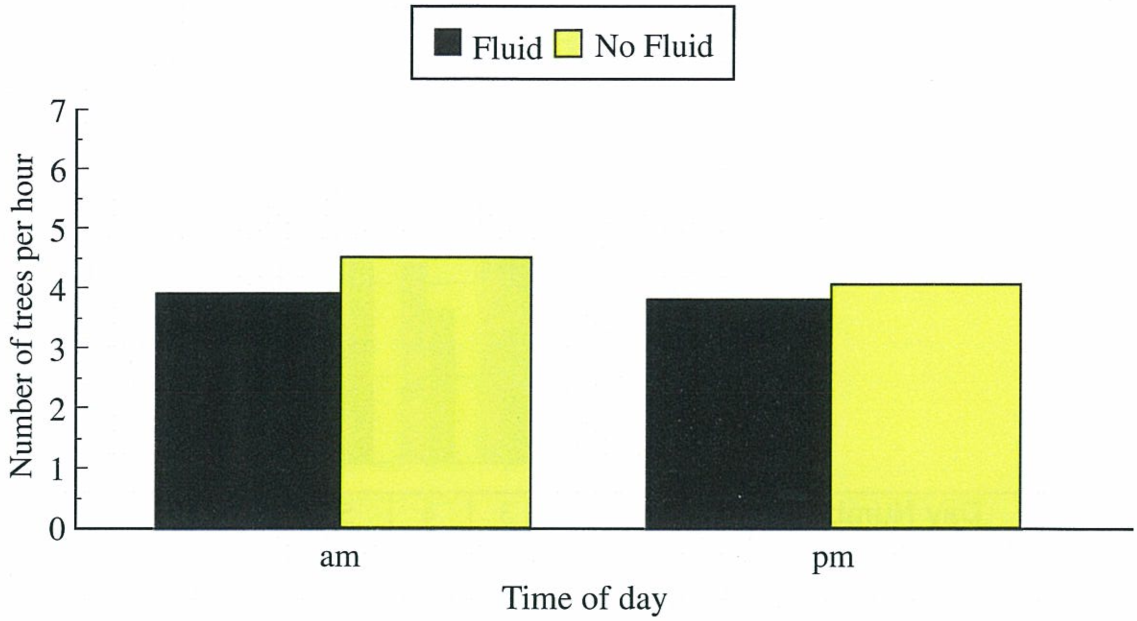


Figure 12: mean number of trees felled per hour during fluid and no fluid conditions

Although work load was reduced when fluid was taken regularly, there was no difference in work output.

Time per Task

The work day was divided into active time (time spent felling and delimbing), and inactive time all delays: operational, mechanical, personal, and meal breaks. There was no significant difference in the time spent active (Figure 13) or inactive (Figure 14) between conditions.

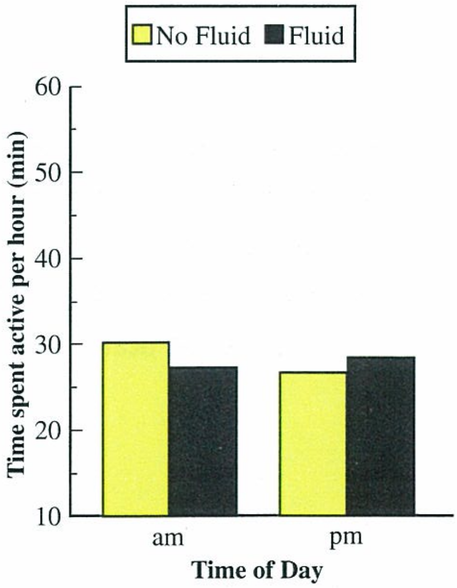


Figure 13: Mean time spent active

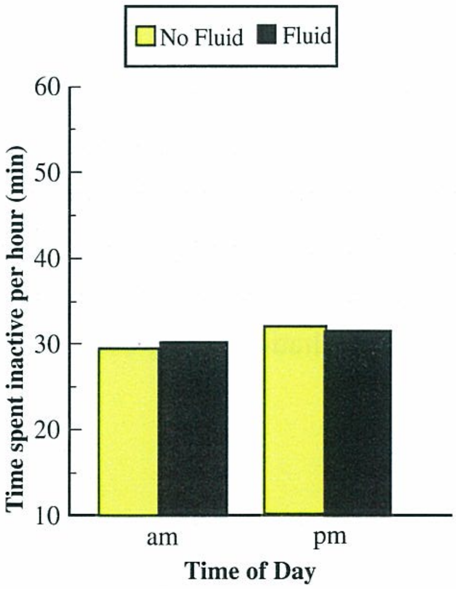


Figure 14: mean time spent inactive

The percentage of time subjects spent on each task during fluid and no fluid conditions is presented in Figure 15. The mean time per day spent active was 49% for fluid and 48% for no fluid. This was less than previous reported for New Zealand fallers where 62% of the day was spent felling and delimbing (Kirk 1996). This lower 'active' time may have been due to greater researcher delay time (such as, time spent completing questionnaires or discussing study details).

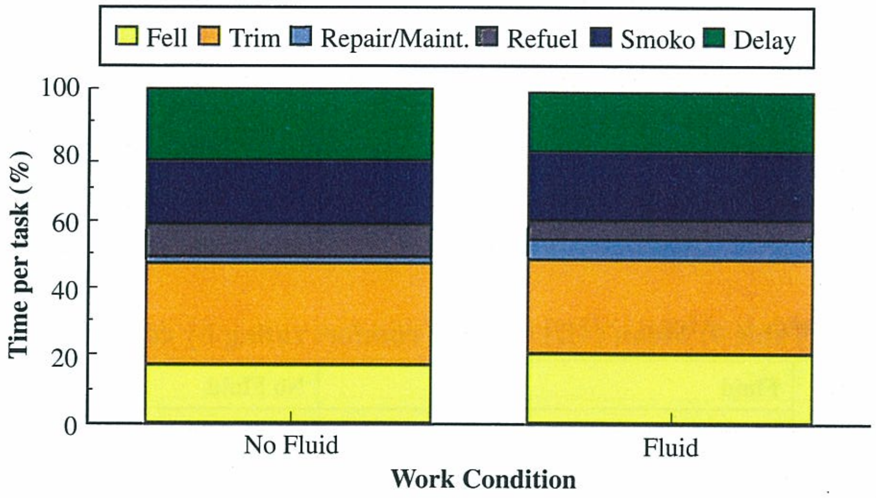


Figure 15: Mean time per task during fluid and no fluid conditions

Workers spent on average half of their work day 'active' (felling or delimbing) while the remaining time was spent 'inactive' (smoko and delays: personal, operational or mechanical)

3.5 : Psychological Measures

Rated Perceived Exertion

Subjects depend on psychological cues to regulate physiological work load (Capodaglio et al 1995) and in doing so have the ability to 'self-pace' and accurately determine the work load required to perform a given task so as to avoid undue stress. There was no significant difference in the 'subjective rating of physical strain' from one condition to the other (Table 8) despite the rating for fluid being lower in the morning and higher in the afternoon compared to that of no fluid. There was however a time effect for the fluid group; a higher level of perceived exertion was reported during the afternoon compared to that of the morning.

Table 8: Mean(SD) rating of perceived exertion (RPE) by condition

CONDITION	Fluid	No Fluid
	Mean ± SD	Mean ± SD
AM	2.9 ± 0.7	3.1 ± 1.1
PM	*4.0 ± 1.5	3.9 ± 0.7
Significant Difference	Yes (* $p<0.05$ significantly greater than am)	No

Scale : 0 (nothing at all) - 10 (very very strong - almost max)

Thermal Comfort

Both groups reported a greater feeling of discomfort in the afternoon versus morning; (Table 9) however the level of discomfort was not significantly different between groups at each point.

Table 9: Mean (SD) thermal comfort rating by condition

CONDITION	Fluid	No Fluid
	Mean ± SD	Mean ± SD
AM	1.5 ± 0.4	1.6 ± 0.5
PM	*1.9 ± 0.7	*2.3 ± 0.6
Significant Difference	Yes * ($p<0.05$ significantly greater than am)	Yes *($p<0.05$ significantly greater than am)

Scale: 1 (comfortable) - 5 (extremely uncomfortable)

Figure 16: Logger filling out questionnaire and wearing body temperature and heart rate sensors

Subjective Fatigue

Table 10 shows that when subjects did not take fluid regularly during the day they became more; weary, tense, weak, sleepy and bored during the afternoon. Although subjects also reported feeling significantly weaker and more bored with fluid, their fatigue scores were significantly lower than those reported for no fluid. Fatigue levels were significantly lower in the fluid group compared to no fluid group for; questions; 1, 3, 4, 5. Subjective assessment of fatigue indicates that subjects felt less fatigued when taking fluid.

Scale:

Q 1:	*FRESH*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*WEARY*
Q 2:	*TENSE*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*RELAXED*
Q 3:	*STRONG*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*WEAK*
Q 4:	*EXHAUSTED*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*VIGOROUS*
Q 5:	*WIDE AWAKE*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*SLEEPY*
Q 6:	*BORED*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*INTERESTED*

Table 10 : Mean (SD) fatigue scores for morning (AM) and afternoon (PM) by condition

CONDITION		QUESTION NUMBER					
		1	2	3	4	5	6
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
FLUID	AM	2.1 ± 0.5	5.0 ± 1.6	2.2 ± 0.8	5.6 ± 0.6	1.8 ± 0.7	4.9 ± 1.9
	PM	3.5 ± 1.0	4.8 ± 0.9	3.2 ± 1.2	4.7 ± 0.8	2.0 ± 1.0	5.0 ± 1.4
NO FLUID	AM	3.0 ± 1.1	5.1 ± 1.0	2.9 ± 1.2	4.9 ± 1.0	2.5 ± 1.2	4.7 ± 1.7
	PM	*4.5 ± 1.3	4.2 ± 0.8	*3.7 ± 1.2	* 4.1 ± 0.8	*3.0 ± 1.5	4.4 ± 1.8
Significantly Difference from fluid		Yes	No	Yes	Yes	Yes	No

(*p<0.05 significantly different than fluid)

Workers felt fresher, stronger, more wide awake and interested when fluid was taken regularly throughout the day to prevent dehydration.

Thermal Sensation

Table 11 shows that subjects experienced increased thermal sensation as the day progressed, feeling hotter during the afternoon. The increase was significant in the no fluid condition only, with no significant difference between the two conditions.

Table 11: Mean (SD) thermal sensation during morning (AM) and afternoon (PM)

CONDITION	Fluid	No Fluid
	Mean ± SD	Mean, SD
AM	3.9 ± 0.7	3.7 ± 0.9
PM	3.0 ± 1.1	*3.2 ± 1.2
Significant Difference	No	Yes *(p<0.05 significantly less than am)

Scale : 1(very hot) - 9 (very cold)

Skin Wetness

During both conditions subjects reported significantly greater skin wetness during the afternoon compared to the morning however the difference between conditions was not significant (Table 12).

Table 12: Mean (SD) skin wetness ratings for morning (AM) and afternoon (PM)

CONDITION	Fluid	No Fluid
	Mean ± SD	Mean ± SD
AM	3.7 ± 0.5	3.8 ± 1.1
PM	*2.8 ± 1.1	*3.0 ± 0.7
Significant Difference	Yes *(p<0.05 significantly less than am)	Yes *(p<0.05 significantly less than am)

Scale: 1 (very wet) - 9 (very dry)

Thermal Regulation

There was no significant difference in thermal regulation as rated on a scale of 1(vigorously shivering) to 7(heavily sweating) either between morning and afternoon or between fluid and no fluid (Table 13).

Table 13: Mean (SD) thermal regulation during morning (AM) and afternoon (PM)

CONDITION	Fluid	No Fluid
	Mean ± SD	Mean ± SD
AM	4.8 ± 0.5	4.7 ± 0.5
PM	4.8 ± 1.7	5.0 ± 1.0
Significant Difference	No	No

Scale : 1(vigorously shivering) - 7(heavily sweating)

Digit Symbol Substitution (DSS)

The DSS information processing as a measure of mental workload did not show any significant difference in the number of matched digits attempted between conditions, however no fluid produced a higher percentage of correct answers, however the effect was small (Table 14).

Table 14: Mean (SD) DSS scores for percentage correct and the number attempted by condition

CONDITION	Percentage Correct/test	Number Attempted/test
	Mean ± SD	Mean, SD
Fluid	98.0 ± 2.9	110.6 ± 14.5
No Fluid	*98.8 ± 1.7	112.2 ± 8.1,
Significant Difference	Yes *(p<0.05 significantly greater than fluid)	No

SUMMARY AND CONCLUSIONS

- The physical work load of fallers, under summer conditions, can be classified as heavy to moderate.
- The specific impact of heat on forest work was not able to be determined as conditions were cooler than that generally experienced at this time of year.
- Subjects reported mean sweat rates of 3.5 l/day and 3.1 l/day, for fluid and no fluid respectively, with a range of 0.1-6.2 litres/day. The variation was explained by individual difference and more importantly environmental conditions.
- The hotter temperatures produced greater sweat losses, and hence demanded a greater commitment to fluid replacement. When temperature exceeded 17°C sweat rate was greater than 3 litres/day, with an exceptional 6.2 litres/day reported during the hottest day (WBGT of 21°C).
- Dehydration occurred during ad lib drinking (no fluid condition), indicating that fluid intake was not adequate to replace sweat loss under these conditions. The variation in dehydration between workers can be explained by the combined effects of individual difference and temperature; sweat rate increased as temperature increased.
- Besides preventing dehydration a *regular fluid regime* allowed subjects to work at a lower heart rate and a lower relative work load.
- Psychologically, subjects reported feeling fresher, stronger, more vigorous and more wide awake when fluid was taken regularly.

In conclusion, a regular fluid regime will prevent dehydration, reduce physiological work load, and maintain production in fallers during mild environmental conditions.

PRACTICAL APPLICATION TO FOREST WORK

The results of this study reinforce previous research indicating that an appropriate fluid intake is critical to peak physical and mental performance. It appears that those employed in the forest are no exception and what remains is the need for workers to recognize the benefit of fluid and implement fluid regimes that meet their individual needs.

It is also important to note that these results are based on a very small sample of forest workers, performing one particular forest task under one set of environmental conditions. Although the results clearly have application to the wider forest community and compare favourably with other studies, further work is required to identify task, environmental and individual specific guidelines.

- **Forest workers must drink at regular intervals throughout the day to ensure sweat losses are fully replaced and dehydration is prevented.**
- **A fluid intake of at least 0.5 litre per hour is recommended under mild conditions (<18°C), while a fluid intake of up to 1 litre per hour may be required during hot conditions (>22°C)**

Individualizing Fluid Intakes

Because sweat rate varies greatly from one individual to the next it is ideal if workers can identify their own sweat rate during any work day. This can be done by weighing before and after work (nude) and accounting for any fluid consumed (intake) and all fluid lost as urine (losses), 1 litre of fluid = 1 kilogram.

	Weight before work (A)	Weight after work (B)	Weight change (A-B)	Fluid intake as drinks (C)	Fluid loss as urine (D)	Sweat Rate (A-B) +C +D
Mike	74 kg	72 kg	2 kg	3.5 litres	2 litres	(2) + 3.5 - 2 = 3.5 litres/day

IMPORTANT

1 litre of fluid is the maximum that can be taken under any conditions as the stomach cannot empty any faster than 1 LITRE/HOUR!

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APPENDIX A

CONFIDENTIAL HEALTH QUESTIONNAIRE

This questionnaire is designed to:
1. Identify any medical conditions or injuries which may affect your results in either the physical tests or the fieldwork
2. Ensure that if you do have an injury or medical condition you will not be putting yourself at further risk by participating in this study

Results will remain confidential between yourself and your researcher.

Please answer the following questions by indicating the appropriate answer.

FIRST NAME ________________________
SURNAME ________________________
AGE ________
DOCTOR NAME ________________
DOCTOR ADDRESS ________________

FAMILY HISTORY

- Have your Grandparents or Parents suffered from any of the following? (Put relationship eg. Grandparent and age condition started)

	YES	NO
• Asthma	___	___
• High blood pressure	___	___
• Heart attacks or angina	___	___
• Raised blood cholesterol	___	___
• Diabetes	___	___
• Other (eg. Epilepsy)	___	___

DO YOU TAKE ANY REGULAR MEDICATION ? **YES** **NO**

- If "yes" please list drug and daily dose

____

DO YOU SMOKE

- Hooch/Dope **YES** **NO**
- If "yes" how often (days/week) ________
- Cigarettes **YES** **NO**
- If "yes" number smoked daily ________

HAVE YOU EVER SUFFERED FROM ?

Hypertension	YES	NO
Chest pain	YES	NO
Palpitation	YES	NO

RESPIRATORY

Asthma	YES	NO
Recurrent Bronchitis	YES	NO

INJURIES

- Please list any injuries; which have prevented you from work or physical activity during the past year or which may affect your performance in a maximal test, describe the injury, when it occurred and how long it caused you to be off work.

Injury When occurred Time off work (in days)

____

____

____

____

____

ACTIVITY/TRAINING DETAILS

- Do you play a summer sport/s or perform any regular physical activity outside work time or during weekends (eg. touch, hunting, fishing, rugby, gym)

YES NO

- If "yes" please identify the **sport/s or activity** and indicate **number of hours per week**.

Sport/activity	**a)**	**b)**	**c)**
Hrs Training/wk			

HAVE YOU EVER BEEN HOSPITALIZED BY ILLNESS? YES NO

- Details (illness, date, length of time in hospital)

____

____

____

Declaration

- I have correctly completed the above questionnaire and have not withheld any medical information.

Signed ________________________________ **Date** _____________

THANKYOU FOR YOUR CO-OPERATION IN COMPLETING THIS QUESTIONNAIRE

ONCE AGAIN YOU ARE ASSURED THAT THIS INFORMATION WILL REMAIN CONFIDENTIAL

APPENDIX B

CONSENT FOR MAXIMUM EXERCISE TESTING

School of Physical Education, Division of Sciences

University of Otago

In order to determine your maximum oxygen uptake or efficiency to use oxygen you will be asked to participate in a maximal treadmill VO2 test.

Maximal exercise of this nature carries some risk of evoking a heart attack. Exact statistics on the risk of maximal exercise evoking a heart attack are unknown but overseas experience suggests that the risks are low with an estimation of one death and three series heart attacks in 10,000 tests (Kretch 1990). Obviously the risks increase if people are unaccustomed to strenuous exercise, as they get older, and if they suffer from some disease.

In order to minimise this risk of anyone suffering a heart attack during maximal exercise we require you to first complete the medical questionnaire and then provide your informed consent prior to participating in a maximal test of this nature. This means that you agree to participate in the test knowing that it could be of some risk to your health. It also means that your understand the safety procedures used in this procedure.

SAFETY PROCEDURES

The test supervisor ______________________ is trained in CPR and emergency medical assistance will be obtained by telephoning the Nelson ambulance service.

CONSENT

- I ______________________ (Print full name) have read and understood the above information.
- I am satisfied with the safety procedures that will be followed.
- I recognize that there are some risks to my health by participating in a maximal exercise test.
- I know of no medical or other factor that is likely to increase my health risk during this exercise test.
- I am willing to participate in a treadmill maximal test.

______________________ (Signature) ______________ (Date)

Witness ______________________ (Full name) ______________ (Signature)

APPENDIX C

BORG'S NEW SCALE
for
RATING OF PERCEIVED EXERTION (RPE)

0	Nothing at all	
0.5	Very very weak	(Just noticeable)
1	Very weak	
2	Weak	(Light)
3	Moderate	
4	Somewhat strong	
5	Strong	(Heavy)
6		
7	Very strong	
8		
9		
10	Very very strong	(almost max)
Maximal		

(From Borg, G.A. Med. Sci. Sports Exerc.,14:377, 1982)

APPENDIX D

THERMAL COMFORT and THERMAL SENSATION RATING SCALES

Thermal Comfort

1.0	Comfortable
1.5	
2.0	Slightly uncomfortable
2.5	
3.0	Uncomfortable
3.5	
4.0	Very uncomfortable
4.5	
5.0	Extremely uncomfortable

Scale from Cotter (1991) based on those used by Gagge et al (1967) and Cunningham et al (1978)

Thermal Sensation

1	Very hot
2	Hot
3	Warm
4	Slightly Warm
5	Neutral
6	Slightly cool
7	Cool
8	Cold
9	Very cold

Scale from Kirk (1996)

APPENDIX E

SELF ASSESSMENT OF FATIGUE

How do you feel now?
(Please circle the appropriate number for each question)

Q1.	Fresh	1	2	3	4	5	6	7	Weary
Q2.	Tense	1	2	3	4	5	6	7	Relaxed
Q3.	Strong	1	2	3	4	5	6	7	Weak
Q4.	Exhausted	1	2	3	4	5	6	7	Vigorous
Q5.	Wide Awake	1	2	3	4	5	6	7	Sleepy
Q6.	Bored	1	2	3	4	5	6	7	Interested

From Kirk (1996)

APPENDIX F

SKIN WETNESS AND THERMOREGULATION RATING SCALES

Skin Wetness

Question : How does your skin feel?

1	Very hot
2	Hot
3	Warm
4	Slightly warm
5	Neutral
6	Slightly cool
7	Cool
8	Cold
9	Very cold

Thermal Regulation

Question : Are you.....?

1	Vigorously shivering
2	Moderately shivering
3	Slightly shivering
4	Neutral
5	Slightly sweating
6	Moderately sweating
7	Heavily sweating

APPENDIX G

DIGIT SYMBOL SUBSTITUTION TEST

Legg et al (1991)

APPENDIX H

INFORMATION SHEET

Researcher: Tracey Paterson
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PO Box 147
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Supervisor: Dr Gordon Sleivert
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PO Box 56
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Thankyou for taking an interest in this project. Please read the following information carefully before you decide to participate, if you decide to participate - thankyou, if you decide not to participate there will be no disadvantage to you and I thankyou for considering it.

STUDY OBJECTIVES

It is well known that felling is very physically demanding what is not known is how difficult it is to work during Summer when conditions become very hot and humid. To stay cool when working in the heat you will sweat more but this means you lose fluid, if you lose as little as 1-2 kg body weight, your mental and physical performance will be reduced. Therefore you must replace the fluid that you lose from sweat by drinking before, during and after work. To ensure that safety, health and productivity are not affected by hot and humid conditions we want to develop more specific strategies for you to use during work. To do this we need to determine :

- Your work load (how hard it is to fell in Summer)
- How much sweat you lose per day, and how hot your body gets during work
- Whether drinking fluid regularly during the day will reduce work stress

YOUR INVOLVEMENT :
Should you agree to participate in this study you will be asked to:

1. Perform a Physical Assessment in the Lab; this involves:

- **A questionnaire to check you are in good health**

- **A maximum effort treadmill run**
This determines your work capacity (how efficiently your body can use oxygen). The treadmill will start at a slow walking pace and every 3 minutes the speed will increase, you will be asked to continue exercising until you feel that you have reached maximum effort and can no longer continue; if you feel uncomfortable at any stage you are free to stop.

- **A body composition assessment,** which involves skinfold measures, bone widths and muscle girths recorded.

2: Field Work - this will require that we spend 2 days at work with you

Day 1 : You will be asked to work as per a '*normal*' work day.
Day 2 : You will be asked to '*drink a cup of fluid*' (Gatorade sports drink) every 15 minutes during work.

For both days you will be asked to wear:

- A heart rate monitor placed around your chest to measure work load
- A temperature monitor placed inside your ear to measure body temperature
- Skin temperature electrodes taped to your skin to measure skin temperatures

You will also be asked to answer a number of questions to determine how you are feeling each hour. To check mental fatigue level you will be asked to perform a simple fatigue test; where you have to match symbols with numbers (the code is given too you), you will have 5 minutes to match as many as possible on each occasion.

PLEASE READ THE FOLLOWING CAREFULLY

- *You are free to* ***ask questions*** *regarding any part of the study at any stage.*
- *The information that you provide is* ***completely confidential*** *to the researchers.*
- *All information collected will remain* ***anonymous*** *and it will not be possible to identify your results in any reports prepared from this study.*
- *You will receive a* ***copy of the results*** *from this study when completed along with a full explanation of findings.*

- *You may* ***refuse to answer*** *any particular question/s put to you, or* ***withdraw*** *from the study at any stage if you choose without any disadvantage to yourself of any kind.*
- *Please don't hesitate to* ***contact the researchers*** *concerned regarding any further questions or concerns you have about the study or your participation in it.*
- *This proposed study has been* ***reviewed and approved by the Ethics Committee*** *of the University of Otago.*

Appendix I

Study Consent Form

I have read the information outlining the study and have had all details fully explained to me. Any questions that I have regarding the study have been answered to my satisfaction and I am aware that I can ask further questions at any stage during the course of the study.

I understand that it is my right to withdraw from the study at any time, and do not have to provide any reason for doing so to any person. I am under no pressure to participate in this study against my will.

I agree to participate in the study on the following conditions;

1. All personal information will remain confidential.
2. My identity will not be revealed in any written or verbal reports.
3. Only LIRO researchers will be able to access the information that I provide.
4. I understand that the study will be discontinued if it appears to cause me harm or if I do not follow the required procedures.
5. I understand that if I have any concerns regarding the study I may contact the researcher in charge at any stage.

I hereby give my free and informed consent to participate in this study

Signed ______________________________

Name ______________________________

Date ______________________________

Researcher: ______________________________