

Second International Conference on Physical Employment Standards (PES 2015) August 23-26, 2015

**Conference Theme
Best Practice in Physical Employment Standards: An
International Perspective**



Photograph courtesy of David Buzzeo (<http://www.buzzeophotography.com>)

Canmore, Alberta, Canada



ORGANIZING COMMITTEE

Stewart Petersen, University of Alberta (Chair)
Greg Anderson, Justice Institute of British Columbia
Randy Dreger, Northern Alberta Institute of Technology
Ann Jordan, University of Alberta
Devin Phillips, University of Alberta
Tara Reilly, Department of National Defence
Nigel Taylor, University of Wollongong, Australia
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Jamie Yakemchuk, Edmonton Police Service

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OFFICE OF THE DEAN
FACULTY OF PHYSICAL EDUCATION AND RECREATION

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August 23, 2015

Dear Conference Attendees,

The Faculty of Physical Education and Recreation at the University of Alberta is pleased to be a major partner in the hosting of the Second International Conference on Physical Employment Standards in Canmore, Alberta - one of the Canada's most scenic communities nestled at the doorstep to the internationally renowned Banff National Park.

As Dean of the Faculty it is my pleasure to welcome you to the conference. I trust your visit will be enjoyable and productive, and your memories lasting. It is certainly pleasing to see strong representation from across Canada and around the world. It is impressive to see that almost half of the delegates come from outside of Canada, including South Africa, Singapore, Finland, Germany, Netherlands, Australia, New Zealand, the United States, and the United Kingdom.

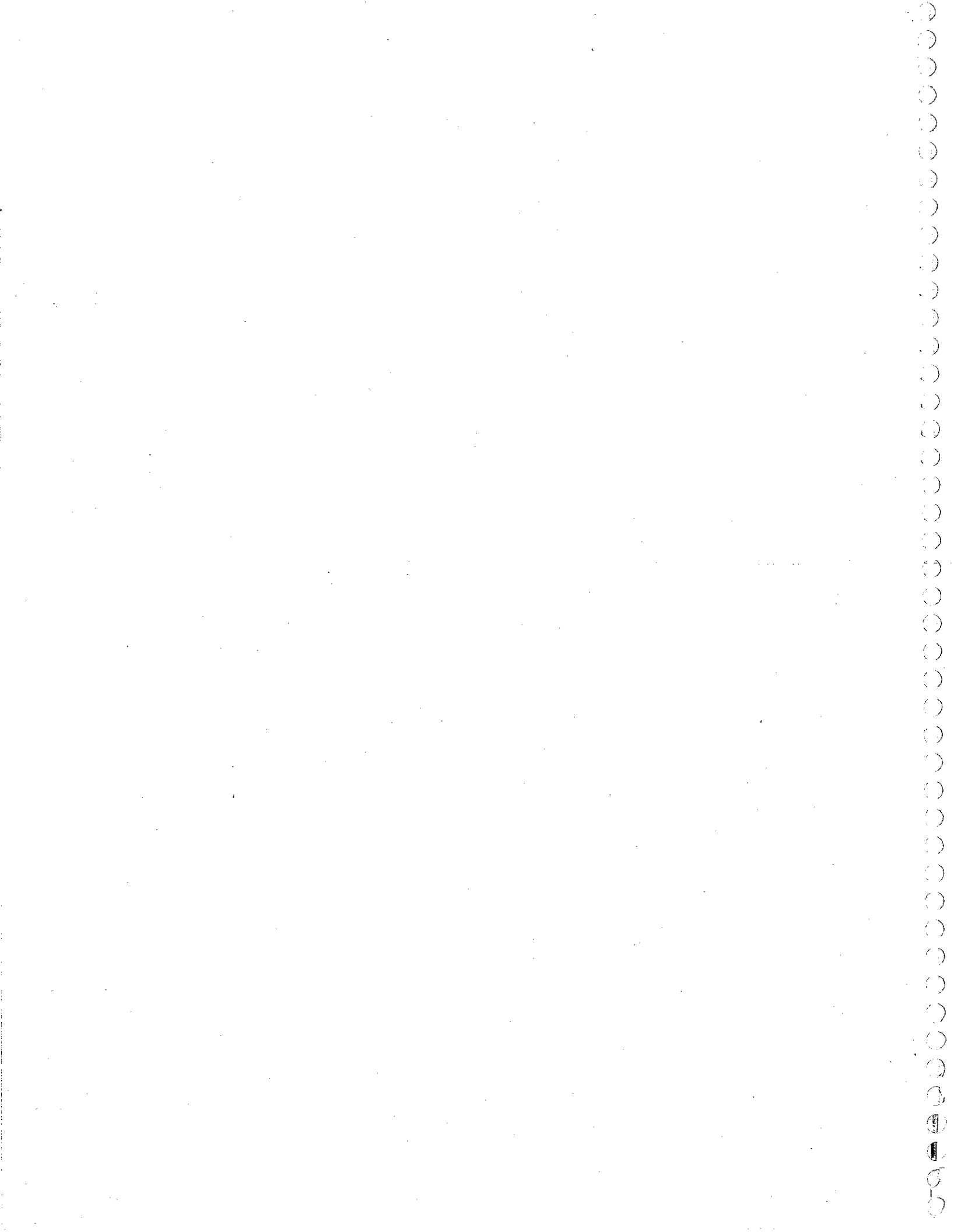
The scientific programme will consist of keynote, plenary and knowledge translation sessions as well as original research presentations from an array of experts from around the world. Given the somewhat niche nature of the work around physical employment standards, the ability to attain a critical mass of leading researchers and practitioners in the area, such as we will see in Canmore, is a rare and valuable opportunity to move the entire field forward.

I would like to thank Dr. Stewart Petersen and the rest of the organising committee for their work at pulling this conference together. The conference looks to be exciting, and the legacy, in the form of a special issue of Applied Physiology, Nutrition and Metabolism (APNM), lasting.

Enjoy your time in Canmore. Best wishes,

A handwritten signature in black ink, appearing to read "W. Kerry Mummery".

W. Kerry Mummery, PhD, FASMF Professor and Dean
Faculty of Physical Education and Recreation





Greetings from the Mayor of Canmore

Welcome to Canmore! On behalf of Town Council and Canmore residents, it is a pleasure to welcome you to our community. Thank you for holding your second conference on Physical Employment Standards in Canmore. We are happy to have you here.

An event like yours provides many great opportunities – for working together, learning new things, challenging dominant ways of thinking, meeting new people, and having some fun. I congratulate you on bringing together great thinkers from a variety of disciplines from around the world.

Thank you for supporting our local businesses and caring for our environment while you are here. I hope that while you're here you'll have a chance to learn a bit about our town's history and to explore the Canmore of today. Our town is filled with unique restaurants, shops and galleries and many trails and recreational opportunities await the adventuresome.

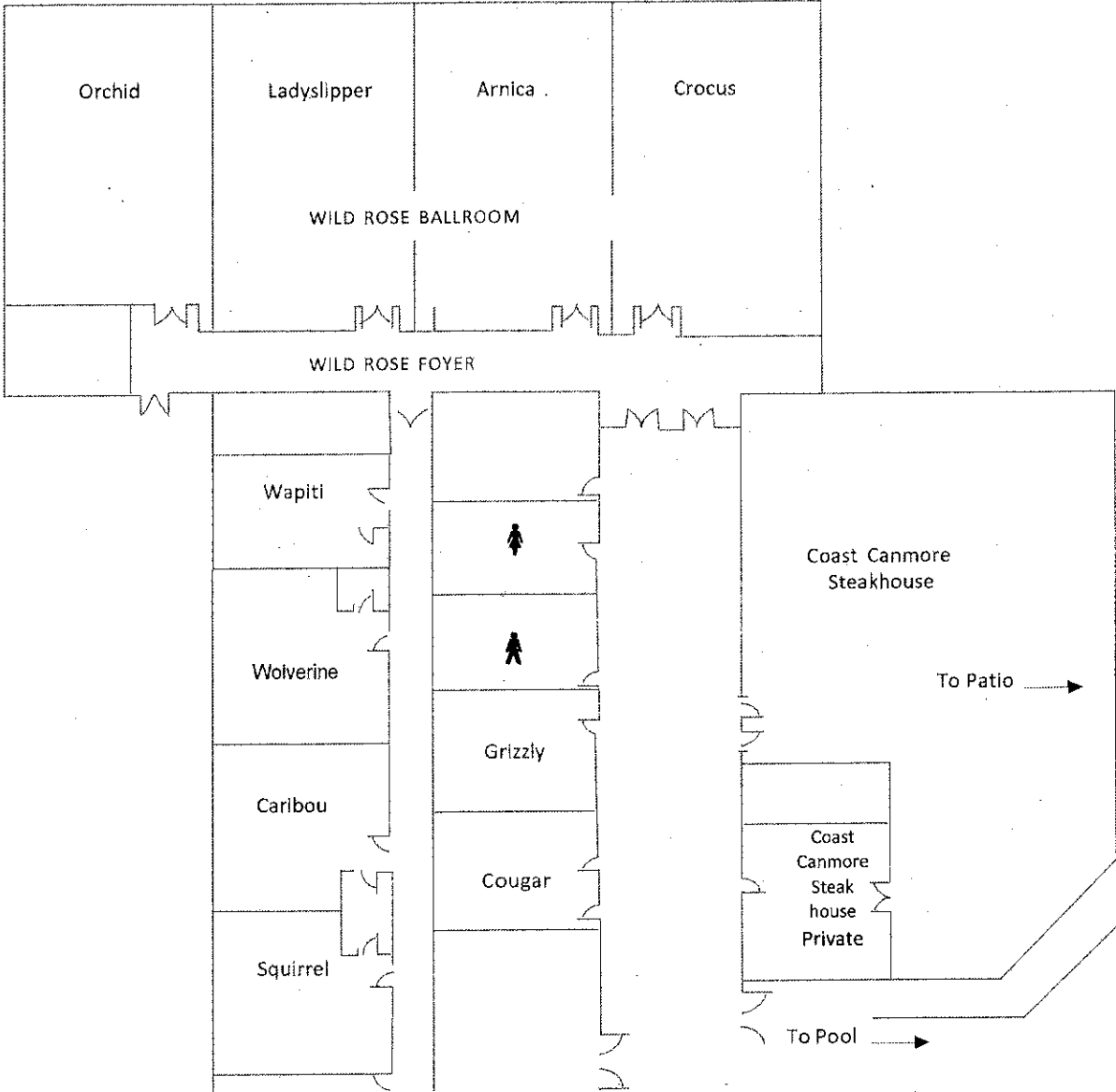
I hope you'll enjoy your time in Canmore and wish you success in your conference.

Yours sincerely,

A handwritten signature in black ink, appearing to read "John Borrowman". The signature is fluid and cursive, with a large initial "J" and "B".

Mayor John Borrowman

Coast Canmore Conference Centre Floor Plan



CONFERENCE PROGRAM

August 23-26, 2015

*Coast Hotel and Conference Centre
Canmore, Alberta, Canada*

SUNDAY, AUGUST 23

1600-2100 Registration: [Concourse]
Canmore Tourism Consultant in attendance

1900-2100 Plenary Session: Stewart Petersen [Orchid/Lady Slipper/Arnica]
Welcome to Alberta!
Representative from the Town of Canmore
John Spence, Associate Dean (Research), Faculty of Physical Education and Recreation,
University of Alberta
Danielle Campbell, Deputy Chief, Edmonton Police Service

Keynote Address: "Lessons from the past and priorities for the future"

Speakers
David Docherty, University of Victoria
Terry Graham, University of Guelph
Brian Sharkey, University of Montana
Nigel Taylor, University of Wollongong
Mike Tipton, University of Portsmouth

2100-2300 Welcome Reception [Crocus]

MONDAY, AUGUST 24

0700-0745 - Hosted Continental Breakfast [Concourse]

0800-0945 - Plenary Session 2: Stewart Petersen [Orchid/Lady Slipper/Arnica]
"Standard-setting methodology: Establishing performance standards and setting cut scores"
Bruno Zumbo

"Validity of tests and standards: the transition from job analysis to occupational fitness test and standard development"
Gemma Milligan, Tara Reilly, Mike Tipton

0945-1015 - Morning Break [Concourse]
Coffee, tea, and juice

1015-1200 - Knowledge Translation Session 1 [*Orchid/Lady Slipper/Arnica/Cougar-Grizzly*]

Organizer/Moderator: Randy Dreger

Breakout Group Facilitators: Vern Elliot, Roni Jamnik, Audrey Holliday, Lynne Stuart-Hill

Participants will examine physical/physiological components associated with various testing paradigms:

1. Applicants and incumbents
2. Task simulation and component
3. Full time and part time (auxillary)
4. Medical and physical standards

1200-1500 - Lunch and Physical Activity Break [*Orchid/Lady Slipper/Arnica*]

1500-1645 - Plenary Session 3 [*Orchid/Lady Slipper/Arnica*]

Moderator: Greg Anderson

"Reliability of test measures"

Will Hopkins

"Human rights at work: Employment standards and human rights law"

Eric Adams

1700-1900 - Free Communications 1, 2, 3

Session 1 Chair: Herb Groeller [*Orchid*]

1700-1720

Job and Physical Demands Assessment of Unionized Jobs at Hayes Logging Company

Lynne A. Stuart-Hill and Catherine A. Gaul

School of Exercise Science, Physical and Health Education, University of Victoria

1720-1740

Establishing a Cross-Canada Fitness Standard for Wildland Fire Fighters: the WFX-FIT

Robert J. Gumieniak¹, MSc., Norman Gledhill¹, PhD., and Veronica Jamnik¹, PhD.

¹*Faculty of Health, Kinesiology and Health Science, York University, Toronto, ON, Canada.*

1740-1800

Physical Demands for Sea Survival: A Standard for Sea Survival?

G.S. Milligan and M.J. Tipton

Extreme Environments Laboratory, Department of Sport and Exercise Sciences, University of Portsmouth, Spinnaker Building, Cambridge Road, Portsmouth, Hants, PO1 2ER, UK.

1800-1820

The Ottawa Paramedic Physical Ability Test (OPPAT): A Review of Process and Development

Kathryn E. Sinden¹, Renee S. MacPhee², Steven L. Fischer¹ & the Ottawa Paramedic Service (OPS) Research Team³

¹*School of Kinesiology and Health Studies, Queen's University, Kingston, ON, Canada*

²*Health Sciences and Kinesiology & Physical Education, Wilfred Laurier University, Waterloo, ON, Canada,* ³*Ottawa Paramedic Services, Ottawa, ON, Canada*

1820-1840

A Task Analysis for the Development of Minimum Physical Employment Standards for Physically Demanding Occupations.

Richard D.M. Stevenson^{1,2}, Andrew G. Siddall¹, Philip J.F. Turner¹, Keith A. Stokes¹, James L.J. Bilzon¹.

¹*Department for Health, University of Bath, Bath, UK*

²*Occupational Health Services, South Wales Fire & Rescue Service, Cardiff, UK*

1840-1900

Development of a Supplemental Ladder Raise and Extension Test to the CPAT

Aaron J. Derouin, PhD Candidate¹ and Jim R. Potvin, PhD²

¹*School of Kinesiology and Health Studies, Queen's University, Kingston, Ontario*

²*Department of Kinesiology, McMaster University, Hamilton, Ontario*

Session 2 Chair: George Havenith [Lady Slipper]**1700-1720**

The Physiological Cost of Palletising Under Time Constraints: Why Slower May be Better.

Joanne N. Caldwell¹, Benjamin Beck², Andrew P. Hunt², Kane Middleton¹

¹*Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Australia,*

²*Land Division, Defence Science and Technology Organisation, Australia*

1720-1740

The Effects of Thoracic Load Carriage on Maximal Work Tolerance and Acceptable Work Duration

Gregory E. Peoples, Daniel S. Lee, Sean R. Notley and Nigel A.S. Taylor

Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Wollongong, NSW, Australia.

1740-1800

Muscle Forces of 18 - 29 Year Old Soldiers and Insights Into Potential Limits of Female Strength Trainability Exemplified by Female Soldiers' Handgrip Forces

D. Leyk^{1,2}, A. Witzki¹, U. Rohde¹, W. Gorges¹, M. Krapick¹, T. Harbaum¹, A. Moedl², M. Kracht², T. R  ther²

¹*Central Institute of the Federal Armed Forces Medical Services Koblenz, Germany*

²*German Sport University Cologne - Research Group Epidemiology of Performance - Cologne, Germany*

1800-1820

Ventilatory Responses to Prolonged Exercise with Heavy Load Carriage in Females

Devin B. Phillips¹, Michael K. Stickland², Stewart R. Petersen¹

¹*Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada*

²*Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada*

1820-1840

Development of Minimum Cardiorespiratory Fitness Standards for UK Firefighters

James L.J. Bilzon¹, Andrew G. Siddall¹, Richard D.M. Stevenson^{1,2}, Philip J.F. Turner¹, Keith A. Stokes¹

¹*Department for Health, University of Bath, Bath, UK*

²*Occupational Health Services, South Wales Fire & Rescue Service, Cardiff, UK*

1840-1900

Stressed and Un-stressed Shooting Performance in Police Officers

Gregory S. Anderson, Michael Trump

Justice Institute of British Columbia, New Westminster, BC, Canada

Session 3 Chair: Glen Kenny [Cougar-Grizzly]**1700-1720**

Lift Performance is Moderated Primarily by Fat-free Mass Rather than Stature

Kane J. Middleton¹, Greg L. Carstairs², Daniel C. Billing², Joanne N. Caldwell¹, Benjamin Beck²

¹*Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Wollongong, Australia*

²*Land Division, Defence Science and Technology Organisation, Melbourne, Australia*

1720-1740

Application of Subjective Job Task Analysis Methodologies in Physically Demanding

Occupations: Evidence for the Presence of Self-Serving Bias

Benjamin Lee-Bates¹, Kane Middleton², Greg Carstairs³, Daniel Billing³, Denise Linnane³, Peter Caputi¹

¹*School of Psychology, University of Wollongong, Wollongong, NSW, Australia*

²*Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Wollongong, NSW, Australia*

³*Land Division, Defence Science and Technology Organisation, Melbourne, VIC, Australia*

1740-1800

Determining Strength and Muscular Endurance Standards for UK Firefighters

Andrew G. Siddall¹, Richard D.M. Stevenson^{1,2}, Philip J.F. Turner¹, Keith A. Stokes¹, James L.J. Bilzon¹

¹*Department for Health, University of Bath, Bath, UK*

²*Occupational Health Services, South Wales Fire & Rescue Service, Cardiff, UK*

1800-1820

Usability of Computer-based Assessment Method of Physical Work Capacity among Firefighters

Sirpa Lusa, Anne Punakallio, Janne Halonen, Miia Wikström

Physical Work Capacity Team, Finnish Institute of Occupational Health, Helsinki, Finland

1820-1840

Modified Box Kinematics and Decreased Stance Duration Explain Improved Box Lift Performance Following Familiarisation

Catriona A. Burdon¹, Joanne N. Caldwell¹, Benjamin Beck², Kane Middleton¹

¹ Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Wollongong,

Australia, ²Land Division, Defence Science and Technology Organisation, Melbourne, Australia

1840-1900

Pre-employment functional capacity assessments predict musculoskeletal injury risk in healthy male coal mine workers

Jennifer Legge^{1,2}, Robin Burgess-Limerick^{2,3}, Geeske Peeters^{2,4}

¹ JobFit Systems International, Mackay

² School of Human Movement Studies, The University of Queensland, Brisbane

³ Minerals Industry Safety and Health Centre, The University of Queensland, Brisbane

⁴ School of Population Health, The University of Queensland, Brisbane

Cash bar with light snacks [Concourse]

Evening – No-Host Dinner & Free time

TUESDAY, AUGUST 25

0700-0745 – Hosted Continental Breakfast [Concourse]

0800-0945 – Plenary Session 4 [Orchid/Lady Slipper/Arnica]

Moderator: David Docherty

“Sex-related issues in physical employment standards”

Delia Roberts, Deborah Gebhardt, Marilyn Sharp

“Age, human performance and physical employment standards”

Glen Kenny, Herb Groeller

0945-1015 – Morning Break [Concourse]

Coffee, tea and juice

1015-1200 – Knowledge Translation Session 2 [Orchid, Lady Slipper, Arnica, Cougar-Grizzly]

Organizer/Moderator: Randy Dreger

Breakout Group Facilitators: Nicole Thomas, Jamie Yakemchuk, Sue Jaenen, Glen Kenny

Participants will examine physical/physiological issues associated with various occupational groups

1. Firefighting
2. Law enforcement
3. Military
4. Industry

1200-1500 – Lunch and Physical Activity Break

1500-1645 – Plenary Session 5 [Orchid/Lady Slipper/Arnica]

Moderator: Terry Graham

“Load carriage, human performance and physical employment standards”

Nigel Taylor, Greg Peoples, Stewart Petersen

“Protective clothing ensembles, human performance and physical employment standards”

Tom McLellan, George Havenith

1700-1900 – Poster Session 1 [Crocus]

Posters up by 1300, authors will be in attendance at their posters from 1800 – 1900

Poster 1

Fitness for Duty: A Canadian Nuclear Regulatory Perspective

Aaron J. Derouin^{1,2}, Lynda Hunter¹, Patrick Adams¹, Richard Tenant¹

¹ *Canadian Nuclear Safety Commission, Ottawa, Ontario, Canada*

² *PhD Candidate, School of Kinesiology and Health Studies, Queen's University, Kingston, Ontario, Canada*

Poster 2

Promoting Health and Wellness While Maintaining Physical and Medical Employment Standards Through a Comprehensive Occupational Medical Program in the Fire Service

E.K. Tomaras

Calgary Fire Department, The City of Calgary, Calgary, AB, Canada

Poster 3

The Most Critically Demanding Strength-Based Generic Tasks Undertaken Onboard UK Royal Navy Warships

Piete E.H. Brown, and Joanne L. Fallowfield

Institute of Naval Medicine, Gosport, Hampshire, UK

Poster 4*

Job-specific functional assessment associated with reduction in musculoskeletal injuries in building security workers

Jennifer Legge

JobFit Systems International, Mackay, Queensland, AUSTRALIA

Poster 5

Job-related test approach for a physical aptitude test in police training context

Annie Gendron, Ph. D., Jean-René Morrissette, M. Sc., Danielle-Claude Bélanger, M. A.

École nationale de police du Québec, QC, Canada

Poster 6

Factors Associated With Success in PARE Testing Among RCMP Officers

R. A. Séguin², J. Irwin¹, A. Johnson¹, A. Mandich¹

¹ Faculty of Health Sciences, University of Western Ontario, London ON

² RCMP Division Fitness & Lifestyle Advisor, HQ "O" Division, London ON

Poster 7

Performance and Gender Factor Differences on Pacing in the RCMP PARE Pursuit Circuit

R.A.G. Séguin², J. Irwin¹, A. Johnson¹, A. Mandich¹

¹ Faculty of Health Sciences, University of Western Ontario, London ON

² RCMP Division Fitness & Lifestyle Advisor, HQ "O" Division, London ON

Poster 8

Is Self-reported Physical Activity Frequency and Intensity a Predictive Factor of Success in the RCMP PARE?

R.A.G. Séguin², J. Irwin¹, A. Johnson¹, A. Mandich¹

¹ Faculty of Health Sciences, University of Western Ontario, London ON

² RCMP Division Fitness & Lifestyle Advisor, HQ "O" Division, London ON

Poster 9

Can an Annual Baseline Physical Employment Standards also be used to Screen at the Occupation-Specific Level?

Stacey Bain, Daniel Théoret, Patrick Gagnon

Directorate of Fitness, Canadian Forces Morale and Welfare Services, Canadian Armed Forces, Ottawa, ON, Canada

Poster 10

Influence of Size and Gender on Performance During a Work Simulation Test of Physical Fitness for Firefighters

Randy W. Dreger¹, Liam P.N. Boyd², Stewart R. Petersen²

¹ School of Health Sciences, Northern Alberta Institute of Technology, Edmonton, AB, Canada

² Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada

Poster 11

The Effect of Body Size on Job-Related Test Performance in Firefighter Applicants

Michael P. Scarlett^{1,2}, Devin B. Phillips¹, Stewart R. Petersen¹

¹ Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada

² School of Health, Wellness and Human Services, Keyano College, Fort McMurray, AB, Canada

Poster 12

The Effect of Body Size on Treadmill Test Performance in Fire Protective Ensemble

Michael P. Scarlett^{1,2}, Devin B. Phillips¹, Stewart R. Petersen¹

¹ Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada

² School of Health, Wellness and Human Services, Keyano College, Fort McMurray, AB, Canada

Poster 13

Quantification and Prediction of Physical Burden in Chemical Protective Clothing

ShuQin Wen¹, Stewart R. Petersen², Jane Batcheller¹

¹*Department of Human Ecology, University of Alberta, Edmonton, AB, Canada*

²*Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada*

Poster 14

The Effects of Backpack Weight on Cardiopulmonary Responses to Treadmill Exercise

Cameron M. Ehnes¹, Devin B. Phillips¹, Michael K. Stickland², Stewart R. Petersen¹

¹*Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada*

²*Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada*

Poster 15

The Effects of Heavy Load Carriage on Physiological Responses and Performance during Graded Exercise in Young Healthy Females

Devin B. Phillips¹, Lauren N. Lee¹, Michael K. Stickland^{1,2}, Stewart R. Petersen¹

¹*Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada*

²*Department of Medicine, University of Alberta, Edmonton, AB, Canada*

Poster 16

The Effect of Body Size on Performance during Treadmill Exercise with Heavy Load Carriage

Devin B. Phillips¹, Michael K. Stickland², Stewart R. Petersen¹

¹*Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada*

²*Faculty of Medicine and Dentistry University of Alberta, Edmonton, AB, Canada*

Poster 17*

The Distillation of Criterion Occupational Tasks from Workforce Job Lists and Physiological Measurements.

Taylor, N.A.S., Fullagar, H.H.K., Sampson, J.A., Mott, B.J., and Groeller, H.

Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Australia.

Poster 18*

The transition from criterion occupational tasks to physical aptitude screening tests.

Groeller, H., Fullagar, H.H.K., Sampson, J.A., Mott, B.J., and Taylor, N.A.S.

Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Australia.

Poster 19*

Physical Abilities Requirement Evaluation Re-Validation

Gregory Anderson¹ and Darryl Plecas²

¹*Justice Institute of British Columbia*

²*University of the Fraser Valley*

Poster 20*

Variability in Performance of a Work Simulation Test of Physical Fitness for Firefighters

Liam Boyd¹, Todd Rogers², David Docherty³, Stewart Petersen¹

¹*Faculty of Physical Education and Recreation, University of Alberta*

²*Faculty of Education, University of Alberta*

³*School of Exercise Science, Physical and Health Education, University of Victoria*

Poster 21*

Establishment of Performance Standards and a Cut-Score for the Canadian Forces Firefighter Physical Fitness Maintenance Evaluation (FF PFME)

W. Todd Rogers¹, David Docherty², Stewart Petersen³

¹*Faculty of Education, University of Alberta*

²*School of Exercise Science, Physical and Health Education, University of Victoria*

³*Faculty of Physical Education and Recreation, University of Alberta*

Poster 22

Ten-year injury analysis for Conservation Officers in the Province of Ontario

Lynneth A. Stuart-Hill¹, Catherine A. Gaul¹ and Brian Morrison²

¹*School of Exercise Science, Physical and Health Education, University of Victoria*

²*Ontario Ministry of Natural Resources*

Poster 23

Development of a Green Chain Task Simulation Test for Seven Weyerhaeuser Mills in British Columbia

Lynneth A. Stuart-Hill and Catherine A. Gaul

School of Exercise Science, Physical and Health Education, University of Victoria

Poster 24*

Job and Physical Demand Analysis of Field Conservation Work in the Province of Ontario

Lynneth A. Stuart-Hill¹, Catherine A. Gaul¹ and Brian Morrison²

¹*School of Exercise Science, Physical and Health Education, University of Victoria*

²*Ontario Ministry of Natural Resources*

Poster 25*

Development of a Pre-employment Physical Abilities Test for Field Conservation Officers in Ontario

Lynneth A. Stuart-Hill¹, Catherine A. Gaul¹ and Brian Morrison²

¹*School of Exercise Science, Physical and Health Education, University of Victoria*

²*Ontario Ministry of Natural Resources*

Poster 26*

Generic Task-Related Occupational Requirements for Royal Naval Personnel

James L.J. Bilzon^{1,2}, Emily G. Scarpello², Emma Bilzon² and Adrian J. Allsopp²

¹*Department for Health, University of Bath, Bath, UK*

²*Environmental Medicine Unit, Institute of Naval Medicine, Gosport, Hampshire, UK*

Poster 27

A Basic Water Skills Test for use in Air Force Pararescue Selection

Neal Baumgartner¹, Orben C. Greenwald², Kimberly N. Hale³, Katherine A. Batterton³

¹USAF Fitness Testing and Standards Unit, Joint Base San Antonio-Randolph, TX, USA, ²USAF 342 Training Squadron, Joint Base San Antonio-Lackland, TX, USA, ³USAF Studies and Analysis Squadron, Joint Base San Antonio-Randolph, TX, USA.

Poster 28

Development of Occupationally Specific, Operationally Relevant Physical Fitness Tests and Standards for US Air Force Battlefield Airmen: New vs Old

Neal Baumgartner¹, Ryan W. Logan¹, Dana L. Pape¹, Matthew F. Gruse¹, Erin M. Flerlage¹, Kimberly N. Hale², Katherine A. Batterton², Sean M. Robson³

¹USAF Fitness Testing and Standards Unit, Joint Base San Antonio-Randolph, TX, USA, ²USAF Studies and Analysis Squadron, Joint Base San Antonio-Randolph, TX, USA, ³Rand Corporation, Washington D.C., USA.

* designates a paper that has been previously presented at a major conference. These abstracts will appear in the conference program but will not be published.

Free Communications 4 [Cougar-Grizzly]

Chair: James Bilzon

1700-1720

Between-Day Repeatability of the Ottawa Paramedic Physical Ability Test (OPPAT)
Steven L. Fischer¹, Kathryn E. Sinden¹, Renee S. MacPhee², Kim Moull¹ & the Ottawa Paramedic Service (OPS) Research Team³

¹School of Kinesiology and Health Studies, Queen's University, Kingston, ON, Canada
²Health Sciences and Kinesiology & Physical Education, Wilfrid Laurier University, Waterloo, ON, Canada, ³Ottawa Paramedic Service, Ottawa, ON, Canada

1720-1740

Is Torso Body Armour Mass or its Bulk Responsible for Diminished Box Lift Performance?

Catriona A. Burdon¹, Joanne N. Caldwell¹, Benjamin Beck², Kane Middleton¹

¹Centre for Human and Applied Physiology, School of Medicine, University of Wollongong, Wollongong, Australia, ²Land Division, Defence Science and Technology Organisation, Melbourne, Australia

1740-1800

Methodologies in Development and Implementation of Commando Proficiency Test Standards

Yee Siang CHNG¹, Kaizhen CHEN¹, Pearl TAN¹, Tong LEE¹, Boon Kee SOH¹, Carolyn FU¹, Wee Hon ANG¹, Siao Ying CHIOU¹, Max CHOW², Samuel WANG², Benson ZHAO², Lydia LAW¹, Jason LEE^{1,3,4}

¹DSO National Laboratories, Singapore, ²Singapore Armed Force, ³Yong Loo Lin School of Medicine, National University of Singapore, Singapore, ⁴Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

1800-1820

Establishing the Performance Standard and Examining Pass Rates on the Canadian Fitness Standard for Wildland Fire Fighters.

Robert J. Gumieniak, Norman Gledhill, Loren Yavelberg, Veronica Jamnik
Faculty of Health, Kinesiology and Health Science, York University, Toronto, ON, Canada.

1820-1840

A Comparison of Performance on Incremental Shuttle Running Tests With and Without Carrying a 15 kg Load and their Relationships with Load Carriage Performance

Sam D. Blacker, Stephen D. Myers, Andrew T. West, David M. Wilkinson
Department of Sport and Exercise Sciences, University of Chichester, Chichester, West Sussex, United Kingdom

1840-1900

Setting a Performance Standard for the Canadian Joint Incident Response Unit Chemical, Biological, Radiological and Nuclear Operator Job Specific Test

C. MacDonald¹, S. Jaenen¹, & A. Smyth¹
¹Canadian Forces Morale and Welfare Services, Directorate of Fitness, Human Performance Research and Development, Ottawa, Ontario, Canada

Cash bar with light snacks [*Concourse*]

1930 – Conference Dinner [*Orchid/Lady Slipper/Arnica*]

WEDNESDAY, AUGUST 26

0700-0745 – Hosted Continental Breakfast [*Concourse*]

0800-09.45 – Plenary Session 6 [*Orchid/Lady Slipper/Arnica*]

Moderator: Mike Tipton

“Thermal stress, human performance and physical employment standards”

Stephen Cheung, Jason Lee, Juha Oksa

“Nutra-Ergonomics: Influence of workplace nutrition on performance, health and the development of chronic disease”

Jane Shearer, Terry Graham, Tina Skinner

0945-1015 – Morning Break [*Concourse*]

1015-1200 – Knowledge Translation Session 3 [*Orchid/Lady Slipper/Arnica/Cougar-Grizzly*]

Organizers/Moderators: Randy Dreger

Participants will examine best practice issues:

1. Test administration
2. Back to work evaluations

This session will conclude with full group discussion

1200-1500 – Lunch and Physical Activity Break

1500-1645 – Plenary Session 7 [Orchid/Lady Slipper/Arnica]

Moderator: Nigel Taylor

“Stress, human performance and physical employment standards”

Greg Anderson

“Development of medical standards and guidelines: Many grey areas”

Deborah Gebhardt

1700-1745 – Closing Session [Orchid/Lady Slipper/Arnica]

Student Research Awards

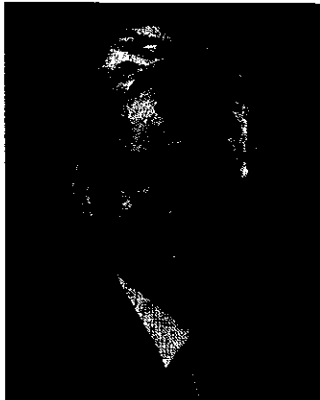
Closing Comments

Plenary Session Summaries:

Keynote Address: Lessons from the past and priorities for the future



Dave Docherty, "Fit for duty: Thinking outside the line about setting standards"



Terry Graham, "Improving the quality of science in physical employment standards research"



Brian Sharkey, "Annual assessment of fitness for duty: Physical accountability"

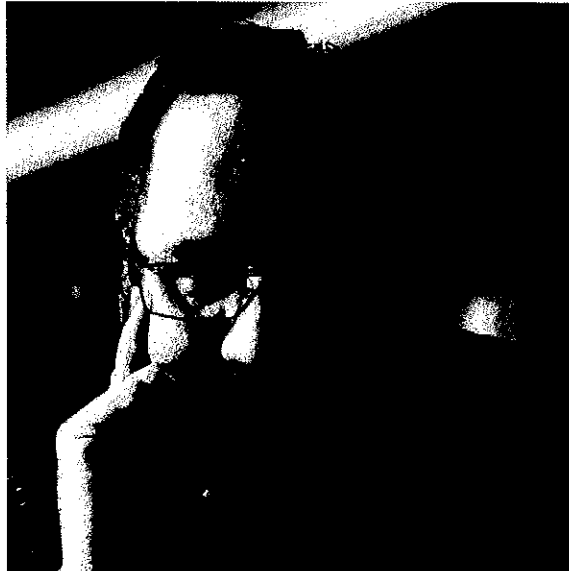


Nigel Taylor, "How to make money and influence people"



Mike Tipton, "Subjectivity cloaked as objectivity in physical employment standards"

Standard-setting methodology: Establishing performance standards and setting cut scores to assist score interpretation



Bruno D. Zumbo, University of British Columbia

A critical step in the development and use of tests of physical fitness for employment purposes (e.g., fitness for duty) is to establish one or more cut points dividing the test score range into two or more ordered categories reflecting, for example, fail/pass decisions. Over the last three decades elaborated theories and methods have evolved focusing on the process of establishing one or more cut scores on a test. This elaborated process is widely referred to as 'standard setting'. As such, the validity of the test score interpretation hinges on the standard setting, which embodies the purpose and rules according to which the test results are interpreted. The purpose of this paper is to provide an overview of standard setting methodology. The essential features, key definitions and concepts, and various methods of standard-setting will be described and contrasted in broad strokes. The focus is on foundational issues with an eye toward informing best practices. Throughout, a case is made that in terms of best practices, establishing a test standard involves, in good part, setting a cut score and can be conceptualized as evidence/data-based policy making that is essentially tied to test validity.

Validity of tests and standards: the transition from task analysis to occupational fitness test and standard development



Gemma Milligan



Tara Reilly*



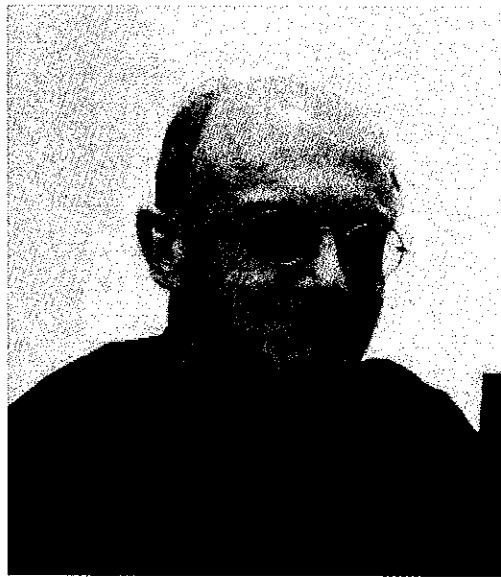
Mike Tipton

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A Physical Employment Standard (PES) must be valid and defensible. This paper will discuss the factors that determine validity when designing and implementing a PES, particular attention will be given to the establishment of the minimum acceptable pace/intensity for the completion of critical tasks. This decision ultimately determines the final pass/fail criteria for a PES, so how it is arrived at and justified is important for the validity and therefore the defensibility of a PES. If a minimum standard cannot be clearly identified and justified on a rationale basis, it is doubtful whether the associated task should be included in a PES. This begs the questions: what is "minimum" and how is it determined? The methods of establishing a minimum standard range from quasi-objective measures through to opinion, these methods are all questionable to some degree. For example, whilst a phrase like "the minimum acceptable pace was established by subject matter experts (SME)" is frequently written, the SMEs in question are often being asked questions that they have little or no experience of. This area will be investigated with reference to published PES and "levels of evidence" methods normally associated with the clinical and scientific literature. It is concluded that if a PES is challenged, it is likely to be on the basis of its evidence-base. Some PES have an evidence-base that may not stand up to scrutiny against the highest levels of evidence.

Reliability of Test Measures



William Gary Hopkins

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The reliability of a test measure in an employment-standards setting refers to the consistency or reproducibility of differences between subjects when the subjects are retested. As such, reliability depends on the relative magnitudes of the between-subject standard deviation (representing differences between subjects in any given trial) and the within-subject standard deviation (representing variability within subjects from trial to trial, the "error" in the test). The best reliability statistic combining these standard deviations is the intraclass correlation coefficient that closely approximates the test-retest Pearson correlation. A consideration of magnitude of the error in relation to the default smallest important change (defined by standardization as 0.2 of the between-subject standard deviation) shows that the correlation needs to be >0.99 for a test that can accurately monitor trivial-small changes in an individual. Tests with similarly high reliability are also needed to quantify trivial-small mean changes in cohorts or in controlled trials with ~ 10 subjects per group. The within-subject error and reliability correlation can be determined in a reliability study consisting of sufficient subjects (10-50) and sufficient trials (preferably 3-4) to properly quantify any test habituation, which may manifest as substantial but diminishing changes in the mean and substantial reductions in the error between the first few trials. The error and correlation are then derived by averaging consecutive pairwise estimates. The error is often more uniform across the range of subjects when derived as a coefficient of variation via logarithmic transformation. A good reliability study should include investigation of the effect of different times between trials, the reduction in error that can be achieved by averaging repeated trials, and separate estimation of reliability in gender or other subject subgroups.

Human Rights at Work: Physical Employment Standards and Human Rights Law



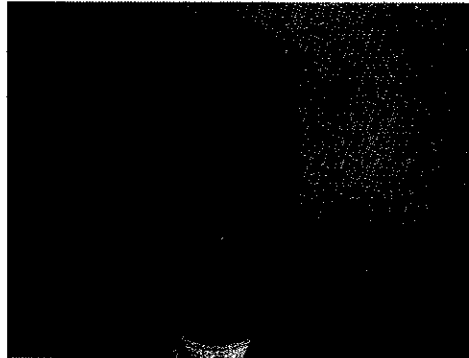
Eric M. Adams
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This article focuses on the human rights dimensions of creating and implementing physical employment standards for prospective and existing employees. The article argues that physical employment standards engage two fundamental legal concepts: freedom of contract and non-discrimination in the workplace. While the former promotes an employer's right to set workplace standards and make decisions of whom to hire and fire, the latter prevents employers from discriminating against individuals upon a number of protected grounds including sex, disability, and age. With reference to applicable human rights legislative regimes and their judicial interpretation in Canada, the United States, and the United Kingdom, this article demonstrates the trend towards criterion validation in testing mechanisms in the finding of bona fide occupational requirements. With particular attention to the Supreme Court of Canada decision in *Meiorin*, this article argues that an effective balance between workplace safety and equality concerns can be found, not in multiple or inconsistent standards, but in an approach that holds employers to demonstrating a sufficient connection between a uniform physical employment standard and the actual minimum requirements to perform the job safely and efficiently. Such an approach conceives of physical employment standards and workplace diversity as emanating from a shared concern for human rights.

Sex Related Issues in Physical Employment Standards



Delia Roberts,
School of University Arts
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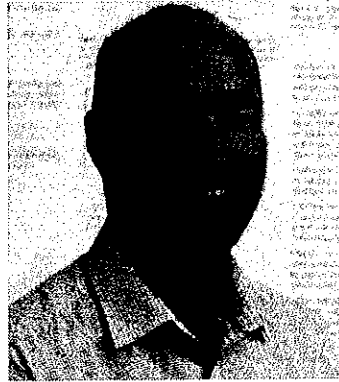
Marilyn Sharp,
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The use of physical employment standards has helped ensure that workers have the physiological capacity to complete their jobs in a safe and effective manner. However, standards used in the selection process have not always reflected the true physical capabilities required for job proficiency. Women generally have smaller anthropometric stature than men, less muscle mass and therefore less strength, power, and endurance, particularly in the upper body. Nonetheless, these attributes are not valid grounds for exclusion from employment in physically demanding occupations. Selection standards based upon size or strength, irrespective of the job requirements, have resulted in barring capable women from physically demanding jobs, claims of gender bias, and costly litigations. In order to ensure all qualified individuals are provided with equal access to employment, accurate characterization of the physical capacity needed to perform a job is paramount. This paper summarizes the existing research related to disparities between the sexes that contribute to sex differences in job performance in physically demanding occupations including anthropometric, physiological, legal, and cultural factors. The primary focus is on occupations in which the nature of the tasks and the work environment can limit the options for reducing the physical demands of a job. Where available, injury rates for women and men in physically demanding occupations are presented. Lastly, areas for further research are discussed.

Age, human performance and physical work standards



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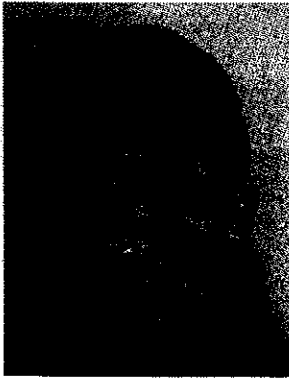


Herb Groeller
Centre for Human and Applied Physiology,
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The proportion of older workers has increased substantially in recent years with over 25% of the Canadian labour force aged ≥ 55 years. Along with chronological age comes age-related declines in functional capacity associated with impairments to the cardiorespiratory and muscular systems. As a result, older workers are reported to exhibit reductions in work output and in the ability to perform and/or sustain the required effort when performing work tasks. However, research has presented some conflicting views on the consequences of aging in the workforce as physically demanding occupations can be associated with improved or maintained physical function. Furthermore, the current methods for evaluating physical function in older workers often lack specificity and relevance to the actual work tasks, leading to an underestimation of physical capacity in the older workers. Nevertheless, industry often lacks the appropriate information and/or tools to accommodate the aging workforce. Ultimately, if appropriate workplace strategies and work performance standards are adopted to optimize the strengths and protect against the vulnerability of the aging workers, they can perform as effectively as their younger counterparts. Our aim in this review is to evaluate the impact of different individual (including physiological decline, chronic disease, lifestyle and physical activity) and occupational (including shift work, sleep deprivation, and cold/heat exposure) factors on the physical decline of older workers, and therefore the risk of work-related injuries or illness.

*Clot
to Herb
about Recovery*

Load carriage, human performance and physical employment standards



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The focus of this review is upon the physiological considerations necessary for developing employment standards within occupations that have a heavy reliance on load carriage. Employees within military, fire-fighting, law enforcement and search and rescue occupations regularly work with heavy loads. For example, soldiers often carry loads >50 kg, whilst structural firefighters wear 20-25 kg of protective clothing and equipment, in addition to carrying external loads. It has long been known that heavy loads modify gait, mobility, metabolic rate and efficiency, while concurrently elevating the risk of muscle fatigue and injury. In addition, load carriage often occurs within environmentally stressful conditions, with protective ensembles adding to the thermal burden of the workplace. Indeed, physiological strain relates not just to the mass and dimensions of carried objects, but to how those loads are positioned on and around the body. Yet heavy loads must be borne by men and women of varying body size, and with the expectation that operational capability will not be impinged. This presents a recruitment conundrum. How do employers identify capable and injury-resistant individuals while simultaneously avoiding discriminatory selection practices? In this communication, the relevant metabolic, cardiopulmonary and thermoregulatory consequences of loaded work are reviewed, along with concomitant impediments to physical endurance and mobility. Also emphasised is the importance of including occupation-specific clothing, protective equipment and loads during work-performance testing. Finally, recommendations are presented for how to address these issues when evaluating fitness for duty.

Protective Clothing Ensembles and Physical Employment Standards



Tom M. McLellan
TM McLellan Research Inc



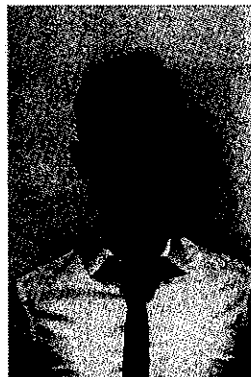
George Havenith
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Physical employment standards (PESs) exist for certain occupational groups that also require the use of protective clothing ensembles (PCEs) during their normal conduct of operations. This review addresses whether these current PESs appropriately incorporate the physiological burden associated with wearing PCEs during respective tasks. Metabolic heat production increases due to wearing PCE; this increase is greater than that due simply to the weight of the clothing and can vary two-fold among individuals. This variation negates a simple adjustment to the PES for the effect of the clothing on metabolic rate. As a result, PES testing that only simulates the weight of the clothing and protective equipment does not adequately accommodate this effect. The physiological heat strain associated with the use of PCEs is also not addressed with current PESs. Typically the selection tests of a PES lasts less than 20 minutes whereas the requirement for use of PCE in the workplace may approach one hour before cooling strategies could be employed. One option that might be considered is to construct a heat stress test that requires new recruits and incumbents to work in a hot environment for a predetermined duration while exposed to a warm environmental temperature, wearing the PCE.

Thermal stress, human performance and physical employment standards



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Many physically demanding occupations in both developed and developing economies involve exposure to extreme thermal environments that can affect work capacity and ultimately health. Thermal extremes may be present in either an outdoor or an indoor work environment, and can be due to a combination of the natural or artificial ambient environment, the rate of metabolic heat generation from physical work, processes specific to the workplace (e.g., steel manufacturing), or through the requirement for protective clothing impairing heat dissipation. Together, thermal exposure can elicit acute impairment of work capacity and also chronic effects on health. Cognitive functioning may also be impaired, increasing the risk of accidents. Overall then, occupational thermal stress may greatly contribute to worker health risk and reduced productivity. Surprisingly, in most occupations even in developed economies, there are frequently no standardized or enforced heat or cold safety standards for workers. Furthermore, specific employment standards or accommodations for thermal stressors are rare, with workers commonly tested under near-perfect conditions. This review surveys the major occupational impact of thermal extremes and existing employment standards, proposing guidelines for improvement and areas for future research.

Nutra-Ergonomics: Influence of workplace nutrition on performance, health and the development of chronic disease



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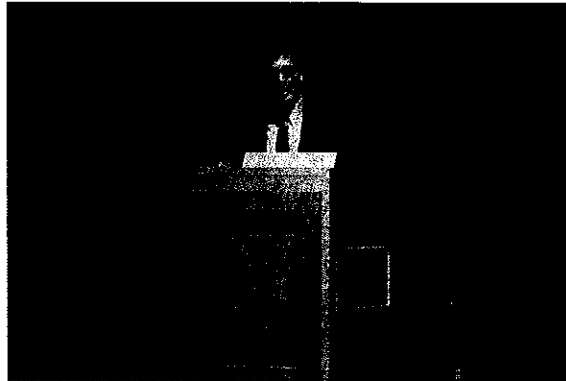
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The importance of ergonomics across several scientific domains including biomechanics, psychology, sociology, and physiology has been extensively explored. However, the role of other factors that may influence the health and productivity of workers, such as nutrition, is generally overlooked. Nutra-ergonomics describes the interface between workers, their work environment and performance in relation to their nutritional status. It considers nutrition to be an integral part of a safe and productive workplace that encompasses physical and mental health as well as the long-term wellbeing of workers. This review explores the knowledge, awareness and common practises of nutrition, hydration, stimulants and fortified product use employed within the workplace. The influence of these nutra-ergonomic strategies on worker safety and performance will be examined. Further, the roles, responsibilities and implications for both the worker and the employer will be discussed within the context of nutra-ergonomics, with reference to the provision and sustainability of an environment conducive to optimise worker health and wellbeing. Beyond workplace productivity and performance, the influence of extended or chronic desynchronisation (irregular or shift work) in the work schedule on metabolism and long-term health, including risk of developing chronic and complex diseases, is discussed. Finally, practical nutra-ergonomic strategies and recommendations for the worker and employer alike will be provided to enhance the short- and long-term safety, performance, health and wellbeing of workers.

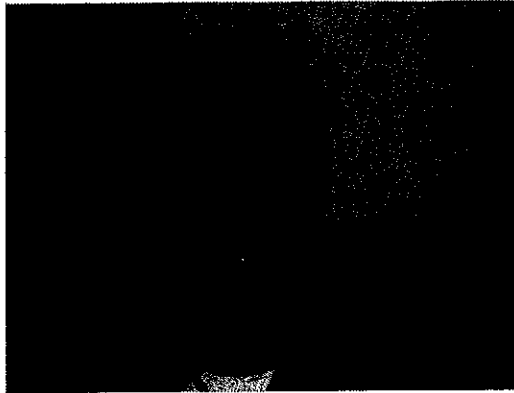
Stress, human performance and physical employment standards



Greg Anderson
Justice Institute of British Columbia

Most emergency responders must function in high-stress conditions. This is especially true in law enforcement, firefighting and many military applications. Commonly, workers are tested under near-perfect conditions with minimal stress (e.g., danger to self, co-workers or public). The premise behind this paper is that many of the physically demanding occupations in public safety and protection that utilize physical employment standards are indeed stressful (causing stress reactivity), and that stress will impact performance and the response to testing of a physical employment standard. The stress response involved is initiated by the brain upon perception of a threat or challenge, which then activates the hypothalamic-pituitary-adrenal (HPA) axis which ultimately stimulates the cortex of the adrenal glands to stimulate secretion of adrenal glucocorticoids (GCs). GCs, such as the main stress hormone cortisol in humans, can travel with the blood to any organ in the body. Most prominently, GC actions are focused on the brain and ultimately alter its main output, behaviour. This paper will review the basic physiology of the stress response, stress and stress hormones as modulators of motor function, skilled movement abilities in response to stress, changes in muscle tension during acute and chronic stress, and their impact on skilled performance.

Development of Medical Standards/Guidelines: Many Grey Areas



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Human Performance Systems, Inc.

Establishing medical standards/guidelines that are legally defensible in the employee selection and retention processes require an interdisciplinary approach. Critical to the process is identification of the job requirements and demands in terms of tasks, working environment, and ergonomic parameters. This information is combined within previous research, clinical outcomes, and medical criteria to determine whether a disease or condition limits or precludes effective job performance. Medical standards/guidelines are prevalent when assessing applicants for law enforcement, firefighting, aviation, and military jobs. They are also found in non-public safety jobs in which a medical condition affects effective job performance (e.g., seizure disorder in a commercial truck driver). Development of medical standards/guidelines requires knowledge of the types of treatment used for a disease/condition, effect of medication on job task performance, and the functional limitation related to symptoms and treatment. This paper provides an overview of the methodologies used to develop medical standards/guidelines and the impact of the legal framework surrounding medical issues. Job analysis methodologies to acquire medically relevant data and integrate this information into the medical framework are highlighted. Examples of the use of existing research in setting medical standards/guidelines is included, along with standards for various body systems (e.g., cardiovascular, endocrine) for several jobs. Finally, formats that summarize the medical standards/guidelines for examining physicians are presented.

Research Presentation Abstracts (alphabetical order)

Stressed and Un-stressed Shooting Performance in Police Officers

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Firearm qualification is a well-established and apparently credible manner that departments and law enforcement agencies attest to officer competence. Police managers rely on officer's qualification scores as an indicator of their ability to function in a critical incident in the field. The purpose of this study was to determine the impact of prior stress on shooting performance in qualified police recruits to determine if this assumption held true. Twenty one police recruits performed a 20 round course of fire under two experimental conditions: no physical exertion, no time constraint, and following the POPAT with time constraints. Course of fire included five rounds fired at standard 51x82 cm targets at 3, 7, 15 and 25 meters. Heart rates were collected using Polar Heart Rate Monitors during both conditions. Targets were scored as a distance from centre of mass. Significance ($p < 0.05$) was explored using paired t-tests. Heart rates were significantly higher in the stressed shooting condition. Significant decrements in shooting performance following a physical stress, in a time-limited shooting qualification. Shooting performance was significantly worse at 3, 7 and 25 meters in the stressed, as compared to the unstressed condition. The distance from center of mass increased 67 - 82% with an increase in the number of missed targets in the stressed condition. Research is critical of present firearms training and qualifying standards globally. Like Morrison and Vila (1998) the present study suggests there are biological limits to handgun-shooting accuracy that substantially limit performance in stressed conditions. There is a need to develop new and valid criteria for police firearms training and qualification.

Re-Evaluation of the Physical Abilities Readiness Evaluation.

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While police work is primarily sedentary, police officers are required to frequently engage in near maximal workloads for short periods of time during incidents of a critical nature. The Physical Activities Requirement Evaluation (PARE) was designed as a physical employment standard in 1988 for the RCMP. To examine the elements of the PARE that are most related to the role of police officers in the field, the present study surveyed a group of subject matter experts, and the incumbents concerning the present elements embedded within the PARE, and potential changes that could be made to improve the extent to which the PARE reflected the true physical requirements of police work. This research project consisted of three distinct phases: 1. instrument development; 2. subject matter experts and instrument modification; and, 3. incumbent survey. Following instrument development, 20 subject matter experts (SMEs) completed the survey and their feedback was then used as a basis for discussion and revision of the instrument. Surveys were distributed to a representative sample of RCMP members across Canada immediately after they completed their PARE. There was a 96% response rate with 844 completed surveys being returned. Results were compiled for each of the SME and regular member groups under three general categories - obstacle courses, push/pull, and weight lift and carry. Of the officers surveyed: 86.1 % report the obstacle course to be relevant or very relevant to their job duties and were supportive of each element embedded within the obstacle course; 84.5% reported the push and pull section to be relevant or very relevant, while 80.3% suggested the duration of the segment was relevant or very relevant; Data from the present study suggest that the lift and carry portion of the PARE is the least supported element by members and generated the most comments for change, however this element is not included in the timed portion of the course. Present data from both SMEs and active members of the RCMP provides strong support for the present configuration in the PARE. While consideration should

be given to the enhancement of the PARE, the current and previous task analysis do support the test in its actual format as being representative or very representative of police work in the 21st century.

Can an annual baseline Physical Employment Standards also be used to screen at the occupation-specific level?

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Occupational Fitness Standards (OFS) are a part of the medical standards for each Canadian Armed Forces (CAF) occupation. They consist of a list of essential and demanding tasks that a member must be able to perform in order to remain in that occupation. These occupational specific tasks and demands are used by the CAF when members are ill / injured and there is a question regarding job suitability. A physical demands category system has been developed to characterize the demands of military tasks. A review of existing literature was performed and resulted in the decision to adapt the (ICF-10) published by the World Health Organization. Chapter 4 of this publication focuses on mobility and was used as a guiding framework in developing physical categories to represent the demands of military occupations. The following six categories were adopted to characterize the physical demands of military occupations: (1) Changing/maintaining body positions, (2) Lifting and carrying objects, (3) Fine hand use, (4) Hand/arm use, (5) Moving around, and (6) Walking. For each of these categories, a 5-point scaling system was established, ranging from "no impairment" to "complete impairment". The CAF recently implemented the FORCE Evaluation (Fitness for Operational Requirements of CAF Employment), a field expedient fitness test performed by all CAF members annually designed to predict the physical requirements of completing the 6 common military task fitness evaluation (CMTFE). We have categorized the 6 common military tasks using our OFS physical category system in order to see what percentage of occupational specific task demands would be captured by the FORCE evaluation. The basis of that comparison is to see if the FORCE test could provide enough information to also screen members at the occupational level on an annual basis. Secondly, as more physically demanding occupations are requesting a more demanding annual fitness test, this will highlight the gaps between occupational demands and the FORCE evaluation and allow us to more efficiently address their concerns. By using our physical demands category system, we have found that 61% of Army, 76% of RCN (Royal Canadian Navy), 74% of RCAF (Royal Canadian Air Force), and 75% of Support trade demands are captured by the CMTFE. Understanding that the CMTFE does not provide a complete assessment of fine hand use, nor sitting or standing over long durations, we have removed them from the analysis and have the following results: 71% (Army), 87% (RCN), 84% (RCAF) and 88% (Support) of demands covered by the CMTFE. These results bring us closer to better understanding the need for environment or deployment specific fitness standards, and the option to identify the gaps that exist between the more demanding occupations and the CAF's minimum standards. To address these gaps, a *FORCEplus* test could be tailored to more accurately represent the demands of those occupations.

A Basic Water Skills Test for use in Air Force Pararescue Selection

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Selection of US Air Force recruits into Battlefield Airmen (BA) career fields is determined by a battery of aptitude assessments to include physical condition. Physical conditioning is currently measured by the Physical Abilities Stamina Test (PAST) which consists of 500 meter surface swim, 1.5 mile run, pull-ups, sit-ups, and push-ups. Despite these assessments, BA students continue to experience high rates of attrition in technical training, especially Pararescue (PJ) which has high attrition due to extensive sub-surface water

training. However, sub-surface water testing is not currently used in any aptitude assessment. This study developed and evaluated the effectiveness of a Basic Water Skills Test (BWST) to assess sub-surface water aptitude prior to PJ pipeline entry. BWST consists of up to six repeat 25 meter underwater swims, with return surface swim, each on cumulative 1 min 45 secs; timed treading water in deep water keeping wrists and ears above the surface for up to 3 minutes; and snorkel test alternating snorkel breaths while floating with face in water for up to 2 minutes. The effectiveness of introducing BWST as an entry requirement for the PJ pipeline was assessed using logistic regression models to determine the relationship between test component performance and initial course pass-fail outcome ($n = 786$ PJ candidates). The BWST components were significant ($p < .01$) for predicting the pass-fail outcome at the initial course. A prediction model using BWST was built from a subset of the data ($n = 551$) and applied to the remaining data ($n = 235$), predicting failure ($< 25\%$ chance of success) and pass ($> 75\%$ chance of success) at 88% and 74% accuracy, respectively. BWST significantly contributes to PAST for predicting success in the PJ water-centric initial course. BWST can contribute to efficiency improvements in recruit selection for the high-demand, high attrition PJ career field.

Development of Occupationally Specific, Operationally Relevant Physical Fitness Tests and Standards for US Air Force Battlefield Airmen: New vs Old

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As early as 1998 US Air Force (AF) exercise physiologists recommended a "Two-Tier" health and performance approach to development of science-based criterion AF physical fitness (PF) standards. The AF officially implemented Tier 1 health and general fitness tests and standards in July 2010 with aerobic and body composition component standards established on professionally recognized health science criteria. Scores reflect degrees of health and general fitness, but do not necessarily reflect military task achievement for military occupations, *i.e.*, AF specialty codes (AFSCs). This study developed Tier 2 occupationally-specific, operationally-relevant PF tests and standards for AF Battlefield Airmen (BA). Critical physical tasks (CPTs) for each BA career field were developed following a multi-step process that included focus groups with BA subject matter experts, a comprehensive web-based CPT assessment / characteristics survey of all BA career field members, observations of BA in operational settings, and finally a review with senior BA leaders. Per operational missions conducted over the past ten years, focus group members and BA AF-wide objectively scored each physical task for frequency, duration, intensity (physical), and importance (critical to mission success). Reviewers achieved consensus on task scores via *a priori* criteria, composite score ≥ 3.5 points on a 5.0 point Likert scale (composite = 0.10 repetition + 0.25 duration + 0.25 intensity + 0.40 importance). This work resulted in a total of 184 critical physical tasks across the six BA career fields. To develop appropriate physical tests to evaluate a person's ability to perform physically demanding work, an extensive review of valid and reliable physical assessments spanning the necessary fitness components and movement patterns was used to create a candidate test battery (TB). In addition, the cost and feasibility of test implementation were considered. Simultaneously, the CPTs were used to develop 15 physical task simulations (PTSs) that mimicked operational tasks. Advanced statistical modeling techniques were used to link subject performances on PTSs and TB. Based on predictive power of operator performance, we propose a new PF TB that includes 10 PF tests. As compared to the current BA TB the proposed TB resulted in a 60% to 230% increase in the explained variance across subject's PTS performance. Comparisons between the current BA TB and the proposed TB demonstrate the efficacy of the study approach. Further validation of the proposed TB will occur as feedback is received on BA operators' performance during operational deployments and their associated physical preparation.

Generic Task-Related Occupational Requirements for Royal Naval Personnel

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Physical tests and selection criteria have historically been used by many military organisations. However, the standards associated with them have come under increasing scrutiny in recent years. This paper describes a series of experiments that were conducted to establish task-related occupational tests and standards (TBTs) for Royal Naval (RN) personnel. A total of 172 (106 male and 66 female) RN personnel volunteered for these experiments, which were designed to: identify the anthropometric requirements for operating various safety hatches and doors on board a RN Frigate (TBT1); quantify the metabolic demands of shipboard firefighting tasks and establish an aerobic fitness standard (TBT2); and identify a battery of tests to predict performance of shipboard casualty-carrying tasks (TBT3). Whilst all subjects completed the criterion tasks during TBT1, performance of the bulkhead door (BD) escape task was related to height ($r = 0.50-0.62$, $P < 0.05$) and vertical reach ($r = 0.42-0.54$, $P < 0.05$), with shorter subjects struggling to perform the task to the required standard. During TBT2, the mean metabolic demand of representative firefighting tasks was $38 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, which must be sustained for 20–30 min. Finally, a battery of tests incorporating measures of lean body mass, fat mass, standing broad jump, 20 m sprint, press-ups, sit-ups and grip strength produced a high correlation ($r = 0.89$, $P < 0.01$) with casualty-carrying task performance. From the results of these experiments, it is recommended that RN personnel perform the BD simulation task at the recruitment stage (TBT1), to prove that they possess the anthropometric characteristics commensurate with survival at sea. Secondly, personnel should be frequently screened to ascertain whether they have the maximal aerobic power ($41 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) commensurate with shipboard firefighting for 20–30 min (TBT2). Finally, they should perform the battery of proposed tests and score at least 34 points, in order to establish whether they have the anaerobic and strength capacity commensurate with shipboard casualty-carrying tasks (TBT3).

This work was sponsored by the Ministry of Defence (Navy).

Development of Minimum Cardiorespiratory Fitness Standards for UK Firefighters

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The cardiorespiratory demands of simulated operational firefighting duties are relatively high and employees therefore require a reasonable level of cardiorespiratory fitness. This will ensure their operational effectiveness and, in addition to their personal safety, enhance the safety of their peers and the wider public. The purpose of this study was to quantify the metabolic demands of generic occupational tasks, performed to minimum acceptable standards by operational firefighters, and propose a minimum cardiorespiratory fitness standard commensurate with safe and effective job performance. Generic firefighting task simulations (i.e., hose running, casualty evacuation, stair climb, equipment carry, wild-land fire), and minimum acceptable performance standards, were endorsed by a technical panel comprising operationally experienced subject matter experts. Sixty-two (50 male, 12 female) operational firefighters (mean \pm SD; age, 39 ± 9 y; height, 1.76 ± 0.07 m; body mass, 80.8 ± 11.8 kg, estimated maximum oxygen uptake $50.0 \pm 6.6 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) completed the simulations in a randomised order whilst wearing a standard protective firefighting ensemble. Metabolic demand and cardiovascular strain were measured during each task, using a portable gas analyser (Cosmed K4) and peak steady-state responses subsequently determined. Group mean steady-state metabolic demand ranged from $27 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (wild-land fire task) to $47 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (hose run). Four tasks, which were deemed to comprise a 'typical' firefighting scenario and endorsed as valid operational simulations by $\geq 90\%$ of participants (excluding wild-land fire; 84%), were deemed to be a valid and reliable basis for a physical employment standard. These tasks elicited an average metabolic cost of $38.1 \pm 7.8 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. It is estimated that healthy adults can sustain the total duration of these operational tasks (~ 16 min) at $\leq 90\%$ maximum oxygen uptake. A minimum cardiorespiratory fitness standard of $\geq 42.3 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ is therefore

recommended for all UK operational firefighters. This should form part of a comprehensive battery of physical employment standards, which are assessed on a regular basis (e.g. 1-year intervals). An occupational capability management protocol should be developed to monitor compliance, assist with case management and ensure that employees are in a state of physical preparedness for occupational performance.

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A Comparison of Performance on Incremental Shuttle Running Tests With and Without Carrying a 15 kg Load and their Relationships with Load Carriage Performance

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Many organisations that implement physical employment standards use 'field' based tests to assess aerobic fitness (e.g. exhaustive shuttle running or timed runs). However, these tests poorly predict performance of critical occupational load carriage tasks. A potential approach to improve the predictive ability of such tests is to carry additional load while running. The purpose of this study was to compare performance during a multistage fitness test (MSFT) carrying no load and with load carriage (a 15 kg vest; LC-MSFT) and the relationships to oxygen uptake ($\dot{V}O_2$) while walking and the time to complete a 2.4 km run wearing a 15 kg vest. Following ethics approval 17 male and 2 female participants (mean \pm SD: age 26.2 ± 7.7 years, stature 1.78 ± 0.07 m, body mass 76.0 ± 11.2 kg, maximal oxygen uptake ($\dot{V}O_{2max}$) 3.8 ± 0.7 L \cdot min $^{-1}$) volunteered. Participants completed a 20 m MSFT with either no load or wearing a 15 kg vest in a randomised crossover design separated by at least 7 days. In a subsequent visit participants walked for 10 minutes at 6.5 km \cdot h $^{-1}$ unloaded and then wearing a 15 kg vest and $\dot{V}O_2$ was measured in the final 2 min using the Douglas bag technique. Participants then completed a best effort 2.4 km run wearing the 15 kg vest. Using MSFT performance, $\dot{V}O_{2max}$ relative to body mass (i.e. ml \cdot kg $^{-1}$ \cdot min $^{-1}$) was predicted and absolute $\dot{V}O_{2max}$ (i.e. L \cdot min $^{-1}$) calculated. Differences between variables were examined using paired T-tests and relationships explored using Pearson's bivariate correlations. Statistical significance was set a priori at $p < 0.05$. Participants ran further during the MSFT compared to the LC-MSFT (1909 ± 418 vs 1387 ± 307 m, $p < 0.001$). There was a positive correlation between the difference in distance covered during the MSFT and LC-MSFT and $\dot{V}O_{2max}$ relative to body mass ($r = 0.74$, $p < 0.001$), however this was not evident for absolute $\dot{V}O_{2max}$ ($r = 0.28$, $p = 0.25$). $\dot{V}O_2$ increased by 0.23 ± 0.09 L \cdot min $^{-1}$ when wearing the 15 kg vest ($p < 0.001$). The change in absolute $\dot{V}O_2$ with the addition of the 15 kg vest showed no relationship with body mass ($r = -0.01$, $p = 0.967$), MSFT distance ($r = -0.01$, $p = 0.97$) or LC-MSFT distance ($r = -0.21$, $p = 0.40$). There were similar relationships between the loaded 2.4 km run time with MSFT distance ($r = -0.84$, $p < 0.001$) and LC-MSFT distance ($r = -0.84$, $p < 0.001$). In conclusion, the reduction in performance with the 15 kg vest during the MSFT was more pronounced for individuals with a higher relative $\dot{V}O_{2max}$, but this bias was not evident for absolute $\dot{V}O_{2max}$. Neither MSFT nor LC-MSFT performance explained the variation in the increase in $\dot{V}O_2$ with load carriage and both tests showed similar relationships with loaded 2.4 km running performance. Future research should examine relationships between LC-MSFT performance and more physically arduous critical load carriage tasks.

Variability in Performance on a Work Simulation Test of Physical Fitness for Firefighters

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The Canadian Forces Firefighter Physical Fitness Maintenance Evaluation (FF PFME) requires firefighters, in full fire protective ensemble including self-contained breathing apparatus, to correctly complete 10 work-

related tasks, on a measured and calibrated course. Fitness for duty is inferred from completion time of the course. We hypothesized that completion time may be dependent on pacing strategy and day-to-day fluctuations in biological function. To examine variability in performance, 20 females and 31 males (mean \pm SD: age, 27.6 \pm 10.5 yr; height, 176.7 \pm 8.3 cm; mass, 77.3 \pm 13.4 kg) were familiarized with the FF PFME and then completed the test on six separate days. Pre-test behaviors (e.g. sleep, diet) and test conditions (e.g., calibration, time of day) were consistent. Repeated measures ANOVA revealed a significant decrease in completion time between Tests 1 and 6 (18.7%) and between all sequential pairs (e.g., Tests 1 and 2). There was also a small, but significant increase in the fraction of total test time for task completion and a corresponding decrease in the time to transition between tasks. The performance improvements cannot be explained by differences in effort (heart rate and perceived exertion). Coefficient of variation (CV) for Tests 1, 2 and 3 was 7% and for Tests 4, 5 and 6 was 2.6%. The results indicate the importance of practice on performance, and the potential for false-positive or false-negative decision errors if biological variability is not taken into account.

The Most Critically Demanding Strength-Based Generic Tasks Undertaken Onboard UK Royal Navy Warships

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Functional strength-based tasks constitute many of the physically demanding and generic duties performed onboard Royal Navy (RN) warships. Previously, no such occupational fitness test existed to assess this requirement within the RN workforce. The purpose of this research was to establish a short-list of generic, critical, and physically demanding strength-based tasks to inform the future development of a role-related occupational fitness test. From a list of 200 ship-based tasks an expert panel identified twenty-five generic tasks that required physical strength. Tasks were incorporated into an anonymous questionnaire and included: Fire Fighting; Damage Control; Casualty Handling; Ammunition Re-supply; Stores Re-supply; and Basic Daily Tasks (e.g. transiting the ship). A total of 515 questionnaires were returned from a representative cross section of RN ranks, roles, and specialisations that included 443 males and 72 females (mean \pm SD: age 30.2 \pm 7.3 y; job experience 10.0 \pm 7.4 y). Participation rates in resistance-based physical training (PT) in this sample were lower than aerobic-based PT (51% vs. 88%). On a scale of 1 – 5, respondents rated the task physical strength demands (from no demand – very high demand), task criticality (from not important – critically important), and task frequency (from seldom – several times per day). Ten tasks were initially down selected that had a mean criticality rating of ≥ 3.5 (\geq important / very important), and a mean strength demand rating ≥ 3.0 (\geq moderate). Of the 15 tasks excluded, nine were routine tasks that were performed with a high frequency. Examples included climbing ladders, opening hatches/doors, movement during high sea states, and getting into a top bunk. The ten down selected tasks were ranked according to the percentage of volunteers that rated each task as highly critical and physically demanding (a rating of 4 or 5). The ranked short-list of critically demanding generic tasks were: Casualty Carrying; Dragging Charged Fire Hoses; Lift and Carry Aqueous Film Forming Foam Drums; Hoisting Items on a Rope; and Lift and Carry Awkward Items. A Pearson's Chi-square Test identified that females rated casualty carrying, dragging charged fire hoses, and lift and carry awkward items as physically more demanding than males ($P < 0.05$). Five critically important ship-based tasks were identified that required physical strength. These tasks should undergo a further job analysis to inform the development of a potential occupational fitness test for the RN. Furthermore, the education and promotion of strength and resistance training within the RN has occupational relevance, and hence benefit, particularly to the female workforce.

Is Torso Body Armour Mass or its Bulk Responsible for Diminished Box Lift Performance?

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Body armour is essential protective equipment for military personnel that are often worn when completing manual handling tasks. Adding an external load reduces locomotive and manual handling performance. However, the effect of added bulk to the torso on lifting technique and performance is less well known. Therefore the aim of this investigation was to determine whether torso body armour mass or its dimension influenced single-repetition maximum (1RM) box lift performance. Twenty subjects (8 male, 12 female; age 24.7 y (SD 6.9), height 172.0 cm (SD 7.1), mass 71.1 kg (SD 8.5)) with no previous resistance training experience volunteered for the investigation. Two-dimensional video of lift performance was obtained on 11 of the subjects (3 males, 8 females) to assess joint angles during the instances of squat, stance, and placement and box distance from the lumbar spine (L5-S1) at stance. In a randomised order, participants completed three 1RM box lift trials to a height of 1.5 m wearing either: No Armour, Armour (7.8 kg) or Replica Armour (3.6 kg). Isometric quadriceps and biceps maximal voluntary contractions (MVC) were assessed at the first and last visit. Trials were conducted after familiarisation and on non-consecutive days within a 14 day period. Data are presented as mean \pm 95% confidence interval. No change ($P > 0.05$) was observed in quadriceps and biceps MVC. 1RM box lift performance decreased ($P < 0.05$) progressively when using Replica Armour (30.2 ± 4.9 kg) and Armour (29.5 ± 4.7 kg) compared to No Armour (31.4 ± 4.9 kg). An increase ($P < 0.05$) in hip and knee flexion during the squat of No Armour ($124 \pm 5^\circ$ and $110 \pm 6^\circ$ respectively) was observed compared to the Armour ($121 \pm 4^\circ$, $105 \pm 6^\circ$) and Replica Armour ($118 \pm 4^\circ$, $104 \pm 4^\circ$) trials. An increase ($P < 0.05$) in shoulder flexion at both stance and placement with Replica Armour ($20 \pm 7^\circ$ and $99 \pm 7^\circ$ respectively) and Armour ($26 \pm 11^\circ$, $94 \pm 6^\circ$) was observed compared to the No Armour ($9 \pm 8^\circ$, $85 \pm 11^\circ$) trial. Box distance from the lumbar spine increased ($P < 0.05$) with Replica Armour (44 ± 3 cm) and Armour (42 ± 3 cm) compared to the No Armour (40 ± 3 cm) trial. Lifting performance appears to decline proportionally to increases in the external mass of body armour. However, lifting kinematics changed with the addition of body armour regardless of mass. This suggests that constraints placed upon lifting performance due to the bulk of the body armour significantly influenced the mechanics of the lift. Participants accommodated the constraint in lifting by increasing the distance of the box from the spine, likely increasing forces through the lumbar vertebrae and work of the erector spinae muscles.

Modified Box Kinematics and Decreased Stance Duration Explain Improved Box Lift Performance Following Familiarisation

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Familiarisation has been demonstrated to improve performance on physical employment tests. One previous investigation observed that soldiers improved their single box lift performance after one familiarisation session, however the basis of this improvement for example, a change in lift technique, is currently unknown. Furthermore, it is likely that novices with no resistance training experience may require additional familiarisation sessions. Therefore the aim of this investigation was to determine whether maximal lift performance and posture improved following familiarisation in a novice population. Twenty-two subjects (10 male, 12 female; age 24.4 y SD 6.7, height 171.9 cm SD 6.8, mass 70.5 kg SD 8.4) with no previous resistance training experience volunteered for the investigation. Participants attended the laboratory six times; at baseline, four familiarisation visits in two weeks (at least 3 days apart) and a final visit seven days after the last familiarisation visit for assessment of single repetition maximum (1RM) box lift performance from the

ground to a 1.5 m shelf. Isometric quadriceps and biceps strength was also measured via maximal voluntary contractions (MVC) on the first and sixth visit. Two-dimensional video of lift performance was obtained on 13 of the subjects (5 male, 8 female) during at the instances of squat, stance, maximal trunk hyperextension and placement to assess joint angles (knee, hip, trunk, shoulder, elbow and wrist). Step length and duration, horizontal distance from the box to L5, box height and tilt was also measured at these points. Data are presented as mean \pm 95% confidence interval. Quadriceps and biceps MVC force was not different between baseline and visit 6 ($P>0.05$). The box mass increased (visit 2: 29.8 ± 4.4 kg, 3: 30.5 ± 4.6 kg, 4: 30.5 ± 4.6 kg, 5: 31.1 ± 4.6 kg, 6: 30.7 ± 4.6 kg) to give an overall improvement ($P<0.05$) with visit 5 significantly greater than visit 2. The difference between visits 5 and 6 was not significant ($P>0.05$). As lift mass increased, there was a decrease ($P<0.05$) in total lift time and time from stance to placement but not for squat to stance time. Finally, there was an increase in box tilt (angle to horizontal) prior to placement (visit 1: $26.9 \pm 7.7^\circ$ vs. visit 4: $37.2 \pm 10.0^\circ$). Joint angles and step length were not different between visits. Lift performance improved significantly after four familiarisation sessions. In contrast, the posture adopted during the task was maintained throughout the investigation, and therefore did not explain improvements observed in lift strength with familiarisation. However, subjects significantly reduced time in a split stance, limiting exposure to a lifting position with the least mechanical advantage. Additionally an increase in the angle of the box prior placement may have assisted in minimising work associated with the lift.

The physiological cost of palletising under time constraints: Why slower may be better

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The completion of manual handling tasks performed under time constraints has not been investigated extensively. This is important because some scenarios require urgent task completion (under time constraints) whilst others are performed slowly (without time constraints). One such task is loading stores and equipment onto a pallet, which is conducted at a speed dependent on the level of task urgency. In the instance where task urgency is paramount, it was hypothesised that speed would increase oxygen consumption and trunk flexion, leading to poor lifting mechanics, thereby exposing an individual to increased risk of musculoskeletal injury. Therefore, the aim of this research was to quantify the physiological cost and lifting technique of palletising at two different levels of urgency. Nine Royal Australia Air Force personnel (4 males and 5 females: mean \pm SD: age, 32.8 ± 8.9 y; height, 1.70 ± 0.10 m; mass, 71.9 ± 8.9 kg) who had 6.5 ± 6.3 years of palletising experience participated in this research. Participants completed two palletising trials differing in urgency and therefore self-selected speed (Air Force Urgency of Need Designator Scale: 1 highest urgency – 16 lowest urgency) for completion. For each trial, subjects were required to individually move 19 items weighing 4-21 kg, with a total mass of 139.8 kg onto a pallet then using a pallet jack pull the pallet to a storage cage (14 m) and unload the items consistent with the predetermined ratings of urgency. Physiological strain was measured during each trial using heart rate (Polar Team2, Polar Electro Inc., N.Y., U.S.A.) and oxygen consumption (Metamax 3B, Cortex, Leipzig, Germany). Trunk flexion angle was measured on three participants using wearable inertial measurement equipment (MVN BIOMECH, XSens, Enschede, Netherlands). All data are presented as means and standard deviations (mean \pm SD). The highest urgency trial was significantly ($P<0.05$) shorter in duration (7.67 ± 0.78 min) but higher in work rate (18.38 ± 1.70 kg \cdot min⁻¹) than the slow paced trial (duration: 10.00 ± 1.55 min; work rate: 14.28 ± 2.24 kg \cdot min⁻¹). While peak oxygen consumption during the highest urgency trial was significantly higher (3.12 ± 0.55 L \cdot min⁻¹) than the lowest urgency trial (2.67 ± 0.58 L \cdot min⁻¹; $P<0.05$) mean oxygen consumption was not different (1.90 ± 0.32 L \cdot min⁻¹; 1.64 ± 0.43 L \cdot min⁻¹, respectively; $P>0.05$). Finally, as palletising became more urgent, trunk flexion increased from $44.76 \pm 4.94^\circ$ (lowest urgency) to $52.08 \pm 0.61^\circ$ (highest urgency), suggesting lifting technique became more stooped. This study demonstrates that although individuals were instructed to perform the palletising task urgently, there was minimal difference in oxygen consumption despite a 22% decline in task duration. This may be explained by the adoption of a stooped lifting technique, which has previously shown to reduce physiological demand when compared with a squat lifting technique.

Methodologies in Development and Implementation of Commando Proficiency Test Standards

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This work aims to develop and implement an operationally realistic proficiency test for individual Commando troopers. Currently, no comprehensive measure is available to objectively assess the effectiveness of basic training, or to ensure that individuals possess the physical and mental foundation for more specialized tasks. Besides providing better resolution on individual operational task performance, the proficiency test will also enhance training effectiveness by identifying training gaps, hence driving improvements to the training program. This paper highlights the methodologies employed in test development and implementation. The work involved two phases – profiling of human performance requirements, and subsequent test development. Human performance requirements were elicited via objective and subjective Job Task Analysis (JTA). Given limited opportunities to profile the full range of operational tasks, the JTA focused more on subjective task analysis, where acceptable levels of performance and important tasks were elicited through interviews, surveys, and questionnaires with troopers and senior leadership. Performance requirements gleaned from the JTA were then used to design individual test stations, assessment metrics, and associated scoring criteria. Considerations such as manpower, safety and logistics requirements, administration time, task repeatability, and scoring subjectivity also influenced test station development. The overall proficiency test circuit included various test stations assessing physical activities, skills and abilities, and cognitive elements such as spatial memory. A pilot trial was conducted with 7 participants to identify choke points, and logistical and manpower requirements. Each station was conducted and scored separately. Following revisions to test stations based on inputs from pilot participants, the proficiency test was then trialed with 37 participants. Results from both trials were used to derive a first-cut performance scoring matrix for each station. A mix of subjective and objective measures was used to delimit performance scores. First, objective measures were applied to differentiate performance based on the standard deviation of scores obtained at each station, and on existing Army performance standards and failure criteria where applicable. Subsequently, commanders provided input on whether the resultant performance standards were realistic. Scoring criteria which were deemed too strict or lenient were then modified to reflect desired training outcomes. A first-cut proficiency test with performance scoring criteria has been delivered. As the training syllabus is expected to evolve to address identified training gaps, a periodic review of test content and scoring criteria is recommended such that the test remains operationally relevant and realistic. Proper knowledge transfer of station setup and scoring will also be affected such that the test can be run autonomously by the unit.

Development of a Supplemental Ladder Raise and Extension Test to the CPAT

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A year after adopting the Candidate Physical Ability Test (CPAT) for assessing candidate firefighters, an Ontario Municipal fire department became acutely aware of the transportability and validity issues of the ladder raise and extension portion of this test, when compared to existing equipment in use. The municipality's ladder was 15.9 kg heavier (61.4 vs. 45.5 kg), 3.35 m longer (10.67 vs. 7.32 m), and had an additional fly section compared to the ladder specified in the CPAT manual. At the time, these discrepancies represented a significant obstacle to successfully qualifying new recruits in training. At the request of the

Municipal Chief, and Deputy Fire Chief, a physical demands analysis was undertaken with the purpose of developing an additional CPAT ladder raise and extension test as a bona fide occupational requirement (BFOR). A strain gauge was securely connected in series with the lower pulley mechanism of the ladder and the force to extend and lower both fly sections of the ladder was recorded and saved onto a laptop computer using a 12-bit A/D card and a custom LabVIEW (National Instruments, Austin, TX) program. The dynamic average and peak forces required to extend the ladder were approximately 240 N and 534 N, respectively. The between-trial consistency of the incumbent firefighter, and the shape of the force-time traces, suggested that an appreciable level of motor skill was required to extend the ladder. In assessing survey data administered to 31 incumbent firefighters, we found that 56% of the respondents rated the ladder raise and extension task as requiring *moderate physical effort*, while 20% indicated that this task requires *excessive physical effort*. As well, 61% of the incumbents ranked this task as critical to the performance of a firefighter's job. We redesigned the simulated ladder raise and extension test by incorporating an industrial lanyard, to ensure safety, and slightly modified the ladder to allow the test to be conducted indoors. This was accomplished by removing and attaching the top fly section of the ladder to the bottom fly section and repositioning the pulley mechanism to maintain the original static force requirement of approximately 133.5 N. Ten randomly selected incumbent firefighters (8 males, 2 females), required an average of 33.2 ± 7.8 seconds to complete the simulated task and generally found the task similar, but slightly easier, compared to the fully functional ladder. Although the literature suggests that one standard deviation be used to establish an acceptable time for defining pass fail criteria, two standard deviations were selected for this BFOR due to the skill required to perform this task, and the observed exemplary fitness levels of the incumbent firefighters. Ultimately, the test was approved for use by the municipality's city council and implemented as part of the candidate firefighter screening process.

Fitness for Duty: A Canadian Nuclear Regulatory Perspective

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Fitness for duty (FFD) is an important aspect of human performance within the Canadian Nuclear Safety Commission's (CNSC's) regulatory framework. The CNSC's approach towards fitness for duty provides reasonable assurance that workers at Canada's nuclear facilities have the requisite capabilities to safely and competently perform their duties and as such do not pose a risk to their safety, the safety of others, the safety of the environment, or the safety and security of the facility. The CNSC promotes stakeholder consultation and transparency as part of its development process for new or revised regulatory requirements. This submission describes the path to date in developing CNSC's draft regulatory document on FFD, REGDOC-2.2.4, within this process. Current regulatory requirements related to FFD are being consolidated and enhanced to ensure alignment and consistency with the International Atomic Energy Agency's (IAEA's) requirements and recommendations, and national standards (i.e. Canadian Standards Association-CSA, American National Standards Institute-ANSI, and National Fire Protection Agency-NFPA). The CNSC's conceptual approach for an effective FFD framework across licensed facilities covers a broad range of FFD components (medical, psychological, occupational fitness, behavioural-performance, and biochemical substance testing) and circumstances (pre-placement, for-cause, etc.) across a diverse group of safety-sensitive positions, including: certified workers (RD-204), security personnel (RD-363 and REGDOC 2.12.1), industrial fire brigade/emergency response team members (CSA N293-12 and NFPA 600-2010), and workers designated in minimum staff complement roles (G-323). Following extensive benchmarking and analysis of best practices from both national and international high-reliability organizations, and input from external experts, the CNSC published a discussion paper on FFD, DIS-12-03, *Fitness for Duty: Proposals for Strengthening Alcohol and Drug Policy, Programs and Testing* and a *What We Heard Report* after a 144 day period of public consultation. CNSC staff presented a broad and comprehensive approach to FFD in the discussion paper with a focus on alcohol and drug testing. Based on feedback received from stakeholders and the public, human factors specialists at the CNSC have worked closely with other CNSC specialists and site inspectors with expertise in emergency management, nuclear security, and nuclear facility operations to harmonize and enhance existing FFD requirements in a proposed regulatory document. In line with the CNSC's strategy on developing new

regulatory documents, REGDOC-2.2.4 on FFD will be available for stakeholder and public consultation prior to going before the Commission for approval.

Influence of Size and Gender on Performance during a Work Simulation Test of Physical Fitness for Firefighters

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Evaluation of fitness for duty in time-sensitive, emergency response occupations often involves a series of essential work-related tasks combined into a test circuit where the variable of interest is completion time. The Canadian Forces Firefighter Physical Fitness Maintenance Evaluation (FF PFME) is an example of such a test where the firefighter, in full fire protective ensemble including self-contained breathing apparatus, must correctly complete 10 work-related tasks, including specified transitions between tasks, on a measured and calibrated course. Fitness for duty is inferred from the elapsed time to complete the test. All test subjects are exposed to the same absolute loads (protective ensemble and task loading), raising the question of whether larger individuals may be advantaged and smaller individuals disadvantaged by the test design. We retrospectively examined the effects of body size on test performance with data from 44 females (mean \pm SD: age, 24 \pm 4.8 yr; height, 169.3 \pm 6.5 cm; mass, 68.2 \pm 8.3 kg) and 78 males (mean \pm SD: age, 31.2 \pm 9.0 yr; height, 181.6 \pm 6.3 cm; mass, 84.1 \pm 10.4 kg) who had completed the test. All subjects had been familiarized with the FF PFME and practiced at least three times on separate days prior to the actual test of record. The physical characteristics (mass, height, Body Mass Index [BMI], and Body Surface Area [BSA]) of the test subjects were very similar with the characteristics of firefighter applicants (N = 2836) and also with age-related cohorts of Canadian adults. As expected, the male and female groups were significantly different in height, mass, BSA, BMI and completion time (males: 348 \pm 50 s vs. 428 \pm 45 s). Linear regression analyses were performed for each of the indices of size and completion time for: all subjects combined; for males only; and, for females only. With all subjects combined, there were moderate but significant relationships between test performance and mass and BSA, but not BMI ($r = -0.451$; -0.509 ; and -0.189 , respectively). When examined separately, male test performance was not significantly correlated to any of the physical measures. Female test performance was significantly correlated to body mass and BSA, but not BMI ($r = -0.402$; -0.427 ; and -0.251 , respectively). Female subjects tended to have lower mass and BSA, but not BMI than males, which may explain these relationships. Based on these data, "size" appears to account for *up to* approximately 25% of the variance in performance on the FF PFME, especially in females. We suggest that prospective studies are warranted to further explore the contribution of size to performance. Furthermore, tests with absolute loading must accurately reflect the physical demands of the occupation in order to avoid challenge on grounds of size or gender bias.

Effects of Backpack Weight on Resting Pulmonary Function and Oxygen Cost of Treadmill Walking

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Many physically demanding occupations involve load carriage. One of the most common and efficient methods of carrying loads is with a backpack. Logically, metabolic rate must increase to support the additional weight and it has been suggested that the oxygen cost of exercise with moderate to heavy loads (~20 kg) is increased by approximately 17 mL per kg of added mass during level walking or bench stepping. It is unknown whether this value can be confidently applied to other exercise conditions and/or load configurations. Previous research has shown that thoracic load carriage of up to 35 kg alters resting

pulmonary function. The purpose of this experiment was to document the effects of systematic increases in thoracic load on resting pulmonary function and physiological responses to treadmill walking at a standardized speed and grade. Eighteen healthy, physically active males (age, 27 ± 5 ; mass, 86.6 ± 15.8 kg; stature, 180 ± 8 cm; $\dot{V}O_{2peak}$, 49.0 ± 7.2 mL \cdot kg $^{-1}$ \cdot min $^{-1}$) completed resting spirometry in four conditions: unloaded and while wearing a properly sized and fitted 80 L backpack weighted to 15, 30 and 45 kg. Subsequently, each subject completed four randomly ordered exercise bouts, each consisting of 10 min of treadmill walking at 80.5 m \cdot min $^{-1}$ and 4% grade. Exercise bouts were bracketed by standardized warm-up and cool-down and were separated by 10 min of rest. Forced vital capacity (FVC) was reduced ($p < 0.05$) by 1.5, 2.7 and 5.0% with the 15, 30 and 45 kg packs, respectively, compared to the unloaded condition. Forced expired volume in 1 second (FEV $_1$) second was reduced ($p < 0.05$) by 2.5, 3.7 and 5.8% with the 15, 30 and 45 kg packs, respectively, compared to unloaded. Peak expiratory flow and FEV $_1$ /FVC were not altered with thoracic loading. During treadmill exercise at a constant speed and grade, oxygen consumption ($\dot{V}O_2$) increased ($p < 0.05$) by 11.0 (unloaded to 15 kg), 14.5 (15 to 30 kg) and 17.8% (30 to 45 kg). When normalized to total mass (body mass + backpack), $\dot{V}O_2$ was reduced ($p < 0.05$) by 4.4% with the 15 kg pack and increased ($p < 0.05$) by 5.6% with the 45 kg pack, when compared to unloaded. Resting pulmonary function was moderately reduced with systematic increases in thoracic load carriage and the decreases in FVC and FEV $_1$ appeared to be explained by pack weight. However, during exercise, increases in metabolic rate were disproportional to changes in backpack weight. Very heavy thoracic loading (45 kg) increased physiological strain beyond what might be predicted from the weight of the load alone. These results support the requirement for specific occupational loading conditions when conducting physical demand analyses, evaluating fitness for duty, or setting physical employment standards.

Between-Day Repeatability of the Ottawa Paramedic Physical Ability Test (OPPAT)

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Repeatability is an important consideration when applying a work simulation test as a physical employment standard. The Ottawa Paramedic Physical Ability Test (OPPAT) has been developed as a physical employment standard, but the test's repeatability has not yet been established. The OPPAT was designed as three circuits, completed in sequence, where each circuit includes a series of common and/or demanding paramedic tasks. The type, frequency and intensity of task requirements were determined based on a physical demands description and data from a survey where paramedics identified their most critically demanding activities. The purpose of this study was to measure the between-day repeatability of circuit completion time and indicators of physiological and psychophysical demand. Twenty-three active duty paramedics were recruited from the Ottawa Paramedic Service (OPS) (mean \pm SD: 11 females; age, 33 ± 5 yr; height, 1.64 ± 0.08 m; weight, 68.7 ± 11.2 kg; experience, 9.5 ± 3.2 yr; 12 males; age, 47 ± 9 yr; height, 1.75 ± 0.11 m; weight, 95.0 ± 22.1 kg; experience, 22.3 ± 8.2 yr). Participation was open to all active duty female paramedics but only active duty male paramedics over 40 years of age. Participants were required to complete the OPPAT on two consecutive days. The test was administered by a member of the research team, using standardized instructions. All partnered lifts were performed with the support of a paramedic lifting partner (OPS research team member). Heart rate was recorded (Garmin Forerunner, Garmin, KS, USA) immediately prior to, and following test completion. Additionally, time to completion and rate of perceived exertion (Borg CR-10 Scale) were recorded following each trial. Participants completed the OPPAT in 891 ± 46 sec on their first attempt, improving by 40 ± 14 sec during the second attempt ($p = 0.013$). However, post-test heart rate (Trial 1, 143 ± 26 bpm; Trial 2, 140 ± 26 bpm) and RPE (Trial 1, 4.6 ± 1.5 units; Trial 2, 4.7 ± 1.8 units) remained unchanged ($p = 0.116$ and $p = 0.490$, respectively). Quicker times during the second attempt were likely indicative of a learning affect. Participants seemed to be more familiar with the test sequence and tended to spend less time pausing to listen step-by-step directions from the test administrator. However, it is unlikely that they improved their time by completing the OPPAT more efficiently as post-test

heart rate and RPE, indicators of physical demand, remained consistent. The data support that the OPPAT provides a repeatable physiological and psychophysical demand to paramedic candidates.

The OPS Research Team includes: Paolo Bottiglia, Monica Di Iorio, Michelle Farragher, Amanda MacIvor, and Sylvie Rochon. This project was funded with support from MITACS, the City of Ottawa and CUPE Local 503.

Job-related test approach for a physical aptitude test in police training context

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In 2002, the École nationale de police du Québec (ENPQ) developed the TAP-ENPQ (Léger & Long, 2003), a test measuring the physical fitness of its applicants. It was built based on a Job-Related Test approach used elsewhere in Canada with police recruits. The TAP-ENPQ consists of a 20 m multistage shuttle run test (Léger et al, 1988), followed by a timed circuit and individual stations reproducing police profession tasks that have been judged physically demanding. A unique standard is applied for both male and female applicants. The successful completion of the TAP-ENPQ is one of the admission requirements for the basic training program in police patrolling. The test is administered to over 700 applicants annually and has a success rate of 96.4%. In October 2013, ENPQ looked into the possibility of revising the TAP-ENPQ following the implementation of the new basic training program in police patrolling. The ensuing conclusions were: (1) the maintenance of a unique standard for both male and female applicants; (2) the implantation of differentiated standards according to an emulation approach; and (3) the need to adjust the timed circuit and individual stations according to the minimum physical requirements of the new training program. The "Job-Related Test" approach is applied to police training context instead of police profession tasks. In collaboration with university experts, ENPQ has designed a research protocol in accordance with the National Forum on Bona Fide requirements (Bonneau, 2000). A thorough analysis of physically demanding activities of the new training program associated with a measure of VO_{2max} is the starting point for this review. This poster presentation will present the recitals supporting the revision of the TAP-ENPQ and the approach applied to the revision.

The transition from criterion occupational tasks to physical aptitude screening tests

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This is the second of two abstracts that focus on the methods for developing employment standards for physically demanding jobs. Firstly, the processes for converting criterion occupational tasks into *bona fide* pre-employment selection tests are presented using urban firefighters as the worked example. Fourteen individuals participated in potential screening tests that targeted three loaded movement categories: single-sided load carriage [4 tests], dragging loads [2 tests], overhead pushing and holding objects [5 tests]. Seven tests emerged, one performed as an isolated pass/fail barrier test (ladder raise) and six incorporated into a sequential, timed circuit simulating Hazmat incidents, ventilation fan carriage (stairs), motor-vehicle rescues, bushfire incidents, fire attacks and a firefighter rescue. Since three tests provided predicted performance speeds to replicate the oxygen cost of firefighters performing the corresponding occupational simulations, then notional performance standards could be projected and recommended for the final phase of this research (Groeller *et al.*, 2015). In that phase, physical aptitude tests were administered to unskilled subjects and operational firefighters to evaluate the impact that testing bias associated with gender, age, activity-specific skills or task familiarity may have upon establishing physiological employment standards. Those tests were administered in sequence, simulating Hazmat incidents, ventilation fan carriage (stairs), motor-vehicle rescues, bushfire incidents, fire attacks and a firefighter rescue. Participants included two unskilled samples ($N=14$ and 22) and 143 firefighters. Firefighter performance was not significantly different from the unskilled

subjects. Participants from both genders passed the test, with scores unrelated to performance skill or age. However, familiarisation significantly improved performance when the test was repeated. These outcomes confirmed this test to be gender-, age- and skill-neutral. Familiarisation effects could be removed through performing a single, pre-selection trial of the test battery. The four stages presented in these two abstracts represent a sequence of research steps that one may utilise when seeking to develop *bona fide* employment tests and standards.

References:

- Groeller, H., Fullagar, H.H.K., Sampson, J.A., Mott, B.J., and Taylor, N.A.S. (2015). Employment standards for Australian urban firefighters. Part 3: The transition from criterion task to test. *J. Occup. Environ. Med.* In press.
- Fullagar, H.H.K., Sampson, J.A., Mott, B.J., Burdon, C.A., Taylor, N.A.S., and Groeller, H. (2015). Employment standards for Australian urban firefighters. Part 4: Physical aptitude tests and standards. *J. Occup. Environ. Med.* In press.

Establishing a Cross-Canada Fitness Standard for Wildland Fire Fighters: the WFX-FIT

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The Canadian Interagency Forest Fire Fighter Centre has a due diligence responsibility to ensure that Type 1 Wildland Fire Fighters (WFF), who are exchanged to fight fires across Canada, possess the physical and physiological ability to perform emergency WFF tasks safely and efficiently in all terrains. The development of the WFF Exchange Fitness Test (WFX-FIT) was initiated with a physical demands analysis (PDA). WFF across Canada identified rolling hills, forest blow-downs, muskeg and steep mountains as the most challenging terrains for fighting fires, and identified carrying a 28.5 kg pump, carrying a 25 kg hose pack and advancing charged hose as the most demanding emergency tasks. The oxygen cost (VO_2) of performing these tasks was measured on a representative sample of incumbent WFF in all terrains.

The mean VO_2 of performing the same tasks was; 35 mL·kg⁻¹·min⁻¹ in New Brunswick (n=53), 35 mL·kg⁻¹·min⁻¹ in Saskatchewan (n=50) and 39 mL·kg⁻¹·min⁻¹ in British Columbia (n=65). Performing the same WFF tasks was significantly more demanding in BC than in NB and SK ($p \leq 0.05$). That is, regional terrain differences resulted in the same tasks being more physically demanding and therefore, these different demands must be built into the WFX-FIT. A circuit was developed incorporating simulations of the critical, frequently occurring and physically demanding on-the-job WFF emergency tasks identified in the PDA and confirmed with VO_2 measurements. The mean (\pm SD) VO_2 of performing the critical and physically demanding WFF tasks on the job was 37 \pm 5 mL·kg⁻¹·min⁻¹, (n=168). The mean VO_2 of performing the same in the WFX-FIT circuit was 37 \pm 4 mL·kg⁻¹·min⁻¹ (n=64). Content validity ratings from the WFF perception of the "likeness" between tasks performed on the job and tasks embodied in the WFX-FIT were "Strongly Agree" (n=128). These two validation methods indicate that the physical demands involved in performing the WFX-FIT are the same as the physical demands involved in wildland fire fighting. As well, the WFF rated the simulated tasks in the WFX-FIT to be as demanding as the tasks performed on the job. Test-retest reliability of WFX-FIT performance times on two separate days after being familiarized with the circuit were 861 \pm 171 sec and 855 \pm 161 sec. There was no significant difference in these times ($p \leq 0.05$) and the associated test-retest reliability coefficient was $r=0.98$ ($r^2 = 0.96$), which indicates very high reliability. These findings provide excellent validity and reliability for WFX-FIT circuit.

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Establishing the Performance Standard and Examining Pass Rates on the Canadian Fitness Standard for Wildland Fire Fighters.

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The Canadian Interagency Forest Fire Fighter Centre (CIFFC) must ensure that Type 1 Wildland Fire Fighters (WFF) from across Canada, who are deployed to fight fires, possess the physical ability to perform emergency WFF tasks safely and efficiently in all terrains. In addition, all job-related fitness tests must meet the criteria established by the Supreme Court of Canada's 1999 Meiorin Decision to qualify as a bona fide occupational requirement (BFOR). Once the critical, physically demanding FF tasks and terrain differences across Canada were identified, a fitness test circuit was constructed to simulate the physical demands of the critically important and physically demanding emergency on-the-job tasks. After the Wildland Firefighter Exchange Fitness Test (WFX-FIT) was standardized and validated the next step was to establish the associated performance standard (PS). There are 13 fire jurisdictions in Canada and to be eligible for out-of-province exchange, a WFF must meet the National Exchange PS. A total of 442 male and 40 female WFF (who were judged by their supervisors to be safe and efficient) from all 13 fire jurisdictions performed the WFX-FIT at a self-selected safe and efficient pace. For a test to qualify as a BFOR, the associated PS must be based on the performance of the sub-group of incumbent workers who have lower physical attributes than the majority group of the workers (generally females or older males), but who perform the job safely and efficiently. The statistical computation that has been used to derive PS for other safety-related occupations which have been grieved and approved in arbitration as a BFOR, is the Mean + 1 SD of the completion times of the identified sub-group of workers. Using this computation, four jurisdictional "groupings" (based on similar mean WFF circuit completion times) and one National Exchange PS were established from the completion times of safe and efficient female WFF. In 2012, CIFFC implemented the WFX-FIT in all fire jurisdictions across Canada. Pass rates¹ (%) during the first year of implementation were 94.4 for males and 82.9 for females on the Jurisdictional PS and 80.7 and 64.0 on the Exchange PS. In 2013, pass rates were 95.9 and 93.8 on the Jurisdictional PS and 85.7 and 79.4 on the Exchange PS for males and females respectfully. In 2014, male and female pass rates were 96.3 and 91.2 on the Jurisdictional PS and 87.6 and 78.6 on the Exchange PS. It is concluded that since the WFX-FIT was implemented in 2012, there have been continual improvements in performance and an increase in the WFF available for exchange across Canada.

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Application of Subjective Job Task Analysis Methodologies in Physically Demanding Occupations: Evidence for the Presence of Self-Serving Bias

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Methodological best practice for the development of any scientifically defensible physical employment standard (PES) is dependent on the conduct of an accurate job task analysis (JTA). Given that subjective methodologies such as surveys and focus groups are highly prevalent in the JTA literature, the purpose of this study was to determine if perceptions of physically demanding job tasks are biased by incumbent employees' demographics or employment profile. It was hypothesised that characteristics relating to participants' employment profile, including experience, length of tenure, rank, and whether they supervised or completed a task, would have a greater impact on job task ratings than participant demographics such as age and sex. To determine the presence of bias, surveys were administered to 427 Royal Australian Navy (RAN) personnel who were asked to characterise 33 generic sea-going job tasks based on their perceptions of physical effort, importance, frequency, duration, and the vertical and horizontal distance travelled while completing each task. Task ratings were then compared across participant employment profile characteristics using

parametric and non-parametric between-group comparisons, correlations and regression analyses while controlling for confounding variables. Results indicated that age, sex, job experience, job tenure and rank had no strong or consistent patterns of bias on job perceptions across all tasks. In contrast, participants who were actively involved in both participation and supervision of a task tended to rate those tasks as more important than those who were only involved in the supervision of that task. These results may indicate the presence of a self-serving bias by which participants who are more actively involved in a task have an inflated perception of that task's importance. Inversely supervisors, who have less physical involvement in task completion, may perceive tasks as less important. Given that ratings of importance can influence the selection of criterion job tasks and the final set of recommended tests and standards, it is important that employment profiles, specifically employees' level of engagement in the task, is considered to ensure methodological best practice for the conduct of JTA in physically demanding occupations. Overall these results have important implications for the future conduct of JTAs, especially those researchers relying on subjective methodologies when developing a scientifically, and by virtue legally, defensible PES.

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Pre-employment functional capacity assessments predict musculoskeletal injury risk in healthy male coal mine workers

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Musculoskeletal injuries in the workplace are a significant economic and social problem in industrial nations worldwide. Pre-employment screening endeavours to identify individuals who are at greater risk of sustaining an injury so that those risks may be managed. Traditional methods of screening, including back x-rays and medical screening are not valid predictors, nor meet current anti-discrimination legislation requirements. Short-form functional capacity evaluations are increasing in popularity despite limited evidence of their ability to predict future risk of injury in healthy workers. The purpose of this study was to determine if job-specific pre-employment functional assessments predict musculoskeletal injury risk in healthy male mine workers and to determine if the injury risk differs for different injury types or over time. This was a prospective observational study involving 600 healthy male coal mine workers who participated in a job-specific pre-employment functional assessment (PEFA) as part of the hiring process of an Australian coal mine. At baseline, participants were screened with a job-specific JobFit System PEFA consisting of a musculoskeletal screen, aerobic fitness test and job specific postural tolerance and material handling activities. PEFA scores were dichotomized into PEFA 1 if they met the job demands and PEFA>1 if they did not. Injury data was obtained from the company's database and injuries were classified according to body location, severity and mechanism. Of the 600 participants (median age 37 years, range 17.0 to 62.6 years), 427 (71%) met job demands (PEFA 1). The median follow-up time was 2 years (IQR 1.2 to 4.0). A total of 121 workers (20.2%) reported an injury and 29 workers (4.8%) reported a back injury associated with manual handling. Statistically significant differences were found between PEFA groups in time to injury over the longer term (>1.3 years) for all injury types: any injury (Hazard Ratio [HR]=2.3, 95% confidence interval [CI] 1.4 to 3.9), manual handling injury (HR=3.3, CI 1.6 to 7.2), any back injury (HR=3.3, CI 1.6 to 6.6), back injuries from (HR=5.8, CI 2.0 to 16.7). These relationships remained significant after adjustment for confounders. Job-specific pre-employment assessments meet anti-discrimination legislation. The JobFit System PEFA predicts musculoskeletal injury risk in healthy male mine workers over the longer term, but not the short term. More research is needed to identify why risk changes over time however, practitioners can maximize the opportunity of the period with physical conditioning and workplace modifications as part of a holistic workplace injury risk management program.

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Job-specific functional assessment associated with reduction in musculoskeletal injuries in building security workers

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Defensive tactics training is an annual requirement for security personnel working in a building security services team. Participants were suffering musculoskeletal injuries during the training sessions. An ergonomist was engaged to assist with the identification and implementation of workplace injury prevention strategies, including job-specific pre-employment assessments. Soon after implementation, injuries increased following an upgrade in training techniques that was not reflected in the initial job-specific functional assessment. The assessment tool was redesigned with positive results. Workers are required to achieve the assessment criteria prior to participating in annual training. Project costs to date are approx \$85,000. Annual claims costs associated with training injuries have reduced from a peak of \$187,000 to nil over the last two years. Ergonomist conducted the initial task analysis and assessment design with input from operations personnel. Secondary review and update of assessment involved more collaboration with operations personnel for the assessment tool activities and grading criteria. Assessment and evaluation; participatory ergonomics; musculoskeletal injury prevention:

- Initial task analysis and design of pre-employment assessment, including training activities (1 month)
- Conduct annual pre-training assessment (4 years)
- Re-evaluate program and training demands with subsequent update to assessment to reflect changes in training activities (1 month)
- Continue annual pre-training assessments (2 years)

Job-specific functional assessments can be a useful tool for injury prevention however they need to be updated as job requirements change to maintain effectiveness.

Muscle forces of 18 - 29 year old soldiers and insights into potential limits of female strength trainability exemplified by female soldiers' handgrip forces

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Despite all technical progress in our high-tech armed forces, carrying of equipment and loads are still core demands in the military. Soldier's equipment alone may induce combat loads of up to 40 kg (helmet, ballistic vest, rucksack, etc.). Depending on the mission, loads might even be substantially higher. Muscle strength often plays a key role for successfully accomplishing important military tasks. Transporting a casualty on a stretcher is a prime example of a challenging occupational task that primarily depends on handgrip strength. This inherent strength-load problem poses great challenges, in particular for female soldiers. In the present study we quantified the gender related strength differences (trunk flexors/extensors, arm flexors, leg extensors, handgrip) of 18 - 29 year old female and male soldiers (n = 2,248) who were not strength trained. In addition female strength trainability in respect to handgrip forces was analyzed by comparing the handgrip strength of this reference collective with maximal handgrip forces from highly trained female athletes (n = 70). The female elite athletes were members of national teams from sports known to require high handgrip forces (judo and handball). Maximal muscle forces (F_{max}) of trunk flexors/extensors, arm flexors, leg extensors, and handgrip were derived from 15s-force-tracings. Basic information (athletics status, biometric data, etc.) were obtained by means of questionnaire and anthropometric measurements. Means and standard deviations (SD) were calculated as descriptive measures and statistical analyses were conducted of mean differences. Female soldiers only produce some 51 % - 66 % of the muscle forces of their male comrades. F_{max} of arm flexors show the highest (mean ± SD: women 102 ± 19 N; men 199 ± 32 N), leg

extensors the smallest (women 362 ± 64 N; men 552 ± 87 N) gender differences. Fmax values of handgrip also differ significantly between female (321 ± 56 N) and male soldiers (509 ± 72 N) and show only a marginal overlap: 80 % of the women do not attain the Fmax of the 5th percentile (382 N) of the men. Even the average of female national elite athletes (395 ± 63 N) does not surpass the 7th percentile of the untrained or not specifically strength men indicating an unbridgeable gap despite longtime and intensive training. Despite these not very promising results, strength training for female soldiers is essential with regard to the strength-load problem in the military and an important preventive measure for health maintenance.

Usability of Computer-based Assessment Method of Physical Work Capacity among Firefighters

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According to the Finnish law and regulations the health and physical work capacity of operative fire fighters has to be assessed regularly. This study is part of large developmental project of the assessment, feedback and follow-up method of firefighters' physical work capacity (FireFit method). The project has been going on since 2006 and the FireFit method is nowadays in use in most of regional rescue services in Finland. Web-based questionnaire was sent to 18 actors of all 22 regional rescue services and to one industrial plant fire brigade and to their occupational health personnel. Actors from 15 rescue services agreed to participate in the study. The response rate was 60 % for both the occupational health personnel (OHP) and the persons of the regional rescue services. The questionnaire aimed to find out: 1) how the use of the FireFit method was organized, 2) short term effectiveness for enhancing work ability of firefighters by using the method and especially 3) the developmental needs of the method. One of the main interest was to clarify how the method acted as a tool for discussion and cooperation between different stakeholders. Most of the respondents (88%) agreed that the FireFit method was good tool for early intervention. In the large picture the quality, equality and the use of tests in professional manner have improved. They reported that it has been easier to influence the problems of work ability than before with the help of the system. As a whole, the comprehensive and work related feedback from the assessments has made discussion easier. The discussion has led to the real causes of the problems and to wider health promotion issues. A total of 88 % of the respondents answered that the cooperation between the OHP and the actors of the fire departments have increased. The consultation of medical doctors and occupational physiotherapists has been more prevalent and early enough, especially for persons with musculoskeletal problems. A total of 77 % of the respondents felt that the quality and comprehensiveness of physical training has improved by the individual instructions obtained from the FireFit system. However, there were also some developmental needs. In all fire departments there should be an established and well-known action plan for what to do when a fire fighter fails to pass the cut-off values of the tests or if there is an accident during the assessment. There should also be plans concerning the assessments of voluntary firefighters. The FireFit method seems to act as a tool of cooperation between occupational health personnel and stakeholders of fire rescue services. It seems to make early interventions more appropriate for firefighters with decreasing work ability. High quality use of the method requires continuous education and training of its users.

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Setting a Performance Standard for the Canadian Joint Incident Response Unit Chemical, Biological, Radiological and Nuclear Operator Job Specific Test

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The Canadian Joint Incident Response Unit (CJIRU) provides specialized, timely and agile Chemical, Biological, Radiological and Nuclear (CBRN) Defence for the Government of Canada. Working in hazardous

environments requires CBRN Operators to wear fully encapsulated protective suits for long periods of time, increasing the physical demand of performing specific tasks. In Jan 09, the Commander Canadian Special Operations Forces Command (CANSOFCOM) directed that a scientifically valid Job Specific Test (JST) and standard be developed to ensure that CBRN Operators possess the physical capacities required for the job. One of the most important steps in developing a JST is setting a performance standard. One of the most notable standard setting methods is the Modified Angoff Procedure, as described by Ricker (2006). However, since the Modified Angoff Procedure focuses on written tests, Lewis et al (1996 & 1999) developed the "Bookmark Procedure" (BMP) for setting performance standards on tests which simulate real work tasks. The BMP was chosen for setting a standard on the CBRN Operator JST since it is a valid simulation of real work tasks. The purpose of this paper is to describe the application of the BMP for setting a performance standard for the CBRN Operator JST. Participants in the BMP working group were 13 (12 male, 1 female) CBRN Operators. All were verified as CBRN Subject Matter Experts (SMEs) and all had previously performed the JST. Each participant was provided a laptop and 6 videos depicting performance of the JST at different standardized paces, based on actual CBRN Operator JST data. All videos were viewed in their entirety and in order from fastest-slowest. After viewing, participants were asked to rate between which videos they believed the performance pace moved from being "minimally acceptable" to "unacceptable". Once all ratings were completed, discussions ensued pertaining to these ratings, and the process was repeated for three rounds. After three rounds, the mean "minimally acceptable" performance time on the JST was recorded, and the standard error of the mean (SEM) was calculated. The SEM accounted for <1% of the mean; 11 (85%) participants agreed on the location of their ratings; and 2 (15%) participants agreed on a rating that was within one video of the majority. These findings helped determine that an acceptable level of consensus had been achieved. To account for the variability in participant ratings, +2 SEMs were applied to the mean rating, resulting in a minimally acceptable performance standard. The CBRN Operator JST and standard were approved by the Commander CANSOFCOM on 05 Feb 15. The application of the JST and standard to the CBRN Operator occupation will ensure that CBRN Operators possess the minimum physical capacities required to safely and effectively perform the job.

Lift Performance is Moderated Primarily by Fat-free Mass rather than Stature

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Stature is known to be strongly associated with lifting performance in manual materials handling. However, in approximately half of all manual handling tasks within the Australian Army, the absolute lifting height is fixed and unable to be adjusted (i.e. vehicle platform height). Under these conditions it is unclear how kinanthropometry may influence lift performance. Therefore this investigation sought to determine the relationship between lift performance and kinanthropometry for a fixed height military-based lifting task. Fifty-one enlisted soldiers (34 male, 17 female; age, 40.9 ± 10.2 yr) volunteered for the investigation. Stature and acromial height were measured using a stadiometer and a dual energy x-ray absorptiometry scan was performed to measure total mass, fat-free mass and percent body fat. Performance on a two-stage (ground-to-waist/chest and waist/chest-to-platform) single repetition maximum (1RM) box lift to a platform height of 1.5 m was then determined for each soldier. Bivariate and partial correlations were used to investigate the relationships between maximum lift mass and kinanthropometric variables. Significance was determined by an alpha of $\leq .05$. Participants were 1.72 ± 0.09 m tall with an acromial height of 1.42 ± 0.08 m. They weighed 80.8 ± 15.6 kg with $23.3 \pm 5.4\%$ body fat, 61.9 ± 11.7 kg of fat-free mass and a 1RM box lift of 35.4 ± 10.6 kg. Lift performance was significantly correlated with stature ($R^2 = 0.49$), acromial height ($R^2 = 0.46$), total body mass ($R^2 = 0.54$), fat-free mass ($R^2 = 0.73$) and percent body fat ($R^2 = -0.11$). Partial correlations revealed that neither stature ($R^2 = 0.00$) nor acromial height ($R^2 = -0.01$) were significantly related to lift performance when controlled for fat-free mass. However, fat-free mass was significantly correlated with lift performance when controlled for either stature ($R^2 = 0.48$) or acromial height ($R^2 = 0.51$). In addition, when stratified into body region, both upper and lower body fat-free mass were correlated with lift performance when controlled for stature (upper $R^2 = 0.49$; lower $R^2 = 0.39$) or acromial height (upper $R^2 = 0.51$; lower $R^2 = 0.43$). The

results indicate that even though stature, acromial height and fat-free mass are related to lifting performance, it is the latter that is the strongest determinant of lift performance. In light of the correlation differences between body regions ($p < .05$), it is likely that the strength requirement to move a box anteriorly and vertically onto a platform is more of a limiting factor of lift performance than that required to lift the box from the ground to the waist or chest. Therefore, strength and conditioning regimens that increase fat-free mass, particularly of the upper body, may enhance performance of lifting to a height of 1.5 m.

Sea Survival Training: Emergency breathing systems, Physical demands and Technique

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Sea survival training (SST) has been identified as the most demanding activity undertaken by many of those with sedentary jobs on offshore oil installations. A task analysis established the most physically demanding training tasks of SST as: Entering a liferaft; Climbing on a liferaft to right it; Climbing on a rope embarkation ladder to get out of the water; Swimming in an immersion suit; Entering the water from height; Helicopter underwater escape training (HUET) and Emergency Breathing System (EBS) training. Only a small number of individuals either initially (0.73%) or permanently (0.34%) fail SST courses (based on 18,100 trainees). The methods of best practice (MOBP) were established for the SST tasks and, where possible, minimum performance standards were established. At this time, due to a change in regulation, the EBS has been changed from a rebreather (RB) to compressed air (CA). Currently it is not possible to train in-water with a CA EBS. As a consequence, trainees only receive in-air training (IAT) with the CA device, and in-water training (IWT) with the RB. It has been suggested that IAT is sufficient. This first study tested that assertion and established the benefit in terms of performance in the HUET of IAT, and IAT + IWT. Two further studies were conducted to assess the physical and physiological demands of swimming with and without a casualty and entering a life raft. Results showed that IWT was of significant value, and helped reduce anxiety in the minute leading up to immersion (mean [SD] heart rate; $IAT_{\text{subsurface}}=108$ [15.76] $\text{b}\cdot\text{min}^{-1}$ vs $IWT_{\text{subsurface}}=91$ [16.47] $\text{b}\cdot\text{min}^{-1}$; $p<0.001$; $d=1.04$), improved confidence, extend underwater time (breath-hold was reduced following IAT[15.72 [5.64] s) and returned back to baseline times (20.66 [11.93] s) following IWT (20.86 [11.96] s), ease of deployment and perceived exertion. The most physically demanding aspect of swimming in a survival suit and lifejacket was towing an unconscious casualty. A defensible performance standard could not be established for the metabolic ($\dot{V}O_2$) demand of towing a casualty. Participants completing the tasks of swimming and towing a casualty at a self-selected pace. Those with a more proficient technique could reduce the physiological demand considerably (105.17 mL/m to 346.87 mL/m). Similarly successfully entering of a liferaft was found to be highly technique driven. Instead of establishing definitive physical demands for sea survival training this work has demonstrated that the training tasks are highly technique based and it would be inappropriate to set a physical employment standard on training tasks with such a reliance on technique. Training should therefore focus on improving technique rather than fitness.

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The effects of thoracic load carriage on maximal work tolerance and acceptable work duration

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Load carriage distributed around the thorax restricts chest-wall movement, most evidently during heavy ventilation. In this investigation, the differential impact of inertial or elastic loading was investigated during progressive treadmill exercise to exhaustion. In addition, maximal acceptable work duration for the same

thoracic load was calculated during low, moderate and intense submaximal exercise. Twelve males (age 22.3 y [SD 4.1], mass 74.8 kg [SD 5.8], height 1.79 m [SD 0.07]) participated in a within-subjects study involving two phases. Phase 1 - Three treatment conditions conducted on separate days: Control (military clothing only), thoracic load carriage (military clothing plus 22-kg weighted vest) and combined military clothing and chest-wall restriction (strapping). For each condition, subjects were studied at rest, and following incremental treadmill exercise to volitional exhaustion. Phase 2 - Calculation of maximal acceptable work duration: This involved five separate exercise intensities (30-80% peak oxygen uptake) whilst carrying the same thoracic load. Acceptable work duration was calculated using two previously published equations based upon time lapse (min) from the commencement of exercise. *Equation 1*: heart rate elevation to 180 b.min⁻¹; *Equation 2*: heart rate elevation to a mean of 150 b.min⁻¹. In Phase 1, the thoracic load carriage, but not strapping, reduced maximal work tolerance (control: 17.21 [±0.93]; load carriage: 13.44 [±0.68]; chest-wall restriction: 17.00 [±0.83] min, $P<0.05$) with a corresponding reduction in mass-specific peak oxygen uptake (control: 61.61 [±2.28]; load carriage: 45.42 [±1.41]; chest-wall restriction: 59.99 [±1.61] mL.kg.min⁻¹, $P<0.05$). Peak minute ventilation was retained in both treatments, however, thoracic load carriage and chest strapping reduced the breathing reserve to <10% ($N=6$). In Phase 2, acceptable work duration decreased in a non-linear relationship with increased exercise intensity. Acceptable work durations were significantly longer at the 30% exercise intensity (equation 1: 220.10 [±48.69]; equation 2: 133.40 [±23.77] min) compared to all other intensities, with the 80% exercise intensity resulting in times of <7 min ($P<0.05$). The strongest predictor of acceptable work time was that based upon relative heart rate (equation 1: $r^2=0.71$, $P<0.05$; equation 2: $r^2=0.80$, $P<0.05$ respectively). In conclusion, thoracic load carriage imposed a unique stress upon the cardiopulmonary system, as reflected by a reduced maximal exercise tolerance, mass-specific peak oxygen uptake and breathing reserve. The acceptable work duration whilst carry a load of 22 kg was always longer than 2 h during low intensity exercise, however, this was rapidly reduced to less than 30 min during moderate- to high-intensity exercise.

The Effect of Body Size on Performance During Treadmill Exercise with Heavy Load Carriage

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Many emergency response occupations require heavy load carriage with backpacks. Tests of aerobic fitness for duty may or may not simulate the type of load carriage encountered during work, leading to questions of test validity for selection of workers best suited for the job. Previous research has inferred that 'smaller' individuals are advantaged by unloaded evaluations of aerobic fitness while 'larger' individuals are disadvantaged. Alternately, it may be assumed that 'larger' workers are better suited to work requiring heavy load carriage. The purpose of this experiment was to study the influence of selected aspects of body size on physiological responses and performance during graded exercise with and without heavy load carriage. Fifty healthy, physically active males (age: 28 ± 6 yr, height: 182.8 ± 6.2 cm, mass: 85.4 ± 12.1 kg) provided written informed consent before completing two randomly ordered graded exercise tests (GXT) on a treadmill. Test conditions were loaded (L) and unloaded (U). During L, each subject carried a correctly sized and fitted 80 L backpack weighing 25 kg. Volume and load distribution were consistent between all packs used in the study. Modified-Balke-treadmill-tests were completed while walking at 91 m.min⁻¹ with stage increases of 2% grade until exhaustion. Paired-t analysis revealed small but significant decreases of 3.9 and 2.4% in $\dot{V}O_2$ at ventilatory threshold (T_v) and peak exercise, respectively, in L compared to U. Power output at ventilatory threshold and $\dot{V}O_{2peak}$ were significantly decreased by 23.6 and 11.1%, respectively, in L. Test duration was reduced by 29.6% in L. The absolute mass of the pack (25 kg) represented a relative load of 29% of body mass for the average subject, however the relative load ranged from 21 - 40% for the heaviest and lightest subjects, respectively. Despite the wide range of body mass (62.6 - 118.0 kg), body mass index (BMI; 20.6 - 31.7 m.kg⁻²), and body surface area (BSA; 1.74 - 2.55 m²) there were no significant associations between size and the change in either physiological variables or power output at T_v or peak exercise between conditions. There were significant relationships between mass, BMI, BSA and the change in test duration between

conditions ($r = -0.47$, -0.47 , and -0.45 , respectively). The present findings provide some support for the general notion that larger individuals are better suited for work with heavy load carriage. However, this suggestion is made with reservation. The correlations were modest at best and suggest that size may account for only about 22% of the variance in performance between unloaded and loaded exercise. We maintain that the use of occupationally-relevant load carriage is important when evaluating fitness for duty and importantly, work performance under load cannot be accurately inferred from body size.

Effects of Heavy Load Carriage on Physiological Responses and Exercise Performance during Graded Exercise in Females

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Many emergency response occupations (e.g., structural firefighting, infantry, search and rescue) require heavy load carriage which may include various combinations of protective clothing, respirators, equipment, tools and weapons. One of the most common and efficient methods of load carriage is with backpacks. There is a large body of work investigating the effects of load carriage on physiological responses and exercise performance in males, however, there are few reports on the effects of load carriage in females. More research with female subjects is necessary to assist with development of equitable physical employment standards. The purpose of this experiment was to study the effects of heavy load carriage on physiological responses and performance during graded exercise in females. Twenty-four healthy, physically active females (age: 24 ± 4 yr, height: 169 ± 7 cm, mass: 65.5 ± 6.1 kg) provided written informed consent before completing two randomly ordered graded exercise tests to measure ventilatory threshold (T_v) and peak oxygen consumption ($\dot{V}O_{2peak}$). Test conditions were unloaded and loaded, where subjects carried a correctly sized and fitted 75 L backpack weighing 25 kg. Pack type and fit parameters as well as load volume and weight distribution were consistent for all packs used in the study. Modified Balke treadmill tests were completed while walking at $91 \text{ m}\cdot\text{min}^{-1}$ with stage increases of 2% grade every two minutes until exhaustion. Analysis revealed a small but significant decrease in $\dot{V}O_2$ at T_v (3.5%) and $\dot{V}O_{2peak}$ (3.5%) in the loaded condition. While under load, breathing pattern was altered towards decreased tidal volume and increased frequency in order to maintain minute ventilation. Other physiological responses such as respiratory exchange ratio and heart rate were the same between conditions at both T_v and peak exercise. Under load, power output at T_v and $\dot{V}O_{2peak}$ were significantly decreased by 40.7 and 20.2%, respectively, and test duration was decreased by 39.3% (1198 ± 40 vs 726 ± 32 s) compared to the unloaded condition. These results demonstrate that, although the cardiorespiratory system is only slightly affected, heavy load carriage with a backpack has a much larger effect on work capacity. Interestingly, there were no significant associations between the changes in power output at either T_v or peak exercise and either body mass, body mass index or body surface area. However test duration was significantly associated with body mass ($r=0.451$) and surface area ($r=0.490$), suggesting that the absolute burden of the pack (25 kg) decreased exercise tolerance more in smaller subjects. These results provide support for the use of occupationally-relevant load carriage when assessing fitness for duty. The relatively small changes in physiological maxima did not accurately reflect the substantial impact that heavy load carriage presents to work capacity.

Ventilatory Responses to Prolonged Exercise with Heavy Load Carriage in Females

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Heavy load carriage is common in occupations such as infantry, structural and wildland firefighting, and search and rescue. One of the most common and efficient methods of load carriage is with backpacks. We have previously shown with male subjects that during extended periods of heavy work, minute ventilation,

breathing pattern and operating lung volume are altered under load, with the changes suggestive of respiratory muscle fatigue. However, there are few reports of the effects of load carriage on physiological responses and exercise performance in females. The purpose of this experiment was to study components of total ventilation; specifically, breathing pattern, operating lung volume, calculated deadspace and alveolar ventilation during 45 minutes of exercise with a heavy backpack (25 kg) and examine the effect of exercise on respiratory muscle strength. Fourteen females (mean \pm SD, age 24 ± 4 years, stature 170 ± 5 cm, weight 65.1 ± 5.6 kg, $\dot{V}O_{2peak}$ 2.83 ± 0.46 L \cdot min $^{-1}$) completed randomly-ordered graded exercise tests on a treadmill with and without a correctly sized and fitted 25 kg pack. Subsequently, on separate days between days 3 and 8 of the menstrual cycle, each subject completed two exercise challenges (loaded and unloaded conditions, in random order) of 45 minutes of treadmill walking with exercise intensity set just below the ventilatory threshold. Oxygen demand was matched between conditions (1.86 vs 1.88 L \cdot min $^{-1}$ for unloaded and loaded, respectively). Under load, breathing frequency, deadspace and minute ventilation increased by 19.9, 29.8 and 11.6% ($P < 0.05$), respectively, while tidal volume and end-inspiratory lung volume (EILV) decreased by 13.6 and 6.0% ($P < 0.05$), respectively. The difference in minute ventilation in the loaded condition was likely secondary to a progressive increase in deadspace ventilation (\dot{V}_D). The increase in \dot{V}_D under load was the result of a more rapid and shallow breathing pattern, compared to the unloaded condition. Interestingly, the change in \dot{V}_D varied widely among subjects from 6 - 70% (0.5 - 13.0 L \cdot min $^{-1}$) however $\Delta\dot{V}_D$ was not associated with either body mass or $\dot{V}O_{2peak}$. Following loaded exercise, maximal inspiratory pressure decreased by 11.5% ($P < 0.05$) with no change in maximal expiratory pressure. No changes in maximal inspiratory or expiratory pressures were observed following unloaded exercise. Despite equivalent oxygen demand, perceived exercise stress and breathing discomfort were always higher ($P < 0.05$) during loaded exercise. The mechanical disadvantage placed on the respiratory system during exercise with a heavy pack led to compensatory changes in breathing pattern and EILV, and a reduction in maximal inspiratory pressure post-exercise. We suggest that in an attempt to minimize the inspiratory elastic work of breathing, subjects adopted a shallow and frequent breathing pattern. However, this pattern increased \dot{V}_D and minute ventilation, which likely contributed to altered perceptions of exercise stress and breathing discomfort.

Establishment of Performance Standards and a Cut-Score for the Canadian Forces Firefighter Physical Fitness Maintenance Evaluation (FF PFME)

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The Firefighter Physical Fitness Maintenance Evaluation (FF PFME) is a task-simulation test used to evaluate physical fitness of Canadian Forces (CF) firefighters. The time required to complete 10 job-related tasks that together simulate a first response firefighting action was accepted as a measure of work capacity. A panel of 25 CF firefighter supervisors set a cut-score with three rounds of the Bookmark procedure. Each round involved independent evaluation of 9 video work samples (WSs, where times systematically increased from 400 to 560 s) followed by discussion among panel members. Each judge identified the point between the WSs where the rate of work changed from acceptable to unacceptable. Taking into account the variability among panel members that remained at the end of Round 3, completion of the FF PFME in 481 s (mean plus 2 SEM) or less was adopted as indicating the physical capacity to complete first response firefighting work.

The Effect of Body Size on Treadmill Test Performance in Fire Protective Ensemble

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Previous research has suggested that smaller subjects are advantaged by unloaded assessments of aerobic fitness, while larger individuals, who may be better suited for work involving load carriage, are disadvantaged. This paper retrospectively explores the relationship(s) between various indices of body size and performance during a treadmill test for firefighters. Over a period of seven years, 2731 males (mean \pm SD: age, 26.5 \pm 5.2 yr; height, 180 \pm 6.3 cm; mass, 85.6 \pm 11.2 kg) completed a maximal treadmill test as part of a fitness evaluation for structural firefighter applicants. Subjects walked at 94 m \cdot min⁻¹ with progressive increases in grade up to 15%, and thereafter speed was increased by 13.1 m \cdot min⁻¹ until volitional exhaustion. Gas exchange data were acquired by a metabolic measurement system and the highest 30 s average was recorded as $\dot{V}O_{2peak}$. Each subject wore properly fitting fire protective ensemble (FPE) including helmet, flash hood, gloves, jacket, and pants over normal exercise clothing. Subjects carried but did not breathe from a self-contained breathing apparatus and wore running shoes for safety during the test. A sample of 468 subjects was randomly selected with 78 subjects in each of six mass categories (<70 kg to >110 kg, in 10 kg increments). The physical characteristics of each of the smaller samples were identical to the mean, median and SD values for the same mass category within the total sample. The mass of the FPE was 20.5 \pm 0.6 kg, which presented a relative burden of 24.3 \pm 3.0% (range: 18.0 - 30.6%, $p < .05$ between all mass categories). There were modest negative correlations ($p < .05$) between body mass and treadmill test time (-0.387) and $\dot{V}O_{2peak}$ (-0.454), normalized to total mass (body + FPE), respectively. Similar correlations were found between test time and both body surface area and body mass index. Test duration was greatest in the <69.9 kg group (16.4 \pm 2.7 min) and shortest in the >110 kg group (14.1 \pm 3.3 min). Significant differences in test time were found between the two heaviest groups and all other groups. $\dot{V}O_{2peak}$ was highest in the <69.9 kg group (39.7 \pm 4.8 ml \cdot kg⁻¹ \cdot min⁻¹) and lowest in the >110 kg group (33.4 \pm 4.0 ml \cdot kg⁻¹ \cdot min⁻¹) with significant differences between the two heaviest groups and all other groups. Body mass accounted for approximately 15 and 20% of the variance in treadmill test time and $\dot{V}O_{2peak}$, respectively, during a maximal treadmill test for firefighters. However, low and high scores were seen in all mass categories, indicating little systematic bias based on size. While present results generally support previous research, we suggest that maximal aerobic power and physical work capacity play far greater roles in treadmill performance with load carriage than size alone.

The Effect of Body Size on Job-Related Test Performance in Firefighter Applicants

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Previous research has suggested that larger individuals may be better suited for work involving load carriage than their smaller counterparts. This paper retrospectively explores the relationship(s) between various indices of body size and performance during six job-related tests of work performance for firefighters. Over a period of seven years, 2569 males (mean \pm SD: age, 26.4 \pm 5.2 yr; height, 180 \pm 6.3 cm; mass, 85.2 \pm 10.9 kg) completed five job-related task simulation tests as part of a fitness evaluation for structural firefighter applicants. Tasks were completed as quickly as possible, and were separated by exactly 3 min of recovery. The test sequence included charged 38 mm hose drag (37.5 m), weighted sled pull (3 x 15 m), forcible entry, victim rescue (30 m), and ladder climb (5 x 10 rungs). With the exception of the ladder climb, where the subject was required to lift and lower his own body mass, all tasks involved working with absolute external loads. Subjects wore properly fitting fire protective ensemble (FPE) that included helmet, flash hood, gloves, boots, jacket, and pants over normal exercise clothing. Subjects carried but did not breathe from a self-contained breathing apparatus. A sample of 360 subjects was randomly selected with 60 subjects in each of six mass categories (<70 kg to >110 kg, in 10 kg increments). The physical characteristics of each of the

smaller samples were identical to the mean, median and SD values for the same mass category within the total sample. The mass of the FPE was 20.5 ± 0.6 kg, which presented a relative burden of $24.4 \pm 3.0\%$ (range: 17.9 – 30.1%, $p < .05$ between all mass categories). There were modest correlations ($p < .05$) between test times and body mass (hose drag, -0.391; sled pull, -0.332; forcible entry, -0.268; victim rescue, -0.254; ladder climb, 0.217). Similar correlations were found between test performance times and other aspects of body size (body surface area and body mass index). For the four tasks that involved work against absolute external loads, test times for the two lightest groups (<69.9 and 70.0 – 79.9 kg) were significantly slower than for the heavier groups. In contrast, the pattern was reversed on the ladder climb where times were slowest for the two heaviest groups (100.0 – 109.9 and >110 kg). Body mass accounted for between 5 – 15% of the variance in performance on the five task-simulation tests for firefighters. While work capacity during load carriage may be modestly related to body size, present results reveal that the dependence is less important than has been previously suggested. We maintain that the use of occupationally relevant load carriage is important in the evaluation of fitness for duty and that task performance cannot be predicted by body size.

Factors Associated With Success in PARE Testing Among RCMP Officers

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To examine the predictive factors for success (pass/fail) in the RCMP's skill-related occupational fitness test, the Physical Abilities Requirement Evaluation (PARE). Various human factors (height, weight, age, sex) and performance factors (pursuit time, body control time) were entered from various historical periods of recruiting. A retrospective observational study used the RCMP Human Resources Management Information System (HRMIS) to download 33,000 records from the national PARE database spanning 2007 to 2013. 14,401 records, were reduced to 13,709 unique best PARE tests per officers, after 2 + SD above the mean PARE scores were removed as outliers. Performance was pass or fail at PES PARE 4:00 min:s, coded 0 or 1. The purpose of the study was to compare the relative predictive power of the pursuit and body control segment for success and assess any differences across sex groups while controlling for covariates of height, weight, and age. Step one entered all data including penalty times from mat and stick jumps during the PARE pursuit into a logistic regression model. A perfect separation of data occurred. Follow-up analysis of residuals showed mat penalty was skewed to failures (80%) with unacceptable residuals (> 10) therefore the analysis was rerun without penalty times. Results: The data supported a prediction model with a 99 % accuracy. A generation of national data supported a predictor model with significant strong log odds effects (LO) for pursuit times LO = 2.78, 95% CI [2.49, 3.11] and body control times LO = 2.80, 95% CI [2.51, 3.14] segments of PARE. Although these times were disproportionately represented in descriptive statistics at 70 and 30% of the total PARE time value, when reported as predictive of success using logistic regression, they were equally predictive in the analysis. Sex group differences reported slight differences in LO metrics that when converted back to probabilities were nearly identical and both in the high 90 th percentiles for probability of passing PARE. Men's group strong pursuit LO = 3.0, 95% CI [2.59, 3.43], and strong body control LO = 3.0, 95% CI [2.60, 3.46], versus women's strong pursuit LO = 2.40 95% CI [2.00, 2.86] and strong body control LO = 2.45 95% CI [2.05, 2.92]. Square root of age was also a statistically significant predictor but with a weak LO effect size, LO = 0.53, 95% CI [0.38, 0.72], with $p < 0.05$ for all. Conclusion: performance factors of PARE pursuit and body control were strong predictors and human factor of age was a weak predictor, whereas sex, height, and weight were not significant predictors of success in PARE. The prediction formula for the combined men and women's data set is:

$$P(Y) = -243 + 1.022(\text{run}) + 1.031(\text{control}) - 0.643(\sqrt{\text{age}}).$$

Performance and Gender Factor Differences on Pacing in the RCMP PARE Pursuit Circuit

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Men and women officers need to be able to respond equally to critical incident callouts as fit for duty officers for public safety, fellow officer safety and their own safety. Some of these critical callouts involve a long foot pursuit. The purpose of this research was to assess the effects of pacing in the pursuit simulation of the skill-related RCMP Physical Abilities Requirement Evaluation (PARE) test and to see if this relationship changes across gender groups, while controlling for human factors of height, weight and age. Two mixed factorial ANOVAs were run for sex (male/female) and performance (pass/fail) as independent between subject group factors with six repeat pursuit lap times as within subject dependent factor. Two data populations were assessed: one, a divisional data set (535 males/ 85 females), unbalanced for sex groups for height, weight and age, and 61 balanced male and female officer pairs, closely matched for BMI and age (< 0.1 difference). Results ANOVA 1: Divisional data supported significant strong performance (pass/fail) effects $F(1,616)=288.3, p<.00$, partial $\eta^2=.32$ but weak sex group (male/female) main effects $F(1,616)=27.2, p=.03$, partial $\eta^2=.01$. Sex*performance interaction was significant, $F(1,616)=50.7, p<.01$, but weak, partial $\eta^2=0.014$. Repeat laps were significant, $F(3,7, 229)=195.1, p<.01$, with a strong effect size, partial $\eta^2=0.24$. Performance*laps interaction was significant $F(3,7, 229)=4.5, p=.02$, with a weak effect size, partial $\eta^2=.007$. The interaction showing failing men slower than failing women, but passing men faster than passing women. No post hoc analysis of main effects because of the interaction. Significant repeat lap contrasts were lap 1-2, strong effects and lap 2-3, lap 3-4, lap 4-5 with weak effects, and lap 5-6 no significance. Results ANOVA 2: Matched pairs data supported significant strong performance group main effects, $F(1,118)=90.9, p<.000$, partial $\eta^2=.44$ and weak sex group main effects, $F(1,118)=13.5, p<.00$, partial $\eta^2=.10$. Significant repeat laps contrasts: laps 1-2, strong effect, lap 3-4 and lap 4-5, weak effect and lap 2-3 & lap 5-6 were no significance. Matched pairs data post hoc showed both sex and performance group contrasts at every repeat lap contrast were significant, with strong performance effects and weak sex effects. Lap time power drops demonstrated men and women pace in PARE in near identical patterns with a slight ordinal interaction at lap three and lap six. Conclusion: Performance effects sizes were statistically and clinically significant versus weak sex effects sizes which were statistically significant but not clinically significant.

Is Self-reported Physical Activity Frequency and Intensity a Predictive Factor of Success in the RCMP PARE?

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Health promotion positive tension activities like promoting physical activity (PA) frequency (Freq.) and intensity (Int.) (Pender, 2010) are seen as mediators of health (Bouchard, 2000). Higher levels of PA with elevated metabolic demands of moderate 4.0 METS to vigorous 8.0 METS activity are speculated to be the mediator link to health outcomes as marked by health-related fitness. Skill-related physical fitness test constructs are now based on agility, balance, reaction time, speed, co-ordination, and power (Thompson, 2010). The purpose of the study was to build on the earlier prediction model studies that saw pursuit and body control times and transformed square root of age, but not height, weight and sex as significant predictors in PARE testing. A divisional cohort of 620 PARE records were downloaded, representing 535 male and 85 female officers. Records were augmented with self-reported PA Freq. (1-7) and Int. (0 no PA, 1 light PA, 2 moderate PA, 3 vigorous PA). A logistic regression analysis was conducted for potential variables of height, weight, BMI, sex, age, pursuit time, body control time, and categorical PA Freq. (days/week), and PA Int. (out of 3.0). Self-reported PA Freq. was 3.47 days/week for combined population, 3.42 days/week for men, 3.78 days/week for women. Self-reported PA Int. was 2.17 out of 3.0 for combined population, 2.15 out

of 3.0 for men, and 2.29 out of 3.0 for women. Sex, age, BMI, PA Freq, PA Int. were not significant predictors at $p < 0.05$. The only significant predictors effects log odds (LO), were body control time LO = 0.67, $p < .001$ CI 95 % [0.55, 0.75] and pursuit time LO = 0.64 $p < .001$ CI 95 % [0.61, 0.77]. Conclusion: Only skill-related performance constructs of pursuit and body control are significant predictors of PARE success. Age, BMI, PA Freq. and PA Int. do not add to predictive model. Habitual free-living physical activity frequency and intensity levels of serving RCMP officers may not have been sufficient to effect a 3.0 level test as significant predictor variables. A moderator of test effort might have been cautious whole population approaches by CEP test monitors when testing from hire to retire age groups. Likewise inexact recall and over brief self-reported may not have captured all the physical activity, with skill-related mode of functional movements being a potential key missing data for self-reported physical activity. Adding PA mode of movement and PA dimensions of movements may enhance self-reporting, but it is suspected that absolute levels of PA must rise to effect PARE as maximal effort police skill-related test.

Determining Strength and Muscular Endurance Standards for UK Firefighters

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Firefighters require physical strength and muscular endurance to safely and effectively perform essential operational tasks. However, insufficient evidence exists to inform on the occupational strength requirements of firefighters. This study aimed to determine the minimum acceptable strength and muscular endurance standards for critical operational firefighting duties by examining the relationship between criterion tasks and surrogate gym-based exercises. Generic firefighting tasks that required the largest applications of physical strength were identified and endorsed by a technical panel comprising operationally experienced experts. The same panel endorsed minimum acceptable performance for these tasks. Fifty one (26 male, 25 female) civilian (non-firefighter) volunteers (mean (\pm SD): age 24 (\pm 6) y, mass 74 (\pm 15) kg, height 1.72 (\pm 0.10) m, BMI 25 (\pm 4) kg·m⁻², estimated body fat 21 (\pm 8)%) completed a series of tasks in a randomised order. Discrete performance (pass/fail) was assessed on three criterion tasks; a ladder lift (LLift), a ladder "extend-to-lower" (LLow) and a ladder extension (LExt). Maximum performance was also measured on surrogate representative gym-based tasks, which simulate performance on LLift, LLow and LEExt, respectively: 1 repetition maximum (1RM) seated barbell overhead press; 1RM rope pull-down and; a repeated 28 kg rope pull-down (repetitions to failure). All data are presented as Mean (\pm SD, range). Receiver-operator characteristic (ROC) curves were plotted to determine performance standards that optimised sensitivity (sens; true positive rate) and specificity (spec; false positive rate). Shoulder press 1RM of those who passed (n=31) and failed (n=20) the LLift were 53 (\pm 13, 35-75) kg and 25 (\pm 5, 20-32.5) kg, respectively. Single rope pull-down 1RM of those who passed (n=39) and failed (n=12) the LLow were 76 (\pm 19, 46-109) kg and 48 (\pm 9, 30-60) kg, respectively. The number of repetitions to failure of the 28 kg rope pull-down of those who passed (n=36) and failed (n=15) the LEExt were 37 (\pm 16, 10-68) and 13 (\pm 9, 1-34), respectively. Optimal performance standards were calculated as 35 kg for shoulder press (sens/spec: 1.00/1.00), 60 kg for single rope pull-down (sens/spec: 0.76/0.92) and 23 repetitions for the 28 kg repeated pull-down (sens/spec: 0.81/0.93). Surrogate gym-based tests were investigated as predictors of performance on criterion firefighting tasks that require strength and muscular endurance, resulting in acceptable performance standards. These findings facilitate the use of normal gym-based practices for testing optimal strength for operational firefighting duties. Since the physical demands of firefighting are multi-faceted, combining these findings with established cardiorespiratory fitness standards could better aid firefighting populations in both attainment and maintenance of appropriate fitness for work.

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The Ottawa Paramedic Physical Ability Test (OPPAT): A Review of Process and Development

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Developing physical employment standards (PES) is a complex process requiring conformity with legal precedents, subject matter expert opinions and research evidence. Although PES exist for firefighters, police and military, widely accepted PES for paramedics do not currently exist. Paramedics are tasked with administering emergency patient care, as well as extricating and transferring patients to a hospital for additional assessment and treatment. A paramedic PES would provide a standard to which all paramedics would be required to meet, ensuring they demonstrate the physical capacity to perform the demands associated with paramedic work. A Consensus Forum Research Process Template (the CFRPT) has been developed to guide development of a physiological employment standard to qualify as a bona fide occupational requirement. The purpose of the study was to implement the same template in development of a physical employment standard for paramedics (the Ottawa Paramedic Physical Ability Test – OPPAT). To ensure the resulting PES was relevant to the work environment, a collaborative approach that included a series of iterative consultations, engaged paramedics, management, union and researchers in the OPPAT development process. The CFRPT guided the OPPAT development process and included the following fundamental phases: 1) development of the OPPAT Project Management Team that included paramedics, union, management and researchers; 2) completion of a paramedic physical demands description (PDD); 3) paramedics completion of a survey based on the PDD to identify the most physically demanding, frequently performed paramedic tasks; 4) development of the OPPAT as a PES and 5) determination of the scientific accuracy and adverse events associated with the OPPAT. The final version of the OPPAT consists of three consecutive circuits that involve a series of job simulation tasks. The current primary pass/fail criterion for the OPPAT is a 20-minute total circuit completion time. Paramedics are also required to perform all tasks without committing an uncontrolled lowering of any equipment utilized during the OPPAT. In summary, the CFRPT previously used to develop physiological standards for other emergency response professions (i.e., firefighters, police) provided a relevant guideline to inform development of a PES for paramedics (the OPPAT). Following the CFRPT ensured the resulting OPPAT conformed to legal precedents, included subject matter expert opinions and the scientific accuracy of the protocol was verified. The OPPAT Project Management Team will continue to monitor adverse events related to the OPPAT and implement protocol changes in response to task and / or equipment modifications to paramedic work.

The OPS Research Team includes: Paolo Bottiglia, Monica Di Iorio, Michelle Farragher, Amanda MacIvor, and Sylvie Rochon. This project was funded with support from MITACS, the City of Ottawa and CUPE Local 503.

A Task Analysis for the Development of Minimum Physical Employment Standards for Physically Demanding Occupations.

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Employees in public safety occupations undertake a variety of activities that are both hazardous and physically demanding. Understanding the minimum requirements of these occupations and determining the physical strain encountered by employees is important to identify appropriate physical fitness standards to help ensure their safety. This study was a task analysis to identify the most important and physically demanding tasks performed by UK firefighters and objectively determine the minimum acceptable performance requirement for each of these tasks. Thirteen experienced operational personnel acted as a technical panel (TP) of subject matter experts who, through a series of focus groups, were tasked to: (a)

identify the critical and most physically demanding tasks; (b) determine the method of best practice for undertaking these critical tasks and; (c) agree on the minimum acceptable level of performance for each critical task. The minimum performance standards were determined through the development of realistic simulations being performed at three different speeds. Video observation and blinded voting were used in order for TP members to independently and objectively identify a minimum acceptable pace for each task, from which a group consensus could be reached. The TP identified differences between operational firefighting and incident command roles. Those in a firefighting role performed the most arduous duties (Casualty Evacuation (CE); Equipment Carrying (EC); Hose Running (HR); Stair Climbing (SC); Wild-land Fires (WF); Lifting Ladders (LLift); Extending Ladders (LExt); Lowering Ladders (LLow)), whilst fire-ground incident commanders walked or performed SC to reach operational incidents such as wild-land fires and high rise building fires. The nature of the firefighting role is well established and the critical firefighting activities identified in this study are similar to those reported for a number of other international fire services. Unlike previous studies, we used video demonstration and observation of bespoke tasks, followed by blind expert panel voting, in order to minimise the risk of subjective bias in determining the minimum acceptable performance requirements for each task. This study formed the methodological basis for two further studies, which: 1) quantified the cardiorespiratory demands of criterion firefighting tasks and; 2) assessed the relationship between criterion firefighter task performance and surrogate tests of strength and muscular endurance. This methodology could be used to determine the minimum occupational requirements for other physically demanding occupations and, subsequently, to identify minimum physical employment standards. *Supported by the Chief Fire Officer's Association and the Fire Research and Training Trust.*

Job and physical demand analysis of field conservation work in the province of Ontario

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This research identified the essential job tasks of field conservation work in Ontario and determined the physical demands of those tasks. 45 Conservation Officers (COs), 39 male and 6 female, were interviewed, videotaped and observed while performing daily duties to identify essential job tasks. Site visits occurred in four regions of the province in all four seasons. Assessment of job demands included the measurement of equipment size and weight, determination of type and repetition of loads moved, the frequency of tasks performed during each season and the modes of transportation utilized. Physical demands were assessed using heart rates, core temperature, activity counts, ergonomic assessment, perceived exertion (RPE) and force measures. From the analysis of the diverse array of tasks required of a CO to perform their job safely and effectively nine physically demanding essential tasks were identified. Assessment of these tasks demonstrated that they range in duration from 1-2 minutes to over 180 minutes requiring sustained heart rates 60-90% of predicted maximum heart rate (heavy to extremely heavy work rating). Six of the essential tasks received an average RPE of 14 or higher. Common lifting and moving of loads (45kg+) included from ground level up to a height of 1.0-2.0 m and carried an average distance of 20 m. These loads were awkward and unbalanced. Forces of 27.2-98.5 kg were required to move common task-related equipment or drag animal carcasses. Agility, balance and flexibility were also required for essential tasks such as suspect pursuit, climbing onto boats, jumping obstacles and traversing uneven terrain. COs are faced with many physical challenges in their work environment as well as from the equipment they operate and loads they are required to move. Having adequate levels of aerobic/anaerobic fitness, muscular strength, and agility, flexibility and balance are key components required to meet the physical demands of their job and to minimize risk of injury.

Development of a pre-employment physical abilities test for field conservation officers in Ontario

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It is common practice for employers to implement physical abilities tests and standards in occupations requiring employees to perform physically demanding tasks. Physical requirements in job selection are justified on a number of grounds including the need to ensure that employee well-being is protected; that employees can meet the occupational demands; and that the integrity of the workforce is maintained by hiring physically prepared workers. The purpose of this study was to develop a valid and reliable pre-employment physical abilities test for field conservation officers (CO) that meets the Canadian Supreme Court and Canadian Human Rights requirements of a Bona Fide Occupational Standard. Based on a previously completed analysis, a test battery was designed which incorporated the Aerobic/Anaerobic Fitness, Muscular Strength and Agility, Flexibility and Balance characteristics of essential CO tasks: 1) an agility/pursuit course that utilized five of the essential tasks, 2) strength completion tasks that utilized five of the essential tasks and 3) a modified PACK (m-PACK) test that evaluated two of the essential tasks. Test performance standards were developed based on physiological data collected from a physical demands analysis, a review of job-related injuries, and input from Subject Matter Experts. Validation testing was completed by 21 conservation officers and supervisors who successfully performed the test battery and answered a questionnaire. 24 non-CO participants completed the test battery on two separate occasions separated by 2 days. Validation of the test battery and standards showed that all participating COs rated the test components and standards 'high to very high' in relation to their perceived physical demands of field conservation work. The Agility/pursuit course and the m-Pack were highly reliable with Intraclass correlations of 0.97 and 0.93, respectively. The strength test had a 100% reproducible criterion standard. The findings indicate that the proposed pre-employment test battery and minimal test standards are valid, reliable and representative of the demands of field conservation work in the province of Ontario.

Job and Physical Demands Assessment of Unionized Jobs at Hayes Logging Company

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In logging environments it is fairly common for workers to move among job positions within a company. This may include moving into a more physically demanding position than the one currently occupied. Data from logging companies and WorkSafe BC indicate that this increases the risk of workplace injury and death for these workers and their co-workers. The purpose of this project was to develop a package of physical ability tests that could be administered to all workers who were moving to a more physically demanding position within the Hayes Forest Services Company. The process of test development followed the guidelines set out in the *Consensus Forum on Establishing BONA FIDE Requirements for Physically Demanding Occupations*. A job and physical demands analysis was completed on a total of fifty three different jobs. The selection of the components of the test battery and the cut scores was based on this analysis as well as injury records, production criteria and employee/supervisor feedback. The physical ability test battery is comprised of a total of 9 tasks. The *specific* test battery for each position within the Hayes company is selected from the 9 tasks and the combination is based on the most physically demanding essential job tasks for that particular position. Once the test battery had been developed two validation sessions were held. A total of 28 subjects (age 25-54 years) representing all departments within the company (22 males and 6 females) completed the test battery, offered feedback and provided subject matter expert validation. All 28 individuals agreed that the tasks chosen were representative of the most physically demanding tasks at Hayes. To assess reliability of the test battery and cut scores, 15 participants (males=10, females=5), average age 24.5 years, completed two testing session, one week apart. The test/retest data were statistically analyzed by Pearson r correlations and intraclass correlations and showed strong reliability (0.90-0.98).

Ten-year injury analysis for field conservation officers in the Province of Ontario

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There is a large body of research that indicates that physical fitness and appropriate physical ability for tasks in physically demanding jobs help diminish the risk of workplace fatigue and thus may decrease the risk of workplace accident and injury. Field conservation officers are faced with many physical challenges and injury risk from the environment in which they work as well as the equipment they operate and loads they move. As part of the development of an appropriate physical abilities test for Ontario field conservation officers, ten years (1998-2008) of injury data reports (provided by OMNR) for this group were analyzed for trends in types of injury, age groups of the subjects incurring the injuries and the times of day when most of the injuries occurred. There were a total of 294 incidents with 66 of them resulting in lost time. Sprains, strains and back pain account for 37% of all the injuries and 60% of the time lost incidents reported in all age groups. Musculoskeletal injury rates peaked in the 45-49 year age group with 29 total injuries and 41% of those being time lost injuries. This group also had a significantly higher rate of back injury compared to the other age groups with 50% of those injuries resulting in time lost. The majority of injuries (50%) occurred when officers were on patrol and 25% during training (Use of Force and Firearms). Of the injuries reported, 226 (77%) of them occurred after 1pm indicating that cumulative fatigue from physical and mental factors may have been a factor. In conclusion, data shows that conservation officers are at risk for a variety of workplace injuries with musculoskeletal injuries make up a significant percentage of reported and time lost injuries.

Development of a Green Chain Task Simulation Test for Seven Weyerhaeuser Mills in British Columbia

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The purpose of this project was to develop a pre-employment physical abilities test for ten entry-level positions at the seven softwood mills of BC Coastal Group - Weyerhaeuser Company Ltd that would meet the criteria for being a Bona Fide Occupational requirement. The process of test development followed the guidelines set out in the *Consensus Forum on Establishing BONA FIDE Requirements for Physically Demanding Occupations*. Site visits occurred in all seven mills where shift managers were interviewed and employees working the entry-level positions were videotaped and observed while performing daily work-related tasks. The selection of the components of the test battery and the cut scores was based on the job and physical demand analysis as well as injury records, production criteria and both employee and supervisor feedback. Measurements were completed to obtain information on the following: the size and weight of tools and equipment; the type and repetition of loads moved; and the frequency of tasks performed. The predominant physically demanding tasks were determined to be gripping wood, flipping or manoeuvring lumber and pulling and/or pushing lumber. The final test battery included: Flip Task, a Pull-Push Task, a Vertical Resaw Task, grip strength test, modified Sorenson back test and a partial curl-up test. To test the validity and reliability of the test battery, 86 employees (ages 18-60 years) with an average of 10.3 years of experience (range = 1-34 years) from the seven mills participated in two testing sessions 24 hours apart and completed a questionnaire. Ninety six percent (83/86) employees strongly agreed that the test reflected the physical demands of the entry-level positions. The test/retest data were statistically analyzed by Pearson r correlations and intraclass correlations. All tests showed strong reliability with correlation scores ranging from 0.83-0.99. The test was reviewed by the British Columbia Human Rights Commission and found appropriate for use in the pre-employment screening of potential employees

The distillation of criterion occupational tasks from workforce job lists and physiological measurements

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This communication is the first of two describing the development of *bona fide* and defensible firefighter-selection tests. The purpose here was to identify a subset of essential, physically demanding tasks performed by contemporary urban firefighters. Using existing procedural documentation and job analyses, 11 fire-station visits and interviews with 106 firefighters, and one focus-group meeting, 31 physically demanding tasks were identified and incorporated into a workforce survey. Using this tool, firefighters rated the importance, perceived difficulty, typical task durations and annual performance frequency of each task. Data from 989 respondents were analysed, enabling a consolidation of these tasks into a subset of essential activities. These processes yielded a content-valid list of 15 essential, physically demanding tasks covering the full width of duties performed by urban firefighters from Australia's largest fire and rescue organisation (Taylor *et al.*, 2015a). Those tasks were investigated to identify criterion activities that might be used for recruit selection. Fifty-one operational firefighters then participated in 15 field-based occupational simulations, with physiological responses measured throughout. The most stressful tasks were identified and classified according to dominant fitness attributes and movement patterns. Three movement classes (single-sided load carriage [5 tasks], dragging loads [4 tasks], overhead pushing and holding objects [2 tasks]) and one mandatory strength task emerged. Seven criterion tasks were identified. Load holding and carriage dominated these movement patterns, yet no task accentuated whole-body endurance. It was concluded that materials handling movements from each classification must appear within a physical aptitude (selection) test for it to adequately represent the breadth of tasks performed by Australian urban firefighters (Taylor *et al.*, 2015a). In our second communication, we summarise the steps involved in the transition from criterion occupational tasks to the development of physical aptitude screening tests and employment standards.

References:

- Taylor, N.A.S., Fullagar, H.H.K., Mott, B.J., Sampson, J.A., and Groeller, H. (2015a). Employment standards for Australian urban firefighters. Part 1: The essential, physically demanding tasks. *J. Occup. Environ. Med.* In press.
- Taylor, N.A.S., Fullagar, H.H.K., Sampson, J.A., Notley, S.R., Burley, S.D., Lee, D.S., and Groeller, H. (2015b). Employment standards for Australian urban firefighters. Part 2: The physiological demands and the criterion tasks. *J. Occup. Environ. Med.* In press.

Promoting Health and Wellness While Maintaining Physical and Medical Employment Standards Through a Comprehensive Occupational Medical Program in the Fire Service

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The NFPA 1582 sets the standards for a Comprehensive Occupational Medical Program (COMP) which aims to reduce the risk and burden of fire service occupational morbidity and mortality while improving the health, and thus the safety and effectiveness, of fire fighters. The NFPA 1582 includes the physical and medical employment standards for recruit and incumbent fire fighters. According to the Fire Service Joint Labor Management Wellness-Fitness Initiative, COMPs are intended to be mandatory and non-punitive. Despite program participation being mandatory, participation in all components of the program cannot be forced upon incumbent employees. Implementing a COMP that is both mandatory and non-punitive can be difficult in practice. That is, creating a safe and inclusive environment that is conducive to supporting and promoting healthy behaviors contradicts efforts to enforce physical and medical employment standards. By enforcing strict physical and medical employment standards, participation is likely to decline, limiting the program's opportunity to promote health and wellness. For this reason, the program must balance creating

an environment that encourages participation, while upholding the expectation that fire fighters meet physical and medical employment standards. With a balanced approach, the COMP will support and educate fire fighters on the importance of maintaining physical and medical employment standards, and simultaneously encourage healthy behaviours. The Calgary Fire Department (CFD) has implemented a COMP since 2005, which includes annual physical and medical testing of more than 1300 uniformed personnel. The CFD provides a unique case study on the challenges of implementing a COMP, particularly with respect to balancing the need to maintain physical employment standards while promoting health and wellness.

Quantification and Prediction of Physical Burden in Chemical Protective Clothing

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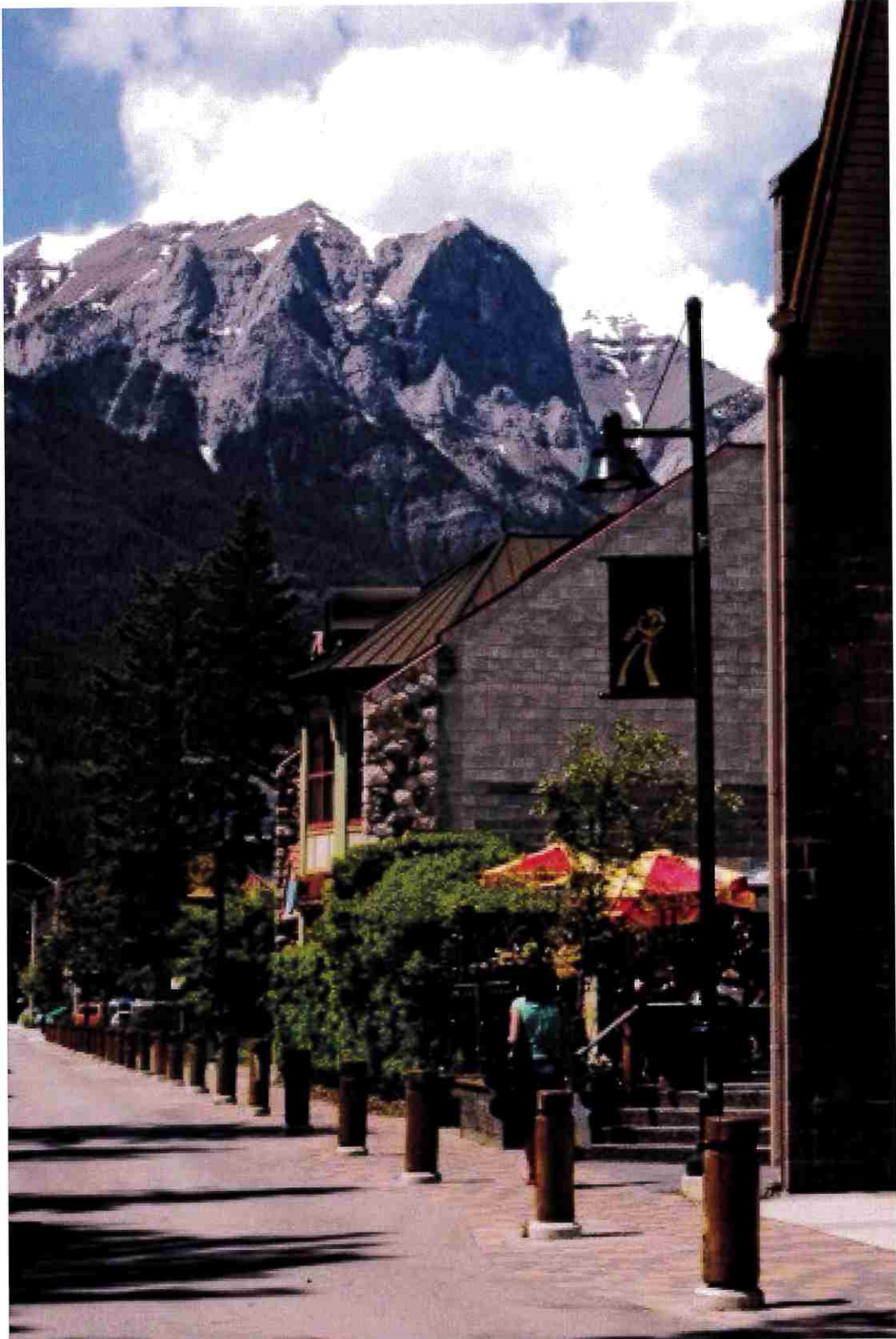
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Chemical protective clothing (CPC) can have negative effects on human performance. Unlike the relatively well-studied thermal stress in other types of protective clothing (e.g., fire protective ensemble), limited attention has been given to the physical burden associated with CPC during exercise. This study examined the effects of three different CPC (Tychem®, Tyvek® and Gulf) on physiological responses and physical burden during moderate treadmill exercise in temperate environmental conditions. We also investigated the relationships between the physiological responses and the mechanical properties of the same CPC materials which had been determined from previous studies. Fifteen healthy men (mean \pm SD: age 26.6 ± 4.5 yr; mass 73.9 ± 7.5 kg; height 180.2 ± 6.8 cm) performed four randomized experimental tests wearing a control system and the three CPC ensembles plus the control garments. In each test, the participant walked on a treadmill at $93.9 \text{ m}\cdot\text{min}^{-1}$ and 4% grade for 60 minutes at $23 \pm 2^\circ\text{C}$, <30% relative humidity, and $1.2 \text{ m}\cdot\text{s}^{-1}$ air speed. Repeated measures ANOVA revealed that wearing Tychem® and Gulf ensembles significantly increased the rate of oxygen consumption ($\dot{V}\text{O}_2$) during exercise by 10.2% ($2.2 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) and 7.7% ($1.6 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$), respectively. The rating of perceived exertion (RPE) agreed with the objective physiological responses in $\dot{V}\text{O}_2$. It was also found that Tychem® and Gulf restricted movements to a greater degree than either the Control garments or Tyvek®. To quantify the contributions of additional garment weight and other textile mechanical properties to the increase in $\dot{V}\text{O}_2$, the relative oxygen consumption to total weight (clothed body weight) was calculated. Adequate evidence showed that garment weight alone did not explain the changes in oxygen consumption. Other garment properties, such as bulkiness, stiffness and inability to stretch were expected to have an impact on movement restriction and physical burden. Pearson's correlation analysis was then used to determine the strength of linear associations between $\dot{V}\text{O}_2$, RPE and the related garment material properties. Predictive models were derived from multiple regression analyses. The average oxygen consumption during the 60-minute exercise was found to be best predicted by garment weight and fabric bending characteristics. The average rating of perceived exertion was best predicted by fabric thickness and water vapor transmission property. While human trials are undoubtedly the best method of evaluating physiological strain and physical burden, the results of this experiment provide unique insight into the possibility of predicting how various garment properties affect responses during exercise.



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Photograph courtesy of David Buzzeo (<http://www.buzzeophotography.com>)