Military Recruit Training Induces a Proximal Shift in Lower-Limb Dynamic Movement Strategies

Jodie A. Wills[1,2], Bradley Nindl[3], Tim LA. Doyle[1,2], Matthew Bird[4], Kristen J. Koltun[3]
Brian J. Martin[3], Elizabeth J. Steele[3], Jennifer N. Forse[3]
[1]Faculty of Medicine, Health, and Human Sciences, Macquarie University, NSW, Australia
[2]Biomechanics, Physical Performance, and Exercise Research Group, Macquarie University, NSW, Australia
[3]Neuromuscular Research Laboratory/Warrior Human Performance Research Center, Department of Sports Medicine and Nutrition, University of Pittsburgh, United States
[4]Extremity Trauma & Amputation Center of Excellence, Womack Army Medical Center, Fort Liberty, NC, United States
Email: jodie.wills@mq.edu.au

Summary
Markerless Motion Capture is a portable movement assessment method, capable of evaluating full body motion. Screening military recruit mobility and movement patterns may provide meaningful insights into injury prevention and adaptive movement strategies adopted as an indicator of injury risk and/or successful job and training completion. After recruit training, there appears to be a proximal shift in joint contribution to military relevant dynamic movements.

Introduction
Lower body mobility is critical for soldiers as it directly impacts their capacity to execute physically demanding job-relevant tasks with efficiency and effectiveness [1]. Non-combat musculoskeletal issues, such as restricted hip mobility, are prevalent among active-duty soldiers, impacting readiness and performance [2]. Identifying potential mobility impairments and understanding adaptive movement strategies adopted by recruits to meet physically demanding training demands may help reduce injury risk and increase soldier readiness. This study aimed to assesses dynamic movement capacity before and after military recruit training.

Methods
608 US Army Officer Candidate School (OCS) recruits (height, 1.7±0.1 m; mass, 78.1±10.6 kg; sex, 111 females and 497 males) provided written, informed consent for participation. Before and after a 10-week recruit training course, five dynamic movements were assessed using the DARI marker less motion capture system (Dynamic Athletic Research Institute-Motion, Overland Park, USA): bilateral squat, overhead squat, lateral lunge, unilateral jump, and vertical jump. Lower limb mobility (range of motion) and kinematics (joint flexion and relative joint contribution) were assessed for all movements. One-way analysis of variance (ANOVA) was used to identify statistical differences between pre-and-post outcomes ($p<0.05$). Welches F test and Games Howell post hoc tests were completed as data violated homogeneity of variances assumption.

Results and Discussion
Table 1 summarises primary outcomes. Post-training, most movements exhibited a proximal shift in movement strategies, characterised by significant increases in hip joint flexion and mobility and reductions at the knee and ankle. The bilateral squat showed significant post-testing changes across all joint angles (hip ($F(1,1210) = 29.278$, $p<0.001$); knee ($F(1,1172) = 4.485$, $p=0.034$)", ankle ($F(1,1196) = 5.498$, $p=0.019$)). For the lateral lunge, reduced joint ranges were observed at both the knee ($F(1,1209) = 9.062$, $p=0.003$) and ankle ($F(1,1206) = 64.580$, $p<0.001$) joints, whereas the overhead squat demonstrated decreases in mobility exclusively at the ankle ($F(1,1203) = 6.703$, $p<0.010$). In unilateral and vertical jump movements, significant decreases in knee and ankle flexion angles were observed during both the loading and landing phases; hip flexion significantly increased ($F(1,1191) = 4.265$, $p=0.039$) in the vertical jump loading phase only.

Conclusions
After OCS training, movement strategies shifted proximally, with increased hip utilisation and reduced knee and ankle utilisation and mobility across various tasks. These adaptations suggest a reliance on proximal joints for dynamic movement control and stability.

Acknowledgments
To all volunteers and for research funding received from Office of Naval Research (Grant: N62909-21-1-2015).

References
[1] Knapik, J (2015). *J Spec Oper Med*, **15**: 123-7.
[2] Molloy et al. (2020). *Mil Med*, **185**: e1472-e1480.

Table 1: Mobility and kinematic main findings of DARI Motion movements of interest before and after 10-weeks recruit training.

Movement	Joint	Pre		Post		*p*-value
		(M±SD)	SE	(M±SD)	SE	
Bilateral Squat Mobility Range of motion (°)	Hip	123.85 ± 16.16	0.655	128.73±15.30	0.621	<0.001*†
	Knee	131.23 ± 14.37	0.583	129.63±11.85	0.481	0.034*#
	Ankle	30.24 ± 7.01	0.284	29.35±6.19	0.251	0.019*#
Overhead Squat Mobility Range of motion (°)	Hip	131.96 ± 15.80	0.641	133.14±14.15	0.574	0.171†
	Knee	125.46 ± 16.20	0.657	124.67±13.33	0.541	0.351
	Ankle	33.45 ± 6.72	0.277	32.50±6.11	0.248	0.010*#
Lateral Lunge Mobility Range of motion (°)	Hip	113.77 ± 17.16	0.696	114.03±15.92	0.646	0.781†
	Knee	118.90 ± 14.05	0.57	116.55±13.15	0.533	0.003*
	Ankle	36.18 ± 8.00	0.325	32.63±7.39	0.299	<0.001*#
Unilateral Jump Joint Flexion Angle (°) *Loading | Landing*	Hip	72.9 ± 18.48 | 37.8 ± 17.66	0.750 | 0.716	73.5 ± 19.40 | 39.5 ± 18.75	0.787 | 0.760	0.560† | 0.103
	Knee	79.6 ± 12.66 | 53.9 ± 12.70	0.513 | 0.515	75.6 ± 11.67 | 55.4 ± 12.32	0.473 | 0.500	<0.001* | 0.004*
	Ankle	27.7 ± 6.28 | 25.4 ± 6.47	0.255 | 0.262	24.5 ± 5.61 | 24.4 ± 6.22	0.228 | 0.252	<0.001* | 0.007*#
Vertical Jump Joint Flexion Angle (°) *Loading | Landing*	Hip	99.6 ± 18.31 | 49.0 ± 32.77	0.743 | 1.329	101.9 ± 21.08 | 50.9 ± 35.73	0.855 | 1.449	0.039*† | 0.337
	Knee	114.5 ± 16.83 | 77.4 ± 24.62	0.682 | 0.999	110.4 ± 17.13 | 73.4 ± 22.89	0.695 | 0.928	<0.001*# | 0.004*#
	Ankle	33.1 ± 6.54 | 31.4 ± 6.53	0.265 | 0.265	30.3 ± 6.26 | 28.2 ± 7.43	0.254 | 0.301	<0.001*# | < 0.001*#

**Indicates statistical significance; † statistically significant ↑ in % joint contribution; # statistically significant ↓ in % joint contribution.*