

# FIRE NOTE

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## THE RELEVANCE OF THE PACK HIKE TEST FOR AUSTRALIAN BUSHFIRE FIREFIGHTERS

### CONTEXT

Fire agencies should become aware of the relevance of the Pack Hike Test (PHT) to Australian bushfire fighting in addition to the human factors associated with successful performance of the test. This research reviews the history, development and validation of the internationally recognised wildfire firefighter work capacity test, the PHT, with emphasis on its relevance for Australian fire agencies.

### BACKGROUND

The annual threat of bushfires to communities across Australia and the world exposes thousands of firefighters to the physically demanding and often dangerous work of suppressing bushfires. The Occupational Health and Safety Act (2004) in Victoria, and similar legislation across Australia, require that employers (including fire agencies) reduce risks to their employees so far as is reasonably practicable. One way of achieving this is by implementing physical competency tests to ensure that firefighters are fit for their required duty and able to work safely and competently. One such test currently being used is the Pack Hike Test (PHT), also known as the Pack Test or Work Capacity Test. The test involves a 4.83 km hike over level terrain carrying a 20.4 kg pack within 45 minutes (Sharkey, 1999). The test is designed to challenge an individual's muscular endurance, strength and cardio-respiratory fitness, and was devised to mimic the physiological strain encountered during wildfire suppression using handtools and to replicate a common USA wildfire firefighter task, i.e. hiking with a pack (DeLorenzo- Green and Sharkey, 1995). The PHT is also currently used as a fit for duty test in Australia. However, the validity of the PHT for Australian firefighters is currently unknown.

### BUSHFIRE CRC RESEARCH

The PHT is a physical competency selection test used to determine if firefighters have the required fitness to perform the necessary tasks for bushfire suppression. As a selection

### SUMMARY

Fighting bushfires is a physically demanding occupation and therefore firefighters need to be physically fit to work safely and productively. Many firefighting agencies employ physical competency tests such as the Pack Hike Test (PHT) to determine whether personnel are fit for duty. The PHT involves a 4.83 km hike over level terrain carrying a 20.4



kg pack within 45 minutes. The PHT was devised to test the job readiness of American wildfire firefighters and is currently used by some fire agencies in Australia, including the Victorian Department of Sustainability and Environment and Australian Capital Territory Rural Fire Service. This Fire Note highlights key points from a recent review (Petersen et al., 2010) of the history and development of the PHT. The review addresses the relevance and validity of the PHT to Australian bushfire firefighters. Different versions and modifications to the PHT have emerged in recent years and the validity of these modified tests is also addressed. Finally, the risks associated with undertaking the PHT are discussed.

### ABOUT THIS FIRE NOTE

This research is from the Firefighter Health and Safety Project within Bushfire CRC Program D: Protection of People and Property

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test, it is vital that the PHT can discriminate between firefighters who possess the essential fitness for the required work from those individuals who do not. The aims of the current research were to:

1. Review the literature on the history and development of the PHT with emphasis

on the process of test validation.

2. Review the validity and suitability of the PHT for Australian bushfire firefighters.
3. Report on the modified versions of the PHT, the human factors associated with successful PHT performance, and risks associated with PHT testing.

## RESEARCH OUTCOMES

### Development and validation of the PHT for USA wildfire firefighters

The PHT was developed by the United States Department of Agriculture Forest Service following concerns that their previous work capacity test (five minutes of bench stepping) was not job related. Tests were conducted to assess the validity of the PHT, as required by the USA Uniform Guidelines on Employee Selection Procedures (UGESP, 1978). As evaluated against the UGESP (1978) guidelines, the content validity of the PHT is mixed, as although the PHT is modelled on an important firefighting task (i.e., hiking with light loads) and is not skill based, the reliability of finishing time and whether the load and test duration are representative of real work practice remain to be verified. The PHT displays modest criterion validity as it is moderately correlated to an important work task (fire line construction using handtools), but it remains unclear whether the 45-min PHT cut-off time is appropriate to differentiate between acceptable and unacceptable job performance on the fireground. Further, future research is required to determine whether the wildland firefighting aerobic energy cost chosen for construct validation is representative of successful performance in the job.

### Use of the PHT in Australian Fire Agencies.

The PHT is being used in Australia by land management fire agencies (e.g., Department of Sustainability and Environment, Victoria; Department of Environment and Heritage, South Australia). Whether the PHT is a valid discriminator of satisfactory job performance in Australian firefighters has not been determined. The reason lies, in part, with the difficulty of determining what constitutes successful job performance for the breadth of tasks performed across a single fire agency, let alone between jurisdictions. Moreover, validating the PHT also requires an understanding of the legal issues surrounding employee selection. The legal requirement of selection tests vary in Australia from state to state compared to USA. Australian land management fire agencies need to demonstrate that the PHT represents an inherent requirement of the job in accordance with Australian anti-discrimination legislation (ADA, 2004). At the very least, Australian land management fire agencies should conduct a job task analysis to determine the inherent bushfire job requirements and then determine whether the PHT is representative of the work firefighters perform when striving to curtail and suppress bushfires. Indeed, a recent study showed that the highest energy expenditure during routine bushfire suppression tasks in Australian tanker-based volunteer firefighters was considerably higher than that elicited by

## REFERENCES

- Age Discrimination Act 2004 (Commonwealth)
- Occupational Health and Safety Act 2004 (Vic)
- Caple D. 2005 Risk assessment: pack hike fitness test. Melbourne, Australia: Department of Sustainability and Environment.
- Delorenzo-Green, T. & Sharkey, B., 1995. Development and validation of a work capacity test for bushfire firefighters. *Medicine and Science in Sports and Exercise*, 27 (suppl), S166.
- Equal Employment Opportunity Commission, 1978. Uniform Guidelines on Employee Selection Procedures. 43 FR 38295; 29 CFR Part 1607; Section 60-3.
- Kohl HW, III, Powell KE, Gordon NF, Blair SN, Paffenbarger RS Jr. 1992 Physical activity, physical fitness, and sudden cardiac death. *Epidemiol Rev.* January 1;14(1):37-58.
- Lord, C, Petersen AC, Netto K, Nichols D, Drain J, Phillips M & Aisbett B. Validating 'fit for duty' tests for Australian volunteer fire fighters suppressing bushfires. *Submitted to Applied Ergonomics, February 2010 – currently in second review.*
- National\_Interagency\_Fire\_Center. Historical Wildland Firefighter Fatality Reports. 20th May, 2009 [cited 20th May, 2009]; Available from: [http://www.nifc.gov/safety/historical\\_stats.htm](http://www.nifc.gov/safety/historical_stats.htm)
- Petersen AC, Payne W, Netto K, Phillips M, Nichols D & Aisbett B. Validity and relevance of the pack hike wildland firefighter work capacity test: a review. *Ergonomics*. 2010;53(10):1276-1285.
- Phillips M, Payne W, Lord C, Netto K, Nichols D & Aisbett B. Physically demanding tasks during bushfire suppression by Australian rural firefighters. Submitted to *Applied Ergonomics*, July 2010. Currently in first review.
- Phillips M, Raines J, Nichols D & Aisbett B. Work demands of tanker based bushfire suppression. In: Thornton R, editor. Australian Fire Authorities/Bushfire Co-Operative Research Centre Annual Conference; 2007a; Hobart, Tasmania, Australia, September 21-23.
- Phillips M, Raines J, Nichols D, Cramer S, McConell G & Aisbett B. Characterization of the physical demands of tanker-based bushfire fighting. In: Thornton R, editor. Australian Fire Authorities/Bushfire Co-Operative Research Centre Annual Conference; 2007b; Hobart, Tasmania, Australia, September 21-23.
- Sharkey, B. and Davis, P., 2008. *Hard work: defining physical work performance requirements* Champaign, IL: Human Kinetics.
- Sharkey, B. & Jukkala, A., 1980. Muscular fitness tests: Development and evaluation. Missoula, MT.
- Sharkey, B. & Rothwell, T., 1996. Validation and field evaluation of a work capacity test for bushfire firefighters. *Medicine and Science in Sports and Exercise*, 28 (5 (Suppl)), S79.
- Sharkey, B. (1999). *Development and validation of a job-related work capacity test for bushfire firefighters*. International Association of Bushfire Fire Conference. Sydney, Australia.
- Sharkey, B., Rothwell, T. & Delorenzo-Green, T., 1994. Development of a job-related work capacity test for bushfire firefighters. *Medicine and Science in Sports and Exercise*, 26 (5 (Suppl)), S88.
- Wildland\_Fire\_Lessons\_Learned\_Center. 20th May, 2009 [cited 20th May, 2009]; Available from: <http://wildfirelessons.net/Home.aspx>
- Vivometrics Government Services, 2007. *A detailed physiologic analysis of the bushfire firefighter pack test* Ventura, CA: Vivometrics Government Services.

the PHT (Phillips *et al.*, 2007b). Whether this level of energy expenditure is necessary for satisfactory job performance in Australian tanker-based volunteer firefighting is yet to be determined.

Australian tanker-based volunteer firefighters do not currently perform fit for duty tests, with the exception of the Australian Capital Territory Rural Fire

Service (ACTRFS). The ACTRFS uses the PHT as a fit for duty test. Recent research conducted (Lord *et al.*, *under review*) reports that firefighters subjectively felt the PHT was more demanding than common fireground tasks, including hose dragging, rake hoe work and combined rake hoe and hose work during a simulated 'blacking out' task. Firefighters' mean walking speed during the PHT was also significantly faster than their speed during

the rake hoe and blacking out tasks. The study showed no differences in mean or peak heart rate between the PHT and simulated fireground tasks. Further, this study identified moderate to strong positive relationships between finishing times for the PHT and three of the four critical tasks performed by Australian volunteer bushfire firefighters. These promising findings need to be balanced, however, by job task analyses (Phillips *et al.*, *under review*) findings that prolonged hiking with a load, the activity upon which the PHT is based (Sharkey 1999) is not a part of tanker-based firefighters' duties when fighting bushfires. Further, a recent study has shown (Phillips *et al.*, 2007a) that Australian tanker-based volunteer firefighters perform intermittent bouts of work, not steady aerobic energy expenditure as required by the PHT. More research and discussion between researchers and fire industry practitioners is required before the validity of the PHT for Australian tanker-based firefighters can be discerned.

#### Human Factors associated with successful performance of the PHT

Across numerous PHT studies, there have been no significant differences identified for completion times of males and females (Sharkey *et al.* 1994, DeLorenzo-Green and Sharkey, 1995, Sharkey and Rothwell, 1996, Sharkey, 1999) indicating that the PHT does not discriminate on the basis of sex. Additionally there appears to be no relationship between body mass and PHT performance (Sharkey, 1999, Vivometrics Government Services, 2007). Slower finishing times for the PHT have, however, been associated with short stature. Studies have reported that those who passed the PHT were taller (1.78 m) than those who failed (1.76 m) (Vivometrics Government Services, 2007). In an additional study, the pass rate for participants less than 1.60 m was only 67 percent, which was significantly lower than for all firefighters (pass rate not reported) in the study (Sharkey 1999). Pass rates for the PHT have been positively associated with measures of cardiorespiratory fitness (Sharkey *et al.*, 1994, DeLorenzo-Green and Sharkey, 1995, Sharkey and Rothwell, 1996, Vivometrics Government Services, 2007), upper body strength and muscular endurance (Sharkey *et al.*, 1994, DeLorenzo-Green and Sharkey, 1995, Sharkey and Rothwell, 1996), and lower body muscular endurance and power (Sharkey *et al.*, 1994). Physical preparation for the PHT and the job should be improved through concurrent endurance and resistance training.

#### Australian Modifications to the PHT

Since the inception of the PHT, some fire agencies have introduced modified versions.



#### END USER STATEMENT

“The Pack Hike Test has been used by the ACT for more than 10 years for assessing fitness of both paid and volunteer fire fighters of the ACT Rural Fire Service. The correlation between this fitness test and the activities of fire fighters has always been questioned. This research has been valuable by assessing the PHT using science. The outcomes of the research now underpin policy in relation to the use of the PHT and improve the health and safety of fire fighters. As seen in the Fire Note, PHT’s have been conducted in variety of ways, and this research has allowed us to strengthen the guidelines around the conduct of our PHT’s to increase safety. Fire fighter safety will always have many components, of which fitness is only one part, but this research has enabled us to link science to decision making, which is exciting as we seek to adopt the learning from across the Bushfire CRC.”

– Andrew Stark, Chief Officer , ACT Rural Fire Service.

Australian land management agencies conduct three versions of the PHT depending upon the fire fighter’s role. If the role is considered arduous, the standard PHT is used (4.83 km with 20.4 kg load within 45 minutes), whereas a moderate role test is termed the Field Walk Test, (3.2 km with 11 kg load within 30 min), and the light role test is the Light Walk Test (1.6 km with no load within 16 minutes; Sharkey and Davis, 2008). In addition, some Australian land management agencies have shortened the standard PHT allowable time to 42.5 minutes for firefighters working in remote areas. At least one Australian land management fire agency has made the provision for pack weight to be reduced to 15.4 kg for firefighters who weigh less than 67 kg. Further research is needed to determine whether this weight allowance and time alterations are justifiable. To the authors’ knowledge, the Light Walk or remote area version of the PHT have not been validated for firefighter job performance in either the USA or Australia. Recent research (Lord *et al.*, *under review*) reports, however, that firefighters’ mean and peak heart rates during the Hose Drag and peak heart rate during the Blackout Hose Drag were significantly lower than during the Field Walk Test (FWT). No

other differences in heart rate were identified between the FWT and simulated fireground tasks. Firefighters’ mean walking speed during the FWT was also significantly faster than their speed during the rake hoe and blacking out hose and rake tasks. There were no differences between firefighters’ perception of effort between the FWT and simulated fireground tasks. This study also identified moderate to strong positive relationships between finishing times for the PHT and for the four critical tasks performed by Australian volunteer bushfire firefighters. On balance, it appears that the FWT has merit in replicating the demands faced by Australian tanker-based firefighters when fighting bushfires. Given the concerns raised earlier about the applicability of the PHT, more research and industry consultation needs to take place before the validity of the FWT for Australian tanker-based firefighters when fighting bushfires can be finalised.

#### Risks associated with the PHT

The PHT is physically demanding and places considerable strain on the body’s cardiovascular and musculoskeletal systems. There is potential for an adverse cardiac event or musculoskeletal injury during the PHT. Due to the potential risks of performing the

## FUTURE DIRECTIONS

Considerable effort has been spent on validating the test to the work demands of US wildfire firefighters, for whom the test displays content validity; however, work is still needed to verify its reliability. Australian land management and fire agencies need to validate the PHT for Australian environmental conditions and should conduct further research to confirm or refute the validity of the PHT (and modified versions thereof) for their personnel. Some ambiguity and conflicting research exists which has shown the PHT may discriminate against shorter statured personnel, indicating the need for further investigation. This report and the review on which it is based underpin the ongoing process of validating the PHT as a fit for duty selection test. Continuing research will assist land management and rural fire agencies decide how, when, and if they implement or continue to use the PHT (or modified versions thereof) as a fit for duty selection test for their bushfire firefighter work roles.



PHT, firefighters in USA and Australia are required to complete pre-test health checks. At least six USA wildland firefighters died after suffering an adverse cardiac event during or following the PHT from 2002 to 2008 (NIIC, 2009; WLLC, 2009). At least two non-fatal heart attacks in USA wildland firefighters have occurred as a result of the PHT over the same period. The numbers of fatalities are similar with those suffered within the general population during exercise testing (Kohl et al., 1992). To date, there have been no reports of fatalities, and one report of a non-fatal adverse cardiac event in Australian firefighters attributed to the PHT. Reports of non-fatal firefighter injuries are often not comprehensive enough to ascertain the exact cause of the injury. Current injury reporting procedures (in Australia, at least) make it

difficult to determine the number of non-fatal injuries that are due to the PHT. A risk assessment prepared for the Department of Sustainability and Environment in Victoria, Australia noted that there had been no manual handling injuries reported as a consequence of the PHT in its land management firefighters (Caple, 2005). More research is, however, required to investigate the likely injury risks that firefighters could be exposed to when training for, or performing the PHT.

### HOW COULD THIS RESEARCH BE USED?

The findings from the review showed that the reliability and cut-off scores for the PHT require further investigation in USA wildfire firefighters. Also, Australian land management and fire agencies will need to conduct a job

task analysis to determine the inherent job requirements and then determine whether the PHT is representative of those requirements. Phillips *et al.* (*under review*) has undertaken job task analysis of tanker-based volunteer firefighters in Australia in accordance with the recommendations from this review. As presented, the review also prompted Lord *et al.* (*under review*) to compare the physical, physiological and subjective responses during the PHT, Field Walk Test and four common tanker-based firefighting tasks. Current research within the Bushfire CRC Firefighter Health and Safety Project is focused on identifying and measuring the associated load on the muscles during the PHT. These studies will help to ascertain if the PHT is representative of the required work of Australian rural firefighters.

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