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Comparative Study of Rivet Gun Vibrations on Riveters with and without a Side Handle

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Abstract: Background/Objective: Power tools have drastically increased the workforce's efficiency since its conception. However, a side effect of most power tools is vibrations applied to the body through the hands. Extended exposure to such vibrations can lead to Hand-arm Vibration Syndrome (HAVS). Approximately two million US workers experience hand-arm vibration in their workplace, and experts predict that around half of them will contract Hand-Arm Vibration Syndrome in the long term. It is therefore imperative to investigate the vibration level experienced by these workers. The objective of this study was to evaluate the effect of adding a second handle to a rivet gun on vibration.

Methods: Four male subjects participated in this experiment. Each participant was made to perform a riveting task on a mounted frame, with an accelerometer sensor attached to the participant's wrist. The accelerometer sensor measured the vibration transmitted from the rivet gun with and without the side handle. Since the right hand was the predominant hand for all participants, the acceleration on the left hand was measured. Comfort ratings of the riveting task with and without the handle were also collected.

Results: Statistical analysis was done using a pooled t-test. The study found that even though there is no statistical difference in the vibrations on the left hand, the participants comfort increased with the addition of a side handle.

Keywords: Vibrations, Rivet gun handle, Riveting

1. Background and Objective

Hand-arm vibration is the transfer of vibration from a tool to a workers' hand, and it is predominant in workers working with or are exposed to high vibrating tools. Approximately two million US workers experience hand-arm vibration in their workplace, and experts predict that around half of them will contract Hand-Arm Vibration Syndrome (HAVS) in the long term (Gerhardsson & Hagberg, 2019). Studies have shown that riveters in aircraft manufacturing are exposed to high vibration levels in the health risk zone, surpassing the Daily Exposure Limit Value (DELV) of 5 m/s^2. It is therefore imperative to reduce the vibration level experienced by these workers.

There have been studies about rivet-gun vibration effects on the hands (Kattel & Fernandez, 1999). These studies tend to focus primarily on health and safety effects from vibrations onto the hands and body. Some studies include hand tool vibrations on the users by Adekunle et al. (2020), protective gloves to reduce vibration from power tools by Milosevic and McConville (2007), and vibrations from hand tools used in the automotive industry by Radwin et al. (1990). However, there is little research on the effects of an extra handle on the tool and its relationship to vibrations on the hands and body. This study evaluates the vibrations from a rivet gun with and without an added side handle for two-hand support and determines differences in vibrations for the different configurations.

2. Methods

This study collected data from four male participants of age ranging 24-27 years. The instructions on the experimental procedures were provided before the start of the experiment. Each participant performed the riveting task on a mounted frame with a diameter of 3/16' and length of 3/8', with an accelerometer sensor attached to the participants' wrist. The accelerometer

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sensor measured the vibration transmitted from the rivet gun with and without the side handles (Figure 1). YOST lab TSS-DL V2 software calibrated the accelerometer sensor to get the orientation and XYZ plane sync.

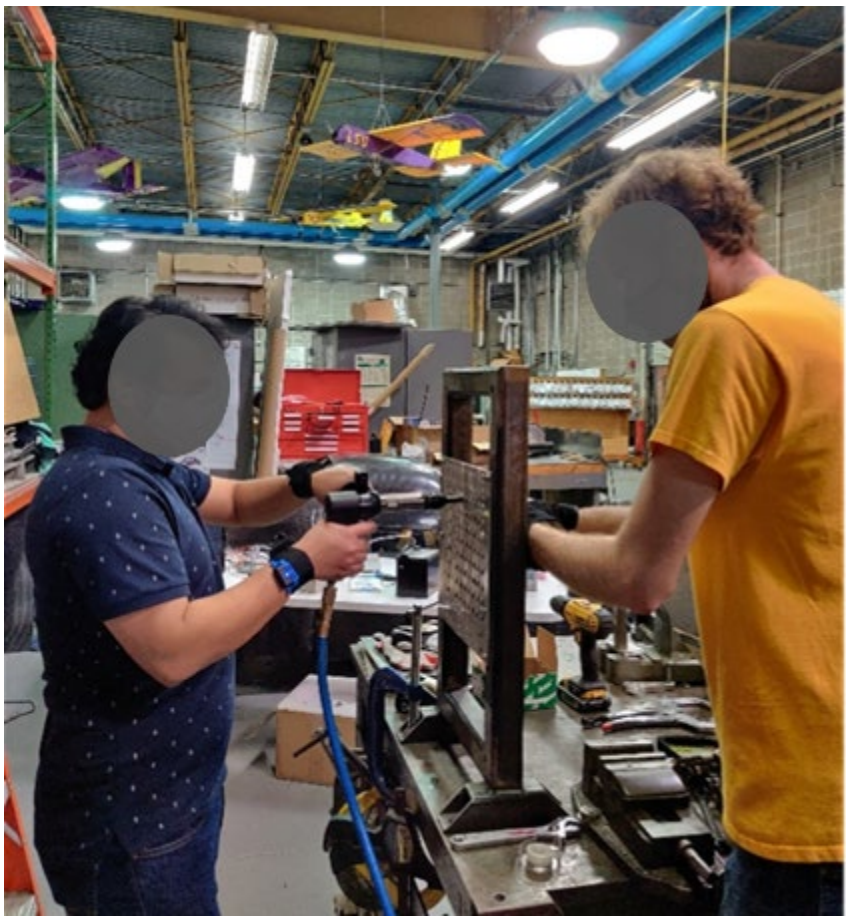

Figure 1. Riveter holding the Rivet gun (Left), bucker (Right)

Since the right hand was the predominant hand for all participants, the acceleration on the left hand was measured by finding the Root Mean Square (RMS) value for each axis (XYZ) with and without the side handle. The experiment required a bucker to push the rivets against the rivet gun as the subject was riveting. After a successful rivet, the riveter would spend about 2 seconds getting in position for the next rivet. This procedure was repeated until a total of 8 rivets had been secured on the riveting sheet. Comfort ratings of the riveting task with and without the handle were also collected.

It is important to note that the operator's left hand assumes a different position depending on if the side handle is attached to the rivet gun. To accommodate the change in wrist orientation, we compared the axes which measure in the same direction. This means that the X-axis with the handle attachment corresponds to the Y-axis without the handle attachment. Therefore, we compare the X-axis with the handle to the Y-axis without the handle. Similarly, we compare the X-axis without the handle to the Y-axis with the handle.

3. Results and Conclusions

A pooled t-test was performed to determine if there was a difference between the RMS values for an axis. The null hypothesis stated that there was no difference between the RMS values for an axis, and the alternative hypothesis stated otherwise. First, the results from the left hand were compared. Comparing the X-axis without the handle to the Y-axis with the

handle, a P-value of 0.2336 was observed, implying there is no statistical significance between conditions. Table 1 shows the respective RMS values for with handle and without handle combinations.

Table 1. RMS Table

	RMS With Handle	RMS With Handle	RMS With Handle	RMS Without Handle	RMS Without Handle	RMS Without Handle
Subject no. and Hand	X Axis	Y Axis	Z Axis	X Axis	Y Axis	Z Axis
1 R	0.776608	0.338082	0.361777	0.763958	0.375563	0.342576
1 L	0.515412	0.716236	0.289712	0.473743	0.758523	0.308914
2 R	0.817101	0.282101	0.35327	0.777399	0.344314	0.349748
2 L	0.241693	0.885495	0.226931	0.832988	0.394641	0.271361
3 R	0.77511	0.349287	0.304716	0.756741	0.383822	0.339523
3 L	0.28616	0.84953	0.238969	0.733093	0.411974	0.304344
4 R	0.714482	0.483081	0.348296	0.819535	0.380484	0.310818
4 L	0.315618	0.823747	0.314155	0.773318	0.440567	0.391362

The calculated percent difference was 15%. The P-value of 0.1756 was observed when comparing the X-axis with the handle to the Y-axis without the handle, implying there is no statistical significance between conditions. The calculated percent difference was 38%. Comparing the Z-axis with the handle to the Z-axis without the handle, a P-value of 0.6935 was observed, implying no statistical significance between conditions. The calculated percent difference was 18%.

Next, the data gathered from the right hand were examined. Comparing the X-axis with the handle to the X-axis without the handle, the P-value of 0.7468 was observed, implying no statistical significance between conditions. The calculated percent difference was 1%. Comparing the Y-axis with the handle to the Y-axis without the handle indicated a P-value of 0.8619, implying there is no statistical significance between conditions. The calculated percent difference was 2%. The comparison between the Z-axis with the handle and the Z-axis without the handle indicated a P-value of 0.6935, implying no statistical significance between conditions. The calculated percent difference was 2%. Comfort level ratings were obtained from the participants on the comfort level they felt during the riveting process (Table 2). The study found that even though there was no statistical difference in the vibrations on the left hand, the participants comfort increased with the addition of a side handle.

Table 2. Comfort Level Rating

Participants	Without Handle	With Handle
1	5	7
2	6	9
3	4	8
4	6	7
Average =	5.25	7.75

The results show that there was no statistical difference between the vibration intensities within the tests. However, the comfort scale and the vibration distribution suggest that the orientation change of the left hand combined with more surface area to hold the equipment and dissipate the vibration transferred from the rivet gun. The setup with the side-handle is recommended for long periods of riveting tasks where the work environment can allow a side handle without interfering in the task to be performed, such as in tight spaces. Further studies may be conducted with different grips and handle positions with alternation of right and left-hand giving rest to the dominant hand to reduce fatigue. Also, different bucking bars combined with handles may be analyzed to determine the difference in vibration intensities that the bucker and riveter experience.

4. References

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