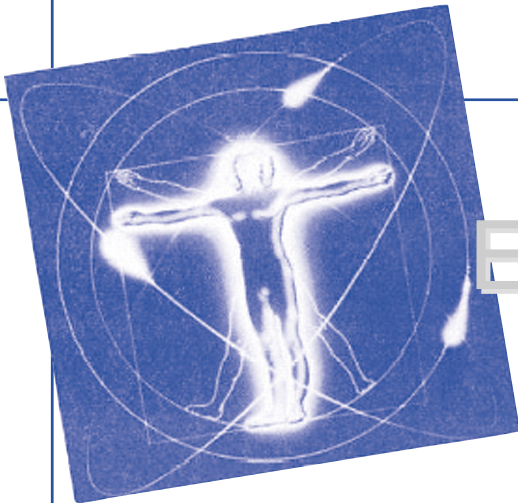


Executive Summary

Ergonomic Lifting Study:

Using Intelligent Assist Devices to Increase Productivity & Reduce Product Damage

The Study

The following summary is based on a study performed by the **Rochester Institute of Technology**. The complete study is available by contacting Gorbel at (800) 821-0086 or at *www.gorbel.com/gforce/study*.

The study compared the performance of Gorbel's G-Force™ Intelligent Lifting Device to manual lifting, an air balancer with pendant control, a variable frequency chain hoist, an electric balancer and an air balancer with electric controls.

The study focused on performance of these devices in the following applications:
High Cycle Applications
- Productivity
- Energy expenditure

Precision Placements
- Productivity
- Energy expenditure
- Potential for product damage

Quick Change in Direction (Inertia Management)
- Handling force required to reverse direction

The subjects simulated high cycle and precision placement tasks typically performed with lifting devices. Subjects were instructed to work as fast as reasonably possible while keeping their heart rate in a target region of 45-55% of their maximum heart rate, which is considered to be a safe working pace.

GORBEL
A CLASS ABOVE

High Cycle Test

To test each lifting device in a high cycle application, a typical palletizing application that one might find in a warehouse or factory was simulated. Each subject lifted a 45 lb. weight from one position to a position 3' away as many times as they could in a ten minute period.

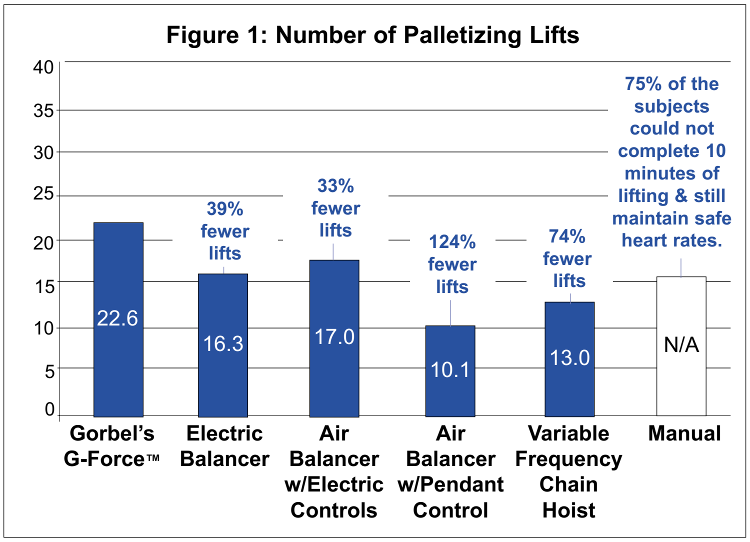
This palletizing application was studied to show the workload associated with repeated manual lifting and to illustrate the extent to which different lifting devices could increase the number of lifts possible while maintaining the energy expended (in order to stay within safe ergonomic lifting parameters).

Productivity

Figure 1: Number of Palletizing Lifts shows the average number of lifts attained with each device while maintaining a constant work load. Subjects wore a heart rate monitor to insure they were working within a safe and comfortable range of 45-55% of their maximum heart rate.[1]

The numbers in blue on Figure 1 show the difference between the number of lifts achieved with the G-Force™ and the number achieved with each particular lifting device.

Operators were an average of 68% more productive with G-Force™ than with the other methods.



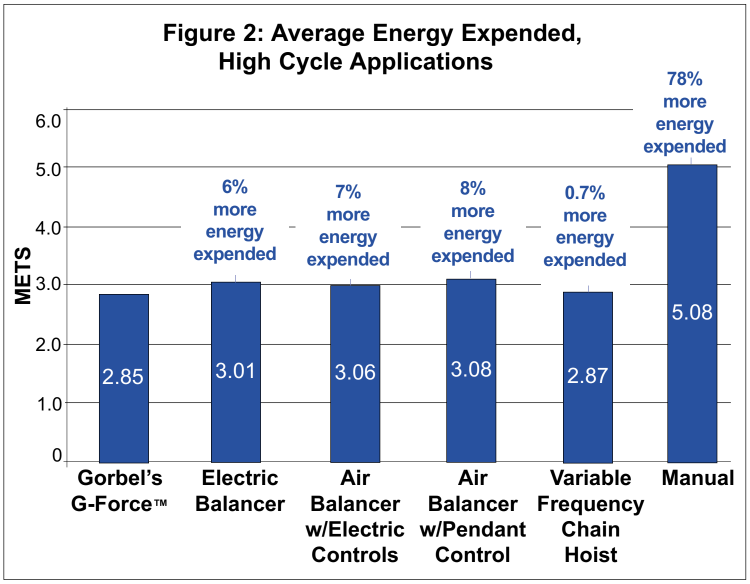
Energy Expenditure

Energy was measured through use of a Sensor Medics system that measured breath by breath energy expenditure for each subject during lifting. Energy was measured in Metabolic Equivalents (METS), which are a measure of how far (as a multiple) the energy expenditure for a certain activity exceeds the resting metabolic rate. In addition to the five lifting devices, subjects performed manual lifting. **Figure 2** shows the average energy expenditure.

The numbers in blue on Figure 2 show the difference between the energy expended with the G-Force™ and the energy expended with each particular lifting device.

On average, manual lifting required 78% more energy than the lifting devices.

G-Force™ required the least amount of energy among the lifting devices.



High Cycle Conclusions:

- **Manual lifting required 78% more energy expenditure than G-Force™ and the other lifting devices.**
- **Operators were an average of 68% more productive with the G-Force™ while exerting approximately the same energy as with the other lifting devices.**

[1]Visit our website at www.gorbel.com/gforce/study for further explanation of this and other components of this study.

Precision Placement Test

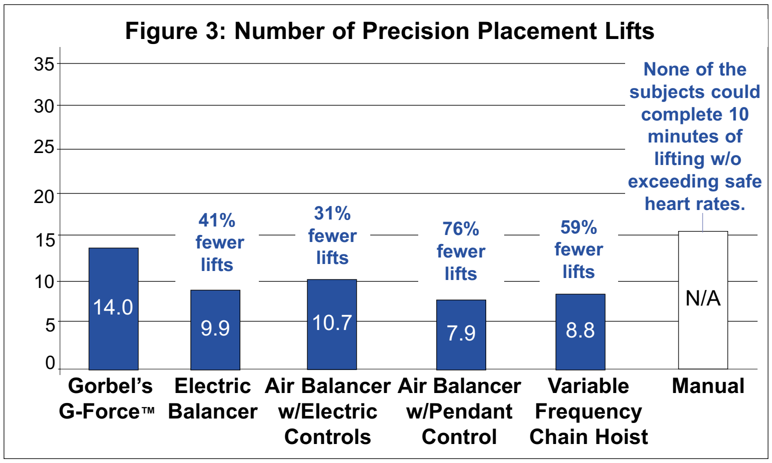
Many precision placement applications require placing a load as gently as possible to prevent damage to the load. To simulate this, subjects picked up a 45 lb. weight and placed it on a table top target 3' away. Underneath the target was a force plate that measured the force at impact.

Productivity

Figure 3: Number of Precision Placement Lifts shows the average number of lifts attained with each device while maintaining a constant work load. Subjects wore a heart rate monitor to ensure they were working within the safe range of 45-55% of their maximum heart rate.

The blue numbers in Figure 3 show the difference between the number of lifts achieved with the G-Force™ and the other lifting methods.

Operators were 51% more productive with the G-Force™ than with the other products.

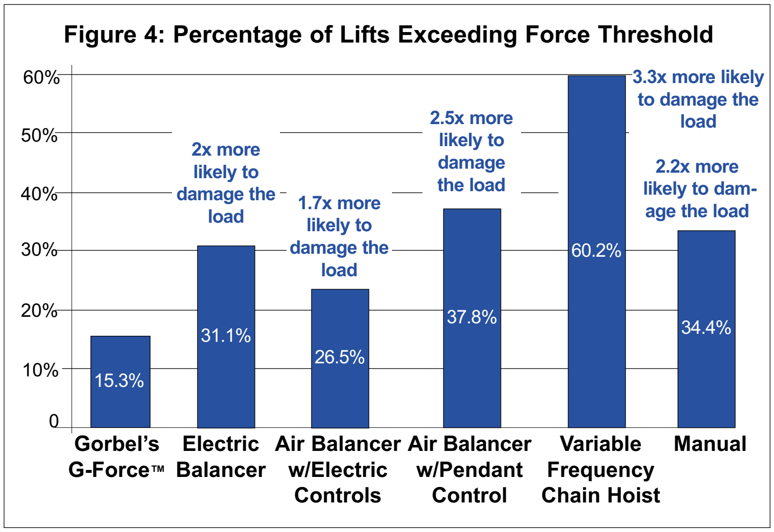


Force of Placement

A force measuring system integrated into the target measured the peak impact force of each load placement. A damage impact threshold of 1.5 times the weight of the load was computed and the number of impact forces exceeding that threshold were counted for each device. The damage impact threshold for the 45 lb. load used in the study is 67.5 lbs. **Figure 4** shows the percentage of lifts that exceeded that threshold.

The blue numbers in Figure 4 show the likelihood of the other lifting methods to damage the load as compared to the G-Force™.

The G-Force™ was 2.5 times less likely to damage the load than the other devices.

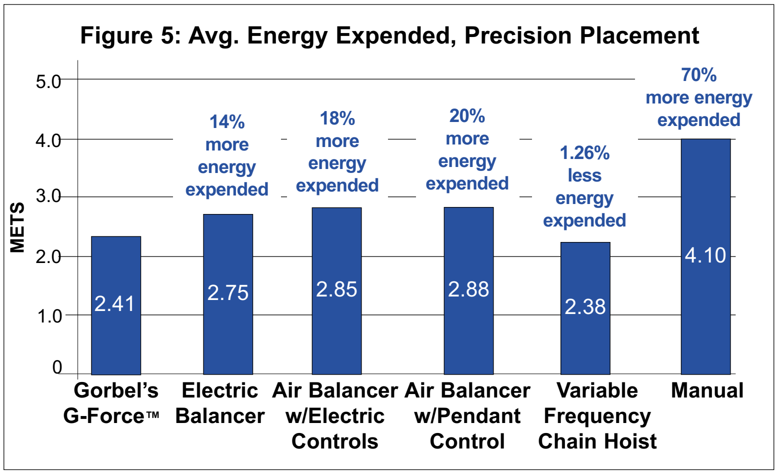


Energy Expenditure

Energy was measured through use of a Sensor Medics system that measured breath by breath energy expenditure for each subject. In addition to the five lifting devices, subjects performed manual lifting in this simulation. See **Figure 5** for the results.

The blue numbers on Figure 5 show the difference between the energy expended with G-Force™ compared to each particular lifting device.

Manual lifting required an average of 70% more energy than the lifting devices.



Precision Placement Conclusions:

- **Operators were an average of 51% more productive with the G-Force™.**
- **G-Force™ was an average of 2.5 times less likely to damage the load than the other devices.**
- **Manual lifting required 70% more energy than the lifting devices.**

Inertia Management Test

The final part of the study measured the handling forces involved in overcoming the inertia required to change the direction of a load being raised or lowered.

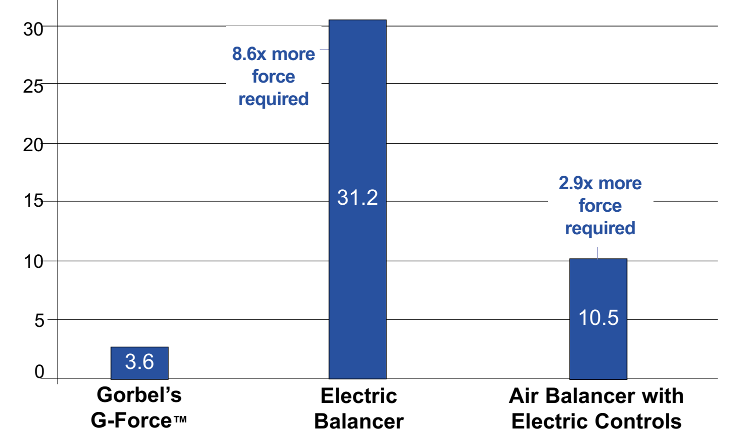
Reversing Load Direction

The force required to change load direction from down to up and from up to down was measured for the G-Force™, the electronic balancer and the air balancer with electric controls. The average force required to change directions is shown in **Figure 6: Force to Reverse Direction**.

The numbers in blue on Figure 6 show the difference between the force required to reverse direction with the G-Force™ compared to the force required with the other devices.

G-Force™ required an average of 5.8 times less handling force to reverse load direction than the other devices studied in this test.

Figure 6: Force (in pounds) to Reverse Direction



Inertia Management Conclusions:

Compared to the electric balancer and air balancer with electric controls, G-Force™ required:

- **An average of 5.8 times less handling force to reverse load direction**

Study Conclusions

High Cycle Applications:

- G-Force™ and other lifting devices require 78% less energy expenditure than manual lifting. And while maintaining the same average energy expenditure as the other lifting devices, operators were 68% more productive with G-Force™.

Precision Placement Applications:

- G-Force™ and the other lifting devices require 70% less energy than manual lifting. G-Force™ excelled above the other lifting devices by being 51% more productive and 2.5 times less likely to damage the load.

Inertia Management:

- G-Force™ requires the least amount of handling force to reverse load direction - saving your operators from the damaging physical strain these direction changes can have on their bodies.

For More Information

- For the full 23 page study, call us toll free at (800) 821-0086 (US and Canada) or (585) 924-6262
- You can also download the annotated PDF file with additional explanations from www.gorbel.com/gforce/study
- To request a free G-Force™ color brochure or to arrange a local demonstration, call (800) 821-0086 or (585) 924-6262

Gorbel Inc.
600 Fishers Run
Fishers, NY 14453