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RESEARCH ARTICLE

EFFECT OF LOAD ON GAIT

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Abstract

Introduction: Material Handling is one of the major activities performed by the workforce in the present scenario in industries. Our study aims to do the experiment with 22 different subjects and to collect the data using MiniSun IDEEA3 Gait Analysis instrument and to analyse the parameters Speed, EE and Stride length and find preventable measures to reduce fall risk.

Material and Methods: Gait analysis experiment has been done with the subject with backpack and double pack with load of 5 kg and 10 kg. In the Industrial scenario, from construction site to cement industry, workers are carrying the load from one place to another. For instance, the typical scenario includes the transferring the load in backpack. All experiments were done in the institutegymnastic. Our study methodology deals with the conditions of experimentation, how sensors, recorder and sub recorder attached to subject body and how it‘s working. This includes subject experiment conditions such as subject is walking on even surface and stairs with 5 kg backpack, 10 kg backpack and 5 kg double pack. When subject walks, data gets collected in recorder from sub recorder through wirelessly.

Results: When subject walks with 10 kg backpack load gait parameters shows the worst condition i.e. prone to fall. However, if 10 kg backpack load distributed to 5 kg each side front and rear i.e. called double pack result shows a reliable change i.e. a safe limit to prevent the fall risk. So rather than preferring a backpack, double pack would be recommendable to prevent fall risk. The reason behind speed reduction is shorter steps with carrying load as compare to no load, which fails to maintain minimum unimpaired walking speed 55m/min. But greater than 75 m/min suggested to exceptional life expectancy. But not prove to be best in reduced fall risk while carrying. When load increases, speed get decreases, energy expenditure increases, stride length decreases. These all-gait parameters indicate a significant change that is the major cause of fall during manual material handling in industries.

Conclusion: So those with high BMI if carry material in manual material handling industries, the Speed and EE will be major and considerable factor to fall. Thus Speed and energy expenditure needs to

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be investigated with Influence of walking speed, external load, energy expenditure and power on gait characteristics, to find the relationship between the risk of injury to kinematic changes due to external load on speed, energy expenditure and power.

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Introduction:-

Material Handling is one of the major activities performed by the workforce in the present scenario in industries. Manual Material Handling is the principle source of compensable injuries in U.S. work force and four out of five of these injuries will affect the lower back. Material Handling can be done manually or mechanically. Although technology has advanced industrial production techniques, manual handling of materials has remained essentially the same. Handling of materials is a primary concern for the occurrence of 20% to 40% of all occupational related injuries. Fall Risk and work related Musculo -Skeletal disorders are the major problems associated with the manual material handling practices adopted in the industrial working conditions. Gait Abnormalities is made up of speed, power, energy expenditure, step length, cadence, stride length, stride duration. Normal Gait primary functions include unimpaired walking, allowing motion, protecting from fall. A perfect Gait posture is the interface between impaired and unimpaired walking. The relationship between backpack carriage and double pack carriage and gait parameters has not been explicitly studied among young adults and mid aged person.

Human Factors Engineering is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. The goal of human factors engineering is to optimize the system performance by taking human physical and cognitive capabilities and limitations into consideration during design. Human factors engineering means engineering for human use. More specifically, Human factors engineering is defined as follows: the design of human tasks, man-machine systems, and specific items of man-operated equipment for the most effective accomplishment of the job, including displays for presenting information to the human senses, controls for human operation, and complex man-machinesystems.

Standing involves a series of relatively immobile positions separated by brief intervals of movement during which swaying occur. When a subject is in the easy standing position, few muscles of the back and lower limbs are active during the immobile periods. The position of the line of gravity, which is determined by the distribution of body weight, is important in determining the degree of muscular activity involved in maintaining all phases of posture. The line of gravity extends superiorly through the junctions of the curves of the vertebral column and inferiorly in a line posterior to the hip joints but anterior to the knee and ankle joints. When a subject is in the easy standing position, the hip and knee joints are extended and are in their most stable positions. Because the line of gravity passes posterior to the hip joint and anterior to the knee joint, the weight of the body tends to hyperextend these articulations.

Locomotion is very complicated, is laboriously acquired, and becomes almost entirely automatic. Disturbances of gait are important signs in many disorders of the central nervous system. When a subject is walking on level ground, the movements of the lower limbs may be divided into "stance" and "swing" phases, which are separated by heel-strike. The swing phase occurs when the limb is off the ground, and the stance phase when it is in contact with the ground and is bearing weight. A cycle of walking is the period from the heel-strike of one foot to the next heel-strike of the same foot.

Gait analysis is used by researchers and clinicians to describe an individual pattern of walking. In modern rehabilitation, there is an increasing need for objective and quantitative measurement of the relevant aspects of gait. This should ultimately lead to a better understanding of speed, step length, power, and energy expenditure. Gait analysis also involves the measurement of muscle activity, and both kinetic and kinematical elements during gait. Most of the problems associated with the gait is the speed, power, energy expenditure and step length.

Gait analysis of subject of young and mid aged, while considering the variable parameters like step length, stride length, stride duration, speed, energy expenditure, power, cadence with backpack and double pack. Influence of walking speed, external load, energy expenditure and power on gait characteristics, to find the relationship between the risk of injury to kinematic changes due to external load on speed, energy expenditure and power. In this study, the gait analysis of the subject with the load of 5 kg and 10 kg in backpack and double pack and three different

types of gait parameters speed, stride length and energy expenditure observed and analyzed the effect of load on these parameters.

Analysis of Gait disorder posture of variable aged people with backpack and double pack and compare the effects using parameters speed, energy expenditure, stride length while using the MiniSun LLC IDEEA3 Life Gait equipment. Our study aims to do the experiment with 22 different subjects and to collect the data using MiniSun IDEEA3 Gait Analysis instrument and to analyse the parameters Speed, EE and Stride length and find preventable measures to reduce fall risk.

Methodology:-

Gait analysis experiment has been done with the subject with backpack and double pack with load of 5 kg and 10 kg. In the Industrial scenario, from construction site to cement industry, workers are carrying the load from one place to another. For instance, the typical scenario includes the transferring the load in backpack. All experiments were done in the institutegymnastic.

Subject was made to fix recorder, sub recorder and sensor to their respective place on the body. Gait analysis experiment was done one after another with load value of 5 kg and 10 kg with backpack and double pack. Subject is made to walk on uniform surface and working stairs. After each experiment, the data was loaded to MiniSun IDEEA3 system software. The Speed, Energy Expenditure and Stride length was compared for each subject while with 5kg, 10 kg backpack and double pack load.

Our study methodology deals with the conditions of experimentation, how sensors, recorder and sub recorder attached to subject body and how it‘s working. This includes subject experiment conditions such as subject is walking on even surface and stairs with 5 kg backpack, 10 kg backpack and 5 kg double pack. When subject walks, data gets collected in recorder from sub recorder through wirelessly.

Results:-

Gait Analysis experiment has been performed with 5kg Backpack. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) are tabulated in Table 1.

Experiment no. 1	Subject Weight- 52 kg	Height- 176cm	BMI- 17.2
Experiment no. 2	Subject Weight- 75kg	Height- 181cm	BMI- 22.8
Experiment no.3	Subject Weight- 93kg	Height- 178cm	BMI- 28.7

Table 1:- Gait analysis of subjects with 5kg Backpack load on Even Surface.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length (m)**	1.22	1.29	1.09
2	**Speed (m/min)**	74.8	76.3	58.1
3	**Cadence (steps/min)**	121.3	118.1	107.2
4	**EE (kcal/min)**	3.51	4.18	4.57

As table 1, shows the variation of gait parameters step length, speed, cadence and energy expenditure. These all parameters are responsible for fall risk of subject during walking which should not exceed the safe limit.

Gait Analysis experiment has been performed with 10kg Backpack. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) is presented in the Table 2.

Table 2:- Gait analysis of subjects with 10kg Backpack load on Even Surface.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length (m)**	1.15	1.23	1.03
2	**Speed (m/min)**	65.7	71.9	52.9

3	**Cadence (steps/min)**	110.2	112.3	102.5
4	**EE (kcal/min)**	3.72	4.29	4.72

As Table 2 shows subjects with 10kg backpack and gait parameters variation with 10kg backpack that should not exceed 10% body weight.

Gait Analysis experiment has been performed with 5kg Double pack. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) is presented in the table 3.

Table 3:- Gait analysis of subjects with 5kg Double pack load on Even Surface.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length(m)**	1.18	1.26	1.06
2	**Speed(m/min)**	68.5	72.8	54.2
3	**Cadence(steps/min)**	113.4	115.2	105.2
4	**EE(kcal/min)**	3.59	4.23	4.64

As table 3, shows variation of gait parameters with 5kg double pack load, here 5kg double pack means 5kg both side front and rear, means total 10kg weight.

Gait Analysis experiment has been performed with 5kg Backpack on Stairs. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) is presented in the table 4.

Table 4:- Gait analysis of subjects with 5kg Backpack load on Stairs.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length(m)**	0.832	0.942	0.789
2	**Speed(m/min)**	49.6	54.6	45.7
3	**Cadence(steps/min)**	102.7	104.1	96.4
4	**EE (kcal/min)**	6.7	7.3	7.52

Gait Analysis experiment has been performed with 5kg Backpack. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) is presented in the table5.

Table 5:- Gait analysis of subjects with 10kg Backpack load on Stairs.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length(m)**	0.802	0.887	0.712
2	**Speed(m/min)**	40.8	50.2	38.2
3	**Cadence(steps/min)**	94.9	96.7	92.9
4	**EE(kcal/min)**	7.23	7.82	8.2

Gait Analysis experiment has been performed with 5kg Backpack. Speed, Step Length, Energy Expenditure and Cadence on subjects with different BMI (underweight, normal and overweight) is presented in the table6.

Table 6:- Gait analysis of subjects with 5kg Double pack load on Stairs.

	BMI	**17.2**	**22.8**	**28.7**
S.no	**Statistics**	**Both feet(mean)**	**Both feet(mean)**	**Both feet(mean)**
1	**Stride length(m)**	0.831	0.906	0.744
2	**Speed(m/min)**	44.1	52.3	41.7

3	**Cadence(steps/min)**	96.9	98.3	94.2
4	**EE(kcal/min)**	7.03	7.54	7.82

Figure 1:- Effect on Speed for 3 different load conditions on different BMIcategories while usingstairs.

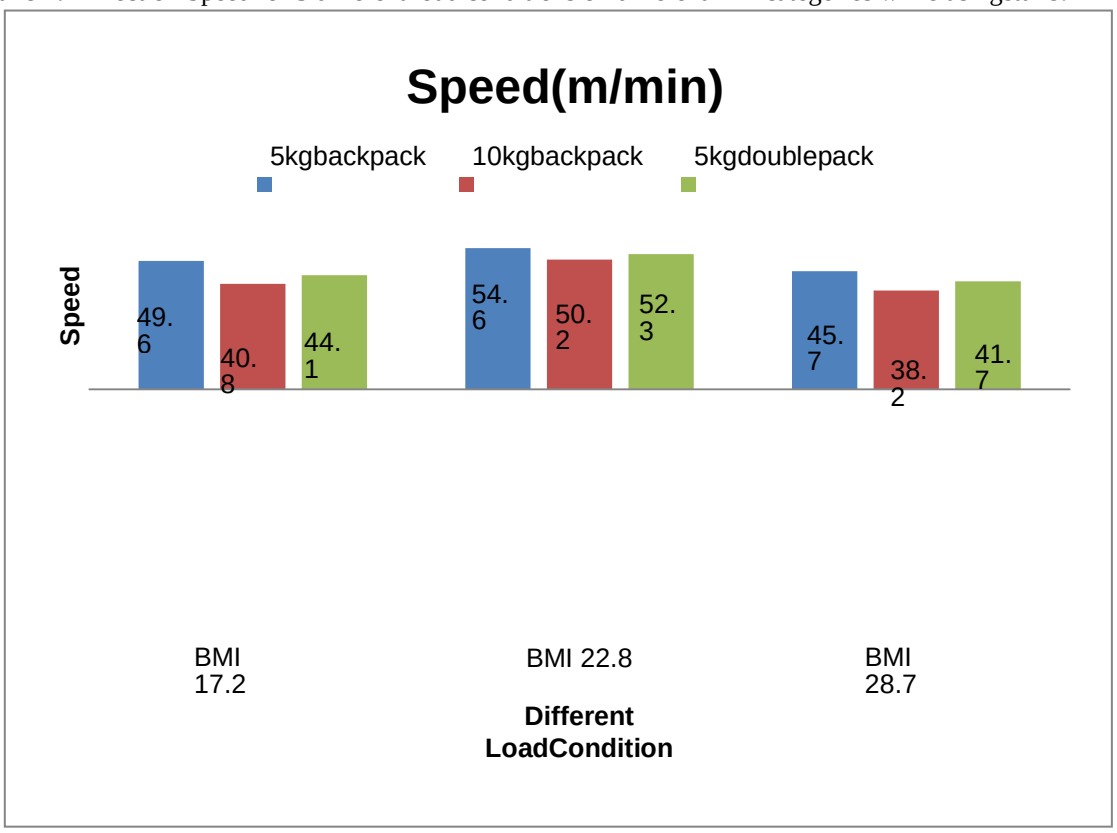
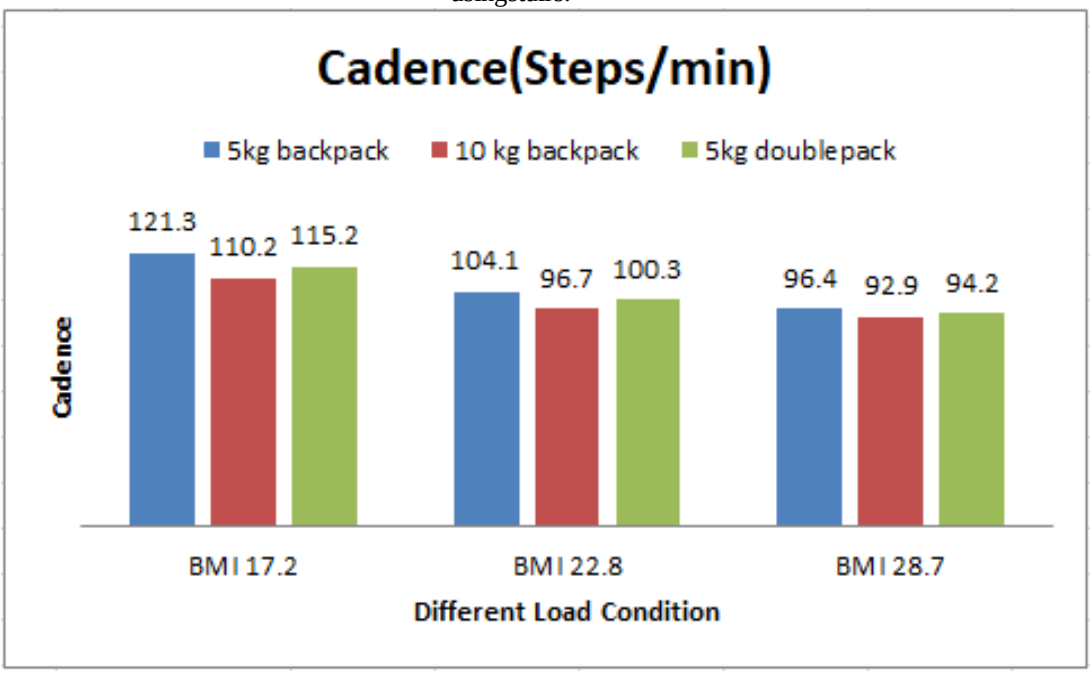


Figure 2:- Effect on Cadence for 3 different load conditions on different BMI categories while usingstairs.



Cadence:
It is the rate at which a person walk, expressed in steps per minute. The average cadence is 95 - 120 steps/min.

Energy Expenditure:
It describes the energy expenditure during a given time unit (kcal/min). It reflects the rate of calorie consumption. The accumulation of EE over a period of time is called energy, representing total energy (calorie) consumed during this period. As per NIOSH result, the 1991 committee recommended that EE value for a person while carry load should not exceed 50% of 9.5 kcal/min if working for less than 1 hour, EE should not exceed 40% of 9.5 kcal/min for 1-2 hour, EE should not exceed 33% of 9.5 kcal/min for 2-8 hour work.

Figure 3:- Effect on Stride Length for 3 different load conditions on different BMI categories while usingstairs.

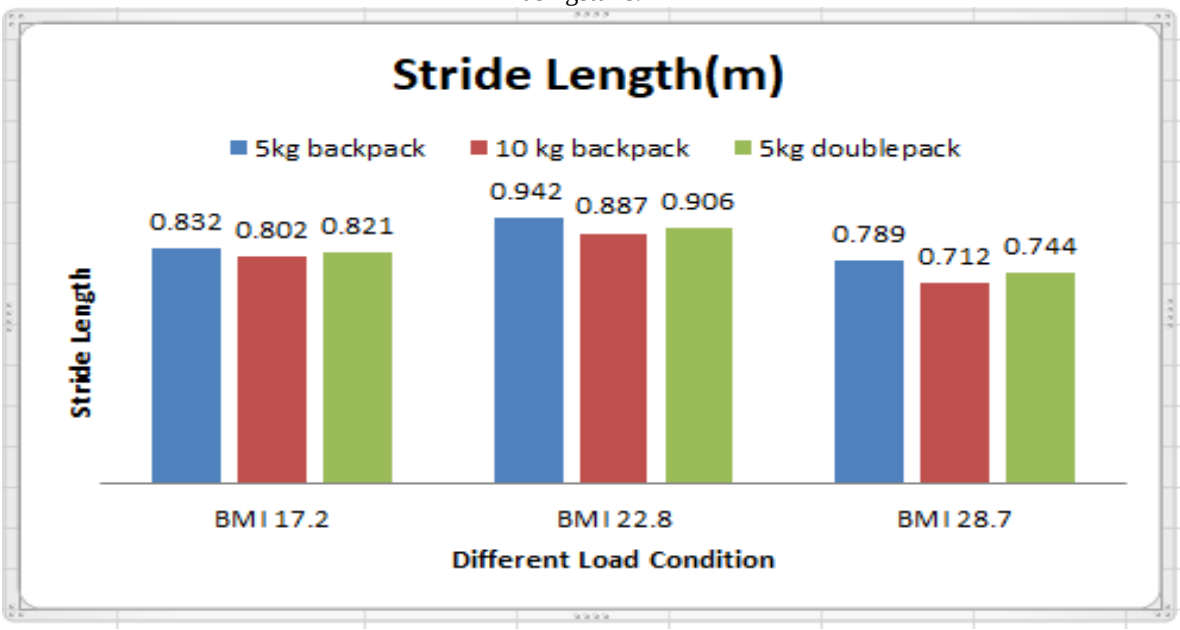
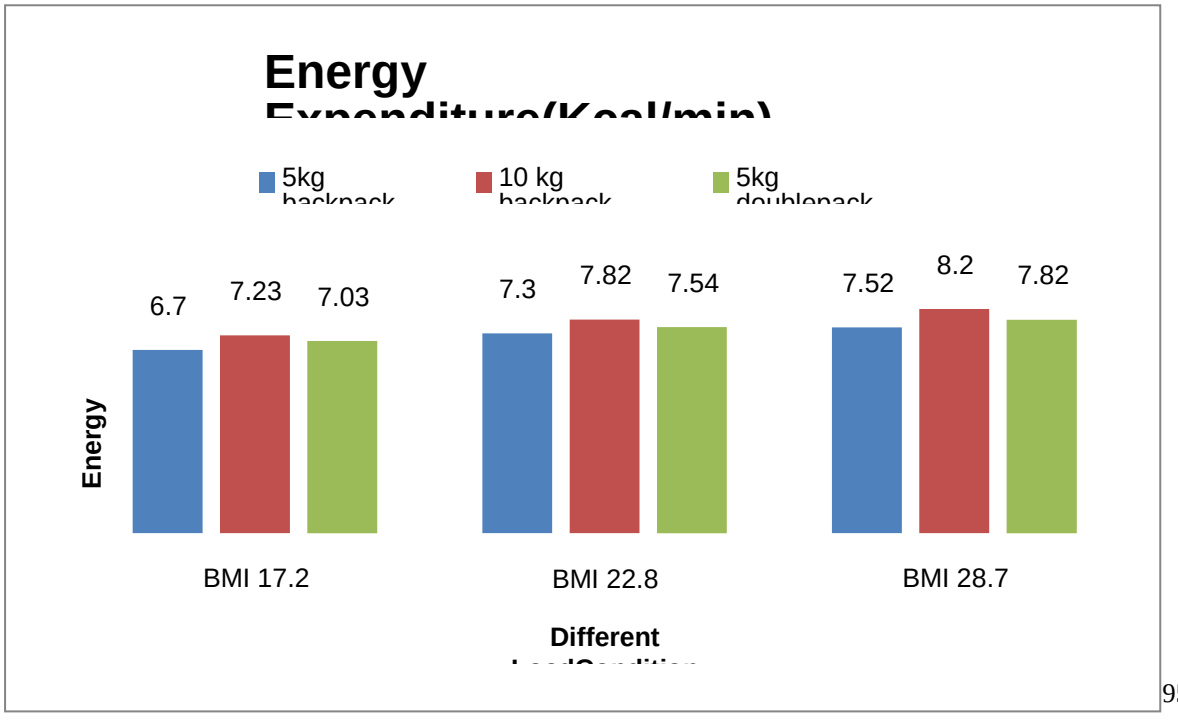


Figure 4:- Effect on Energy Expenditure for 3 different load conditions on different BMI categories while usingstairs.



We can see from the figures 1, 2, 3 and 4 that irrespective of the BMIs the gait parameters such as Speed, Cadence, Stride Length or Energy Expenditure are reduced when load is changed from 5kg to 10 kg but after double pack is introduced a significant can be observed in the respective values.

Discussion:-

This deals with the experimental result comparison that shows a significant change with increasing load. When subject walks with 10 kg backpack load gait parameters shows the worst condition i.e. prone to fall. However, if 10 kg backpack load distributed to 5 kg each side front and rear i.e. called double pack result shows a reliable change i.e. a safe limit to prevent the fall risk. So rather than preferring a backpack, double pack would be recommendable to prevent fall risk. The reason behind speed reduction is shorter steps with carrying load as compare to no load, which fails to maintain minimum unimpaired walking speed 55m/min. But greater than 75 m/min suggested to exceptional life expectancy. But not prove to be best in reduced fall risk while carrying

The study pointed out that the Energy Expenditure could only reflect the total work of the body decreases while walking in slower speed could compensate the additional EE required for load carrying from low to heavy. We found correlations of load vs speed, cadence, stride length and EE. We conclude that young adults can cope upto 10% of body weight load under single backpack but 12% body weight load affects gait efficiency. Hence 10% body weight load on single backpack or 10% body weight load on double pack is proven to be a safe limit. These recommendations may assure increased gait stability, decreased muscle fatigue reducing back pain occurrence. Excess weight increases the stress within the bones, joints and soft tissues resulting in impaired musculoskeletal function which in turn affects gait efficiency.

When load increases, speed get decreases, energy expenditure increases, stride length decreases. These all-gait parameters indicate a significant change that is the major cause of fall during manual material handling in industries. When subject walk with load their speed decreases, because stride length and step length decrease. Minimum requirement for unimpaired walking, i.e. 75m/min and energy expenditure that shows amount of calorie consumption during repetitive material handling exceed their maximum safe limit as per NIOSH.

When subject walks with 10 kg backpack load, gait parameters shows worst condition i.e. prone to fall. However, if 10 kg backpack load distributed to 5 kg each side front and rear i.e. called double pack result shows a reliable change i.e. a safe limit to prevent the fall risk. So rather than preferring a backpack, double pack would be recommendable to prevent fall risk. The reason behind speed reduction is shorter steps with carrying load as compare to no load, which fails to maintain minimum unimpaired walking speed 55m/min. But greater than 75m/min suggested to exceptional life expectancy. But not prove to be best in reduced fall risk while carryingload.

Another one of the important considerable parameters is EE (Energy Expenditure) in (kcal/min) which reflects the rate of calorie consumption required to walking with carrying load. From the above study it is clear that EE consumed more in walking with load of 20 kg compared to walking with no load and walking on stairs. In this study EE exceeded the maximum physical aerobic capacity of subject, because of it subject got tired and lost control on steps and speed which is prone to fall. As per NIOSH recommended threshold value that EE value for a person while carry load should not exceed 50% of 9.5 kcal/min if working for less than 1 hour, EE should not exceed 40% of 9.5 kcal/min for 1-2 hour, EE should not exceed 33% of 9.5 kcal/min for 2–8-hour work and if exceeded workers get fatigue and more prone to fall during materialhandling.

Conclusion:-

In the present industrial scenario, the number of overweight and obese people is constantly increasing and the future will witness a major proportion of the population with high body mass index (BMI) in the industry. So those with high BMI, if they carry material in manual material handling industries, the Speed and EE will be major and considerable factor to fall. Thus Speed and EE needs to be investigated with Influence of walking speed, external load, energy expenditure and power on gait characteristics, to find the relationship between the risk of injury to kinematic changes due to external load on speed, energy expenditure and power. Thus, research activities in Speed and EE Especially for high-BMI people pose a challenging task for the scientific community worldwide. It also has wide scope in clinical system to identify the biomechanical abnormalities.

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