Comparison of Traditional and Ergonomic Snow Shovels

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Executive Summary

Snow shovels are a main component of any household in regions where snow falls yearly. This report aims to compare the traditional snow shovels, which have been the standard shovel in most places, to the more ergonomic snow shovels that have claimed to help reduce the chances of injuries by introducing a bend in the stem of the shovel. Despite the claim that the more ergonomic shovels are better than traditional, by and large they have not replaced the traditional snow shovels in the market or in many households.

This reports explores various analyses of the shovels in order to compare the two designs. These include anthropometry, energy expenditure, and lifting biomechanics and strength analysis. The results of these analyses were used to determine whether the ergonomic shovels claims are valid that the design provides an advantage over the traditional shovel.

Anthropometric results proved to be similar due to the similar dimensions used in each of the shovels. Results showed that 100% of males and 91% of females can properly use either of the shovels. There is less energy expenditure when using the ergonomic shovel, males expended 0.0476 kcal/min less energy and 0.064 kcal/min less for females, which translates to 4.5% less energy expended by males and 4.76% less energy expended for females.The largest difference in design was observed on the lifting biomechanics and strength analysis, more specifically on the compression of the L4/L5 vertebra, a traditional shovel has a calculated compression of 588 lb and the ergonomic shovel a compression of 477 lb. That is a difference of 111 lb and an improvement of 18.88% less compression.

An ergonomic shovel does provide an advantage over traditional shovels and can therefore prevent injuries when compared to the traditional shovel by improving the posture assumed while shoveling snow. It is recommended that people use the ergonomic shovel for shoveling snow.

Introduction

Each year millions of snow shovels are manufactured and sold during the snow seasons in many places around the world. Snow shovels have become ubiquitous in households where snow is a constant occurrence for part of the year. Snow shovels can be found in almost any general hardware store around the world, but once you locate the at the aisles containing the snow shovels, you will be faced with a dilemma, do you purchase a traditional snow shovel, or purchase the *better and more ergonomic* snow shovel.

This report aims to explore the answer to this question by conducting various analysis to understand the ergonomics of each shovel, as well as quantify various properties in order to facilitate the comparison. The analysis included in this report are: anthropometry, energy expenditure,and lifting biomechanics and strength. Results of these analysis will be used to determine the advantages and disadvantages of each design. The results will then be used to provide a recommendation on whether the ergonomic shovel is a better design than the traditional shovel, or elucidate as to why although an ergonomic shovel exists, it has not replaced the traditional shovel in the market and is still readily available in stores, households worldwide.

Figure 1. Traditional Shovel (left). Ergonomic Shovel (Right).

The most important design constraint is the introduction of the bend on the stem of the ergonomic shovel. This design change was made so that the person is at a standing posture a longer amount of time over the traditional shovel.

Anthropometry analysis was chosen to determine the percent of people who would be able to use a traditional shovel versus the ergonomic shovel. Shoveling snow is a very energy intensive task. With any major or slight improvement, we should be able to calculate difference in energy expended for the same task with the two shovel designs. Lastly, shoveling snow involves a lot of lifting and strength, therefore with the 3DSSPP software for lifting biomechanics and strength analysis, we will be able to analyse the forces distributed throughout the body in order to determine which shovel will provide less changes for injuries.

Methods

Data Sources, Equations and Models Used

- Body Weight - US Army 1988 Anthropometric Survey
- US Army 2012 Anthropometric Survey
- US Army 1988 Female/Male Hand Anthropometric Survey
- 1988 US Army Female/Male Hand Correlation
- Metabolic Model and Equations
- Joint Moment Strength Equations
- 3D SSPP Lifting Biomechanics and Strength Software

Assumptions

- Shovel dimensions, and therefore analysis are representative of similar shovels in the market. Given this assumption, we can extrapolate the project results to similar ergonomic and traditional shovels.
- Shovel dimensions do not have much variability in production, therefore we assume they have good quality assurance.
- Although US Army data sources will not be representative of the general population, data on anthropometry for the large population does not exist and therefore the US Army database is the best set of data we can use to determine anthropometry for the shovel.
- Snow weight will be evenly distributed along the blade of either the shovel with center of mass at the centroid of the blade.
- Shovel blade is full of snow which is estimated to be 10 Lb (see calculation below)
    - Blade Load = 18 in x 12 in by 4 inch height or snow. Snow is about 20 lbs per ft^3, so fixed weight of snow is $(1.5ft\ x\ 1ft\ x\ 0.33ft)\ *\ 20\ lb/ft^3\ = 10lb\ Load$

Anthropometry

Shovels are designed with a one-size-fits mentality. Unlike shoes, shovels do not come in small, medium and large sizes. By analyzing the anthropometry of the shovel, I will identify the percent of males and females that are able to properly use the shovel. The shovels dimensions will be measured and compared to the anthropometry tables provided and percentiles determined.

<u>Procedures and Quantifications Measurements</u>

- **Handle, Stem Grip and Handle Opening Analysis**
    - Grip handle circumference
    - Stem circumference (second hand position)
    - Handle opening width
- **Height and Shovel Grip Location Analysis**

- Height of shovel
- Grip location within stem of shovel (bend on ergonomic shovel)

Analysis Method Evaluation

Handle, Stem Grip and Handle Opening Analysis

Hand grip analysis and stem grip analysis will determine the percent of males and females that can comfortably grip the handle and stem based on the circumference of the the shovel. The opening of the handle will also be analyzed to determine how many people the handle open can accommodate. Comparing changes in the handle will determine if there is an increase or decrease in the percent of the population able to use either shovel.

Usage Height and Shovel Grip Location Analysis

Analyzing the optimal usage height of shovel, will determine the percent of males and females that can comfortably hold the shovel. Comparison of the recommended usage height of the shovel will determine if there is an increase or decrease in the number of users who can use the shovels.

Proper use of the shovel requires one hand on the handle and the other on the stem of the shovel. Comparing hand positions on the shovels will determine the percent of the population who are comfortably able to hold and use either shovel. This analysis will also take into account the position of the bend on the stem versus holding a traditional shovel.

Energy Expenditure Rate

Procedures and Quantifications Measurements

- **Energy Expenditure Tasks**
    - Scoop Snow
    - Lift Shovel (Assumed to be 32 in, below waist)
    - Throw Snow to the Side
    - No rest provided in between task cycles

Analysis of Method Evaluation

Energy Expenditure

Energy expenditure is a measure of how much energy is needed to perform a task. Clearing the snow with a shovel is very energy intensive, and therefore analysing the energy expenditure of the shovels is a good way to compare if one design is better than the other and therefore the user will expend less energy due to the optimal design. The purpose of ergonomics is to improve the devices, workflows or tasks so that less energy is needed by the user, this analysis will determine if one shovel offers an improvement over the other as far as energy expenditure.

Lifting Biomechanics and Strength

<u>Procedures and Quantifications Measurements</u>

Lift Analysis

- Compression in L4/L5
- Strength Percent Capable

<u>Analysis of Method Evaluation</u>

3D SSPP Lifting Biomechanics and Strength Software will allow me to place the model in various intermediate motion positions required by each shovel. The software will then allow me to analyse how much force is placed throughout the body and determine where most of the stress is placed when shoveling snow. This analysis will be good at determining of the ergonomic design does indeed put less pressure and stress on the body by providing a design that takes the human body into consideration.

Analysis of Existing Design

The traditional shovel provides a very simple design, a handle attached to the stem of the shovel, ending with a blade for shoveling and or pushing snow. Table 1 below summarizes many specifications of the shovel being analyzed.

Figure 2. Traditional Shovel

Traditional Snow Shovel Specifications	
• Cost: $38.45 (Amazon 3/28/2018) • Galvanized Steel Wear Strip • Ribbed Steel Core handle • Overall Length 51-Inches • Blade 18-by-12-Inches (WxH) • Shovel/Pusher Combo	• Handle 1-⅛” diameter • Stem Handle diameter: 1” • Handle Material: Steel • Handle Stem Length: 39"

Table 1. Specifications of a Traditional Shovel.

Anthropometry

Handle, Stem Grip and Handle Opening Analysis

In order to perform the anthropometric measurement for grip, measurements for Digit 1 length and digit 3 length were used to determine the percent of the population that is able to grip the shovel at the handle and the stem, as well as fit their hand through the handle opening given the shovels dimensions.

<u>**Handle and Stem Grip Analysis**</u>

- **(1) Digit 1 Length**
  - **Male:** Mean = 2.74 in St. Dev = 0.19in
  - **Female:** Mean = 2.50 in St. Dev = 0.19 in

- **(29) Digit 3 Link Length**
  - **Male:** Mean = 4.32in St. Dev = 0.28 in
  - **Female:** Mean = 3.95 in St. Dev = 0.25 in

- **Digit 1 Length + Digit 3 Link Length**
  - **Correlation:** Male = .5948 Female= .6671

- **Combined Measurements**
  - **Male:** Mean = 7.06 in St. Dev. = 0.4216 in

	X	Y	X+Y	X-Y
Mean	2.74	4.32	7.06	-1.58
Standard Dev	0.19	0.28	0.42164763	0.226303513
Correlation	0.5948			

  - **Female:** Mean = 6.45 in St. Dev. = 0.4025 in

	X	Y	X+Y	X-Y
Mean	2.5	3.95	6.45	-1.45
Standard Dev	0.19	0.25	0.40246056	0.187684576
Correlation	0.6671			

- **Diameter of handle is 1-⅛" inches (1.125 in or 2.86 cm)**
  - Radius = 1.125in ÷ 2 = 0.5625 inches
  - Circumference = 2 * π * radius = 3.534 in

- **Diameter of stem is 1" inches (2.54 cm)**
  - Radius = 1 in ÷ 2 = 0.5 inches
  - Circumference = 2 * π * radius = 3.141 in

- **Male Handle and Stem Circumference Percentiles**
  - Handle ⇒

Mean	Standard Dev	X	Percentile
7.06	0.4218	3.534	0%

  - Stem ⇒

Mean	Standard Dev	X	Percentile
7.06	0.4218	3.141	0%

- **Female Handle Circumference and Stem**

- Handle ⇒

Mean	Standard Dev	X	Percentile
6.45	0.4025	3.534	0%

- Stem ⇒

Mean	Standard Dev	X	Percentile
6.45	0.4025	3.141	0%

Handle Opening Width Analysis

- Opening of handle shovel is a rectangle of 4.5 in by 2 inches. Width will be considered when analysing percentage of population that it can accomodate.
- **(63) Hand Breadth Measured**
  - **Female**: Mean = 3.13in, St. Dev. = 0.15 in

Mean	Standard Dev	X	Percentile
3.13	0.15	4.5	100%

  - **Male:** Mean= 3.56 in, St.Dev. = 0.17 in

Mean	Standard Dev	X	Percentile
3.56	0.17	4.5	100%

Height and Shovel Grip Location Analysis

Proper use of the shovel scoop motion starts with the stem at roughly 45° from the floor. The overall length of 51- inches for the traditional shovel is used to determine recommended height. Recommended height is determined based on proper handle height for traditional shovel which is waist high.

Due to the straight stem of the shovel, the user can grip anywhere within the stem to accommodate their arm length. The recommended location to hold on to the stem is at about halfway point between the handle and the blade of the shovel. This location is used to determine percent of population able to reach both handles

Height Analysis

- $Height\ of\ handle = sin(45^o) = \frac{Height\ of\ handle}{Overall\ length} = \frac{Height\ of\ handle}{51\ in} = 36.06\ in$
- 95% of population height based on measurement (119) Waist Height (Omphalion)
  - Male
    - Mean: 41.69 in St.Dev: 2.00 in

Mean	Standard Dev	X	Percentile
41.69	2	36.06	0%

  - Female
    - Mean: 38.67 in St.Dev: 1.92 in

Mean	Standard Dev	X	Percentile
38.67	1.92	36.06	9%

Grip Location Analysis

- Grip Location on stem = $\frac{Handle\ Stem\ Length}{2} \Rightarrow \frac{39\ in}{2} = 19.5\ in$ from handle
- Stem from shovel handle to stem grip location is 45° apart

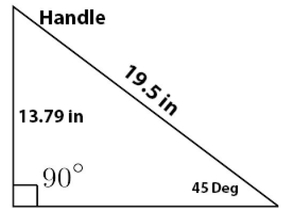

Figure 3. Vertical distance from handle to stem grip location

- (79) Arm Length is a good measurement of the arm length need to hold the shovel's stem at the optimal location.
  - **Male**
    - Mean = 31.11 in St. Dev = 1.51 in
Mean	Standard Dev	X	Percentile
31.11	1.51	19.5	0%
  - **Female**
    - Mean = 28.50 in St. Dev = 1.53 in
Mean	Standard Dev	X	Percentile
28.5	1.53	19.5	0%

Anthropometry analysis shows that the handle and the stem circumference corresponding to the hand positions to hold the shovel are adequate enough so that everybody in the anthropometric data from the US Army from 1988 can hold the shovel. The handle opening is also large enough so that 100% of the population can fit their hand through the opening without any problems.

Analysis of the shovel height shows that 100% of the males are able to hold the shove optimally at waist height, but only 91% of the female population are able to. Given the arm length of the population, all of the males and females are able to hold the shovel at the optimal places, the handle and midway of the stem.

Energy Expenditure

The following positions are assumed when shoveling snow. Using the energy expenditure equations (Appendix B), a value of energy expended can be calculated for each positions as well as for the overall task. This is calculated for an 8 hour work period. Analysis takes into consideration only energy expent using the shovel and not stepping in order to walk to the next pile of snow. The initial push is estimated at bench height (~32in) since handle height is at about bench height and it is a horizontal push forward. Energy expenditure is calculated for 5 percentile to determine energy expenditure for 95% of the population, it is estimated that a lighter person will have a harder time lifting and using the shovel and therefore will be the person least able to use the shovel. Body mass is calculated in Appendix B with 5th percentile male and females weighing 133.84 lb and 106.76 lb respectively. It is estimated that the person spends about 15% in an upright position while spending 85% in a bent position due to the lower grip of the shovel at the midpoint of the stem.

Energy Expenditure Positions

- Scoop Snow
  - Push or Pull: 32 inch (Bench) Height
- Lift Shovel (Assumed to be 32 in, below waist)
  - Lift: Stoop (At or Below 32 in Only)
- Throw Snow to the Side
  - Move Both Arms Sideward: 90° Sit
- No rest provided in between task cycles

Predicting Energy Expenditure During Manual Handling										
Name of Analyst:	Walk Speed (mph)	Walk Grade (%)	Push or Pull Force (lb)	Horizontal Movement (in)	Lifts or Lowers Lowest Point (in)	Lifts or Lowers Highest Point (in)	Load Weight (lb)	Number of Repetitions	Task Duration (min)	**Task Kcal**
Current Date: May. 05, 2018										
Task										
Push or Pull: 32 inch (Bench) Height			**10**	**36**				**1**		**0.1273**
Move Both Arms Sideward: 90° Sit							**10**	**1**		**0.0867**
Lift: Stoop (At or Below 32 in Only)					**0**	**32**	**10**	**1**		**0.24077**
Worker Characteristics										
Gender (1=Male, 0=Female)	1								**Posture Component (Kcal):**	809.464
Body Weight (lb)	133.84								**Task Component (Kcal):**	0.53537
Job Duration (min)	480								**TOTAL JOB ENERGY DEMANDS (kcal):**	810
Percent of Job Duration	**%**	**Kcal**								
Spent in a Sitting Posture	0%	0							**JOB DURATION (min):**	480
Spent in a Standing Posture	15%	105.04								
Spent in a Standing, Bent Posture	85%	704.43							**JOB ENERGY EXPENDITURE RATE (kcal/min):**	1.6875

Figure 4. Energy expenditure for 5% percentile males using traditional shovel.

Predicting Energy Expenditure During Manual Handling										
Name of Analyst:	Walk Speed (mph)	Walk Grade (%)	Push or Pull Force (lb)	Horizontal Movement (in)	Lifts or Lowers Lowest Point (in)	Lifts or Lowers Highest Point (in)	Load Weight (lb)	Number of Repetitions	Task Duration (min)	**Task Kcal**
Current Date: May. 05, 2018										
Task										
Push or Pull: 32 inch (Bench) Height			**10**	**36**				**1**		**0.09472**
Move Both Arms Sideward: 90° Sit							**10**	**1**		**0.0754**
Lift: Stoop (At or Below 32 in Only)					**0**	**32**	**10**	**1**		**0.18026**
Worker Characteristics										
Gender (1=Male, 0=Female)	0								**Posture Component (Kcal):**	645.624
Body Weight (lb)	106.75								**Task Component (Kcal):**	0.41638
Job Duration (min)	480								**TOTAL JOB ENERGY DEMANDS (kcal):**	646.04
Percent of Job Duration	**%**	**Kcal**								
Spent in a Sitting Posture	0%	0							**JOB DURATION (min):**	480
Spent in a Standing Posture	15%	83.777								
Spent in a Standing, Bent Posture	85%	561.85							**JOB ENERGY EXPENDITURE RATE (kcal/min):**	1.34592

Figure 5. Energy expenditure for 5% females using traditional shovel.

The energy expenditure for 5 percentile male and female using a traditional shovel are 1.6875 kcal/min and 1.346 kcal/min respectively.

Lifting Biomechanics and Strength

Figure 6 below shows typical postures assumed for scooping snow and throwing it with a traditional shovel. Weight of shovel is estimate at 5 lb. Total weight of snow and shovel is 15 lb.

Figure 6. Person in “Lift Shovel”posture using traditional shovel

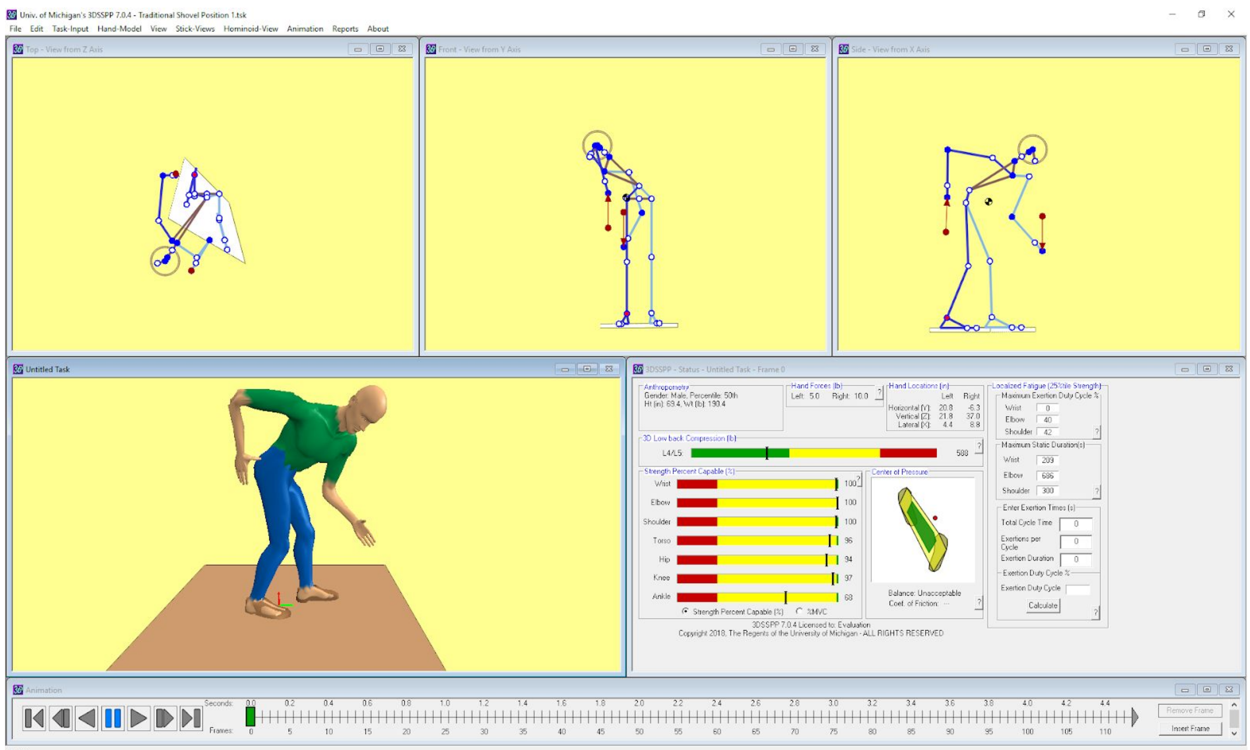

Figure 7. Estimation of various forces on the body using 3DSSPP software using a traditional shovel posture.

Lower back compression was calculated to be 588 lb using 3DSSPP. The lowest three *Percent Strength Capable* values were Ankle (68%), Hip(94%) and Torso (96%). This is consistent with the weight distribution while using the shovel, most of the strain is in the lower back and one leg as it becomes the load bearing point during the lifting posture.

Ergonomic Design and Analysis

The proposed ergonomic design of the shovel introduces a bend on the stem of the shovel. This allows the body to be in a position closer to standing posture than to bent posture. The grip at the bend of the handle is still the same length from the recommended position of a traditional shovel at 19.5 inches, but the vertical distance from the handles is shorter.

Figure 8. Ergonomic shovel with a bent handle

Ergonomic Snow Shovel Specifications	
● Cost: $29.80 (Amazon 3/28/2018) ● Galvanized Steel Wear Strip ● Ribbed Steel Core handle ● Overall Length 52.5-inches ● Blade 18-by-12-inches (WxH) ● Shovel/Pusher Combo ● Handle 1-⅛" diameter	● Stem Handle diameter: 1" ● Handle Material: Steel ● Handle Stem Length: 46" ● Bend location: 19.5" from handle ● Ergonomic S Handle To Reduce Stress on body

Table 2. Specifications of an Ergonomic Shovel.

Anthropometry

Handle and Stem Grip Analysis

Both traditional and ergonomic shovels have same handle diameter and design. Therefore results obtained in the previous section for the traditional shovel are the same as the results obtained for the ergonomic shovel with 100% of the males are able to hold the shove optimally at waist height, but only 91% of females can. Both shovels having the same handle is likely due to the manufacturer repurposing parts to minimize manufacturing cost, although a more suited ergonomic handle for the design could have been implemented.

Height and Shovel Grip Location Analysis

Proper height of the ergonomic shovel is still positioned at waist height, therefore previous measurements for traditional shovel translate to the ergonomic shovel. The main difference is on the grip location. The overall length of the ergonomic shovel is 52.5- inches with much of the extra length is due to the bend that protrudes off the middle section of the stem.

Because the bend separation is equidistant as the traditional shovel, (79) Arm Length measurement is used to determine the percent of the population able to reach both the handle and bend locations.

<u>Grip Location Analysis</u>

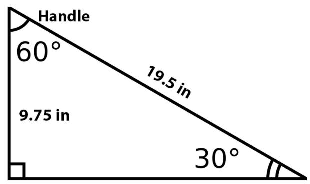

Figure 9. Vertical distance from handle to stem grip location

Results for the anthropometry were not very different as that of the traditional shovel. The shovel is designed so that the same percent of males (100%) and females (91%) are able to properly use the shovel. The main difference anthropometrically with the design is the posture assumed when using the traditional vs the ergonomic shovel.

Energy Expenditure

The redesign of the shovel changes the various assumed positions slightly. A person shoveling snow still goes through the same positions as before (Scoop Snow> Shovel Lifting Position> Throw Snow to the Side) The main differences are that the **Lift Shovel** and the **Throw Snow to the Side** are done from a more upright position, and therefore the percent of time the person spends in a standing vs a bent posture is higher. It is estimated that the person spends about 55% of the time in a bent posture, and 45% in a standing posture.

Predicting Energy Expenditure During Manual Handling											
Name of Analyst:		Walk Speed (mph)	Walk Grade (%)	Push or Pull Force (lb)	Horizontal Movement (in)	Lifts or Lowers Lowest Point (in)	Lifts or Lowers Highest Point (in)	Load Weight (lb)	Number of Repetitions	Task Duration (min)	**Task Kcal**
Current Date:	May. 05, 2018										
Task											
Push or Pull: 32 inch (Bench) Height				10	36				1		**0.1273**
Move Both Arms Sideward: 90° Sit								10	1		**0.0867**
Lift: Stoop (At or Below 32 in Only)						0	32	10	1		**0.24077**
Lower: Stoop (At or Below 32 in Only)											0
Worker Characteristics											
	Gender (1=Male, 0=Female)	1									
	Body Weight (lb)	133.84								**Posture Component (Kcal):**	770.918
	Job Duration (min)	480								**Task Component (Kcal):**	0.53537
										TOTAL JOB ENERGY DEMANDS (kcal):	771.454
Percent of Job Duration		**%**	**Kcal**								
	Spent in a Sitting Posture	0%	0							**JOB DURATION (min):**	480
	Spent in a Standing Posture	45%	315.11								
	Spent in a Standing, Bent Posture	55%	455.81							**JOB ENERGY EXPENDITURE RATE (kcal/min):**	1.6072

Figure 10. Energy expenditure for 5% percentile males using ergonomic shovel.

Predicting Energy Expenditure During Manual Handling											
Name of Analyst:		Walk Speed (mph)	Walk Grade (%)	Push or Pull Force (lb)	Horizontal Movement (in)	Lifts or Lowers Lowest Point (in)	Lifts or Lowers Highest Point (in)	Load Weight (lb)	Number of Repetitions	Task Duration (min)	Task Kcal
Current Date:	May. 05, 2018										
Task											
Push or Pull: 32 inch (Bench) Height				**10**	**36**				**1**		**0.09472**
Move Both Arms Sideward: 90° Sit								**10**	**1**		**0.0754**
Lift: Stoop (At or Below 32 in Only)						**0**	**32**	**10**	**1**		**0.18026**
Lower: Stoop (At or Below 32 in Only)											0
Worker Characteristics											
	Gender (1=Male, 0=Female)	0								**Posture Component (Kcal):**	614.88
	Body Weight (lb)	106.75								**Task Component (Kcal):**	0.41638
	Job Duration (min)	480								**TOTAL JOB ENERGY DEMANDS (kcal):**	615.296
Percent of Job Duration		**%**	**Kcal**								
	Spent in a Sitting Posture	0%	0							**JOB DURATION (min):**	480
	Spent in a Standing Posture	45%	251.33								
	Spent in a Standing, Bent Posture	55%	363.55							**JOB ENERGY EXPENDITURE RATE (kcal/min):**	1.28187

Figure 11. Energy expenditure for 5% percentile females using ergonomic shovel.

The energy expenditure for male and female using an ergonomic shovel are 1.6072 kcal/min and 1.282 kcal/min respectively.

Lifting Biomechanics and Strength

Below are typical position assumed used when properly using an ergonomic shovel.

Figure 12. Person using an ergonomic shovel properly

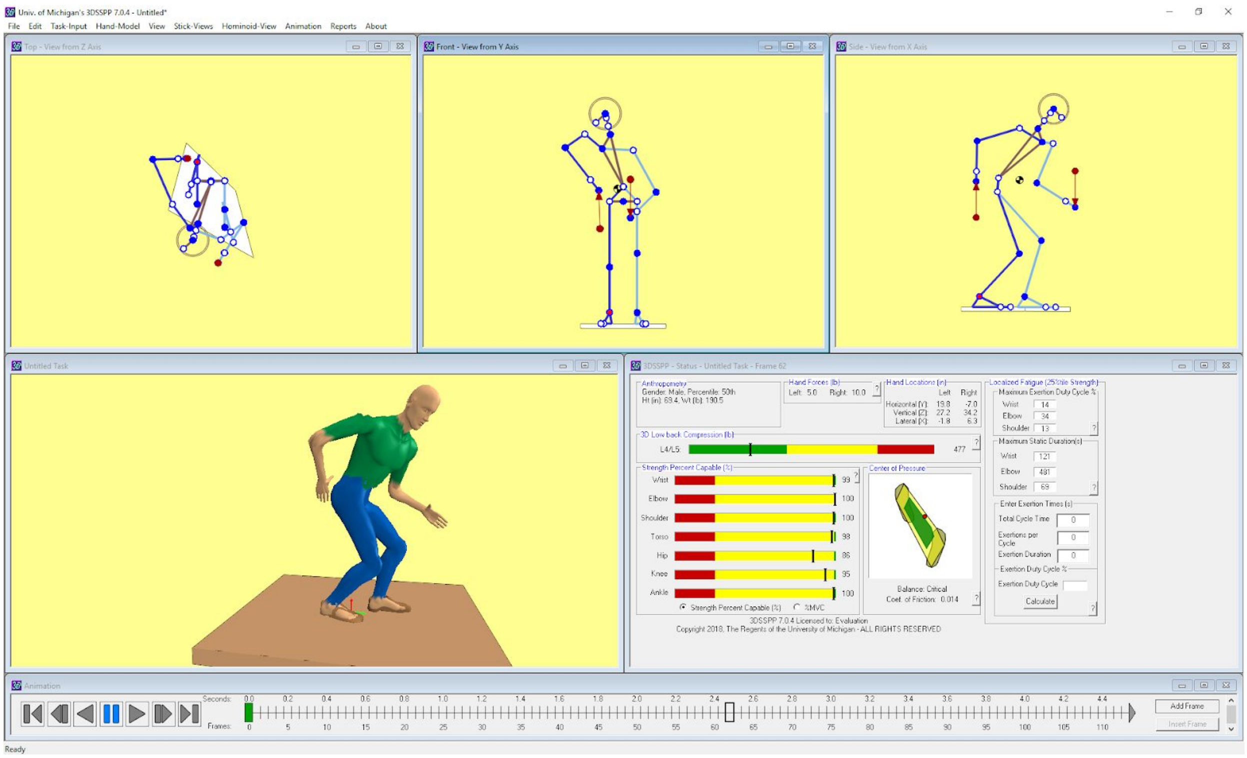

Figure 13. Estimation of various forces on the body using 3DSSPP software using a traditional shovel posture

Lower back compression was estimated to be 477 lb using 3DSSPP. The lowest three *Percent Strength Capable* values were Hip (86%), Knee (95%) and Torso (98%). Results show most of the train during the “Lift Shovel” posture is on the hips, torso and lower body.

Comparison of Analysis

Anthropometry

Anthropometry results were not very different between the traditional and ergonomic shovels. Both shovels are designed with almost the same measurements and specifications. Because the shovels have almost the same design, the percent of males and females that are able to properly use the shovel are the same (100% and 91% respectively). The main difference with the design is the posture assumed when using the traditional vs the ergonomic shovel. This affects the energy expenditure rate as well as the lifting biomechanics and strength measurements.

Energy Expenditure

Through the energy expenditure equations, it was determined that using a traditional shovel males expend 1.6875 kcal/min and females expend 1.346 kcal/min. This is higher than energy expenditure when using an ergonomic shovel with males expending 1.6072 kcal/min and females 1.282 kcal/min respectively. That is a difference of 0.0476 kcal/min for males and 0.064

kcal/min for females which translates to 4.5% less energy expended by males and 4.76% less energy expended for females. Although that may seem like a minor improvement, that is a significant improvement when shoveling large amounts of snow. For example shoveling for 2 hours will save males 5.4 kcal and females 5.712 kcal. Therefore the ergonomic shovel provides an improvement over the traditional shovel

<u>Lifting Biomechanics and Strength</u>

Strength Percent Capable between a traditional shovel and ergonomic shovels were not significantly different, the main discrepancy was on the strain place on the ankle using a traditional shovel, but it is possible that the model was not placed in the exact position that a person does a “Lift Shovel” posture as the software is very hard to use and position the model correctly. The largest difference observed was on the compression of the L4/L5 vertebra, a traditional shovel has a calculated compression of 588 lb and the ergonomic shovel a compression of 477 lb. That is a difference of 111 lb and an improvement of 18.88% less compression. This improvement is due to the more upright posture while performing the various tasks shoveling snow. A more upright posture produces a smaller moment on the L4/L5 joint in comparison to the bent posture and this is evident by the large difference of compression.

Recommendations

Anthropometrically, the shovels are identical, the same percent of people can use either shovel, the main difference is the posture assumed. As far as energy expenditure, the ergonomic shovel provides a slight advantage and requires less energy to use. Although the advantage is small, the longer the ergonomic shovel is used the larger the effects observed in less energy expended. Lastly, the 3DSSPP software calculated that using the ergonomic shovel places less pressure on the L4/L5 joint which is frequently the place of injury. Using the ergonomic shovel provides a safer workflow and therefore would prevent injuries from frequent use.

Through this analysis I have shown that an ergonomic shovel does have advantages over the traditional shove, but despite these advantages, it has not replaced it. I think it’s possible that people are resistant to change and prefer a traditional shovel without analysing the advantages of an ergonomic shovel. It may seem like cost would be a factor in people’s decisions to purchase a traditional versus the ergonomic shovel, but as of the time writing this report, the ergonomic shovel is cheaper than the traditional shovel. It seems like the ergonomic shovel would take more resources to fabricate, but it’s possible the manufacturer has lowered the price possibly due to competition, or until the shovel becomes more widely adopted.

I would suggest purchasing an ergonomic shovel instead of a traditional shovel given the price difference and improved safety postures assumed during its use.

References and Sources

Suncast SC3250 18-Inch Snow Shovel/Pusher Combo with Ergonomic Shaped Handle And Wear Strip, Green.
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Suncast SC1350 18-Inch Snow Shovel/Pusher Combo with Wear Strip, Green.
https://www.amazon.com/Suncast-SC1350-18-Inch-Shovel-Pusher/dp/B000A26WVE

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[3] Lewinson, R. T., Rouhi, G., & Robertson, D. G. E. (2014). Influence of snow shovel shaft configuration on lumbosacral biomechanics during a load-lifting task. Applied ergonomics, 45(2), 234-238.

Appendices

Appendix A→ Anthropometry

Handle and Stem Diameter Measurements

- **1988 Hand Anthropometry Measurement**
  - (1) Digit 1 Length
  - (29) Digit 3 Link Length

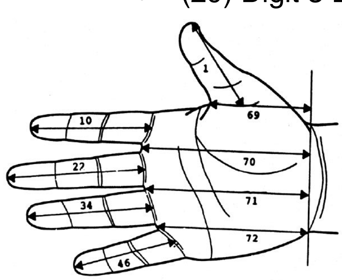

Figure 7. VISUAL INDEX

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(22)	DIGIT 3 LE[illegible]TH	p.	84
(34)	DIGIT [illegible] LENGTH	p.	108
(46)	DIGIT 5 LENGTH	p.	132
(69)	CROTCH 1 HEIGHT	p.	178
(70)	CROTCH 2 HEIGHT	p.	180
(71)	CROTCH 3 HEIGHT	p.	182
(72)	CROTCH 4 HEIGHT	p.	184

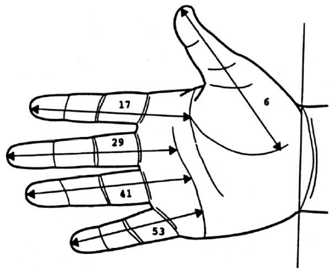

Figure 7. VISUAL INDEX (Continued)

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(17) DIGIT 2 LINK LENGTH p. 74
(29) DIGIT 3 LINK LENGTH p. 98
(41) DIGIT 4 LINK LENGTH p. 122
(53) DIGIT 5 LINK LENGTH p. 146

Handle Opening Analysis

- **1988 Hand Anthropometry Measurement**
  - (63) Hand Breadth Measurement

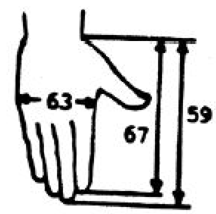

Figure 7. VISUAL INDEX (Continued)

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(67) WRIST-INDEX GRIP LENGTH p. 174
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(77) FOREARM CIRCUMFERENCE, FLEXED p. 194
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US 1988 Anthropometry

- (119) Waist Height (Omphalion)

(79) Arm Length

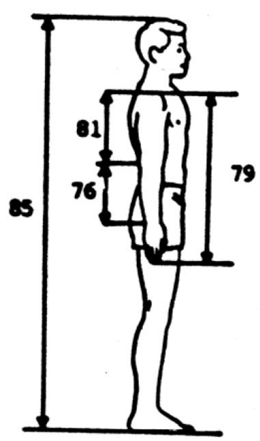

Figure 7. VISUAL INDEX (Continued)

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Appendix B → Energy Expenditure

Body Weight (1988 US Army Anthropometric Survey)

- **Male**
  - Mean: = 78.75 kg (173.61 lb)

- St. Dev. = 11.00 kg (24.25 lb)
- **5% percentile = 173.61lb -1.64*24.25lb = 133.84 lb**

- **Female**
  - Mean = 62.08kg (136.86 lb)
  - St. Dev. = 8.33kg (18.36 lb)
  - **5% percentile = 136.86lb -1.64*18.36lb = 106.75 lb**

Pushing/pulling, at bench height (32”) (KCal/push)
dE=0.001(0.012BW+0.135F+0.058SxF)X

Stoop Lift (KCal/lift)
dE=0.0001[0.375BW(32-h1)+(1.63L+0.875SxL)(h2-h1)]
for h1 < h2 <= 32

Lateral arm work 90 degrees, standing, one or both hands (KCal/movement)
dE=0.01(3.31+0.286L+0.065SxL)

dE = KCal for walking, carrying, holding, general arm work, and general hand work. For all other tasks, units are KCal/performance.
BW = Body weight (pounds)
F = Pushing/pulling force (pounds)
G = Grade of the walking surface (percent)
h1 = Vertical height from floor (inches); starting point for lift and end point for lower
h2 = Vertical height from floor (inches); end point for lift and starting point for lower
L = Weight of load (pounds)
S = Sex; 1 for males, 0 for females
V = Speed of walking (miles/hour)
X = Horizontal movement of work piece (inches)
t = Time (minutes)

Appendix C → Lifting Biomechanics and Strength

3D SSPP Software

- Predicts static strength requirements for tasks such as lifts, presses, pushes, and pulls
- https://c4e.engin.umich.edu/tools-services/3dsspp-software/