Occupational Load Carriage for Tactical Populations: Green, Blue and Red

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Conflict of Interest Statement

- **I have no actual or potential conflict of interest in relation to this presentation.**


Content

- Military
- Law Enforcement
- Fire and Rescue
- Injuries
- Impacts
- Conditioning


HISTORICAL CONTEXT – MILITARY

Background

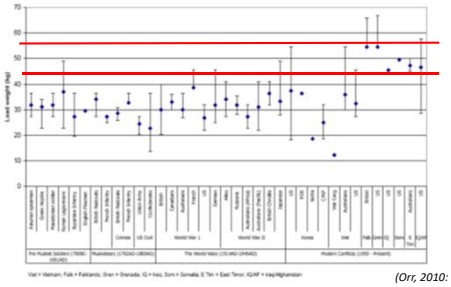
- From the early Assyrian spearman of antiquity (circa 800 B.C.), soldiers have been required to carry external loads consisting of weaponry, equipment and food

(Orr, 2010; Knapik et al., 2012:2004)

- Downstream effects of these loads have been shown to impact on the tactics of warfare, cause injury and reduce fighting force size

(Lee, 2007; Breen, 2002;Lothian , 1921)

HISTORICAL CONTEXT – MILITARY



(Orr, 2010: Orr et al., 2015)

CURRENT CONTEXT – AUSTRALIAN ARMY

On Operations (2001-2010)

- PO loads
  - M=28.4 ± 10.0 kg
    - heaviest mean load in 2008 (M=36.9±10.8 kg)
- MO loads
  - M=56.7 ± 15.3 kg
    - heaviest mean load in 2009 (M=65.1 ±16.3 kg)
- OVERALL loads
  - 47.7±21.0 kg, (mean range over 10 years = 40.7 kg to 50.9 kg) *(Orr et al., 2015).*

CURRENT CONTEXT – AUSTRALIAN ARMY

- Approximate relative load carried by Roman Legionnaires = 56%
- Australian Soldiers in East Timor = 56%
- *US Soldiers in Afghanistan = 57%*

(Orr et al., 2010)

ABSOLUTE VS RELATIVE LOADS

- Currently female soldiers carry lighter absolute loads than male soldiers but only slightly heavier relative loads

*ABSOLUTE LOADS**	*RELATIVE LOADS*
FEMALE: *M* = 26.4 kg	FEMALE: *M* = 43%
MALE: *M* = 39.0 kg	MALE: *M* = 47%
p=.045	**p=.55**

(Orr et al., 2015)

ABSOLUTE VS RELATIVE LOADS

- Currently lighter soldiers carry the same absolute loads as heavier soldiers but heavier relative loads

ABSOLUTE LOADS	*RELATIVE LOADS*
Light 20%: *M* = 34.7 kg	Light 20%: *M* = 49%
Heavy 20%: *M* = 35.7 kg	Heavy 20%: *M* = 36%
p=.902	**p=.0509**

(Orr et al., 2015)

HISTORICAL CONTEXT – LEO





HISTORICAL CONTEXT – LEO

- Police are becoming Christmas trees

HISTORICAL CONTEXT - LEO

- Increasing levels of threat

CURRENT CONTEXT – AUSTRALIAN LEO

ILAV type (A-C) & Normal station wear (N)	ILAV Weight (kg)	Duty load Complete (kg)	Total load including officer weight (kg)
A	4.12 ± 0.65*	11.53 ± 0.77‡	88.03 ± 20.49
B	3.54 ± 0.70*	11.01 ± 1.01‡	87.51 ± 20.60
C	3.24 ± 0.48*	10.77 ± 1.16‡	87.27 ± 20.66
N	NA	8.69 ± 0.68	85.19 ± 20.24

* Significantly different (p<0.05) between vests: ‡ Significantly different (p<0.001) from normal station wear *(Orr et al., 2016)*

CURRENT CONTEXT – AUSTRALIAN LEO

	FEMALE	MALE	FEMALE	MALE
ILAV type	ILAV + Duty Loads (kg)	ILAV + Duty Loads (kg)	%BW	%BW
A	11.14	11.85	16.90	14.90
B	10.80	11.18	16.43	13.91
C	10.24	11.22	15.60	13.95
N	8.68	8.70	13.20	10.92
	*p=0.225		*p=0.009	

(Orr et al., 2016)

CURRENT CONTEXT – US LEO

	COMBINED (n=246)
Age (yrs)	30.82±5.84
Years sworn (yrs)	3.62±3.46
Body Wt (Kg)	85.69±15.08
Load Wt (Kg)	**10.72±1.73**
Relative load (%)	**11.83±2.38**

(Dulla et al., 2017)

CURRENT CONTEXT – US LEO

	FEMALE (n=43)	MALE (n=203)
Age (yrs)	30.60±4.56	30.86±6.09
Years sworn (yrs)	4.03±2.92	3.54±3.56
Body Wt (Kg)	68.78±10.96*	89.27±13.31
Load Wt (Kg)	**9.99±1.66***	**10.87±1.71**
Relative load (%)	**13.36±2.46***	**11.50±2.24**

* Significantly different from male sheriffs, p<.001

(Dulla et al., 2017)

CURRENT CONTEXT – US LEO (2)

(Dawes, Kornhauser, Holmes, et al., submitted)

	Cohort Mean ± SD (Range)	Male Mean ± SD (Range)	Female Mean ± SD (Range)
Age (years)	38.79 ± 7.97 (22 – 66)	38.36 ± 8.06 (22-66)	40.88 ± 7.68 (25-50)
Height (cm)	177.45 ± 8.36 (156.21 – 195.58)	179.53 ± 6.95 (165.10 – 195.58)	167.32 ± 7.49 (156.21 – 177.80)
Weight (kg)	88.61 ± 19.44 (51.71 – 154.59)	91.35 ± 18.20 (66.04 – 154.58)	75.22 ± 20.95 (51.71 – 118.16)
Absolute load (kg)	**9.57 ± .94** (7.08 – 12.02)	**9.61 ± .97** (7.08 – 12.02)	**9.34 ± .81** (8.26 – 10.70)
Relative load (% of body weight)	**11.19 ± 2.14** (5.93 – 17.02)	**10.82 ± 1.87** (5.93 – 14.56)	**13.00 ± 2.56** (8.41 – 17.02)

ABSOLUTE VS RELATIVE LOADS

- Both LEO studies found female officers carried either the same (AUST) or lighter (US) absolute loads compared to the male officers
- However when expressed as a percentage of their body weight female officers carried significantly more relative load than male officers

CURRENT CONTEXT – AUTRALIAN LEO (TOU)

	Mean ± SD	Range
Absolute load carried (kg)	22.8 ± 1.8	20.6-25.6
Relative load carried (%BW)	25.9 ± 4.0	21.2-28.8

(Carbone et al., 2014; Carlton et al., 2014)

HISTORICAL CONTEXT - FIREFIGHTING

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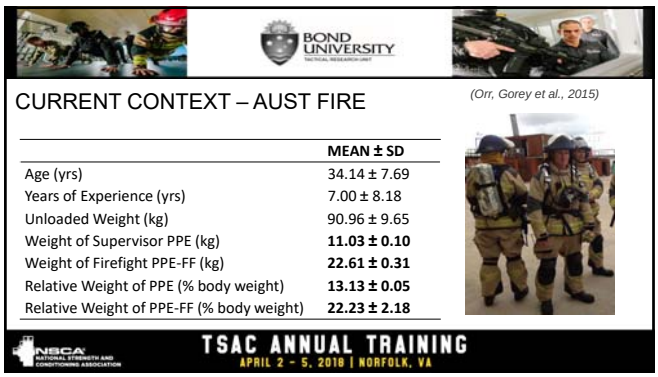
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CURRENT CONTEXT – AUST FIRE
(Orr, Gorey et al., 2015)
MEAN ± SD
Age (yrs) 34.14 ± 7.69
Years of Experience (yrs) 7.00 ± 8.18
Unloaded Weight (kg) 90.96 ± 9.65
Weight of Supervisor PPE (kg) 11.03 ± 0.10
Weight of Firefight PPE-FF (kg) 22.61 ± 0.31
Relative Weight of PPE (% body weight) 13.13 ± 0.05
Relative Weight of PPE-FF (% body weight) 22.23 ± 2.18
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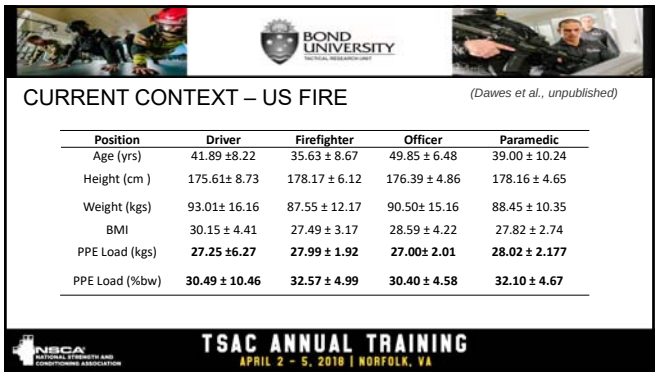
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CURRENT CONTEXT – US FIRE
(Dawes et al., unpublished)
Position | Driver | Firefighter | Officer | Paramedic
Age (yrs) | 41.89 ±8.22 | 35.63 ± 8.67 | 49.85 ± 6.48 | 39.00 ± 10.24
Height (cm) | 175.61± 8.73 | 178.17 ± 6.12 | 176.39 ± 4.86 | 178.16 ± 4.65
Weight (kgs) | 93.01± 16.16 | 87.55 ± 12.17 | 90.50± 15.16 | 88.45 ± 10.35
BMI | 30.15 ± 4.41 | 27.49 ± 3.17 | 28.59 ± 4.22 | 27.82 ± 2.74
PPE Load (kgs) | 27.25 ±6.27 | 27.99 ± 1.92 | 27.00± 2.01 | 28.02 ± 2.177
PPE Load (%bw) | 30.49 ± 10.46 | 32.57 ± 4.99 | 30.40 ± 4.58 | 32.10 ± 4.67
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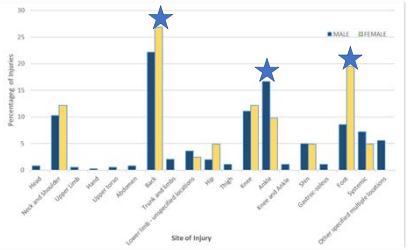
SEX DIFFERENCES IN LC INJURIES

(Orr et al., 2016)

- Mean ARA population over 2 years = 24,876 personnel
  - Female n= 2441 (10%): Male n= 22435 (90%)
- 401 reported injuries associated with load carriage
  - Female n=40 (10%): male n= 361 (90%)
  - RR = 1.02 (95% CI 0.74 to 1.41)
- SPI
  - Female n=6 (15%): male n= 23 (6%)
  - RR of SPI = 2.40 (95% CI 0.98 to 5.88)

(Orr et al., 2016)



IMPACTS ON PERFORMANCE - MARKSMANSHIP

- Decrements in performance:
  - ↓ Marksmanship (Knapik et al., 1990:1991:1997: Rice et al., 1999).

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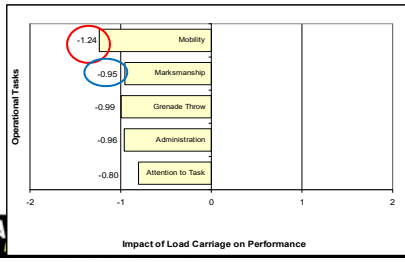
IMPACTS ON PERFORMANCE - MARKSMANSHIP

- **Reduced performance**
  - Survey of 218 soldiers on operations

(Orr et al., 2013)



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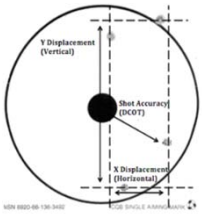
IMPACTS ON PERFORMANCE - MARKSMANSHIP

- Distance to centre of target
  - DCOT
- Horizontal shot spread
  - X-Dispersion
- Vertical shot spread
  - Y-Dispersion

(Carbone et al., 2014)



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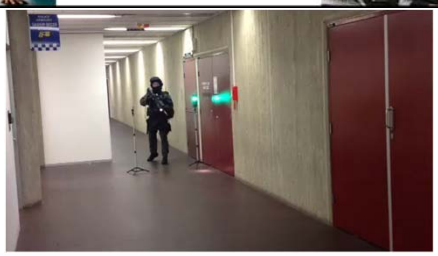

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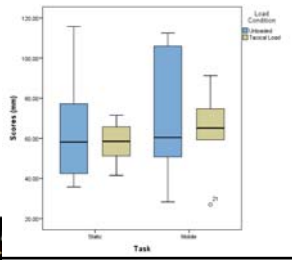
IMPACTS ON PERFORMANCE - MARKSMANSHIP

- Marksmanship



(Carbone et al., 2014)

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IMPACTS ON PERFORMANCE - MARKSMANSHIP

- No significant difference when TL

Table 1. Primary weapon marksmanship results from all four conditions

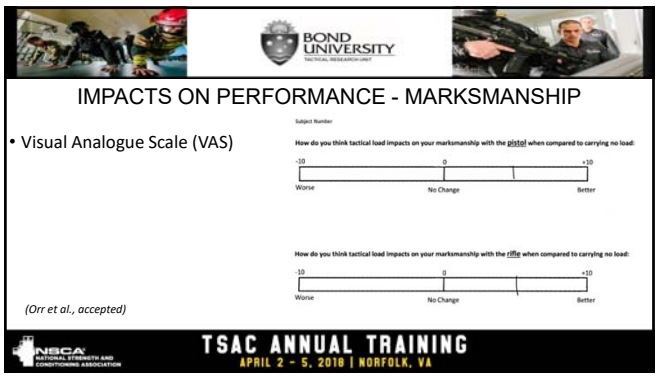
Task & Loading Condition	DCOT (mm)	X-Dispersion (mm)	Y-Dispersion (mm)
Short Forward Movement			
Fatigues Only	75.93 ± 17.97	112.50 ± 31.35	143.58 ± 44.88
Tactically Loaded	70.48 ± 19.57	76.42 ± 46.99	168.42 ± 50.39
Mobility Task			
Fatigues Only	74.83 ± 36.95	116.67 ± 70.05	173.25 ± 139.65
Tactically Loaded	100.10 ± 20.14	112.50 ± 51.59	213.67 ± 70.99

Data are mean ± standard deviation

Table 2. Secondary weapon marksmanship results from all four conditions

Task & Loading Condition	DCOT (mm)	X-Dispersion (mm)	Y-Dispersion (mm)
Short Forward Movement			
Fatigues Only	107.35 ± 37.68	178.33 ± 81.62	206.33 ± 85.87
Tactically Loaded	112.60 ± 44.37	128.83 ± 59.55	188.25 ± 60.33
Mobility Task			
Fatigues Only	128.23 ± 33.20	197.00 ± 70.43	274.08 ± 176.61
Tactically Loaded	108.70 ± 52.48	176.25 ± 70.13	213.08 ± 131.60

(Orr et al., accepted)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IMPACTS ON PERFORMANCE - MARKSMANSHIP
• Visual Analogue Scale (VAS)
Subject Number:
How do you think tactical load impacts on your marksmanship with the pistol when compared to carrying no load:
-10
0
+10
Worse
No Change
Better
How do you think tactical load impacts on your marksmanship with the rifle when compared to carrying no load:
-10
0
+10
Worse
No Change
Better
(Orr et al., accepted)
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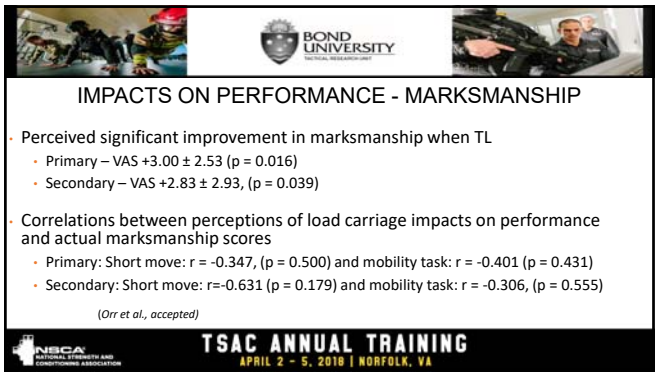
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IMPACTS ON PERFORMANCE - MARKSMANSHIP
• Perceived significant improvement in marksmanship when TL
• Primary – VAS +3.00 ± 2.53 (p = 0.016)
• Secondary – VAS +2.83 ± 2.93, (p = 0.039)
• Correlations between perceptions of load carriage impacts on performance and actual marksmanship scores
• Primary: Short move: r = -0.347, (p = 0.500) and mobility task: r = -0.401 (p = 0.431)
• Secondary: Short move: r=-0.631 (p = 0.179) and mobility task: r = -0.306, (p = 0.555)
(Orr et al., accepted)
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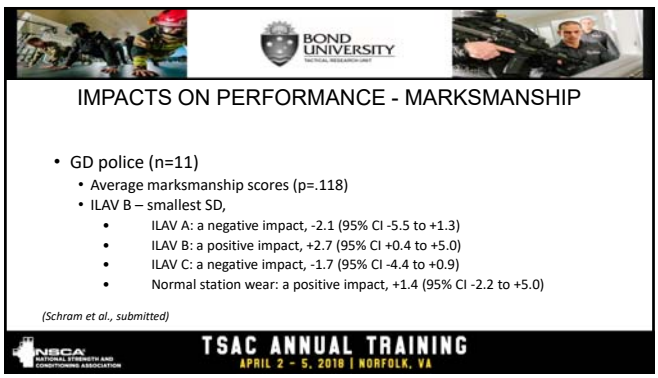
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IMPACTS ON PERFORMANCE - MARKSMANSHIP
• GD police (n=11)
• Average marksmanship scores (p=.118)
• ILAV B – smallest SD,
• ILAV A: a negative impact, -2.1 (95% CI -5.5 to +1.3)
• ILAV B: a positive impact, +2.7 (95% CI +0.4 to +5.0)
• ILAV C: a negative impact, -1.7 (95% CI -4.4 to +0.9)
• Normal station wear: a positive impact, +1.4 (95% CI -2.2 to +5.0)
(Schram et al., submitted)
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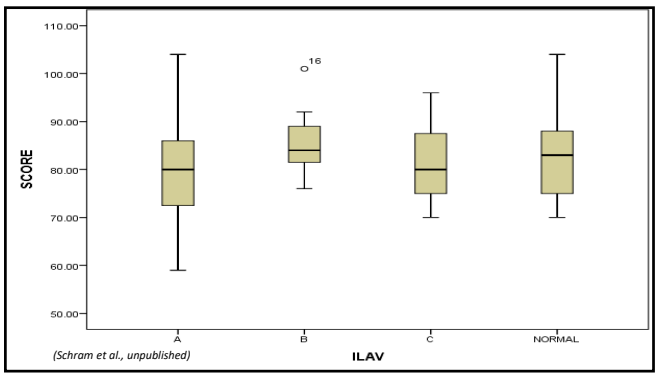
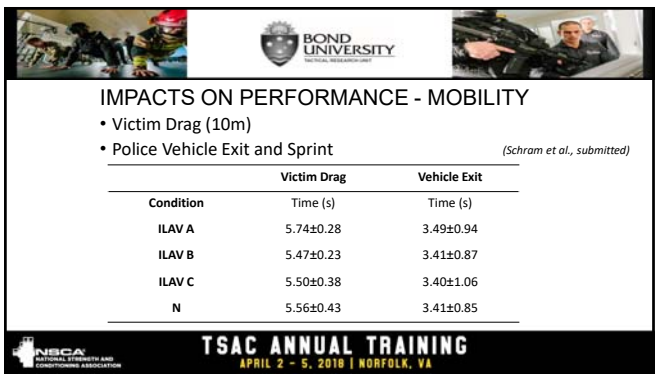
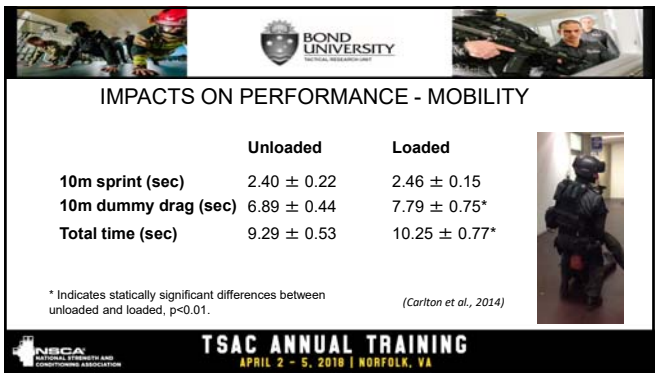


(Schram et al., unpublished)



	Victim Drag	Vehicle Exit
Condition	Time (s)	Time (s)
ILAV A	5.74±0.28	3.49±0.94
ILAV B	5.47±0.23	3.41±0.87
ILAV C	5.50±0.38	3.40±1.06
N	5.56±0.43	3.41±0.85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IMPACTS ON PERFORMANCE - MOBILITY
Unloaded
Loaded
10m sprint (sec) 2.40 ± 0.22 2.46 ± 0.15
10m dummy drag (sec) 6.89 ± 0.44 7.79 ± 0.75*
Total time (sec) 9.29 ± 0.53 10.25 ± 0.77*
* Indicates statically significant differences between unloaded and loaded, p<0.01.
(Carlton et al., 2014)
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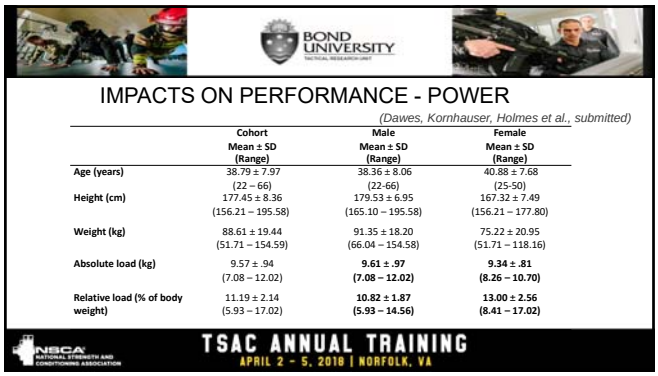
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IMPACTS ON PERFORMANCE - POWER
(Dawes, Kornhauser, Holmes et al., submitted)
Cohort Mean ± SD (Range)
Male Mean ± SD (Range)
Female Mean ± SD (Range)
Age (years) 38.79 ± 7.97 (22 – 66) 38.36 ± 8.06 (22-66) 40.88 ± 7.68 (25-50)
Height (cm) 177.45 ± 8.36 (156.21 – 195.58) 179.53 ± 6.95 (165.10 – 195.58) 167.32 ± 7.49 (156.21 – 177.80)
Weight (kg) 88.61 ± 19.44 (51.71 – 154.59) 91.35 ± 18.20 (66.04 – 154.58) 75.22 ± 20.95 (51.71 – 118.16)
Absolute load (kg) 9.57 ± .94 (7.08 – 12.02) 9.61 ± .97 (7.08 – 12.02) 9.34 ± .81 (8.26 – 10.70)
Relative load (% of body weight) 11.19 ± 2.14 (5.93 – 17.02) 10.82 ± 1.87 (5.93 – 14.56) 13.00 ± 2.56 (8.41 – 17.02)
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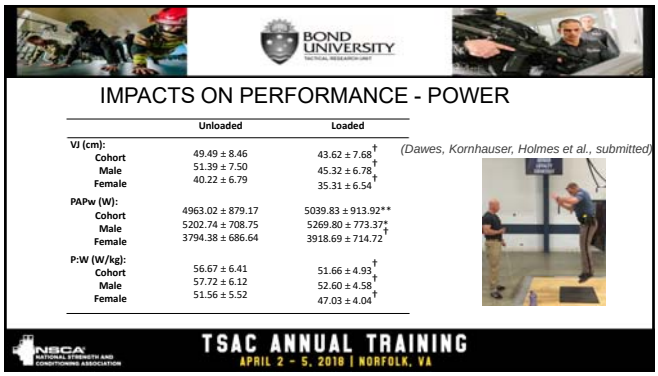
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IMPACTS ON PERFORMANCE - POWER
Unloaded
Loaded
VJ (cm):
Cohort 49.49 ± 8.46 43.62 ± 7.68†
Male 51.39 ± 7.50 45.32 ± 6.78†
Female 40.22 ± 6.79 35.31 ± 6.54†
PAPw (W):
Cohort 4963.02 ± 879.17 5039.83 ± 913.92**
Male 5202.74 ± 708.75 5269.80 ± 773.37†
Female 3794.38 ± 686.64 3918.69 ± 714.72†
P:W (W/kg):
Cohort 56.67 ± 6.41 51.66 ± 4.93†
Male 57.72 ± 6.12 52.60 ± 4.58†
Female 51.56 ± 5.52 47.03 ± 4.04†
(Dawes, Kornhauser, Holmes et al., submitted)
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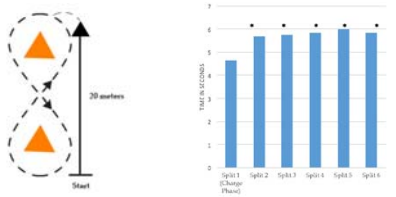
IMPACTS ON PERFORMANCE - AGILITY

(Dawes, Kornhauser, Holmes, et al., submitted)



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Example: Active Shooter Resulting from a High Risk Warrant Execution

(Robinson, Irving, et al., 2015)

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Example: Physical Assessments to mimic physiological stress encountered during key tasks-SPURT

(Robinson, Irving, Orr, et al., 2015)

PRACTICAL APPLICATION - Conditioning

- Tactical personnel need to be reconditioned to carry loads following injury as part of a RTW process
  - F (7-10 days),
  - I (loads required),
  - T (work duration),
  - T (Load carriage / combined RT & Aerobic)

(Orr et al., 2010; Knapik et al., 2012)

Measure	Pack March 1 (mins:sec)	Pack March 2 (mins:sec)	Pack March 3 (mins:sec)
Pack March 1 (mins:sec)	1	.840**	.815**
Pack March 2 (mins:sec)	.840**	1	.881**
Pack March 3 (mins:sec)	.815**	.881**	1
Body Weight (kg)	0.097	0.010	0.081
1 RM Bench Press (kg)	-.360*	-.318*	-.295*
Bench Ratio (%)	-.465**	-.365*	-.379**
1 RM Squat (kg)	-.401**	-.335*	-.316*
Squat Ratio (%)	-.500**	-.381**	-.396**
1 RM Deadlift (kg)	-.288*	-0.248	-0.215
Deadlift Ratio (%)	-.403**	-.294*	-.305*
1 RM Pull up (kg)	-.452**	-.439**	-.416**
Pull up Ratio (%)	-.607**	-.512**	-.541**
Vertical Jump	-.501**	-.541**	-.523**
Shuttle Run (Level)	-.712**	-.709**	-.711**
10 meter sprint	.373*	0.178	0.217

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).


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Pack March 1 r = -.712
Pack March 2: r = -.709
Pack March 3 r = -.711
Pack March Time (mins)
Shuttle Run Levels
Pack March 1
Pack March 2
Pack March 3
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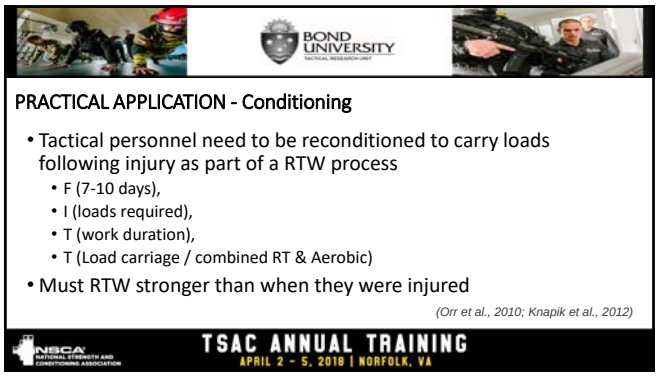
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PRACTICAL APPLICATION - Conditioning
• Tactical personnel need to be reconditioned to carry loads following injury as part of a RTW process
• F (7-10 days),
• I (loads required),
• T (work duration),
• T (Load carriage / combined RT & Aerobic)
• Must RTW stronger than when they were injured
(Orr et al., 2010; Knapik et al., 2012)
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Load Carriage across Tactical Personnel: Green, Blue and Red
Dr Rob Orr (PhD, PHTY, BFET, TSAC-F, ADFPTI)
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