Comparison of the lifting ability of an Artificial Exoskeleton verses an Unaided Arm.

by Sam Watson

Exoskeletons have appeared in science fiction movies for decades but are now a reality and have been tested in both medical and military settings. Exoskeletons are beginning to be sold commercially and are designed to help workers lift and carry objects more easily and to reduce injuries. As this becomes more common it will make a difference in many manual labour jobs and as an aid to an aging workforce. Exoskeletons have been used in rehabilitation; for workers who perform repetitive tasks; and as walking aids.

Aim: To determine if artificially aided human strength, using an exoskeleton, is stronger than human strength alone.

Hypothesis: The use of the artificial exoskeleton will enable weights to be lifted for a longer period of time, in comparison to an unaided arm.

Risk assessment:

Possible risks and precautions taken:

1. Over pressurised muscles, may cause explosions:

   Pressure release valves will be in place to vent excess pressure. Glasses and earmuffs will be used during testing.

2. Weights may be too heavy to be properly held by the individual:

   A support/spotter will be used to help control weights

3. Muscle fatigue:

   At least 30mins rest between lifting of weights.

Materials:

Exoskeleton

- Aluminium rectangle tube 25 mm x 10 mm
- Aluminium flat bar 25mm x 2mm
- Rivets
- Drill
- Drill bits
- T piece hose connectors
- Clear hose
- Cable ties
- Flexo electronics cable management sheathing
- Elastic, silicone medical tubing
- Hose clamps
- Foam matting

Air compressor

Weights to be used for testing: 5kg, 10kg, 15kg, 20kg, 25kg, 30kg, 35kg

Stop watch

Exoskeleton

Method:

1. Using an un-aided arm as a control, the length of time (mins:secs)(dependent variable) in which varying weights (independent variable) (5kg, 10kg, 15kg, 20kg, 25kg, 30kg and 35kg) could be lifted was recorded using a stopwatch. The arm was held at a 45 degree angle (from the elbow) ie. the weight was held at this angle until the arm needed to lower.
2. If the weight was held for 10 mins or more then the time was recorded as >10mins.
3. Each weight was lifted 3 times, with at least 30 minutes recovery time allowed between lifts. Results were recorded and tabulated.
4. The process was repeated with an arm being actively aided by an exoskeleton. Results were recorded and tabulated.

Results

Table 1: Length of time weight is lifted by Unaided arm

Weight	Time 1 (mins:sec)	Time 2 (mins:secs)	Time 3 (mins:secs)	Average time (mins:sec)
5kg	5:45	5:30	5:50	5:42
10kg	3:35	3:54	3:43	3:44
15kg	1:28	1:38	1:42	1:36
20kg	0:30	0:46	0:36	0:37
25kg	0:24	0:30	0:28	0:27
30kg	0:14	0:18	0:20	0:17
35kg	0:07	0:12	0:14	0:11

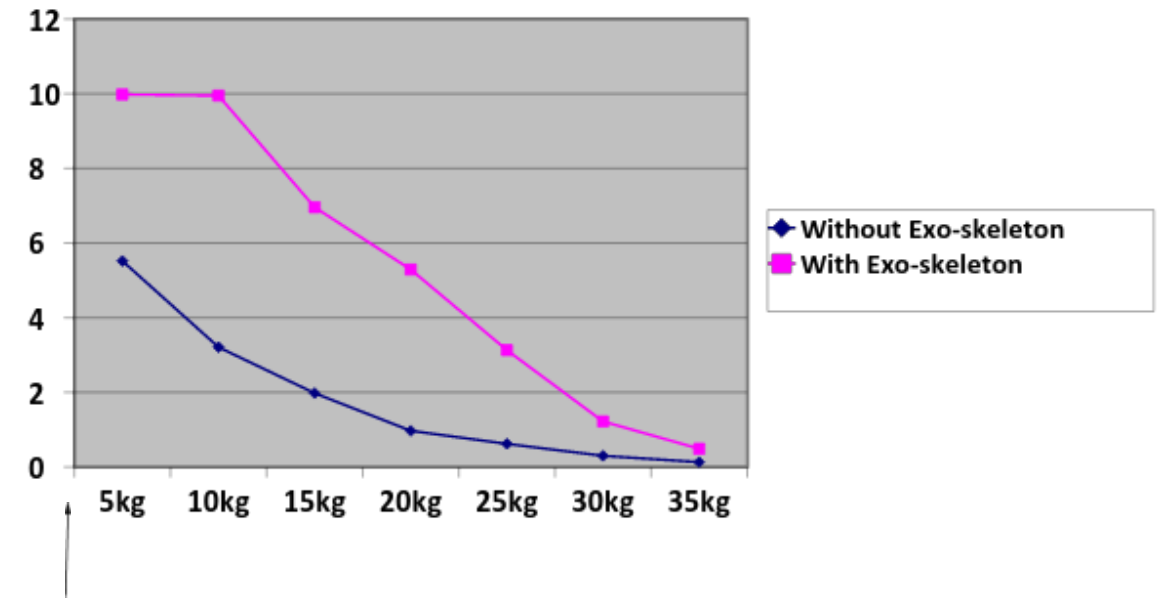
Table 2: Length of time weight is lifted by Aided-Arm

Weight	Time 1 (mins:sec)	Time 2 (min:sec)	Time 3 (min:sec)	Average time (min:sec)
5kg	Infinite (no strain)	Infinite (no strain)	Infinite (no strain)	Infinite (no strain)
10kg	Infinite (no strain)	Infinite (no strain)	Infinite (no strain)	Infinite (no strain)
15kg	7:00	7:15	6:54	7:03
20kg	5:40	5:32	5:50	5:41
25kg	2:30	2:15	2:36	2:27
30kg	1:32	1:50	1:43	1:42
35kg	0:24	0:27	0:32	0:28

Table 3: A comparison of Aided and unaided arm averages and differences

Weight	Average Time held without exoskeleton (mins:sec)	Average time held with exoskeleton (mins:sec)	Difference (mins:sec)
5kg	5:42	Infinite (no strain) > 10 Minutes	Infinite
10kg	3:44	Infinite (no strain) >10 Minutes	infinite
15kg	1:36	7:03	5:27
20kg	0:37	5:41	5:03
25kg	0:27	2:27	2:00
30kg	0:17	1:42	1:25
35kg	0:11	0:28	0:17

Graph 1: A comparison of average length of time weights can be lifted between aided and unaided arm.



Discussion:

The lifting of weights with the unaided arm, show that the length of time the weights could be supported was considerably less than when the exoskeleton was used as an aid (Table 1. and Table 2.). The results show that the exoskeleton greatly improves performance, reducing muscle fatigue by over half. To try to reduce muscle fatigue, measurements were taken with at least a 30 minute interval between lifts.

We were limited to using a single subject as the mechanical arm was not adjustable and would only fit a certain sized arm. As as result, replication was used to improve the accuracy of the experiment. Results would be far more accurate if more participants could be used. The experiment was also subjective as it relied on the person lowering the weight when they thought the weight was too heavy. The repetition of results also to tried to reduce this variability.

Three repetitions for each weight was used, then the results were averaged. The comparison of average length of time weights can be lifted between aided and unaided arm (Table 3 and Graph 1) shows that the artificially aided arm was able to lift the required weights for, on average, over twice the time that the unaided arm was able to achieve. The mechanical arm was less of an aid when weights above 20 kg were lifted and showed little difference in lifting 35kg.

Conclusion:

The results support the hypothesis that the use of the artificial exoskeleton will enable weights to be lifted for a longer period of time, in comparison to an unaided arm. They also demonstrate the importance of exoskeletons now and into the future as an aid to manual lifting and manoeuvrability of everyone, from builders, military personnel and even the elderly.

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Fitted Exoskeleton

Appendices – log book with raw data, table etc.

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