

UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY



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## **Evaluation of Litter Strap Tension on the Biodynamics of Supine Patients**

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<b>14. ABSTRACT</b> The goal of the study was to evaluate how litter strap tension effects patient biodynamics during transport. The hypothesis that strap tension has significant effects on transmitted vibration during transport was tested during three phases of testing. In Phase 1, standard tension practices were observed by having medics strap a manikin to a litter. This phase determined average litter strapping tension. Phase 2 consisted of test setup validation using an instrumented vibration manikin. The simulated patient manikin was tested on a ride simulation platform in several configurations while vibration data was collected. In Phase 3, data was collected using 25 human subject participants with different body weights. The weight of each participant was between 102 and 275 pounds. The human subject participants were secured to a litter on the ride simulator and subjected to multiple vibration profiles. The level of strap tension did significantly affect the biodynamics of the supine patient. The effects of strap location and strap tension varied by segment because of the difference in strap proximity to and placement on each segment. Results from this project will provide significant information and strategies that can be used toward increasing patient safety, reducing discomfort, and developing vibration mitigation systems.					
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# Evaluation of Litter Strap Tension on the Biodynamics of Supine Patients

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# Background



Recent surveys from health care providers in the field have reported severe discomfort and pain experienced by patients during military transport, with the pain often attributed to vehicle vibration and shock.

The method of strapping a patient to a transport litter and the degree of strapping tension varies depending on patient injuries.

The level of tension may play a role in the severity of the motion transmitted to the patient's body segments.





# Objective



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Evaluate the effect of the strapping tension on patient vibration biodynamic response during simulated transport.

Hypothesis: The level of litter strapping tension will produce different patient biodynamic responses during vehicle vibration.

The strapping tensions that were tested were a standard strapping tension (two fingers will fit beneath the strap), and a low strap tension (half the tension of the standard method).



Three phases:

Phase 1 – Determine Standard Litter Strap Tension

Phase 2 – Test Setup Validation with Instrumented Manikin

Phase 3 – Human Subject Testing



68W Health Care Specialists (Medics) were asked to strap a manikin to a litter, then the strap tensions were measured.

No direction on how to secure the patient was given the first time and an abundance of straps were provided. Afterward, we asked them to secure the patient in a 2 strap and 3 strap configuration.





An instrumented biofidelic vibration manikin as used to validate test setup and collect vibration data on the Multi-Axis Ride Simulator (MARS).

Three ride profiles were used for each configuration: Air, Ground Vehicle, and White Noise.

Configuration	Strap Placement	Strap Tension
1	2 Straps (chest, and legs)	Standard Tension
2	2 Straps (chest, and legs)	Low Tension
3	3 Straps (chest, hips, and legs)	Standard Tension
4	3 Straps (chest, hips, and legs)	Low Tension
5	No Straps	N/A



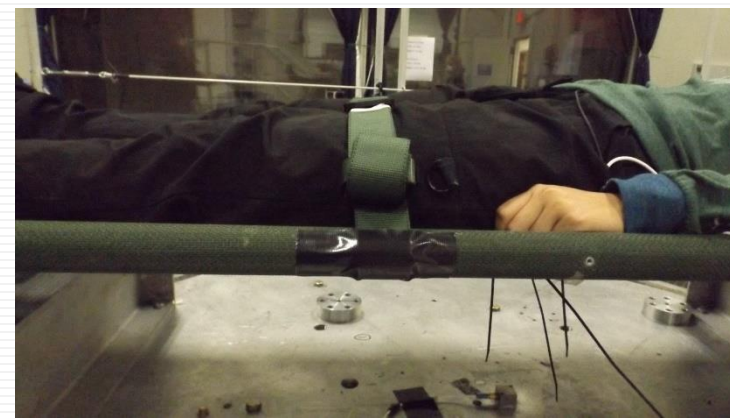


# Methods – Phase 3 Human Subject Testing



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Tested 25 human subjects who weighed between 102 to 275 pounds (lb) on the MARS platform.



<b>Lowest Weight</b>	106.24 lb
<b>Highest Weight</b>	232.74 lb

<b>Lowest Height</b>	60.8 inches (in.)
<b>Highest Height</b>	74.9 in.

<b>Configuration</b>	<b>Strap Placement</b>	<b>Strap Tension</b>
1	2 Straps	Standard Tension
2	2 Straps	Low Tension



# Results - Phase 1 Average Tension

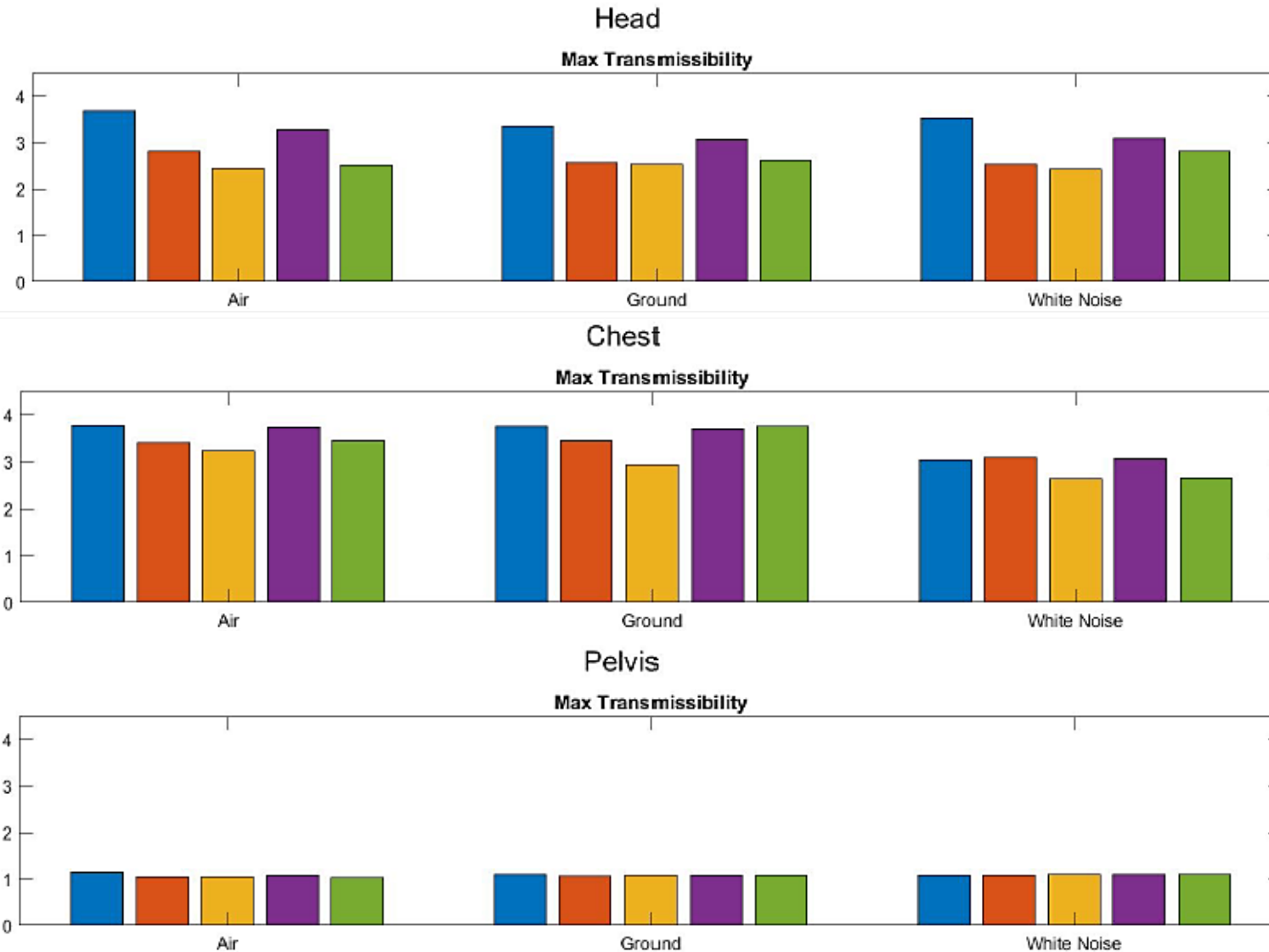


Strapping tensions from nine Medics were measured and averaged. The lowest and highest value for each category was dropped to help normalize the data.

2 Strap Configuration			3 Strap Configuration			
Medic	Chest (pound-force(lbf))	Legs (lbf)	Medic	Chest (lbf)	Pelvis (lbf)	Legs (lbf)
1	10.2	10.8	1	2.2	5.6	6.6
2	9.8	5.2	2	9.6	14.6	3.4
3	8.6	10.2	3	4.8	13.2	13
4	3.8	7.2	4	1.2	4.6	4.4
5	2.4	4.4	5	5.2	1.4	3.2
6	1.6	7.2	6	1.6	5.2	5.8
7	4.2	5.6	7	8.4	15.4	7.6
9	1.2	12	9	1	5.2	1.6
10	6.2	3.2	10	3.6	5.6	5.2
<b>Average</b>	5.2	7.4	<b>Average</b>	3.9	7.7	5.9
<b>SD</b>	3.1	2.8	<b>SD</b>	2.5	4.3	3.3



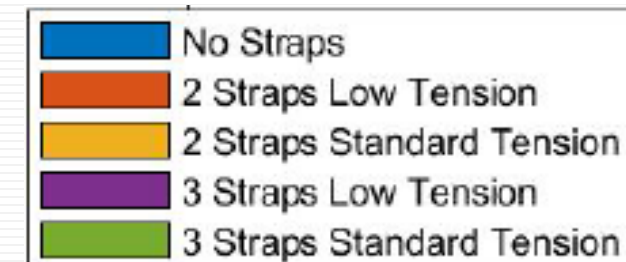
# Results – Phase 2 Manikin Testing



Transmissibility is a transfer function that can be interpreted as the ratio of the output to the input.

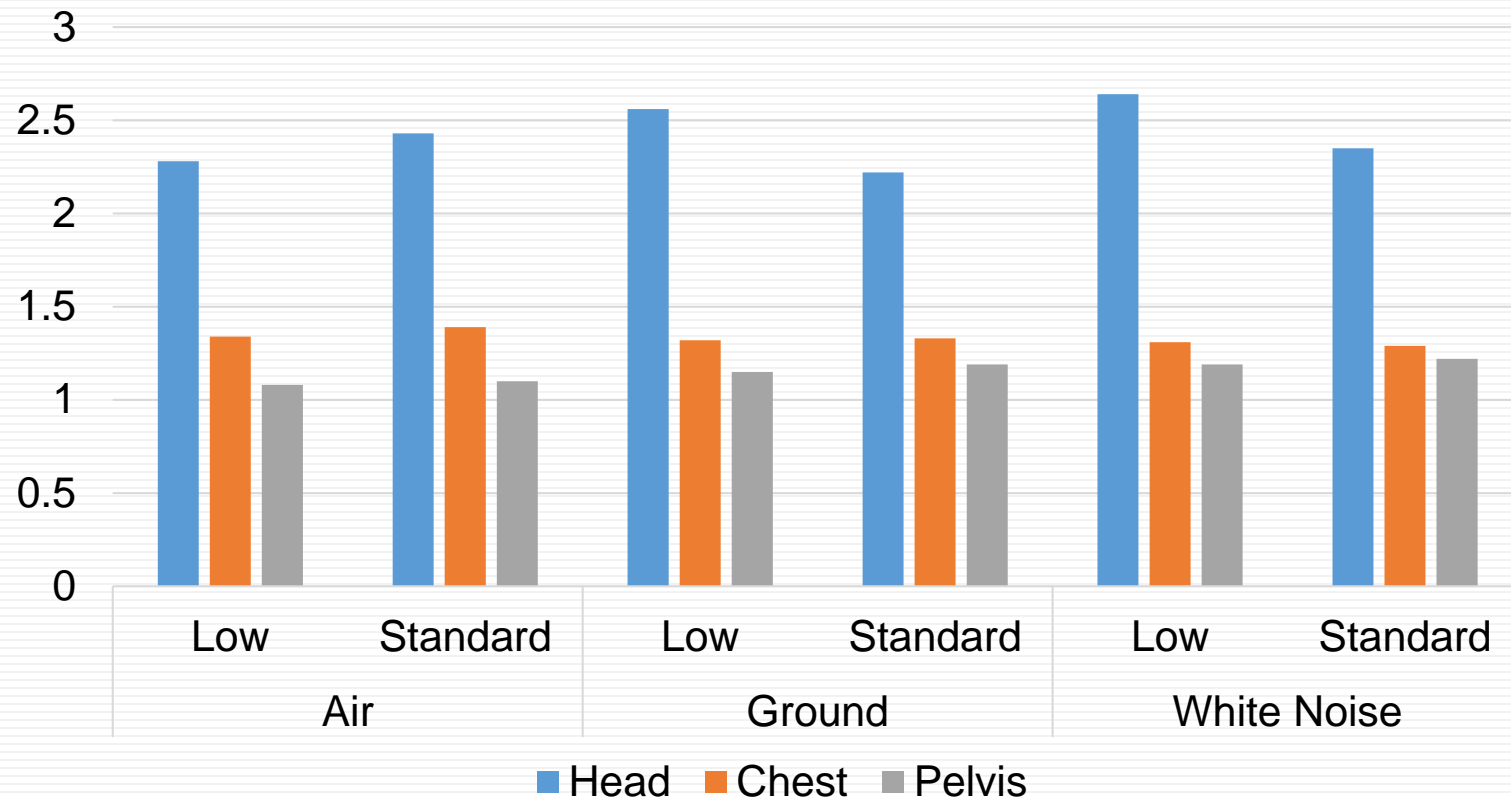
The standard tension reduced the maximum transmissibility in the Ground and White Noise profiles.

Three straps did not always decrease the transmissibility response.





### Maximum Transmissibility



Similar to the manikin testing, the maximum transmissibility was lower with the standard strapping tension for the Ground and White Noise profiles, which consisted of low frequency inputs.



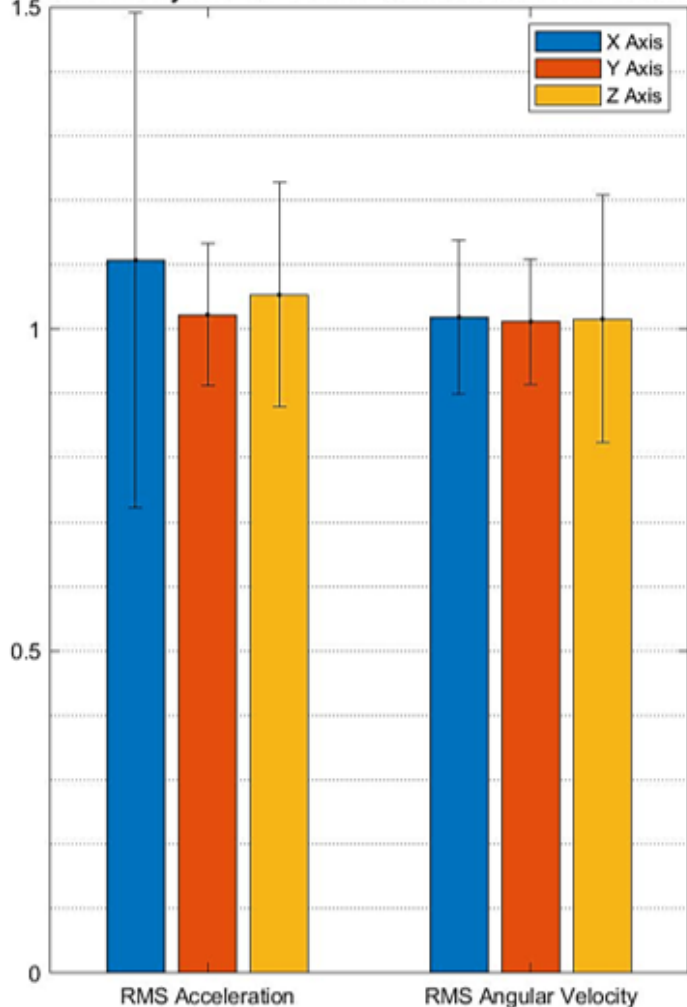
# Results – Phase 3 Human Subject Testing



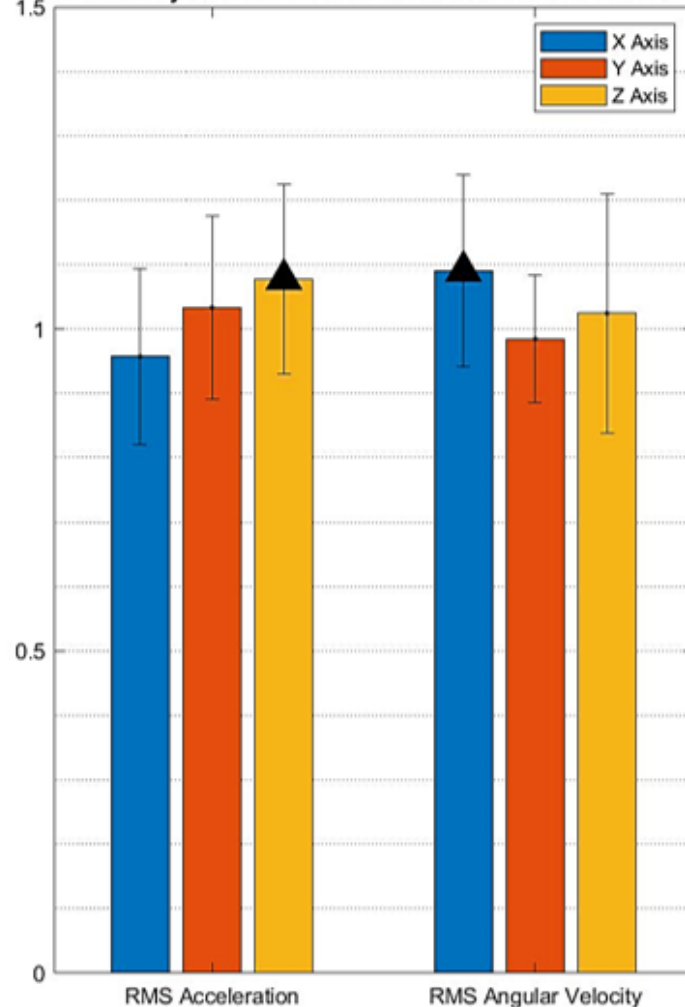
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Human Subjects - Air Profile - Head relative to Chest RMS



Human Subjects - Air Profile - Pelvis relative to Chest RMS



The higher frequency input (Air profile) exhibited an increase in relative segment motion for the low tension condition.

The lower frequency inputs (Ground and White Noise profiles) exhibited either no change or a slight decrease in relative segment motion for the low tension condition.



## Higher frequency input vibration (Air profile and low strapping tension)

- Exhibits slightly lower maximum transmissibility than the standard tension condition
- Also permits more relative segment motion

## Lower frequency input vibration (Ground and White Noise profiles) and low strapping tension

- allows more vibration energy to the head, increasing the head's transmissibility
  - by up to 19%, in the White Noise profile



# Conclusions



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The results suggest the use of standard strapping tension is generally preferable to low tension strapping, since the standard tension produced less absolute and relative body motions.

Further research would need to be completed to see if the reduction in motion improves patient outcomes.



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# Questions?



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