

Motion Capture, Validation, and Vibration

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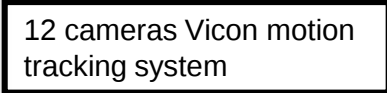
July 18, 2018

Facility Description (3D-Biomotion Research Lab)

16 cameras Motion Analysis tracking system



12 cameras Vicon motion tracking system



Inertia (Xsens) motion capture suit



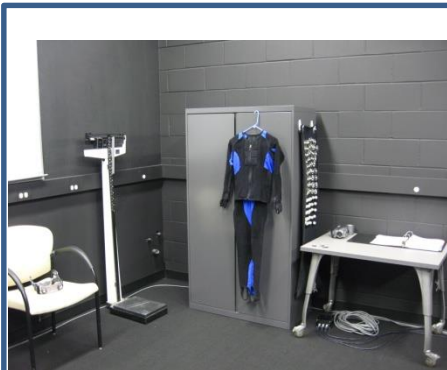
Mock-Up of a heavy construction machine



Six-degree of freedom Moog FCS motion platform



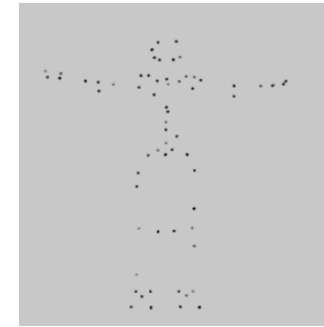
Motion Capture Process at CCAD



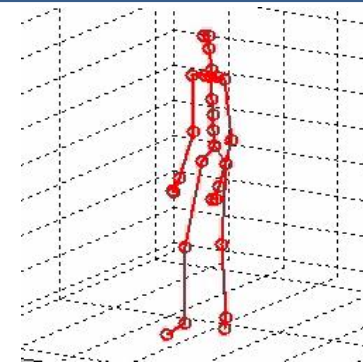
Experimental Protocol



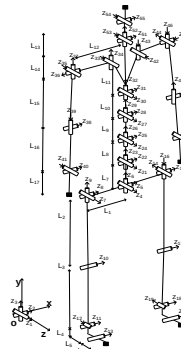
Motion Capture



Post Processing



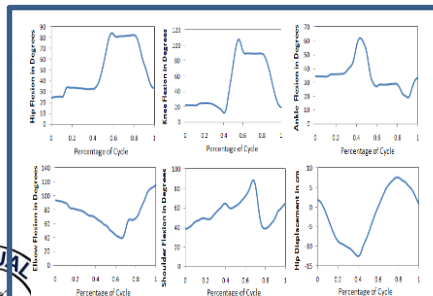
Joint Centers



Inverse Kinematics

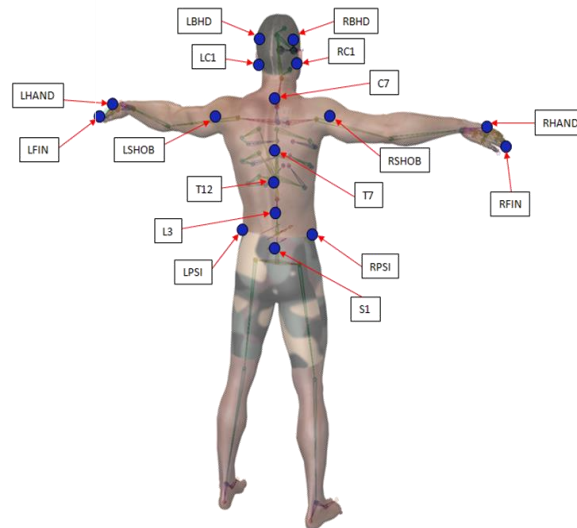
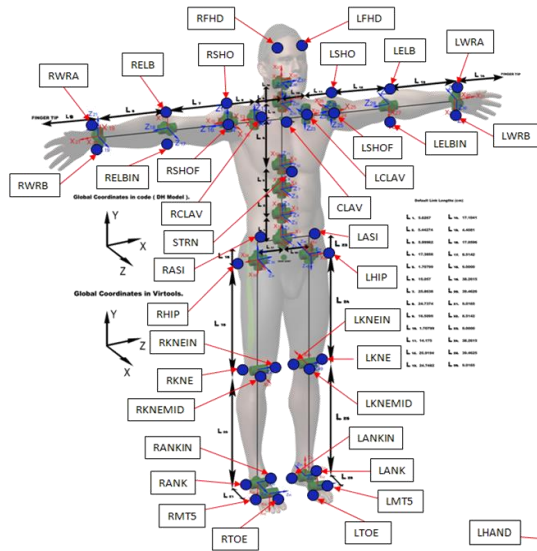


Visual Comparison

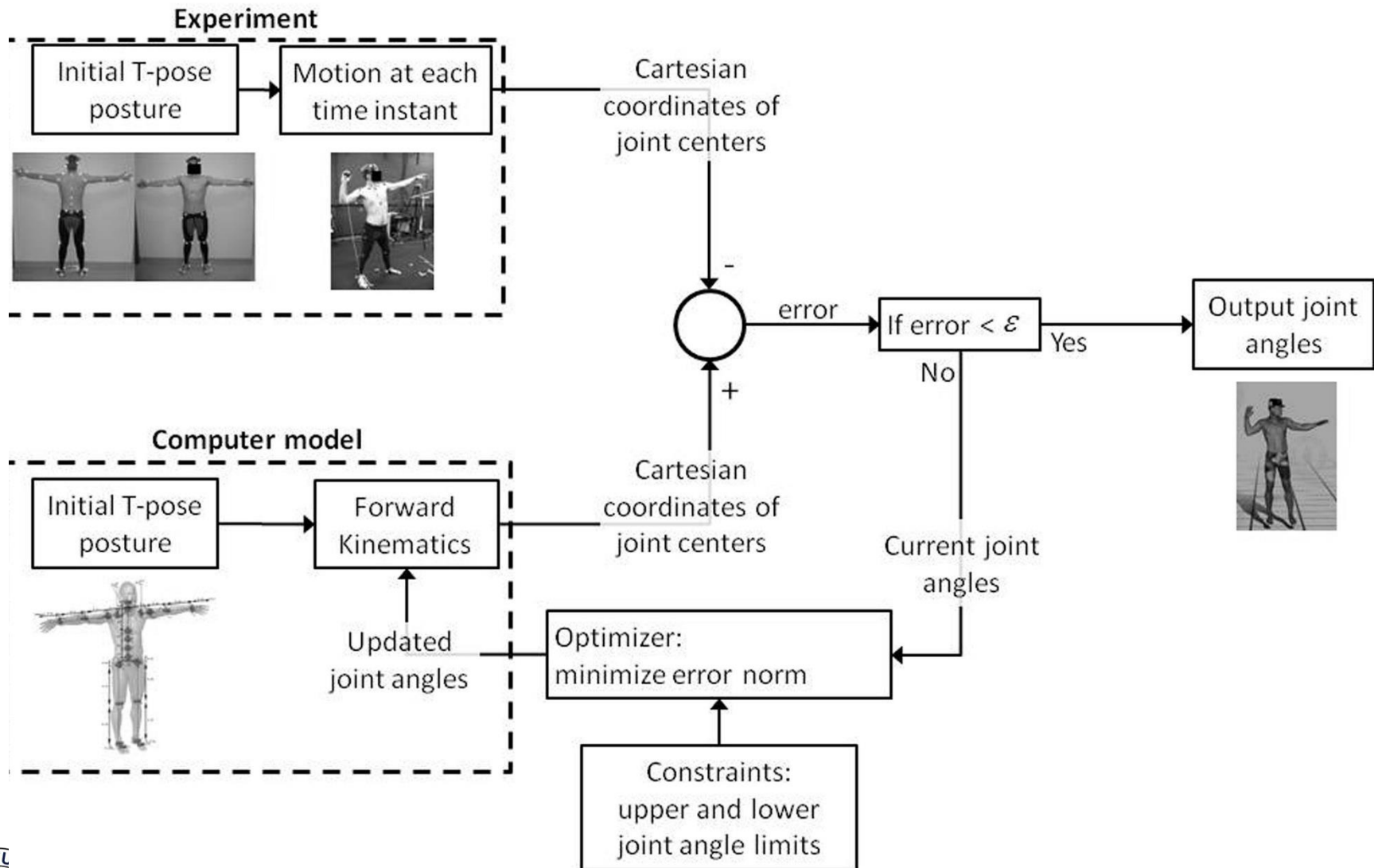


Qualitative Comparison

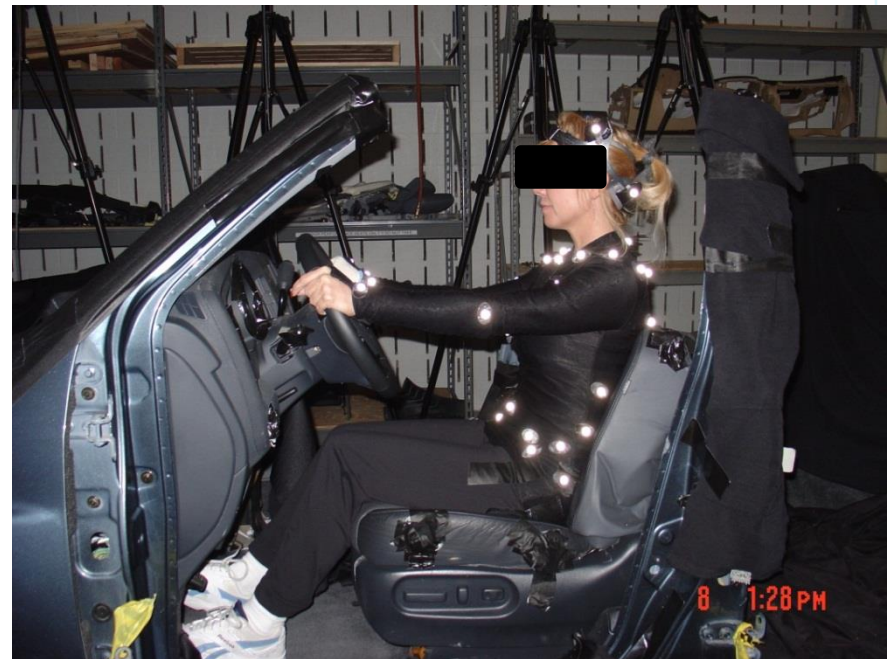
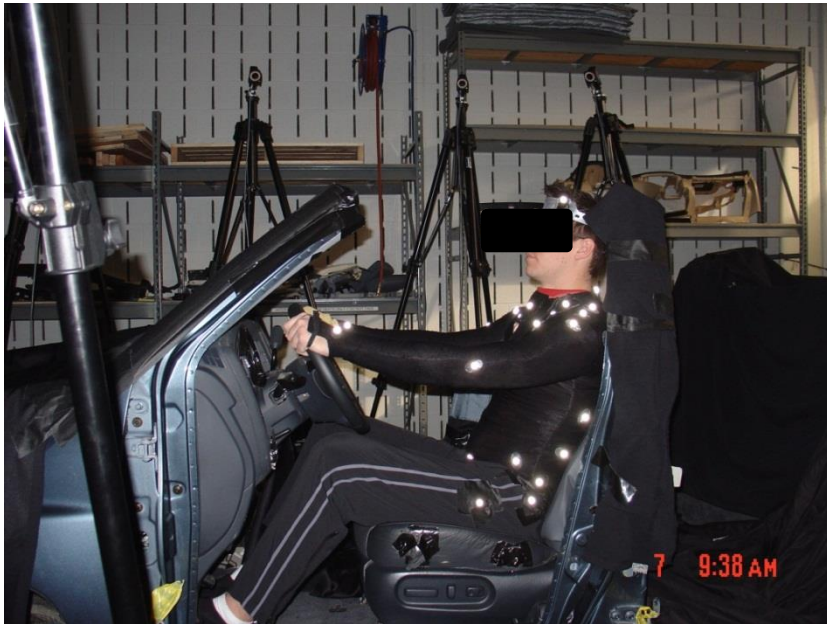
Motion Capture setup and marker protocols



In-House Inverse Kinematics for Santos



Whole-Body Posture Honda R&D

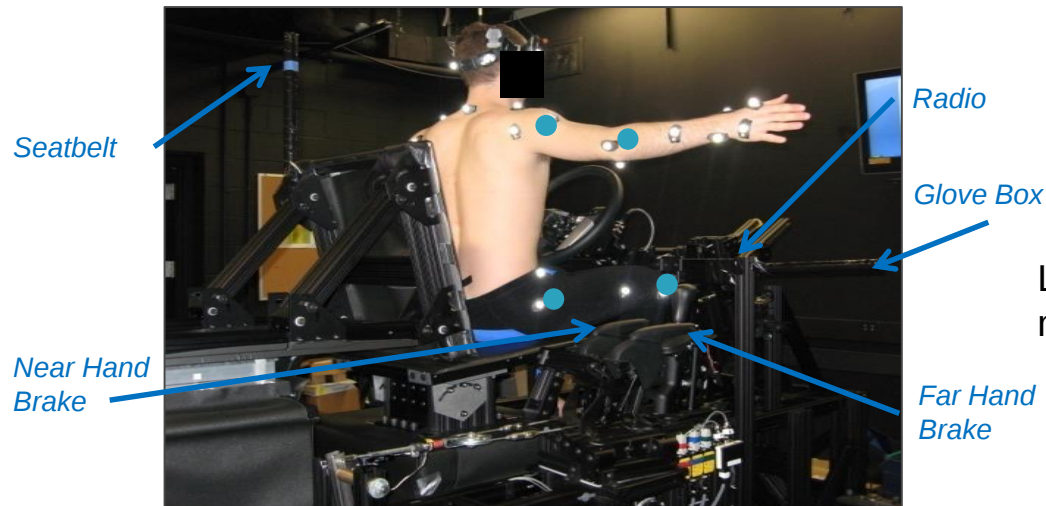


Motion Capture Evaluation Inside a Vehicle

Motion Capture Cameras
Attached to the ceiling



Whole-Body Posture With and Without Load



Lab testing using a car
model on a shaker table

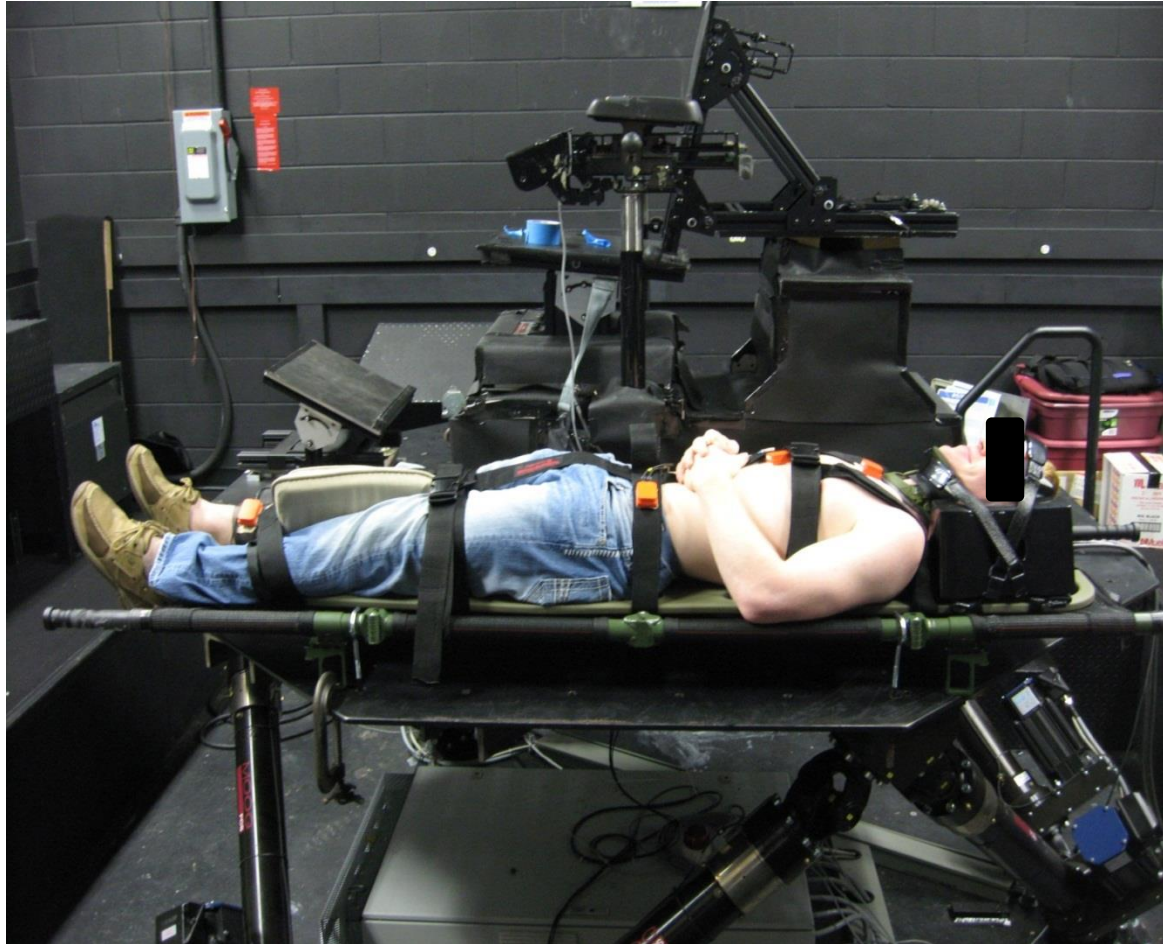
● Indicates joint center location

➔ Indicates target location for reaching task

Human Response to Whole-Body Vibration, Caterpillar Inc.



Motion capture studies in supine transportation, Collaborative work with EMS and USAARL



Task Determinants:

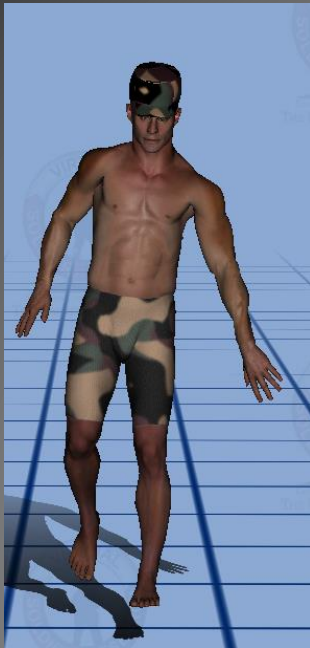
Joint angles that play a crucial role during the task

Example:

Based on the literature, there are six determinants that define normal walking:

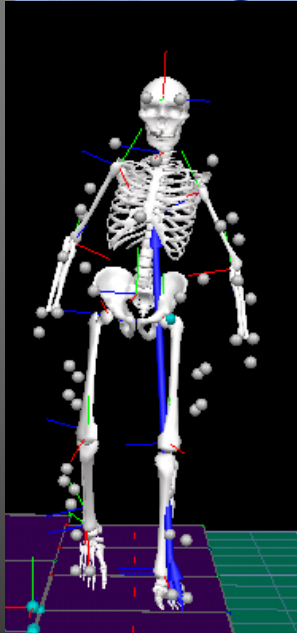
- ☐ Hip flexion/extension
- ☐ Knee flexion/extension
- ☐ Ankle plantar/dorsiflexion
- ☐ Pelvic tilt
- ☐ Pelvic rotation
- ☐ Lateral pelvic displacement

Application in Medical Field (Prosthetic Gait)

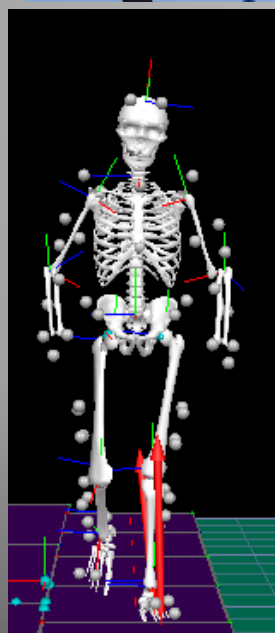


Military
Performance
Laboratory (MPL)

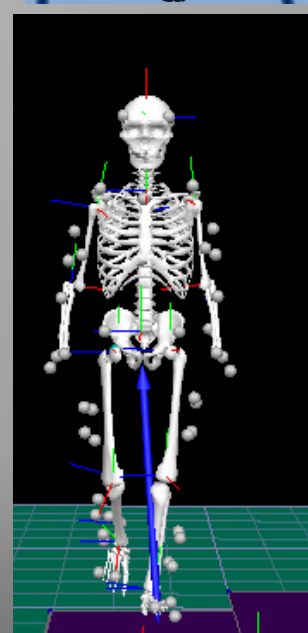
Santos



Femoral



Tibial

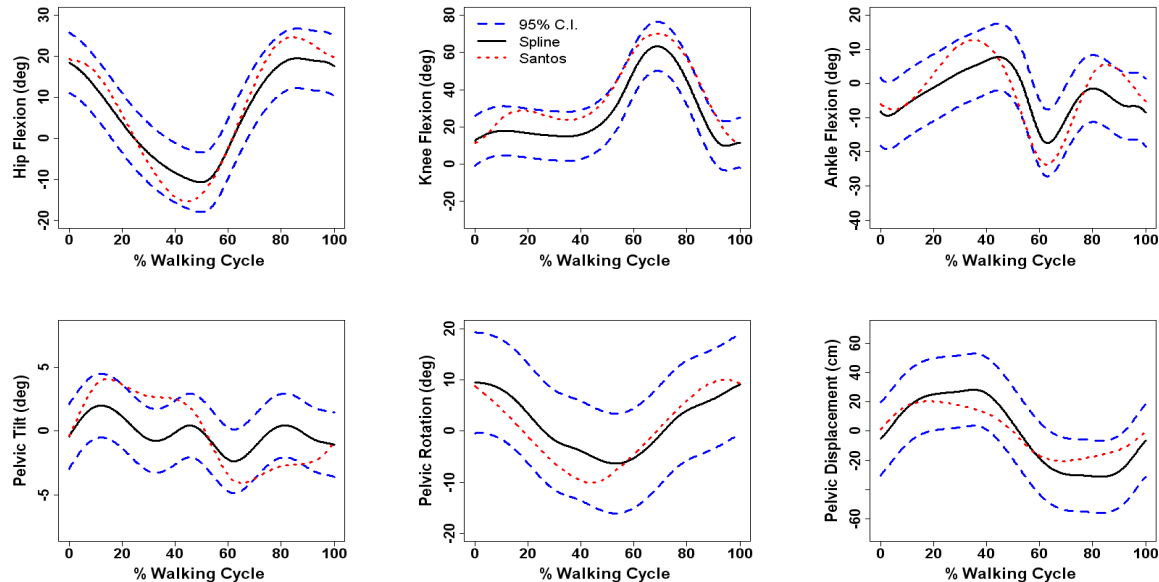


Control

Visual3D

Confidence Intervals

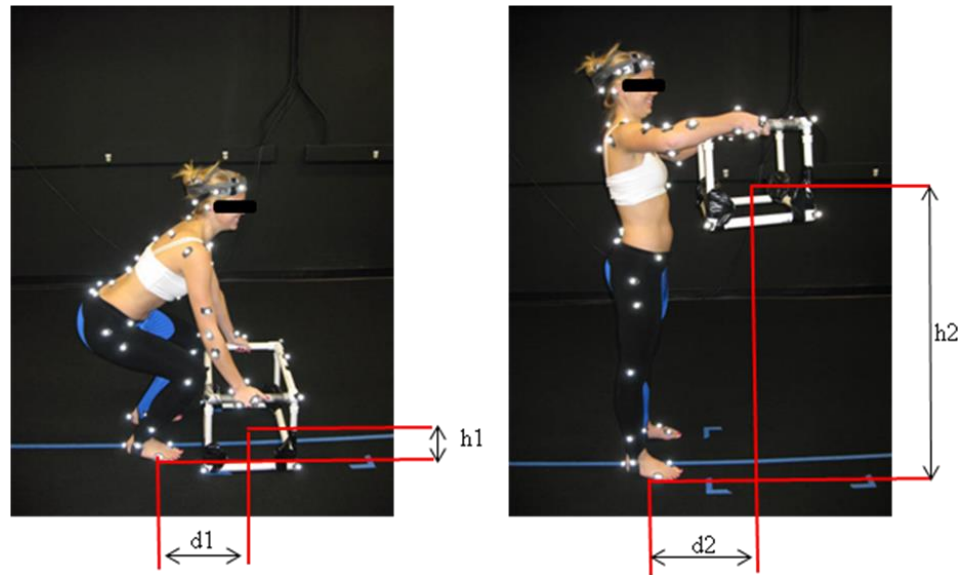
Quantitatively examine trends of simulation



Validation of Walking determinants

Validation of Santos: Example: Box-Lifting

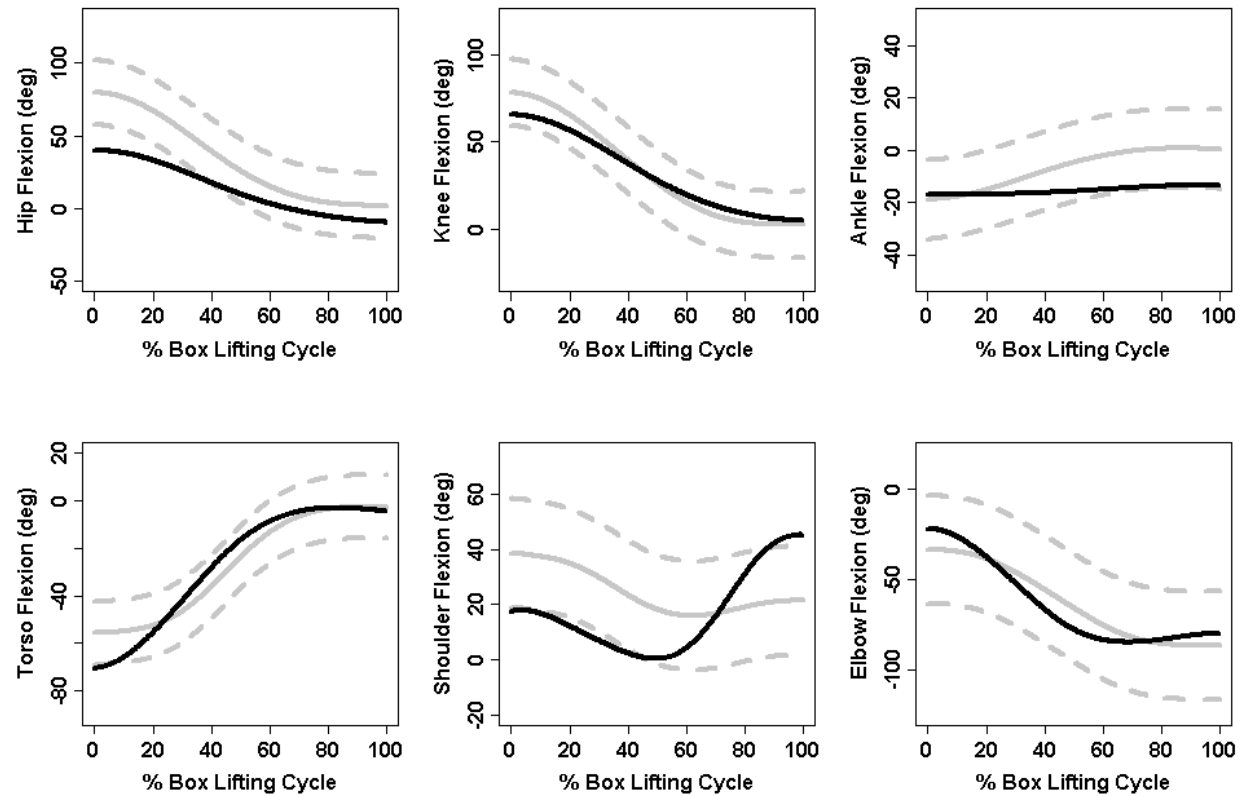
Experiment



Simulation

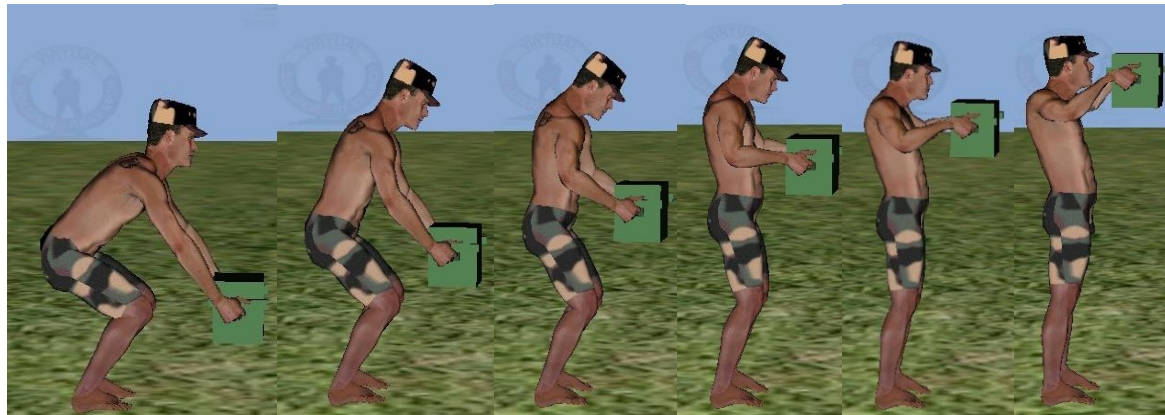


Validation of Santos: Box-Lifting determinants



Validation of box-lifting determinants

Validation of Santos: Key-Frames ANALYSIS



0% height

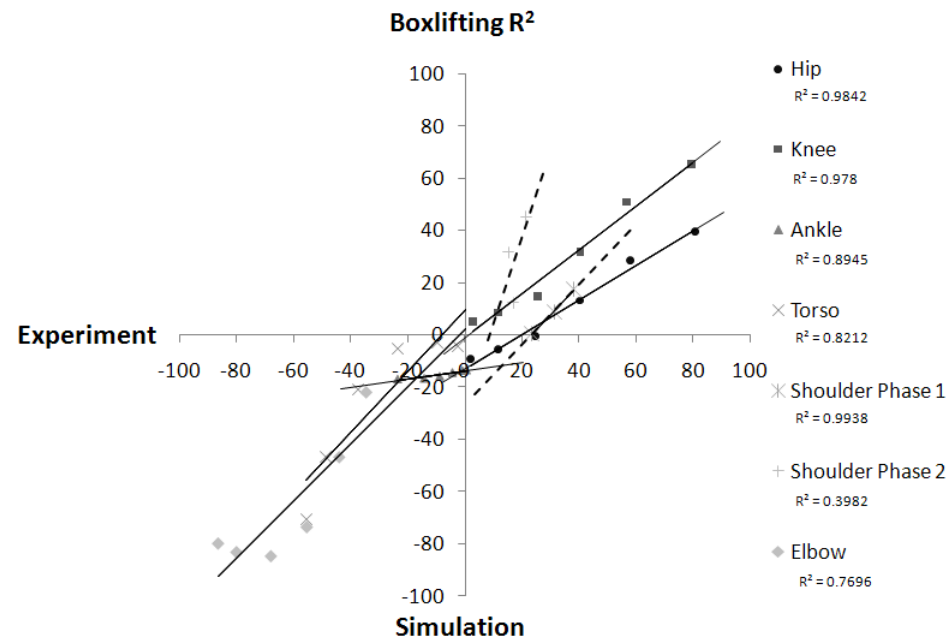
20% height

40% height

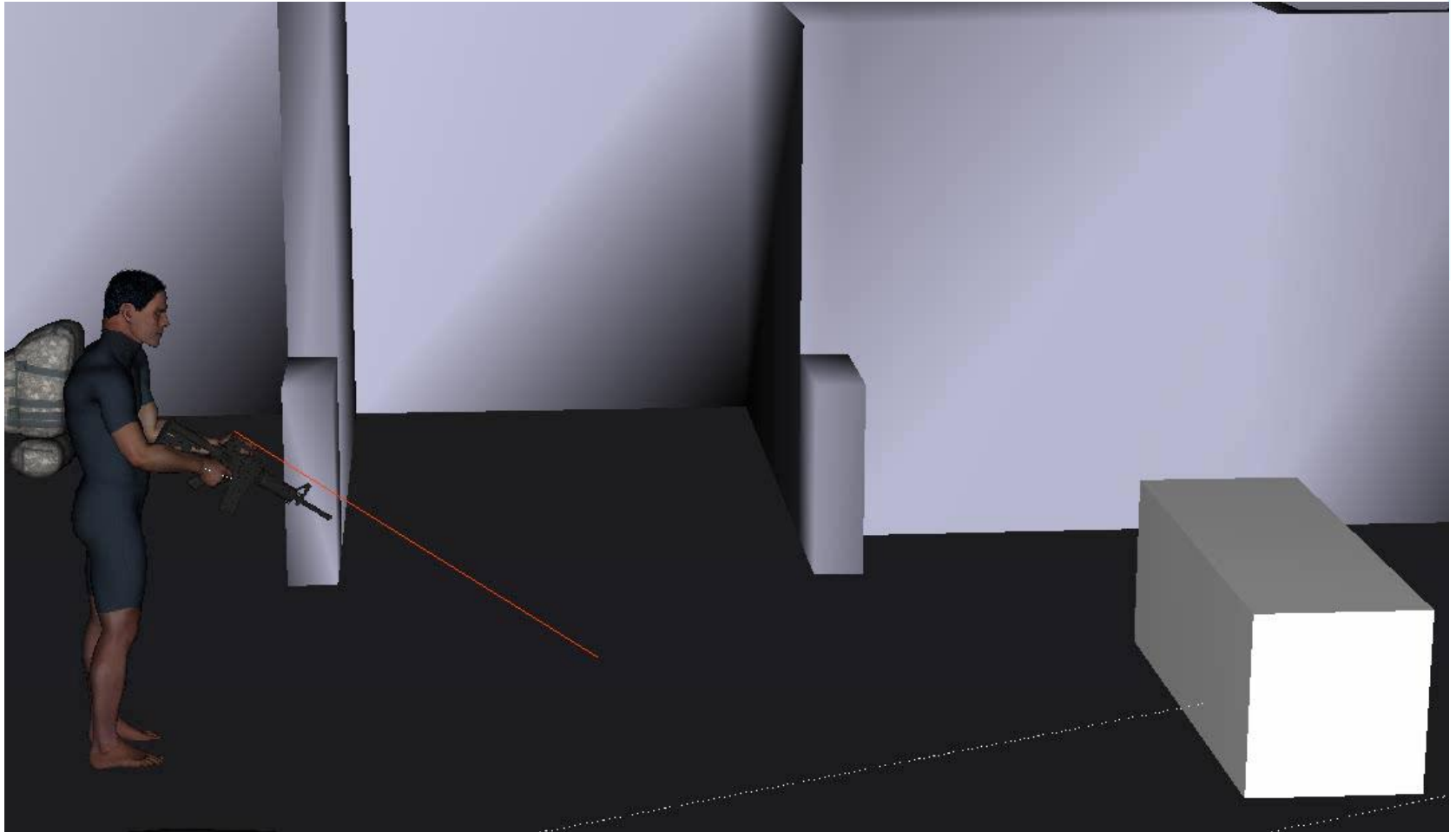
60% height

80% height

100% height



ETOWL TASKS



(Challenging Applications (ETOWL Examples))



Jumping From A Box

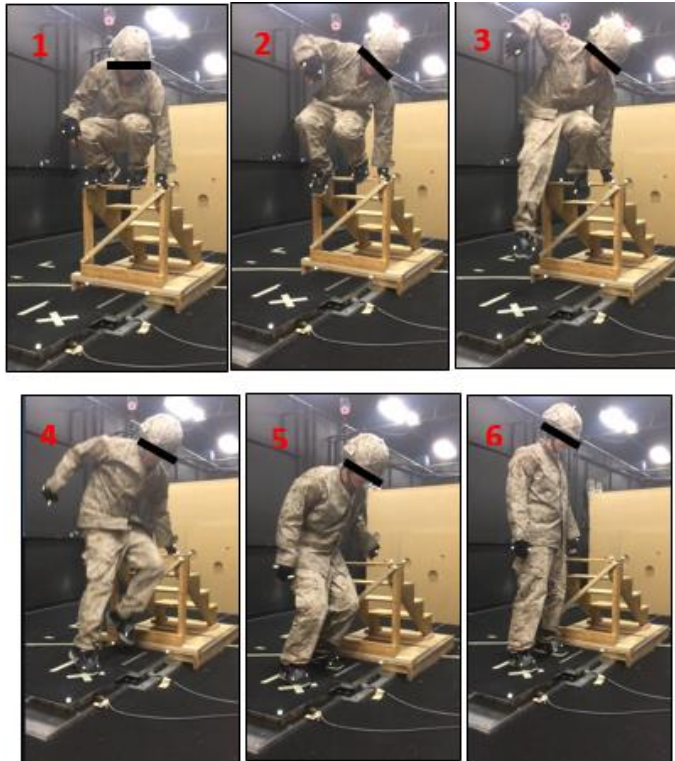
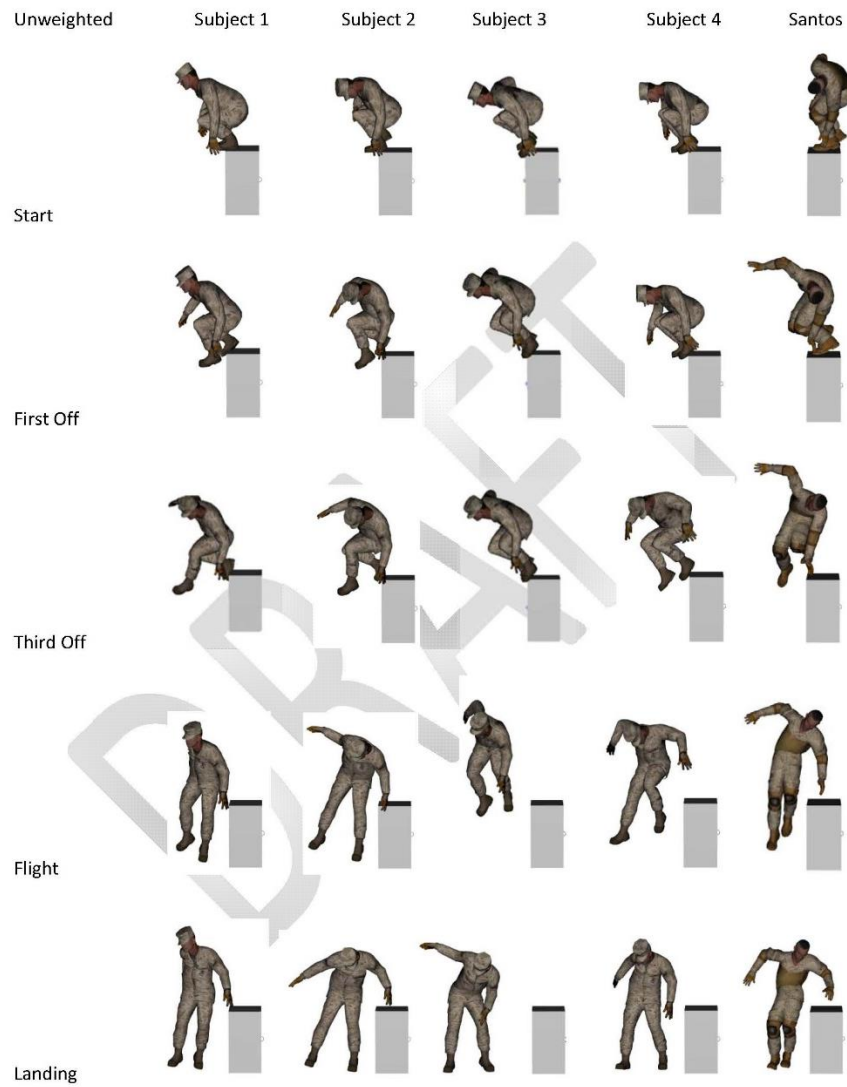
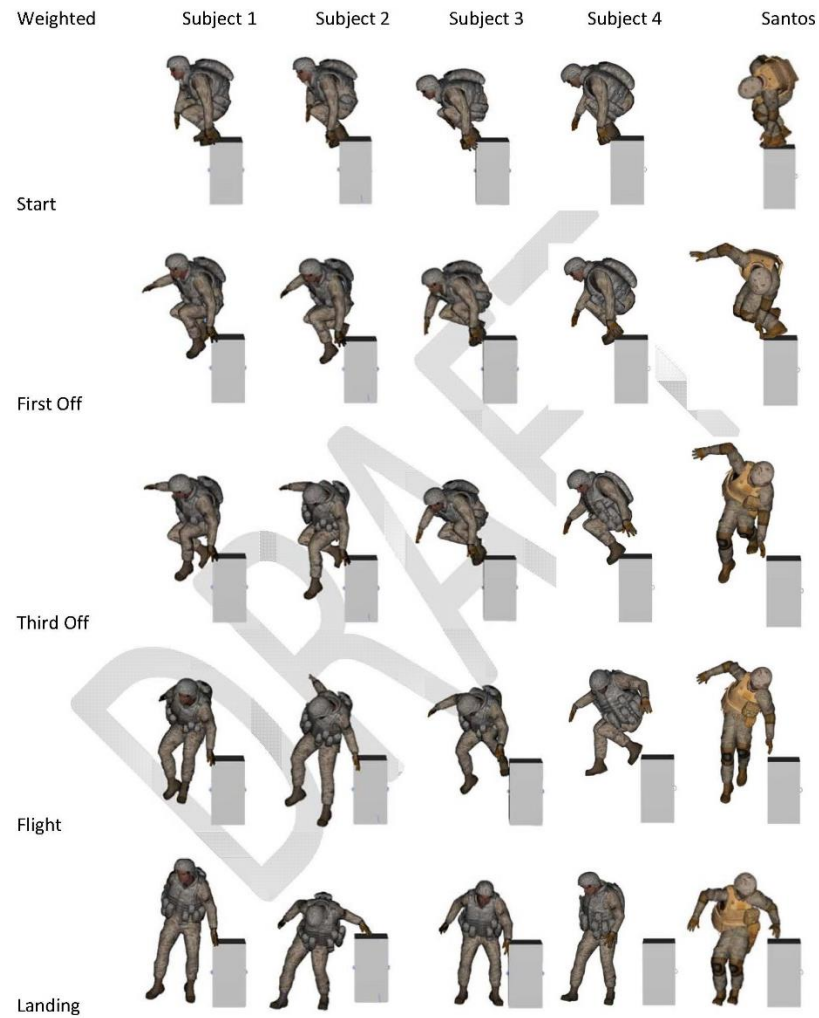


Figure 2 –Subject performs an RFF jumping-from-a-box cycle: 1) Start, 2) Right Foot Off (RFO), 3) Left Foot Off (LFO), 4) Hand Off (HO), 5) Landing (LD), and 6) Final Pose (FP).

Jumping From A Box



Jumping From A Box



Z-SCORE



All Strategies

Unweighted		Ankle(flex)		Knee(flex)		Hip(flex)		Torso(flex)	Elbow(flex)		Shoulder(flex)		Shoulder(abd)	
		Left	Right	Left	Right	Left	Right		Left	Right	Left	Right	Left	Right
Start		-0.417	-1.4786	79.3428	21.9769	2.2309	3.2741	0.4119	-0.4177	-2.0533	0.2710	2.1263	-1.4869	1.3550
Right Foot Off	RFO	2.0770	1.8105	0.6741	2.8428	2.3495	4.0831	0.1119	0.2393	-1.9366	-1.8889	0.7584	1.1048	-2.9389
Left Foot Off	LFO	2.1788	1.1526	1.9919	-0.2398	1.3685	2.9312	-0.1569	0.5012	-1.6660	-2.4528	0.9944	1.3366	-1.6043
Hand Off	HO	4.3484	0.2072	-1.1695	-0.4404	1.1904	2.5610	-0.2259	0.9620	-5.3079	-2.1158	0.8787	0.3422	-4.1139
Landing	LD	-0.4568	-1.1088	-0.3652	-0.7814	5.7247	5.6553	-2.1148	-1.2685	-8.3754	1.5148	0.4040	-0.6050	-2.9002
Final Pose	FP	1.7025	2.0722	0.4398	-0.2274	2.6416	1.2697	-0.3863	-1.4253	-5.3792	1.5922	-0.2608	0.0847	-0.6051
Weighted														
Start		-0.4170	-0.6204	21.4632	24.0276	2.8580	3.9720	0.3501	-0.9613	-0.3010	1.6233	4.1468	-2.4819	0.9707
Right Foot Off	RFO	2.0798	1.2363	0.7158	5.5118	5.0325	3.9675	-0.1198	-0.1334	-1.5229	-2.1574	0.8760	1.2846	-0.5498
Left Foot Off	LFO	5.4427	0.8084	1.2954	-0.6064	1.8871	3.6194	-0.4551	0.4344	-1.7734	-3.5693	1.7937	1.0885	-0.6319
Hand Off	HO	3.8018	0.0806	-1.0895	-0.1960	1.2964	2.2312	-0.5299	0.3829	-6.8239	-1.4610	0.6511	0.2828	-3.6599
Landing	LD	-0.1453	-0.5723	0.0545	-0.5485	4.1990	4.1301	-2.7791	-1.0971	-4.5016	1.1545	0.6889	-0.7857	-2.3663
Final Pose	FP	1.4291	2.0037	0.4543	-0.1329	1.8237	0.8424	-1.8022	-1.6030	-4.0231	1.5176	-0.0477	0.0442	-0.7398

Z-SCORE

This score takes the difference in the mean of the subjects' joint angles and Santos's predicted angles and divides by the standard deviation of the subjects, measuring how many standard deviations Santos is away from the mean.

Thank You!