HAND ARM VIBRATION

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Interference of Vibration Exposure in the Force Production

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Purpose of Research: Concepts and Ideas

- Study aimed to evaluate the influence of the mechanical vibration on neuromuscular activation and motor parameters as force production.
- The hypothesis is that vibration exposure can induce early fatigue and unbalanced motor control during a motor task.
- Experimental conditions were: without external vibration and
- vibration at several amplitude levels.
- Grip force exerted was uniform among subjects because scaled respect to individual motor performance.

Material and Methods: Tests

- The tests were performed at 30 Hz at different accelerations with a grip force.
- Moreover 30 Hz is a typical operative tool frequency in different professional activities.
- 30% of the maximum voluntary contraction (MVC).
- The selected frequency represents the frequency inducing maximal hand-arm energy transmission.

Motor Task

- The motor task consisted of holding the instrumented handle with the dominant hand at predetermined grip force values.
- The handle had two strain gauges, measuring push and pull forces.
- The subject had to maintain the target force value for as long as possible.
- The handle was divided into two halves to measure both components of gripping force (push and pull).
- The deformation of the handle resulted in a strain gauge response.
- Continuous control of push and pull forces on an oscilloscope.
- Temperature and humidity are constant values.

Motor Task

- MVC was evaluated as the maximal force between three trials of maximal gripping.
- The subject stood on an elevated platform to adjust the forearm and handle axes.
- The subject was instructed to balance push and pull force to attain pure grip force, reducing other muscular contributions except the forearm one as more as possible.
- The minimum rest period between successive tests was 60 min.




Push-Pull Balance

- 30% of the maximum voluntary contraction (MVC);
- Mean Push Force;
- Mean Pull Force.

$$\Delta G = \frac{MeanPushForce - MeanPullForce}{MVC30\%}$$

Maximum Voluntary Contraction Values

Subject	A	B	C	D	E
Height [cm]	170	167	170	184	181
Weight [kg]	103	72	65	93	88
Gender	M	M	M	M	M
MVC 1 [N]	470	400	380	470	330
MVC 2 [N]	490	430	360	460	310
MVC 3 [N]	490	400	350	450	330
MVC 30% [N]	140	120	110	140	100

Different percentages of MVC tests on the same subject were randomized to avoid hysteresis.

Values of ΔG evaluated on 5 Subjects: Absence and Presence of Vibration

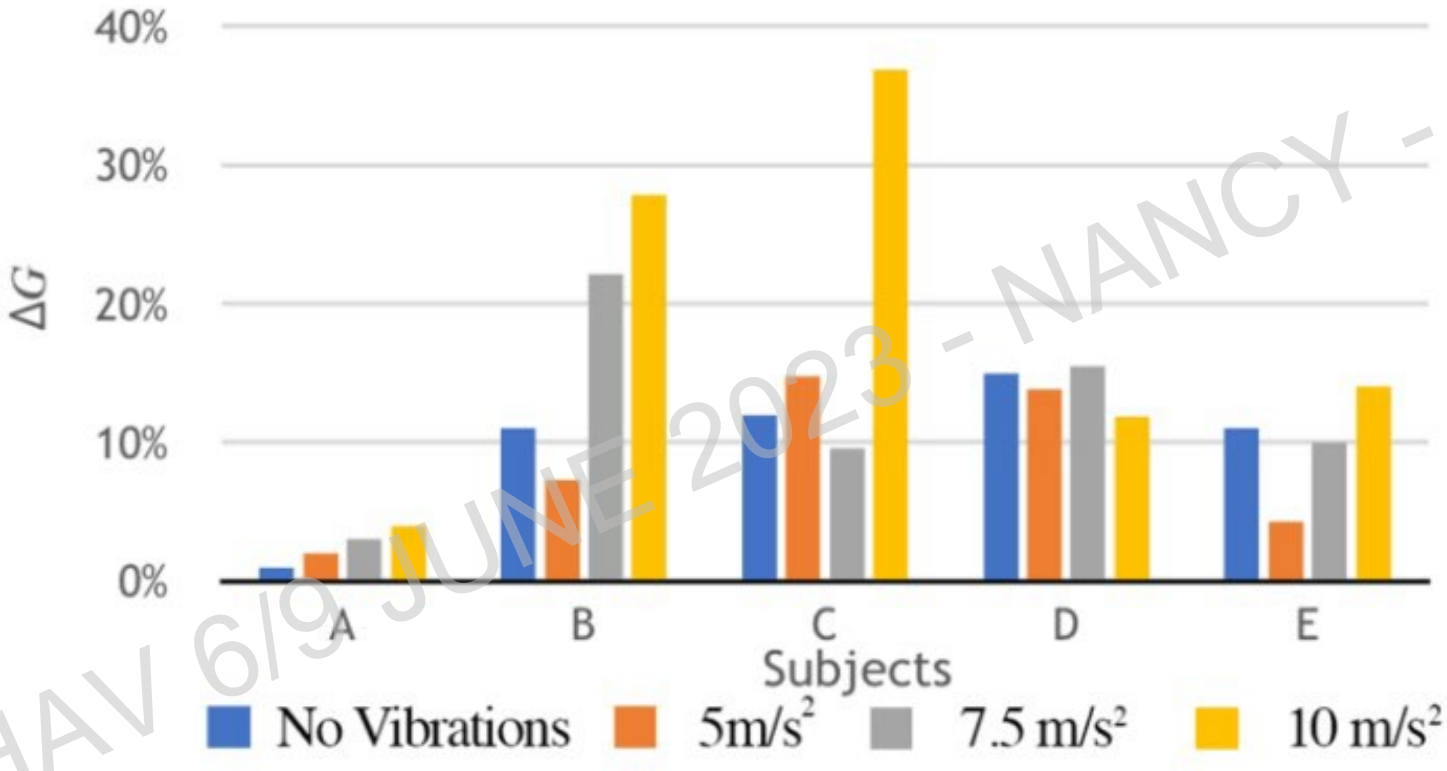

Figure 1. Values of ΔG evaluated on 5 subjects in the absence of vibration and in the presence of vibration with accelerations at 5 m/s^2, 7.5 m/s^2 and 10 m/s^2.

The ΔG value and the Standard Deviation: Absence and Presence of Vibration

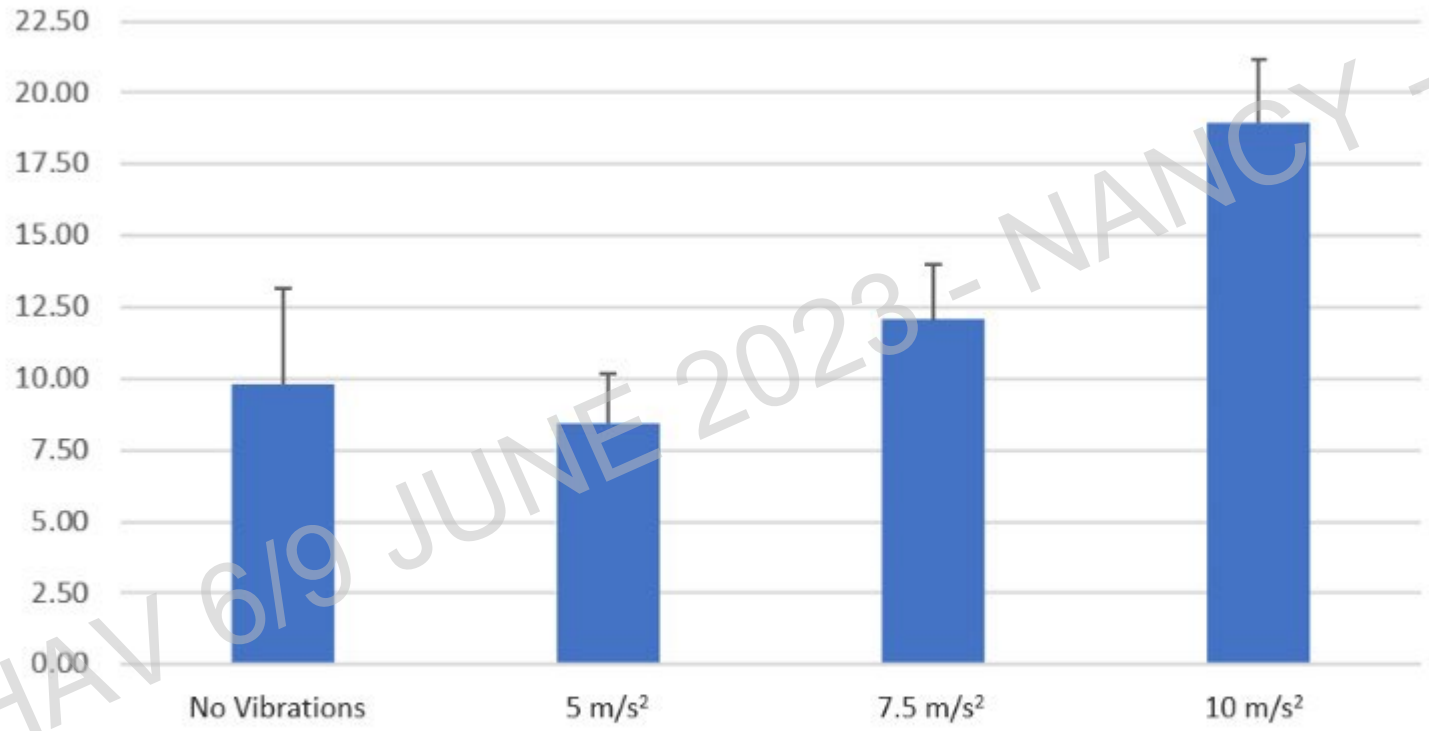

Figure 2. The ΔG value and the standard deviation evaluated in the absence and presence of vibration with accelerations of 5 m/s^2, 7.5 m/s^2 and 10 m/s^2.

The ΔG value and the Standard Deviation

- The nervous system can perform the target task in all conditions but with different muscular interplay engagement.
- We observe a different behavior, an unbalance, of the forearm muscles being responsible for the production of push and pull forces.
- The unbalance is related to the vibration's acceleration

Time of Gripping Maintenance

Subject	No Vibrations	Vibrations		
		5 [m/s^2]	7.5 [m/s^2]	10 [m/s^2]
A	205	146	140	145
B	264	312	242	293
C	288	204	202	280
D	275	307	286	307
E	303	305	302	295

The fatigue results did not show evidence of changes in the time of force exertion with vibration.

Discussion

- In every experimental condition, the nervous system modulates muscular activation of several muscles to maintain grip force as long as possible.
- The force production is a complex task involving the nervous and muscular systems which responds with the contraction.
- The time duration before fatigue is quite unchanged with vibration compared to without vibration.
- The gripping task involves a great number of muscles belonging to different anatomical districts, such as the hand, forearm, arm and shoulder.

Discussion

- Handle vibration evokes a neuromuscular response as the tonic vibration reflex is acting as a sort of interference on the motor drive to gripping.
- Changes in the push and pull force control could be observed by measuring the gripping forces on the handle's palm and fingers.
- Higher handle vibration levels induce a relative increment of push and pull force imbalance.

Conclusion

- Force production parameters, fatigue and push and pull force values were assessed with and without vibration on five subjects.
- Vibration does not seem to influence the fatigue phenomenon because of a neuromuscular rearrangement.
- These changes were recognized by the push and pull balance during the gripping task.
- Data confirm the neuromuscular plasticity involved in adapting the force production in interfering conditions at the dispense of fine muscle control.
- The loss of fine muscle control should be better investigated to monitor muscular integrity.




Thank You
for your kind attention