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

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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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Conflict of Interest Statement

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

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Content

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




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HISTORICAL CONTEXT – MILITARY

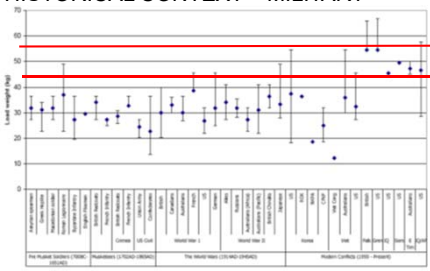
Background

- 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)




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HISTORICAL CONTEXT – MILITARY



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



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CURRENT CONTEXT – AUSTRALIAN ARMY

On Operations (2001-2010)

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

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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)

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ABSOLUTE VS RELATIVE LOADS


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

<u>ABSOLUTE LOADS:</u>	<u>RELATIVE LOADS</u>
FEMALE: $M = 26.4$ kg	FEMALE: $M = 43\%$
MALE: $M = 39.0$ kg	MALE: $M = 47\%$
<u>p=.045</u>	<u>p=.55</u>

(Orr et al., 2015)

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ABSOLUTE VS RELATIVE LOADS

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


<u>ABSOLUTE LOADS</u>	<u>RELATIVE LOADS</u>
Light 20%: <i>M</i> = 34.7 kg	Light 20%: <i>M</i> = 49%
Heavy 20%: <i>M</i> = 35.7 kg	Heavy 20%: <i>M</i> = 36%
<u>p=.902</u>	<u>p=.0509</u>

(Orr et al., 2015)

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HISTORICAL CONTEXT – LEO



Historical photos show police officers in traditional uniforms. Modern photos show police officers in tactical gear, including vests and helmets.

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HISTORICAL CONTEXT – LEO

- Police are becoming Christmas trees



Comparison of police gear in 1979 and 2014. The 1979 officer has minimal gear, while the 2014 officer has a full tactical vest and helmet.


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HISTORICAL CONTEXT - LEO

- Increasing levels of threat



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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)

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CURRENT CONTEXT – AUSTRALIAN LEO

ILAV type	FEMALE		MALE	
	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)


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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)



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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)




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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)




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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

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CURRENT CONTEXT – AUSTRALIAN 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)

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HISTORICAL CONTEXT - FIREFIGHTING

1770 1879 2016




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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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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)

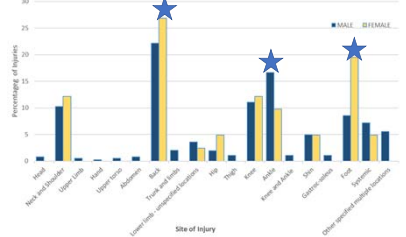
- Mean ARA population over 2 years = 24,876 personnel
 - Female n= 2441 (10%); Male n= 22435 (90%)
- 401 reported injuries associated with load carriage
 - Female n=40 (10%); male n= 361 (90%)
 - RR = 1.02 (95% CI 0.74 to 1.41)
- SPI
 - Female n=6 (15%); male n= 23 (6%)
 - RR of SPI = 2.40 (95% CI 0.98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






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SEX DIFFERENCES IN LC INJURIES (Orr et al., 2016)




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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)

Operational Task	Impact of Load Carriage on Performance
Mobility	-1.24
Marksmanship	-0.95
Grenade Throw	-0.99
Administration	-0.96
Attention to Task	-0.80

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Impact of Load Carriage on Performance

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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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IMPACTS ON PERFORMANCE - MARKSMANSHIP

- Marksmanship



(Carbone et al., 2014)





APRIL










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IMPACTS ON PERFORMANCE - MARKSMANSHIP

- No significant difference when TL


Task & Loading Condition	DCOT (mm)	X-Dispersion (mm)	Y-Dispersion (mm)
Table 1. Primary weapon marksmanship results from all four conditions			
Short Forward Movement			
Fatigues Only	75.93 ± 17.97	112.50 ± 31.25	143.58 ± 44.84
Tactically Loaded	70.48 ± 19.57	76.42 ± 46.95	148.42 ± 50.35
Mobility Task			
Fatigues Only	74.83 ± 36.95	136.67 ± 70.68	212.25 ± 129.64
Tactically Loaded	100.10 ± 20.14	112.50 ± 51.93	213.67 ± 70.99
Data are mean ± standard deviation			
Table 2. Secondary weapon marksmanship results from all four conditions			
Short Forward Movement			
Fatigues Only	107.35 ± 37.68	178.33 ± 81.62	206.33 ± 85.87
Tactically Loaded	112.60 ± 44.37	126.43 ± 58.57	192.91 ± 60.33
Mobility Task			
Fatigues Only	128.23 ± 33.20	157.00 ± 70.41	274.08 ± 176.81
Tactically Loaded	108.70 ± 52.48	178.25 ± 70.11	212.08 ± 131.66

(Orr et al., accepted)





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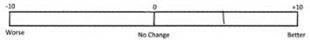


IMPACTS ON PERFORMANCE - MARKSMANSHIP

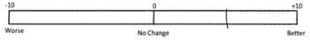
• Visual Analogue Scale (VAS)

Subject Number: _____

How do you think tactical load impacts on your marksmanship with the **20kg** when compared to carrying no load:




How do you think tactical load impacts on your marksmanship with the **25kg** when compared to carrying no load:



(Orr et al., accepted)

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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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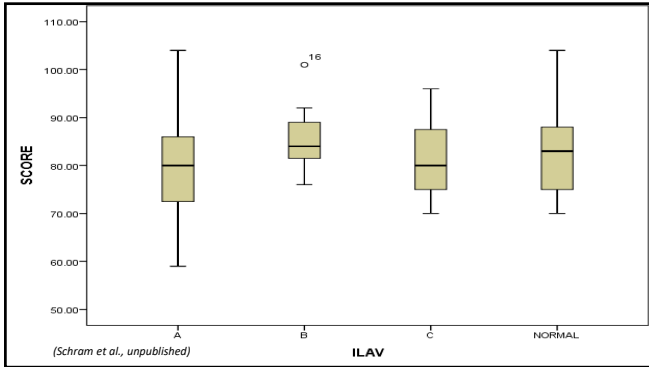


IMPACTS ON PERFORMANCE - MARKSMANSHIP

- 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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IMPACTS ON PERFORMANCE - MOBILITY

- Decrements in performance:
 - ↓ Mobility
 - Impeded mission success (Breen 2000)







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IMPACTS ON PERFORMANCE - MOBILITY

- Victim Drag (10m)
- Police Vehicle Exit and Sprint (Schram et al., submitted)

Condition	Victim Drag	Vehicle Exit
	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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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 ± 7.57 (22 - 66)	38.36 ± 8.06 (22-66)	40.98 ± 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)
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IMPACTS ON PERFORMANCE - POWER


	Cohort	
	Unloaded	Loaded
VI (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)



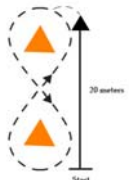
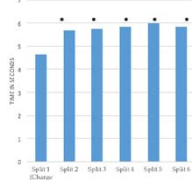
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IMPACTS ON PERFORMANCE - AGILITY

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





Split	Time (seconds)
Split 1 (Change Phase)	~4.5
Split 2	~6.0
Split 3	~6.0
Split 4	~6.0
Split 5	~6.0
Split 6	~6.0

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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)

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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)

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

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Measure	Pack March 1 (min:sec)	Pack March 2 (min:sec)	Pack March 3 (min:sec)
Pack March 1 (min:sec)	1	.840**	.815**
Pack March 2 (min:sec)	.840**	1	.881**
Pack March 3 (min: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*	-.0248	-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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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

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