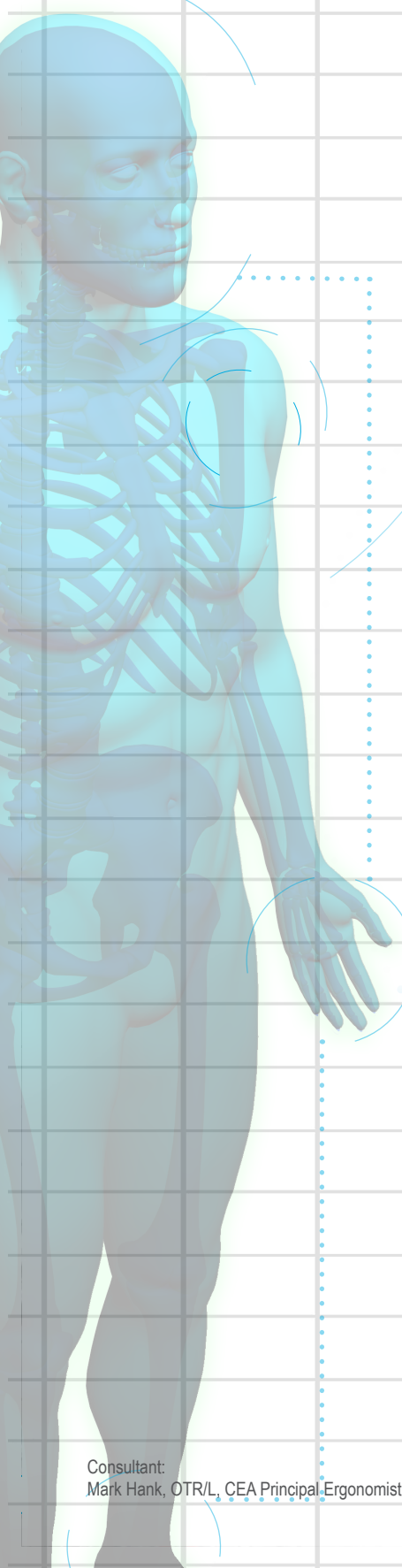

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ERGONOMICS

Cart Based Manual Material Handling

cannon EQUIPMENT

Consultant:
Mark Hank, OTR/L, CEA Principal Ergonomist at Eucentra Consulting

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Introduction

Wheeled carts are used in virtually every industry serving a variety of transportation & distribution purposes. Operating in most manufacturing, distribution facilities and retail locations, these wheeled carts are often unassuming and overlooked, but are an integral component of efficiency and personnel safety. From the manufacturing floor, to the back of 18-wheel tractor trailers, and the store backroom, wheeled carts support each step of the distribution cycle.

In total we estimate that there are currently over 1 million **CannonCarts®** in operation throughout the world. While there aren't documented ergonomic standards for wheeled cart use, **CannonCart®** engineers have taken the principles of basic ergonomics and integrated them into each and every **CannonCart®.**

The following white paper illustrates the importance of ergonomics in wheeled cart based manual material handling systems, and is designed to give the reader a brief overview of ergonomics, wheeled carts and just how much ergonomics is a factor in the design process of **CannonCarts®** .

Background

What is Ergonomics?

The origin of the word ergonomics comes from the Greek words, "*ergon*" which means "*work*" and "*nomos*", which means "the study of". Today Ergonomics is best defined as "the study of the interaction of *people* with their *work environment*". This includes not only the physical space we work in, but also the furniture, equipment, tools and machines that are used to complete essential work tasks. Today, more than ever, employers have begun to develop ergonomic initiatives because they see the advantage of how operating in an ergonomically based manner brings benefits to their employees and the company.

In the old economy of the mid-19th century and earlier, people worked primarily for themselves as farmers or service providers (blacksmiths, store keepers, etc.) or clerks and laborers in small enterprises. People were able to make many of their own decisions about when to work, how long to work and how much to produce. Consequently the volume was low and concern over productivity was minimal.

The industrial revolution changed work environments and the demands made by employers on the workers. Now workers were expected to do more and faster, in work environments that were inefficient and dangerous. While the push to "do more, faster" has not changed since the late 19th century, work environments have improved dramatically, which can be attributed to an increased understanding of safety and ergonomics.

Ergonomics principles developed as a means of improving work efficiency after factories became more prevalent (post-industrial revolution). Industrial engineers, with a goal of improving manufacturing facilities, began using ergonomics principles in the 1950's. Since then the principles of ergonomics have been used as a means of improving job safety as well as efficiency. Technically speaking, designing something ergonomically means that the item is designed to accommodate 5% Female - 95% male users.

Elements Affecting Ergonomics

Posture, tools, tasks, equipment and movement are all elements affecting ergonomics. How these elements interact with each other affects the positive or negative outcomes of performing any given task. Aligning these elements correctly creates ergonomically accurate tasks.

<u>Posture</u>

Ergonomics is most closely associated with personal posture. More importantly how posture relates to varied work environments and the level at which people are able to maintain a comfortable posture during performing the required task. Ergonomically comfortable postures are known as "neutral postures".

"Neutral Posture" refers to the resting position of each joint-the position in which there is the least tension or pressure on nerves, tendons, muscles and bones. It is also the position in which muscles are at their resting length neither contracted nor stretched. Muscles at this length can develop maximum force most efficiently. One aspect of ergonomic redesign is the reworking of tools, work stations and processes to allow the worker's joints to remain in neutral position as much as possible" – *Nicholas Warren , MS, MAT, ScD and Timothy F. Morse, PhD, ErgoCenter, UConn Health Center*

These "neutral postures" are characterized by an upright spine, the absence of twisting or rotation, minimal reach distances, and limbs that remain close to the body's core.

Opposite to "neutral postures" are "static postures" where the environment, tools and tasks predispose people to use awkward postures.

"Static postures (or "static loading") refer to physical exertion in which the same posture or position is held throughout the exertion. These types of exertions put increased loads or forces on the muscles and tendons, which contributes to fatigue. This occurs because not moving impedes the flow of blood that is needed to bring nutrients to the muscles and to carry away the waste products of muscle metabolism. Examples of static postures include gripping tools that cannot be put down, holding the arms out or up to perform tasks, or standing in one place for prolonged periods." – *Iowa State University*

These "static postures" are characterized by body postures being outside of "neutral" position. The spine is not upright but bent awkwardly (forward, to the side, or rotated) and a lack of movement for several minutes. Also, the extremities may be positioned away from the body for a lengthy duration of time.

Tools, Tasks and Equipment

Neither a tool, task or piece of equipment should require excessive force of any kind; in fact the mechanics of the tool or equipment should ease the physical demands on the operator. Excessive force is defined as any force greater than 15% of a person's maximal voluntary effort (physical effort) which creates a potential for fatigue and injury. There is a wide range of locations where excessive forces can occur, for the purpose of this paper, we have developed examples that relate directly to excessive force and wheeled carts.

Forceful Gripping *Forceful Pushing* *Forceful Turning* *Lifting/ Bending*

Additionally, there are ways to reduce the need to use excessive force. Some methods include making adjustments to fixtures that allow operations and movements to be more easily made, efficient location or placement of containers/racking and to install mechanical powered devices that eliminate the need for excessive manual force.

Movement

Ergonomics also incorporates knowledge of the human body; its strength, movements, capabilities and limitations. In order to understand these areas, we will address them individually.

Normal capacity for strength

While the capacity for physical work varies, maintaining work tasks that are within reasonable physical exertion are essential to workplace safety and efficiency. Dr.s Snook and Ciriello of Harvard University and the Liberty Mutual Research Institute for Safety developed multiple tables that help to evaluate tasks requiring manual handling such as lifting, lowering, pushing, pulling and carrying tasks. Snook and Ciriello found this information could be broken out according to segments of the industrial workforce according to population percentages that are able to perform such physical tasks (for more information regarding Snook and Ciriello, please visit www.libertymutualgroup.com). What these tables demonstrate is the initial push forces and sustained forces that are acceptable for 90% of all female workers (and therefore, most males).

Normal capacity for motion

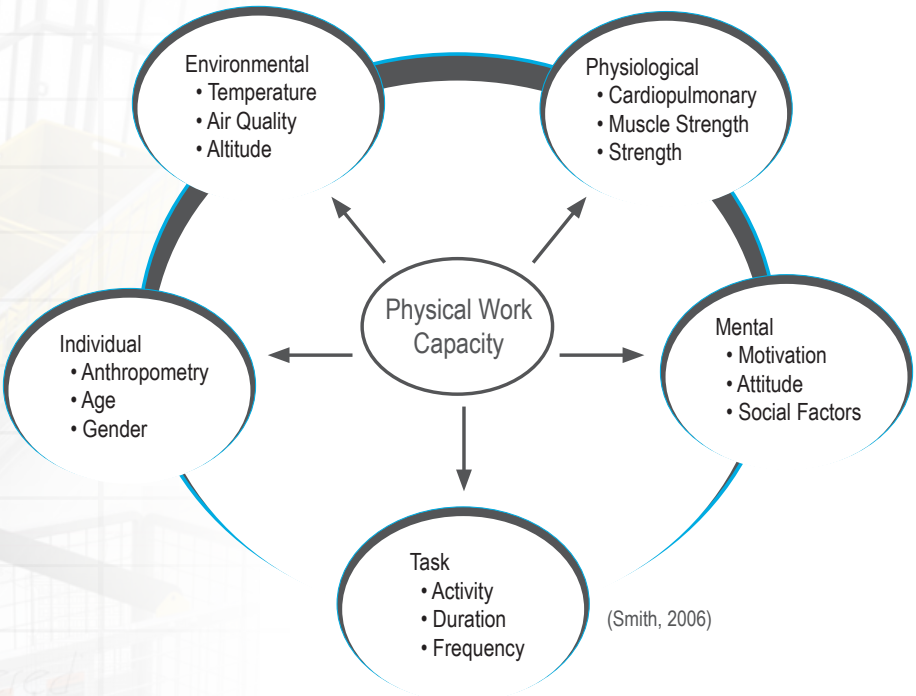
Range of motion refers to the amount of movement that a particular joint or body part can move measured in degrees. The normal human range of movement about the various joints and limbs is well-known, documented, settled scientific information. Tasks that would require movement outside the normal range of motion are easily the most un-ergonomic tasks and should be identified and resolved immediately. The particular task can be engineered to reduce the required physical range of motion or an equipment solution can be developed.

Normal capacity for doing physical work

Physical work capacity (PWC) refers to a physiological limit of human capabilities (Smith, 2006). For instance, physical work capacity is reduced in environments that are too hot or cold. Exhaustion, heat stroke, hypothermia are all physically limiting factors. Additionally, when work hours/shift hours are increased or there is overtime, our ability to perform the same level of physical work diminishes. Many military branches have developed specific work-rest cycles based on environment, workload and the protective equipment required. What these charts reflect is the allowable work time based on various conditions.

Limitations

Once humans are stretch beyond their normal range of motion and/or past their physical work capabilities, there is greater risk of injury. Humans are limited by these factors. Some tasks should be performed by machines because the task is too repetitive, too strenuous, or requires a level of precision that cannot be consistently done by a person. Additionally, some tasks are just too dangerous or hazardous to be done safely by anyone, while other tasks would take too long if performed by a person.



(Smith, 2006)

Benefits of **CannonCarts®**

Example: Moving heavy, irregular shaped products/materials by hand is more time-consuming and more strenuous than using a wheeled cart.

- Use of a cart allows a person to load and move more material safely than lifting and carrying the same amount of material
- Using a cart is a more efficient means of moving materials because the cart can hold more than the human arms/hands
- The cart bears the load the person would have had to bear without the cart

Range of Motion

Age 9–19		
Motion	**Females**	**Males**
Hip extension	20.5 (18.6 – 22.4)	18.2 (16.6 – 19.8)
Hip flexion	134.9 (133.0 – 136.8)	135.2 (133.0 – 137.4)
Knee flexion	142.3 (140.8 – 143.8)	142.2 (140.4 – 144.0)
Knee extension	2.4 (1.5 – 3.3)	1.8 (0.9 – 2.7)
Ankle dorsiflexion	17.3 (15.6 – 19.0)	16.3 (14.9 – 17.7)
Ankle plantar flexion	57.3 (54.8 – 59.8)	52.8 (50.8 – 54.8)
Shoulder flexion	171.8 (169.8 – 173.8)	170.9 (169.1 – 172.7)
Elbow flexion	149.7 (148.5 – 150.9)	148.3 (146.8 – 149.8)
Elbow extension	6.4 (4.7 – 8.1)	5.3 (3.6 – 7.0)
Elbow pronation	81.2 (79.6 – 82.8)	79.8 (77.8 – 81.8)
Elbow supination	90.0 (88.0 – 92.0)	87.8 (85.7 – 89.9)

Age 20–44		
Motion	**Females**	**Males**
Hip extension	18.1 (17.0 – 19.2)	17.4 (16.3 – 18.5)
Hip flexion	133.8 (132.5 – 135.1)	130.4 (129.0 – 131.8)
Knee flexion	141.9 (140.9 – 142.9)	137.7 (136.5 – 138.9)
Knee extension	1.6 (1.1 – 2.1)	1.0 (0.6 – 1.4)
Ankle dorsiflexion	13.8 (12.9 – 14.7)	12.7 (11.6 – 13.8)
Ankle plantar flexion	62.1 (60.6 – 63.6)	54.6 (53.2 – 56.0)
Shoulder flexion	172.0 (170.9 – 173.1)	168.8 (167.3 – 170.3)
Elbow flexion	150.0 (149.1 – 150.9)	144.6 (143.6 – 145.6)
Elbow extension	4.7 (3.9 – 5.5)	0.8 (0.1 – 1.5)
Elbow pronation	82.0 (81.0 – 83.0)	76.9 (75.6 – 78.2)
Elbow supination	90.6 (89.2 – 92.0)	85.0 (83.8 – 86.2)

Age 45–69		
Motion	**Females**	**Males**
Hip extension	16.7 (15.5 – 17.9)	13.5 (12.5 – 14.5)
Hip flexion	130.8 (129.2 – 132.4)	127.2 (125.7 – 128.7)
Knee flexion	137.8 (136.5 – 139.1)	132.9 (131.6 – 134.2)
Knee extension	1.2 (0.7 – 1.7)	0.5 (0.1 – 0.9)
Ankle dorsiflexion	11.6 (10.6 – 12.6)	11.9 (10.9 – 12.9)
Ankle plantar flexion	56.5 (55.0 – 58.0)	49.4 (47.7 – 51.1)
Shoulder flexion	168.1 (166.7 – 169.5)	164.0 (162.3 – 165.7)
Elbow flexion	148.3 (147.3 – 149.3)	143.5 (142.3 – 144.7)
Elbow extension	3.6 (2.6 – 4.6)	-0.7 (-1.5 – 0.1)
Elbow pronation	80.8 (79.7 – 81.9)	77.7 (76.5 – 78.9)
Elbow supination	87.2 (86.0 – 88.4)	82.4 (80.9 – 83.9)

(Center for Disease Control and Prevention, 2010)

Manual Material Handling

A critical part of industry today - manual material handling, affects nearly all industries and is a component of the product distribution system throughout the world. Each product requires handling in a special manner to get an item from point A to point B, as such, more and more companies are looking at ways to make this cycle more efficient, safe, and ergonomically designed.

What Poor Ergonomics Means To You

According to the Material Handling Industry of America (MHIA), manual material handling work contributes to a large percentage of the over half a million cases of musculoskeletal disorders (MSDs) reported annually in the United States. The rate of occurrences and costs of work-related musculoskeletal disorders (MSDs) vary by profession and industry but we know that costs associated with these injuries will rise if the injuries involve time away from work (also known as LTA - loss time accidents), extensive medical treatment or surgery. Costs to employers include, absenteeism, lost productivity, increased health care, disability and workers compensation costs. Costs to the employee include lost time, lost earnings, and lost enjoyment of their leisure time. These costs are the driver for workplace safety and ergonomics programs. The total direct and indirect costs associated with these injuries and illnesses were estimated to be $155.5 billion, or nearly 3 percent of gross domestic product (Leigh, J.P et al. 2000).

The Center For Disease Control and Prevention lists the following data relating to MSD costs.

1. Musculoskeletal disorders account for nearly 70 million physician office visits in the United States annually, and an estimated 130 million total health care encounters including outpatient, hospital, and emergency room visits (National Center for Health Statistics, 2009).
2. The Institute of Medicine estimates of the economic burden of MSDs, as measured by compensation costs, lost wages, and lost productivity, are between $45 and $54 billion annually (National Center for Health Statistics, 2009).
3. The Bureau of Labor Statistics reported 26,794 Carpal tunnel syndrome cases involving days away from work in 2001(Kaiser Family Foundation and Health Research and Educational Trust. 2010).
4. In 2001, the Bureau of Labor Statistics reported 372,683 back injury cases involving days away from work (Stewart, W.F et. al, 2003).
5. In 2003, the total cost for arthritis conditions was $128 billion—$81 billion in direct costs and $47 billion in indirect costs (Toose M., 2009).

Although there are risks associated with manual material handling, some tasks need to be done by hand due to practical or financial considerations; handling product with carts may be a more realistic than other means (i.e. conveyor systems, robotics, pallets). Wheeled carts permit a more versatile method of material handling when they are designed to perform in a manner that reduces the risk factor for injury.

Benefits of **CannonCarts®**

It is Cannon Equipments experience that wheeled carts improve the "fit" between the demands of work tasks and capabilities of workers by incorporating several design features into **CannonCarts®** making them:

ii. easy to handle and maneuver
iii. easy to load/unload
iv. minimize the tendency to bend/stoop (use awkward postures)

Ergonomics and Wheeled Carts

Environments are part of systems and people are part of those systems, as such, systems must be designed for ease and efficiency. Normal environmental activity should not predispose people to awkward postures or over-exertion.

During the past 20 -30 years, ergonomics has gained broader acceptance as a means of injury prevention by insuring that job requirements incorporate knowledge of normal human dimensions (anthropometrics) and strength abilities in order to increase job safety. Designing equipment to minimize force exertions and reduced reach distances and motions provide a safer, more efficient work environment. Inefficiencies often lead to excessive motions and force exertions, which typically result in an increased risk of musculoskeletal strains (MSDs) and injuries.

Benefits of **CannonCarts®**

It is crucial to design a work environment to fit within normal human capabilities; therefore designing wheeled carts with an understanding of ergonomics ensures that the critical aspects of the cart design will:

- Encourage upright, "neutral postures"
- Include features that are a more natural fit with the human form
    - Handle diameter "fits" the hand
    - Handle placement and width is natural and will not strain the shoulders
    - Product depth and height will not block visual field
    - Shelf height to reduce bending and reaching

Cannon Equipment defines a cart as a ***"manually operated wheeled container (4 wheels or more) that is used in the production and distribution of goods"***; please note that our definition does not take into account the use of shopping carts or wheelbarrows/wheelbarrow type containers.

CannonCarts® are used in 4 main areas: work-in-process, distribution, stocking and display

Work-in-Process (WIP) carts allow large and/or small partially completed goods, parts or subassemblies to have a secure storage location within a warehouse or manufacturing facility. These mobile carts are often used as a transportation application between work stations and assembly areas in manufacturing plants, assembly plants and other industrial settings. **CannonCarts®** utilized for WIP applications allow users to more easily move items from one place to the next without having to use excessive force or assistance of any kind.

Distribution Carts provide stability for large individual items, case goods, and totes reducing product spillage, damage and loss. At the warehouse, distribution carts allow an entire trailer to be picked and staged prior to being loaded which in turn allows for the loading and unloading process to be completed in a fraction of the time that it would take using other handling methods. While distribution carts are often some of our larger **CannonCarts®**, they enable users to reduce repetitive motions often associated with loading product onto pallets.

Stocking Carts are used to help retail locations of all sizes move large volumes of product more efficiently and more customer friendly. Stocking carts serve many purposes in a retail location, from unloading trucks and staging products in the backroom, to assisting in keeping aisles clear of boxes and debris that can interrupt customers' shopping patterns. Items in retail locations are often varying sizes and weights, because of this, moving them around can be cumbersome and awkward. Using a slim designed **CannonCart®** allows employees to easily maneuver store aisles and stock shelves efficiently.

Display carts increase sales and stock-keeping efficiencies; they also keep products visible, neatly organized and readily available to shoppers. Most often, items merchandised on these carts DO NOT need to be "touched" meaning the items arrive to the location on the same cart that get's rolled out to the sales floor. These carts DO NOT require any additional handling.

Ergonomic Engineering (fitting the work to the workers)

There are various elements that need to be taken into consideration when designing a **CannonCart®**. This includes understanding certain aspects of physics and mechanics of the cart as well as the manner which it is used.

Force

Force is a physical term used to explain the relationship between mass and velocity. Mass refers to the size and weight of an object, while velocity refers to the speed of movement. The two elements encountered in daily practice of material handing with wheeled carts are initial force and sustained force. Initial Force is the amount of force exerted on an object (in this instance a wheeled cart) required to move that object from a state of rest. Sustained force is the amount of force required to maintain the objects velocity and requires much less effort than initial force. For example a cart will remain in a state of rest, until initial force is applied by a person which causes the object to change its velocity (movement). This initial force is always higher than the sustain force, because it takes more energy to push an object from its state of rest, than it does to maintain its velocity once it is in motion. Once the object is in movement, it is the sustained force applied by the person which keeps the object in motion.

CannonCarts® are designed to include casters (wheels), objects with wheels are easier to move then objects with no wheels. This is a basic but important feature of **CannonCarts®** as it allows users of different stature (covers the 5% female to 95% male demographic) in the workforce to move a cart easily without strain.

Push/Pull

Pushing an object and pulling an object may get the object to the same end result, but in very different manners. During pulling, you are most often facing the same direction that you are moving. When this occurs, your arm is stretched behind your body and your shoulder is rotated, placing your spine and back in an awkward position.

	Recommend force for 90% male population	Recommend force for 90% female population
PUSHING: Two-handed initial	340 N	220 N
PUSHING: Two-handed Sustained	230 N	130 N
PULLING: Two handed initial	320 N	230 N
Pulling: Two-handed sustained	240 N	140 N

The above table is for a frequency of one-eigth hour, a handle height of 95cm for males and of 89cm for females, and a push distance of 2m. (WorksafeNB, 2010)

CannonCarts® are designed to be pushed, a safer and more ergonomically method than pulling. Pushing an object generally takes less effort than pulling because body weight is used to assist the exertion. Pulling an object behind you is often uncomfortable and awkward which can cause a person to "run over" their own feet and/or strain their arms. Pulling also decreases your level of control over the wheeled cart which can cause injuries to those around you.

CannonCart® engineers use a gauge which takes variables such as weight, friction and acceleration into account to determine initial pushing and pulling forces.

Lifting/Loading/Bending

The Lifting Index (LI) is a term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit. The recommended weight limit (RWL) and lifting index (LI) can be used to test work environment ergonomics and task designs (Waters, 1994). The lifting equation could either under- or over- estimate the extent of physical stress associated with a particular work-related activity.

CannonCarts® are most often designed with either removable shelf(s) and/or folding shelf(s) this allows employees to adjust the cart according to their loading needs. Additionally we recommend that each cart is loaded with the heaviest items on the bottom to the lighter items on the top. This ensures that the cart remains stable. While unloading, the shelf(s) can be removed or folded which allows employees to safety reach into the cart to retrieve the items.

During the design phase, our engineers are looking at multiple factors associated with how the cart is going to be used in loading and unloading activities. Depending on the use minimizing cart heights and increasing widths allows a more comfortable loading level. In this case, items will not need to be lifted vertically, moved over and out of a crate. For other carts, the lowest shelf will be higher off the ground which reduces the distance employees have to bend over, lessening the likelihood of back injuries.

Handle Design

CannonCarts® that utilize handles often minimize the possibility of awkward postures through the incorporation of ergonomic handle designs. CannonCart® handles are designed in a continuous, vertical shape/configuration to maximize ability to use upright posture while pushing. If continuous handles aren't an option then dual handles are used. Dual handles are placed approximately 18" apart and the height of the continuous loop should be 36 – 45" from the floor which is the most ergonomically comfortable arm/shoulder positioning and accommodates users of different stature and covers the 5% female to 95% male demographic in the workforce. This is the most ergonomically preferred location and is within range for "normal posture". The handle diameters of **CannonCarts®** are designed to maximize and maintain control of a wheeled cart, this is why they are designed with a diameter of approximately 1.5", a diameter which provides a comfortable and controlled experience.

Casters

Casters are in integral part of cart mechanics and contribute to a carts overall ease of use. Depending on the type of cart, surface conditions in which the cart will operate, and type of product the cart will carry, there are varying types of casters that can be used. Understanding the effects of the friction that occurs in and around the caster wheel is integral to efficient cart design. Whenever two surfaces are in contact, friction occurs and may resist movement. Friction is defined as either static (starting) or dynamic (rolling). The static forces are usually higher than the dynamic. Therefore, the initial force to create motion will almost always be higher than the force needed to sustain motion. Having the right caster on a cart decreases the occurrence of strain because resistance and friction can be kept to a minimum. Overall, the proper caster will reduce friction and force, minimizing initial force and sustained force to keep the cart in motion. It is integral to proper cart usage that casters are maintained correctly and are replaced immediately if not operating properly. Casters that are not operating properly can cause excessive force injuries to an employee.

Caster Material	Description	Hardness	Ergonomically Speaking
Polyurethane	Polyurethane casters are designed for added strength for loads subject to shock and hard impacts. Tread is molded in, around and through a ribbed extension of the core to prevent debonding.	55 (± 10)	Polyurethane is a softer material that requires more initial force to instigate movement of a cart.
Polyolefin	Polyolefin casters are designed for hard impacts and heavy loads. Very light in weight, yet impact strength is far superior to hard rubber wheels.	65 (± 10)	Polyolefin works best on hard surfaces and requires less force to initiate movement of a loaded cart.
Phenolic	Phenolic casters are quieter than steel or aluminum, are resistant to hard impacts as well as most chemicals and steam.	90 (± 10)	Phenolic works best on hard surfaces and requires less force to initiate movement of a loaded cart.
Cushioned Rubber	Cushioned rubber casters offer the advantages of both hard and soft tread materials. The cushioned rubber rolls easily like the hard materials, but like soft materials it rolls quietly, protects floors, and resists impact.	65 (± 10)	Cushioned rubber is best for multi-surface environments and had good shock absorption. A softer wheel though requires more force to initiate movement of the loaded cart.

Braking Mechanisms

Braking mechanisms on a cart may be necessary when operating on an incline or decline. Without a brake, cart operators would be forced to act as a counterbalance to the weight not only of the cart but also of the product contained within the cart. This will demand awkward and dangerous maneuvers to control the cart, creating opportunities for injury. There are multiple breaking options available on a **CannonCart®**, all designed to increase safety and operate ergonomically.


Slide Lock Brake


Push Pedal Brake


Lock Brake


Tred Lock Brake

Mechanism	Description	Ergonomically Speaking
Side Lock Brake	With a capacity up to 1,400 lbs each, the side lock brake places a positive force against the wheel hub to hold loads securely.	The larger foot pedal makes the side lock brake easier to operate and provides better foot placement.
Push Pedal Brake	The push pedal brake offers a weight capacity of 1,250 lbs each and is ideal for wet or corrosive conditions, and heavy loads.	The push pedal locks the wheel in place providing a solid "hold" and will not disengage until the user pushes the pedal upwards.
Complete Lock Brake	With a capacity of 1,250lbs each the complete lock brake locks the wheel tread and caster fork to prevent swiveling.	This brake is engaged and disengaged by the press of a foot. The low angle design makes foot access easy to operate.
Tread Lock Brake	The tread lock brake has a capacity up to 1,500lbs each and is toe activated locking the wheels and tread securely.	This brake is engaged and disengaged by the press of a foot. The low angle design makes foot access easy to operate.

Ergonomically, CannonCarts® provide benefits pallets do not offer

Pallets	Carts
Require the use of multiple different assistance mechanized vehicles to maneuver into place. If wooden pallets are moved manually there is a high risk of back injury.	Carts are human operated and in most cases can be easily maneuvered by one person (without the use of assistance vehicles) into the best ergonomically placed position.
Wooden pallets do not have handles.	While all carts may not have handles, all carts are designed with tubular steel allowing for "handles" to be located at a level suitable for any operator.
Pallets are most often square, which can cause back injuries while bending, trying to reach across to remove items.	**CannonCarts®** are rectangular in design allowing the operator to easily reach into and safely remove all contents without having to bend, pull or reach in awkward motions.
Pallets Require stretch wrap, straps, etc to protect product.	Product contained in a cart is protected by the cart frame, increasing retention, and eliminating hazards associated with falling items.

Conclusion

This paper illustrates the importance of ergonomics in wheeled cart based manual material handling systems and how Cannon Equipment designs ergonomic principles into each and every **CannonCart®**. Additionally, we addressed the rates and costs associated with MSDs and how ergonomically designed equipment benefits both employers and employees.

An ergonomically designed wheeled cart must take many features into consideration. Handle placement, casters, height and depth, push/pull, lifting/ bending and force are all necessary elements to address in any design. Not to mention ensuring any users are operating the cart in a "neutral posture". Through our design and testing process, Cannon Equipment is able to develop **CannonCarts®** that often exceed these ergonomic requirements.

Benefits of **CannonCarts®**

Testing

Cannon Equipment is a company devoted to safety above all else. To ensure our **CannonCarts®** are safely built and can be safely used they are put through rigorous quality and testing procedures. These procedures are used to evaluate:

• Performance • Benchmark standards • Evaluate component vendors • Material strength • Welding quality • Design flaws

Benefits of **CannonCarts®**

Safety and Handling

Cannon Equipment goes to great lengths to ensure our carts are safe for use. There are a number of common sense safety practices that apply to carts in general. If carts are used improperly or carelessly, even the simplest application may result in an accident and/or serious personal injury.

To ensure CannonCarts® are handled properly, we have developed a Safe Cart Usage and Handling DVD, along with a printed Safety Manual. Each of these address the necessary information any cart operator needs to know prior to operating a **CannonCart®**.

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Government/Associations

b. International Ergonomics Association www.iea.cc
c. OSHA/Department of Labor www.osha.com
d. Human Factors and Ergonomics Society www.hfes.org
e. American National Standards Institute www.ansi.org
f. Bureau of Labor Statistics www.bls.gov
g. International Organization for Standardization
h. Worksafe NB
i. Center for Disease Control and Prevention

Consultant: Mark Hank, OTR/L, CEA Principal Ergonomist at Eucentra Consulting

Cannon Equipment
15100 Business Parkway
Rosemount, MN 55068
1-800-252-0944
651-322-6300
Info@CannonEquipment.com

Eucentra Consulting, LLC
P.O. Box1102
Burnsville, MN 55337
952-895-9859

cannoncarts