One-Handed Carrying on Flat and Inclined Surfaces

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One-Handed Carrying on Flat and Inclined Surfaces

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Preliminary Report

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Abstract

Obese individuals have been identified as being more susceptible to work-related musculoskeletal disorders (MSDs) caused by load carrying when compared to healthy individuals. One-handed carrying is considered one of the most fatiguing and physically demanding methods of load carrying. In manual material handling jobs, employees must be able to perform tasks without excessive stress relative to their capability. Cardiorespiratory fitness is a measure of the body's maximal ability to transport and use oxygen to perform physical work. Physiological measurements provide an objective scale on which to compare physical tasks with respect to the stress. Performing one-handed carrying tasks on inclined surfaces has not been comprehensively studied. The objective of this study was to compare the physiological and psychophysical responses of obese and healthy individuals performing different one-handed carrying tasks on flat and inclined surfaces. Physiological and psychophysical responses were determined from two treadmill protocols, in 4 female and 4 male participants. Among the experiment's trials, one-handed carrying and inclined surfaces were reported to be more physically and psychophysically demanding. More data collection will be conducted to verify the preliminary results.

Introduction

Despite increasing levels of automation and mechanization intended to reduce physical work in many industries, manual material handling (MMH) remains an important feature of many jobs. MMH is associated with the development of musculoskeletal disorders (MSDs) that are major contributors to escalating healthcare costs to businesses. It is estimated that employers spend $20 billion a year on MSD-related workers' compensation and up to five times that much for indirect costs, such as hiring and training replacement workers (OSHA, 2014). Despite this knowledge, the International Organization for Standardization (ISO) does not address one-handed MMH in (*ISO 11228-1:2003*), the standard pertaining to MMH. The “Liberty Mutual Manual Materials Handling Tables” provide the percentage of the population capable of performing two-handed lifting and carrying tasks without overexertion (SNOOK, 1978; Ciriello & Snook, 1983; Liberty Mutual Manual Materials Handling Tables, n.d.). Although one-handed carrying is more physically demanding than two-handed carrying and other carrying methods (COOK & NEUMANN, 1987; Ganguli & Datta, 1977; Lind & McNicol, 1968; Rohlmann et al., 2014), no formal guidelines are included in the Liberty Mutual Manual Materials Handling Tables for one-handed carrying tasks. This gap in available guidance may contribute to an increased risk of MSDs.

Obesity is a crucial risk factor for various diseases, including MSDs (Onyemaechi et al., 2016). Obese employees might be more vulnerable to falls, their MMH ability may be compromised (Gates et al., 2008), and the work-related injuries are reported to be higher among these employees (Viester et al., 2013). Moreover, the medical cost for people who suffer from obesity has been reported to be $1,429 higher than for those of a healthy weight in 2008 (Adult Obesity Facts | Overweight & Obesity | CDC, 2019). Badawy et al. (2018) examined the physiological and psychophysical effects of one-handed carrying among working aged males. The study indicated that total oxygen consumption was substantially larger among obese individuals than among those participants that had a healthy BMI. However, the physical fitness level of these participants was not considered. Exercise and fitness are important factors to consider in the management of disease, and cardiorespiratory fitness is directly related to the integration of the musculoskeletal system with other systems in the human body. Additional research examining the effects of obesity during one-handed carrying is needed to understand the risk one-handed carrying presents to workers.

Previous research has indicated that walking on sloped surfaces requires specialized neural control strategies and may affect lifting kinematics and kinetics (Duysens & Van de Crommert, 1998; Earhart & Bastian, 2000; Gregor et al., 2001). Meanwhile, there are many work environments that require workers to perform MMH on surfaces that are not flat (e.g., agriculture, construction, maritime and aviation). Studying MMH performance on inclined surfaces is, therefore, necessary to understand a worker’s risk of overexertion. Unfortunately, we are unaware of any research that has evaluated one-handed carrying on inclined surfaces, particularly among participants of different obesity levels. Thus, the specific aims of this study were as follows:

Specific Aim 1: Compare the physiological and psychophysical responses of participants of different obesity and physical fitness levels while performing one-handed carrying tasks.

Specific Aim 2: Compare the effect of inclined surface angle on the physiological and psychophysical responses of participants with different obesity levels while performing one-handed carrying tasks.

Participants

This ongoing pilot study aims to recruit participants from two groups with respect to their body mass index (BMI) following National Institute of Health (NIH) recognized ranges [Non-obese: BMI < 25 kg/m2, obese: BMI ≥ 30 kg/m2]. However, all participants that have been recruited to date have been categorized into the non-obese group. The physical activity of the participants was assessed using "The Compendium of Physical Activities" (Ainsworth et al., 1993) coding scheme. This compendium, based on previously published data, expresses activities as Metabolic Equivalent Tasks (METs) by grouping the activities in terms of type and intensity. The self-administrated short version of the International Physical Activity Questionnaire (IPAQ) that was developed based on the compendium data was also used. As the aerobic fitness decreases by an average of about 8–10% per decade beyond 30 years (Norton et al., 2010), the recruited participants are all within the age of 19-30 years old. Participants with smoking history were excluded to participate in the study.

The eligibility criteria for the subjects to participate in this study was: 1) fit one of the BMI categories; 2) report no history of physician-diagnosed MSDs or cardiovascular disease; 3) report no chronic pain in the neck, shoulder, or low back in the six months preceding the data collection; 4) not be pregnant, and 5) not be receiving radiation therapy at the time of the study. Participants that weigh more than 160 kg were excluded. The participants were asked to specify any type of medication they are taking at the time of study as the knowledge of a person's medications provides information on current physical condition (Derman et al., 1992). Mackey et al., 2007 study have shown that some medications can block the adaptive activation of satellite cells, the stem cell of skeletal muscles, and therefore reduce the hypertrophy of skeletal muscle in response to loading.

An equal number of female and male participants have been recruited for this study. However, since 'women' and 'men' are not homogenous categories (L et al., 2018), different experimental protocols based on sex were followed. Female participants were asked not to perform the experiment during their menstruation phase, as cardiovascular responses to psychological and physiological stressors is dependent on the phase of the menstrual cycle (Tersman et al., 1991). In addition, a team of female and male researchers was used to ensure all participants feel comfortable during the experimental procedures.

Devices and Tools

Percent body fat was obtained from a Body Composition Scale by Health-o-meter (BCS-G6-ADULT) which provides a measure of resistance or impedance. All experiments were conducted using a NordicTrack Commercial X11i Treadmill. A COSMED K5 (Wearable Metabolic Cart Technology) was used to measure the physiological effects (e.g., oxygen uptake, heart rate). The COSMED features a face mask that seals around the mouth and nose to measure oxygen consumption and carbon dioxide emissions during respiration (Figure I). The COSMED device also includes a battery pack and data logger, secured to straps on an upper body harness, resting on the chest and upper back. Garmin heart rate sensor that was secured to the subject's chest via a strap that goes around the subject's torso. Heart rate and oxygen consumption data was stored on OMINA (COSMED Software). To ensure accurate measurements, COSMED K5 device was calibrated with the four recommended calibrations by the manufacturer; flowmeter, scrubber, reference gas, and delay calibrations, prior to each data collection.

Borg’s ratings of perceived exertion (RPE) scale, for the whole body (WB) and arm, and rating of perceived dyspnea scale (RPD) were used for the psychophysical effect estimation (Borg, 1982), because they are widely accepted as methods of quantifying individual’s effort during occupational safety and health practices (Williams, 2017). In addition to that, the multi-dimensional NASA-TLX scale was used to estimate the psychophysical response of performing the tasks.

Figure I. The COSMED K5 device.

Experimental Protocol and Procedure

All experiments were conducted in the Human Factors Laboratory at Auburn University. Data collection for each subject was completed on three different days; two days for Aim 1, and one day for Aim 2. The experiments within the three days were randomized using the counterbalancing restricted randomization method, and the participants were asked to keep their living habits constant for the course of the study. Each day the participants completed three minutes of warm up walking on the treadmill at a speed of 1.7 km/hr. Prior to the start of the data collection, measurements of age, weight, height, and BMI were obtained. If the subject meets the inclusion criteria and fits in one of the two groups, informed consent was acquired.

For both aims, the participants carried a load with their dominant hand while walking on the treadmill. All subjects carried the same load size with dimensions of (22.4 cm L x 17.8 cm W x 31.8 cm H).

Specific Aim 1: Compare the physiological and psychophysical responses of participants of different obesity and physical fitness levels while performing one-handed carrying tasks.

Balke and Ware Experiment Protocol

The Aim 1 protocol was conducted in one-minute stages (Table I) until 85% of the maximum heart rate (MHR) was achieved or until the subject terminated the experiment. The submaximal target exercise HR was estimated using the Tanaka, Monahan, and Seals (2001) formula [(208 – (0.7 x Age)) x 85%].

For men, the treadmill speed was set at 5.3 km/hr, with an incline starting at 0%. After one minute, the grade was raised to 2% incline and increased by 1% each minute until the test was terminated (i.e., 85% MHR, or subject stops the experiment). For women, the treadmill speed was set at 4.8 km/hr to begin, with the incline starting at 0%. After three minutes, the grade was raised to 2.5% incline and increased by 2.5% every three minutes until the test was terminated (i.e., 85% MHR, or subject stops the experiment).

Table I: Balke & Ware treadmill test protocol

Minute	Incline (Males) 5.3 km/hr	Incline (Females) 4.8 km/hr
1	0	0
2	2	
3	3	
4	4	2.5
5	5	
6	6	
7	7	5
8	8	
9	9	
10	10	7.5
11	11	
12	12	
13	13	10
14	14	
15	15	
16	16	12.5

The investigator continuously measured and monitored the oxygen uptake (O2), carbon dioxide production (CO2), inspired pulmonary ventilation (VE), respiratory quotient (RQ), and HR during the experiment. The RPE (WB), RBE (Arm), RPD were recorded before and after the experiment is terminated for each subject. The task was assessed by NASA-TLX after each experiment trial. The subjects were allowed to cool down after the experiment by walking at a moderate speed until HR dropped below 100 bpm and breathing returned to normal.

The same protocol was repeated on two different days; one day with no-load for the baseline collection. On the other day, the subjects were carrying a load with their dominant hand (9 kg and 5.5 kg for males and females, respectively), and the same protocol was followed. The reason for conducting the experiments on separate days was to reduce the chance that the participants have muscle soreness or fatigue.

The loads were selected based on the findings of (Kilbom et al., 1992) that prolonged carrying in one-hand of weights higher than 10.0 kg for males and 6.0 kg for females is not recommended and could lead to cardiovascular non-steady states. The same weight range for men was tested during recent one-handed carrying studies that have suggested 10 kg to be a safe load to carrying for short durations (Badawy et al., 2018, 2019).

Preliminary Results

Eight participants have been recruited thus far (4 male, 4 female). Descriptive statistics (mean and standard deviation) for age, height, weight, BMI, and percent body fat for each group are presented in Table II.

Table II. Physical characteristics of participants

	Female (N=4)	**Male (N=4)**	**Overall (N=8)**
Age (years)			
Mean (SD)	27.0 (2.58)	28.5 (1.73)	27.8 (2.19)
Median [Min, Max]	27.0 [24.0, 30.0]	29.0 [26.0, 30.0]	28.5 [24.0, 30.0]
Height (cm)			
Mean (SD)	163 (6.62)	174 (6.29)	169 (8.15)
Median [Min, Max]	161 [158, 173]	173 [168, 183]	170 [158, 183]
Weight (kg)			
Mean (SD)	55.3 (8.65)	65.5 (6.65)	60.4 (8.98)
Median [Min, Max]	58.9 [42.5, 61.0]	64.0 [59.2, 74.9]	60.5 [42.5, 74.9]
Body Mass Index (kg/m^2)			
Mean (SD)	20.3 (3.07)	21.4 (0.622)	20.9 (2.13)
Median [Min, Max]	21.1 [16.2, 22.8]	21.2 [20.9, 22.3]	21.2 [16.2, 22.8]
%Fat			
Mean (SD)	18.4 (5.92)	8.13 (1.25)	13.3 (6.78)
Median [Min, Max]	20.1 [10.5, 23.0]	7.50 [7.50, 10.0]	10.3 [7.50, 23.0]

Psychophysical Responses

The below boxplot figures present the psychophysical responses reported by the participants for the different assessment tools that were used.

Figure II: Rating of perceived exertion for the whole body as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. Balke NL represents the experiment with no load, Balke L represent the experiment with a load.

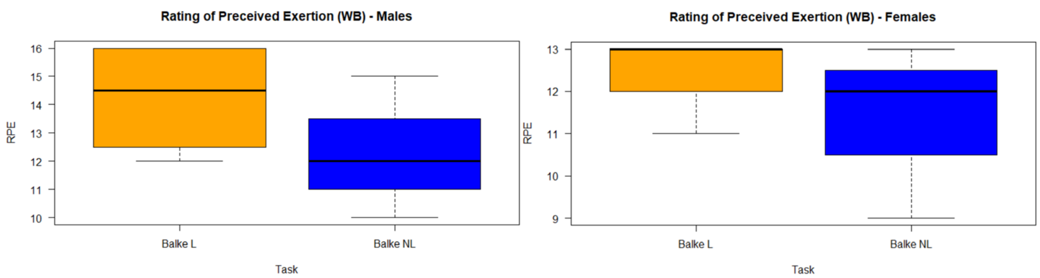


Figure III: Rating of perceived exertion for the dominant arm as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. Balke NL represents the experiment with no load, Balke L represent the experiment with a load.

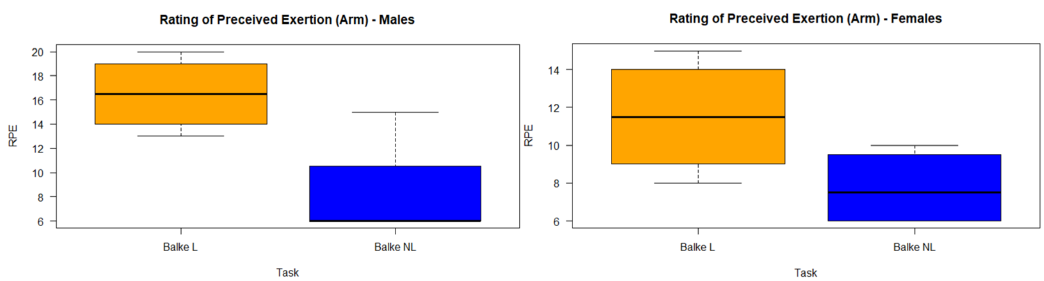


Figure IV: Rating of perceived dyspnea as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. Balke NL represents the experiment with no load, Balke L represent the experiment with a load.

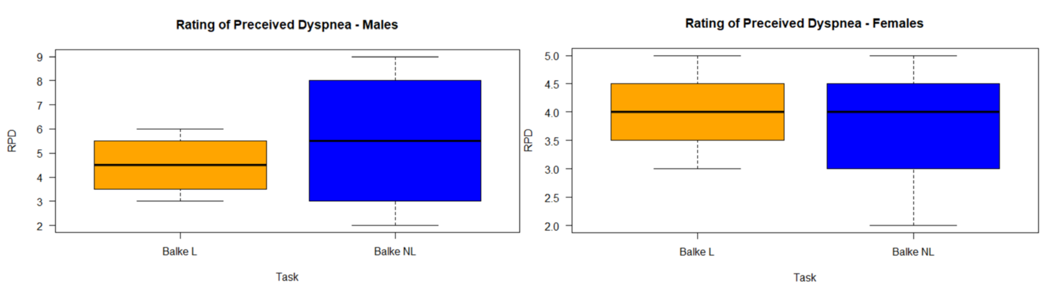
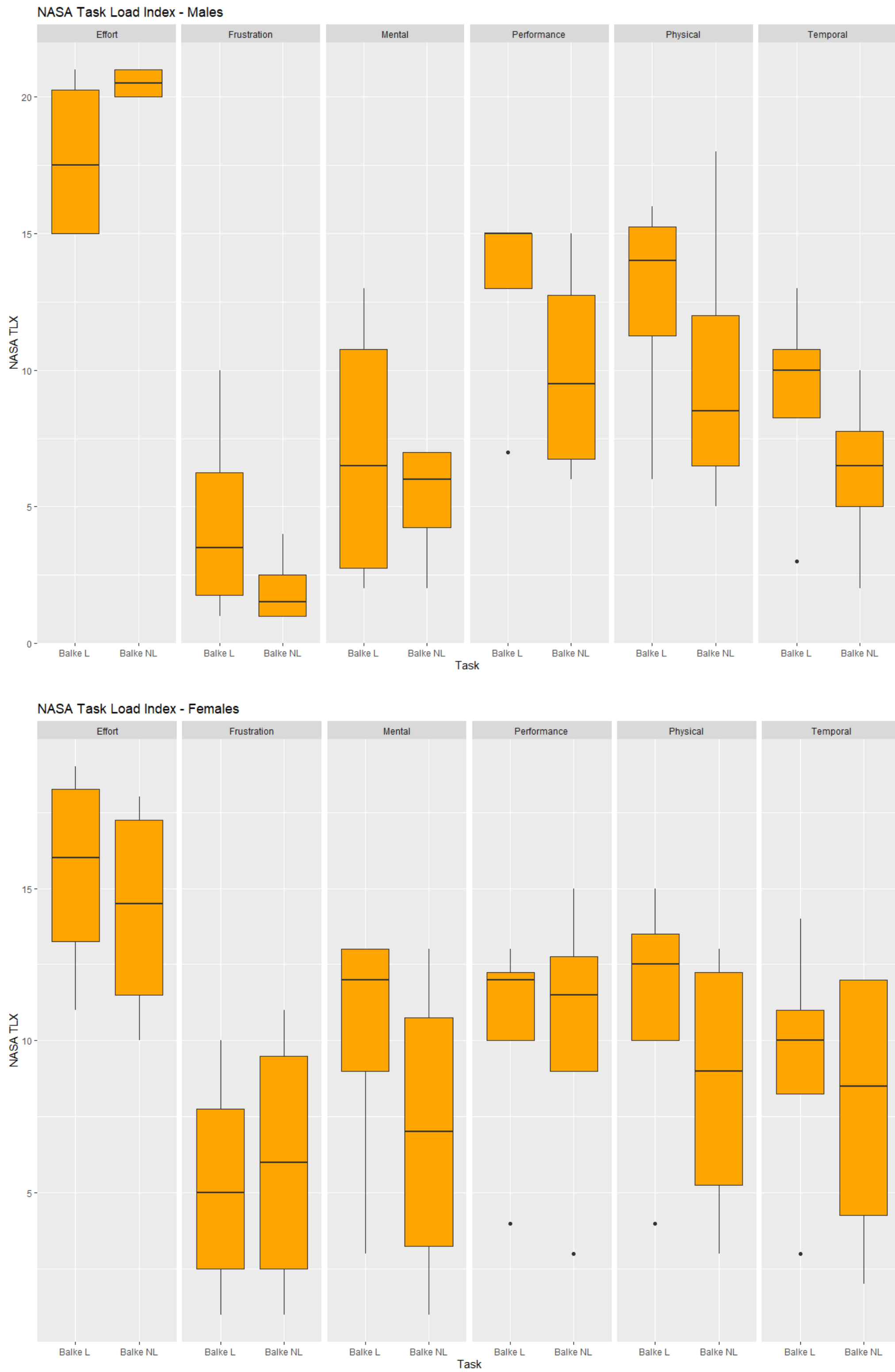


Figure V: NASA Task Load Index as reported by male and female participants. Balke NL represents the experiment with no load, Balke L represent the experiment with a load.



Physiological Responses

Maximal physiologic data for the two tests; with load [Balke L], and no-load [Balke NL] are shown in table (III) and table (IV) for male and female participants, respectively.

Table III: Maximal physiologic data for Balke and Ware treadmill protocol with a load and with no load for male participants

	Balke L (N=4)	Balke NL (N=4)	Overall (N=8)
VO2 (ml/kg.min-1)			
Mean (SD)	29.9 (9.88)	33.6 (7.37)	31.7 (8.30)
Median [Min, Max]	31.6 [16.3, 40.0]	33.8 [24.3, 42.3]	32.6 [16.3, 42.3]
Duration (sec)			
Mean (SD)	520 (66.8)	844 (92.6)	682 (189)
Median [Min, Max]	518 [442, 604]	809 [779, 980]	692 [442, 980]
HR (beats/min)			
Mean (SD)	157 (5.25)	158 (1.50)	158 (3.59)
Median [Min, Max]	159 [150, 162]	158 [156, 159]	158 [150, 162]
VE (1/min-BTPS)			
Mean (SD)	49.6 (17.0)	47.8 (14.3)	48.7 (14.6)
Median [Min, Max]	44.4 [35.9, 73.7]	44.7 [34.7, 67.2]	44.5 [34.7, 73.7]
RQ			
Mean (SD)	0.830 (0.0400)	0.840 (0.0356)	0.835 (0.0355)
Median [Min, Max]	0.810 [0.810, 0.890]	0.835 [0.810, 0.880]	0.810 [0.810, 0.890]

Table IV: Maximal physiologic data for Balke and Ware treadmill protocol with a load and with no load for female participants

	Balke L (N=4)	Balke NL (N=4)	Overall (N=8)
VO2 (ml/kg.min-1)			
Mean (SD)	30.5 (7.62)	31.3 (12.4)	30.9 (9.53)
Median [Min, Max]	28.4 [24.0, 41.1]	28.5 [19.6, 48.7]	28.5 [19.6, 48.7]
Duration (sec)			
Mean (SD)	704 (234)	785 (323)	744 (265)
Median [Min, Max]	601 [562, 1050]	751 [427, 1210]	676 [427, 1210]
HR (beats/min)			
Mean (SD)	160 (2.99)	159 (0.957)	160 (2.07)
Median [Min, Max]	159 [157, 164]	160 [158, 160]	159 [157, 164]
VE (1/min-BTPS)			
Mean (SD)	43.4 (19.0)	45.5 (18.8)	44.5 (17.5)
Median [Min, Max]	41.9 [25.9, 64.0]	42.0 [27.7, 70.4]	42.0 [25.9, 70.4]
RQ			
Mean (SD)	0.798 (0.0660)	0.785 (0.0574)	0.791 (0.0577)
Median [Min, Max]	0.805 [0.710, 0.870]	0.810 [0.700, 0.820]	0.805 [0.700, 0.870]

Discussion

For the Balke and Ware experiment, preliminary results suggest that the RPE (WB) and RPE (Arm) received higher scores for the trial that involved carrying the load. On the other hand, the RPD was reported to be slightly higher by the female participants for the load trial, and slightly lower by the corresponding male participants for the same trial. These early observations opposing the hypothesis may be related to the randomization of the experiments. Additional data collection is ongoing.

Among the six subscales for NASA-TLX, more effort was required by female and male participants for both trials; with load and the no-load trial. However, male participants reported higher effort being needed when performing the no-load trial relative to the with a load trial. Moreover, the load trial received higher ratings for all trials by male and female participants, excluding the reporting of higher frustration by the female participants when performing the trial than the no-load trial.

The findings for the physiological investigation for the Balke and Ware experiment was that the participants from both sexes had higher endurance time when performing the no-load trial. Moreover, the oxygen consumption was measured to be higher for the same trial, likely because of the higher duration recorded for this task. The HR, VE, and RQ were slightly different for the both trials; with load and with no-load.

Specific Aim 2: Compare the effect of inclined surface angle on the physiological and psychophysical responses of participants with different obesity levels while performing one-handed carrying tasks.

Inclined Surfaces Effect Experiment Protocol

For Aim 2, both the baseline and experimental session were collected in one day. The subjects were asked to walk four randomized trials on a treadmill at 3.2 km/hr walking speed for a distance of 96.5 meters, the same distance used by (Badawy et al., 2018) at a speed similar to (Kilbom et al., 1992). The selected speed was maintained in all trials to minimize the effect of speed on performance measurements. The stages were randomized to control for potential sequence effects. The experiment included two variables with two levels; load (9 kg and 5.5 kg, for males and females respectively) and no-load, inclined surface (11.21 degrees equivalent to 20% grade) and flat surface (i.e., No-load and flat surface [NF], no-load and inclined surface [NI], load and flat surface [LF], load and inclined surface [LI]). The incline was selected based on a previous study that examined the effect of trunk kinematics during lifting (Shin & Mirka, 2004), as well as OSHA's provisions concerning maximum allowable slopes that any ramp with an angle greater than 20 degrees from the horizontal must be provided with handrails. Readouts of O2, CO2, VE, RQ, and were recorded continuously. The RPE (WB), RBE (Arm), RPD were measured before and after the experiment was terminated for each subject. NASA-TLX measurements were documented after each experimental trial. The participants were given 10 minutes to rest between the trials. The participants were allowed to drink water between the trials to ensure good hydration, and food was not allowed between the four trials.

Preliminary Results

Eight participants were recruited (4 male, 4 female). Descriptive statistics (mean and standard deviation) for age, height, weight, BMI, and percent body fat for each group are presented in Table II.

Psychophysical Responses

The below boxplot figures present the psychophysical responses reported by the participants for the different assessment tools that were used.

Figure VI: Rating of perceived exertion for the whole body as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. No-load and inclined surface [NI], load and inclined surface [LI], No-load and flat surface [NF], load and flat surface [LF].

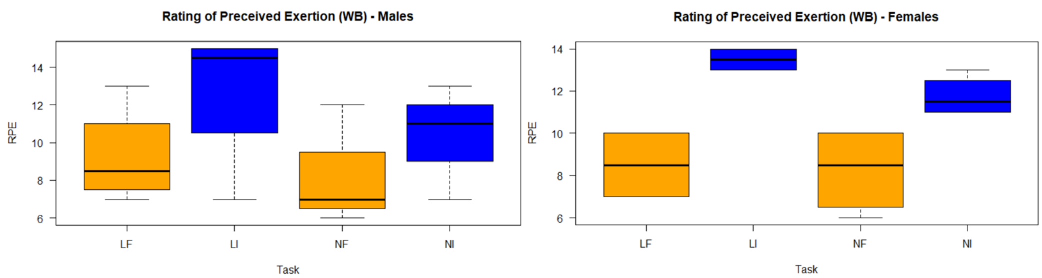


Figure VII: Rating of perceived exertion for the dominant arm as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. No-load and inclined surface [NI], load and inclined surface [LI], No-load and flat surface [NF], load and flat surface [LF].

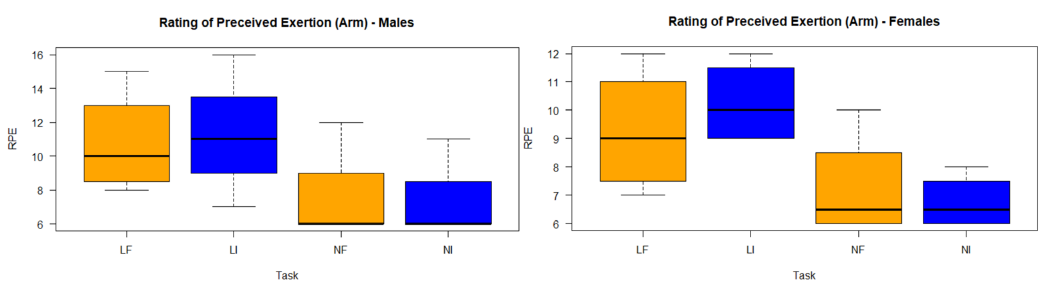


Figure VIII: Rating of perceived dyspnea as reported by male and female participants. B-RPE reported before the experiment, E-RPE reported after the experiment. No-load and inclined surface [NI], load and inclined surface [LI], No-load and flat surface [NF], load and flat surface [LF].

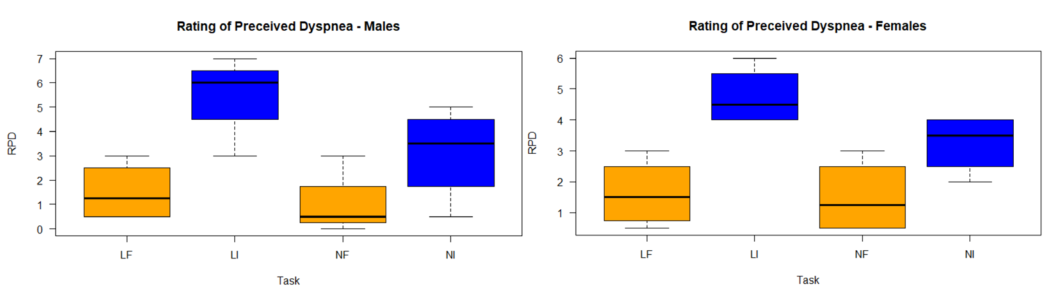
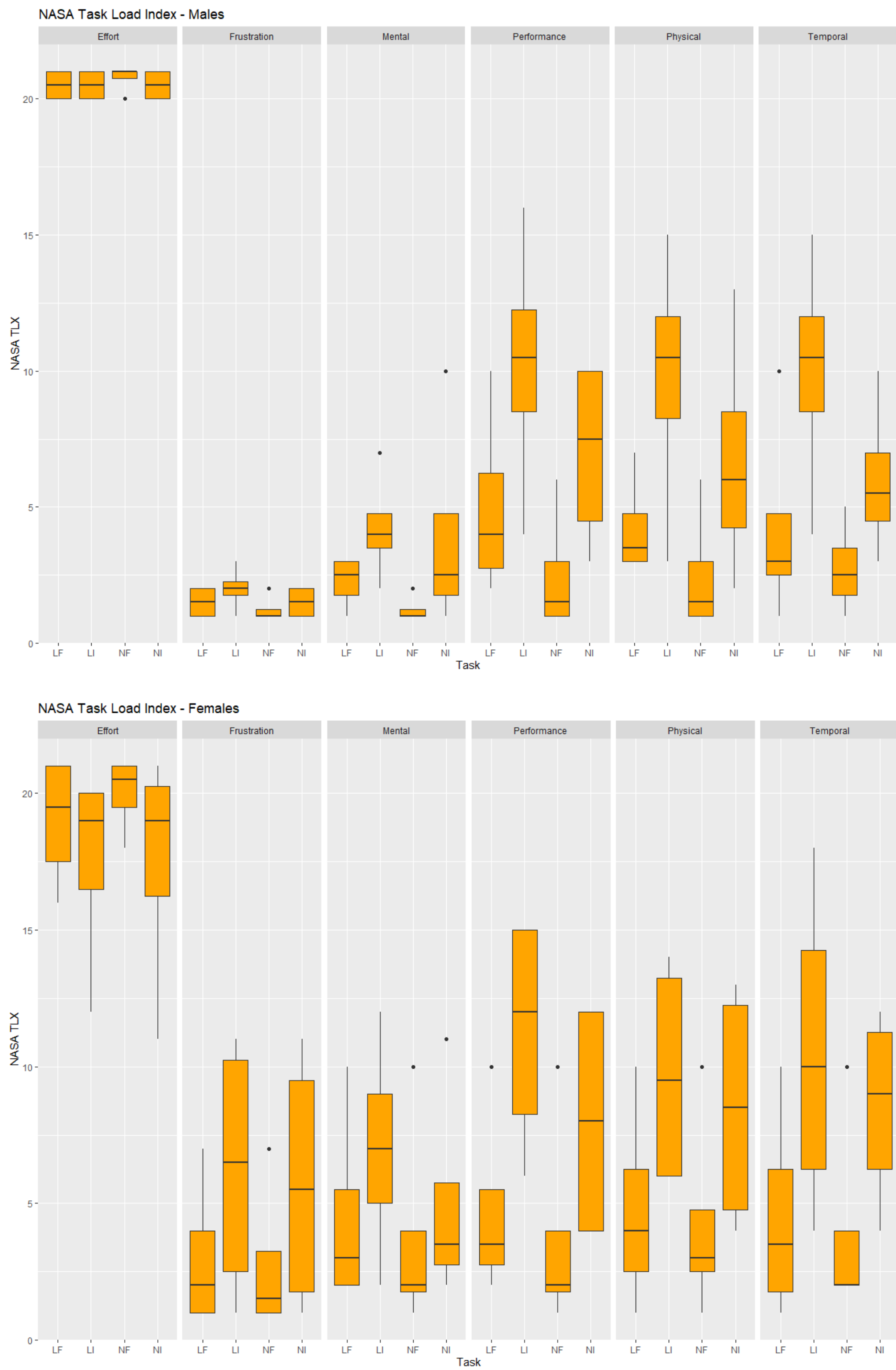


Figure IX: NASA Task Load Index as reported by male and female participants. No-load and inclined surface [NI], load and inclined surface [LI], No-load and flat surface [NF], load and flat surface [LF].



Physiological Responses

Table (V) and table (VI) below present the physiologic values of the 32 task trials that were performed by 4 male participant and 4 female participants.

Table V: Physiologic values for the 4 tasks; load and flat surface [LF], load and inclined surface [LI], no-load and flat surface [NF], no-load and inclined surface [NI] that were performed by 4 male participants.

	LF (N=4)	LI (N=4)	NF (N=4)	NI (N=4)	Overall (N=16)
VO2 (ml/kg.min-1)					
Mean (SD)	11.2 (3.34)	31.4 (3.44)	7.60 (1.02)	24.4 (5.49)	18.6 (10.5)
Median [Min, Max]	10.8 [7.90, 15.2]	30.4 [28.5, 36.2]	7.25 [6.80, 9.10]	25.7 [17.1, 29.2]	16.2 [6.80, 36.2]
HR (beats/min)					
Mean (SD)	102 (13.3)	158 (12.8)	96.0 (10.9)	145 (8.43)	125 (29.5)
Median [Min, Max]	96.5 [93.0, 121]	158 [145, 172]	94.5 [86.0, 109]	148 [132, 150]	127 [86.0, 172]
VE (1/min-BTPS)					
Mean (SD)	17.2 (3.88)	45.6 (3.40)	12.0 (2.34)	35.1 (11.9)	27.5 (15.2)
Median [Min, Max]	17.7 [12.0, 21.4]	45.9 [41.4, 49.2]	12.1 [9.39, 14.1]	40.0 [17.5, 43.1]	19.7 [9.39, 49.2]
RQ					
Mean (SD)	0.648 (0.0465)	0.845 (0.0443)	0.643 (0.0727)	0.730 (0.0216)	0.716 (0.0957)
Median [Min, Max]	0.640 [0.600, 0.710]	0.860 [0.780, 0.880]	0.655 [0.550, 0.710]	0.735 [0.700, 0.750]	0.710 [0.550, 0.880]

Table VI: Physiologic values for the 4 tasks; load and flat surface [LF], load and inclined surface [LI], no-load and flat surface [NF], no-load and inclined surface [NI] that were performed by 4 female participants.

	LF (N=4)	LI (N=4)	NF (N=4)	NI (N=4)	Overall (N=16)
VO2 (ml/kg.min-1)					
Mean (SD)	16.5 (1.93)	33.9 (6.13)	13.8 (2.89)	28.8 (12.0)	23.3 (10.7)
Median [Min, Max]	16.5 [14.5, 18.5]	31.1 [30.5, 43.1]	12.9 [11.5, 17.9]	29.8 [14.3, 41.5]	18.2 [11.5, 43.1]
HR (beats/min)					
Mean (SD)	112 (7.14)	166 (13.7)	107 (8.83)	158 (18.2)	136 (29.5)
Median [Min, Max]	113 [102, 119]	170 [146, 177]	109 [95.0, 116]	158 [139, 176]	129 [95.0, 177]
VE (1/min-BTPS)					
Mean (SD)	22.2 (3.81)	46.1 (5.40)	19.0 (5.43)	35.6 (14.4)	30.7 (13.5)
Median [Min, Max]	21.9 [18.2, 26.9]	44.4 [41.9, 53.7]	18.1 [13.4, 26.5]	36.4 [17.7, 51.6]	26.7 [13.4, 53.7]
RQ					
Mean (SD)	0.568 (0.0472)	0.818 (0.0850)	0.585 (0.0507)	0.733 (0.0797)	0.676 (0.123)
Median [Min, Max]	0.580 [0.500, 0.610]	0.835 [0.700, 0.900]	0.605 [0.510, 0.620]	0.740 [0.630, 0.820]	0.625 [0.500, 0.900]

Discussion

In all observations of the second experiment, tasks with load were reported to have a higher perceived exertion and perceived dyspnea for both sexes. In general, tasks that were performed on the incline were reported to have a higher exertion. Inclined surfaces while carrying a load had the highest reported values between the four trials for both male and female participants.

Both sexes reported significantly higher values of required effort among the other subscales for the NASA-TLX assessment. For the other five subscales, the load-inclined trial was the highest reported among the four experimental trials.

The physiological measurements indicated that the load-inclined trial required more oxygen consumption, and higher HR, VE, and RQ values were recorded. Although it was observed that the incline has a higher effect than the load for both sexes, data collection is ongoing.

Future Work

The purpose of this study is to provide a more comprehensive understanding of the physiological and psychophysical effects of one-handed carrying on flat and inclined surfaces. The increased understanding will result in an enhanced evaluation of risk factors associated with MSDs in the workplace and allow for better prediction and prevention of these injuries.

Due to the unforeseen and devastating circumstances of the spreading of coronavirus, the project was delayed as a result of the pandemic during different phases. The study is currently in the data collection phase. Twenty-four additional participants will be recruited during the upcoming several months. Once the data collection is completed, the data will be analyzed using Analysis of variance (ANOVA) and regression models to evaluate the statistical significance of the main effects and interactions between them following visual inspection for necessary assumptions. If the data are non-normal, transformations or equivalent nonparametric techniques will be applied as necessary.

Journal and conference publications are expected to be submitted from this study, and the acknowledgment of support via the National Institute for Occupational Safety and Health (NIOSH) will be reported. Additionally, this study will be presented at the Deep South Center 2022 conference.

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