The Influence of Load Carrying Modes on Gait variables of Healthy Indian Women

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ABSTRACT

Many studies have been carried out worldwide on various load carriage and gait pattern of healthy men, but similar studies on healthy women are scanty. Especially there is no such reference in Indian literature. Women were found to have higher incidence of musculoskeletal injuries when carrying a heavy load during daily activities. The objective of this study was to examine the changes in gait patterns of healthy Indian women with different mode of load carriage. Nine healthy university female students without existing orthopaedic problems were selected for this study. Thirty six reflective markers were placed on the volunteer's lower limb. Six infrared cameras were used to film the volunteers walking along a 5 meter walkway. Each volunteer was asked to walk at her self-selected speed without any load to establish a baseline and then, in random order, they were asked to walk with a 10-Kg. load on the head, hand, and diagonally across one shoulder. The gate pattern was studied using the Qualysis Motion Capture System (Gothenburg, Sweden). The age, height and weight of the volunteers were 22.3±1.64 yrs, 157.5±7.42 cm and 58.5±8.6 kg respectively. It was observed that the stride length was maximum during free walking (1.3m) and minimum while carrying load (1.1m) on head. Double limb support used throughout the walk way was maximum while carrying shoulder load (12 times) and was minimum during free walking (4 times).Cycle time and double limb support time were almost same in each case except during free walking where both were found to be less compared to load conditions. Walking speed was found to be decreased while walking with head load (1.1m/s).

Key words: Load carriage, gate pattern, stride length, double limb support, walking speed

INTRODUCTION

Women in daily work were found to have a higher incidence of musculoskeletal injuries when carrying a load during their daily activities (Ross & Woodward, 1994).Females were found to have smaller stature, wider pelvis, upper body strength less, and smaller feet and ankles, compared to males. Many factors contributed to the high rate of musculoskeletal injuries among Indian women. Female military trainees with limited leg extensor muscle strength appeared to have a higher incidence of musculoskeletal injuries than female trainees with strong leg extensor muscle (Kowal, 1980). Based on previous research, it is discernible that not only the magnitude but the positioning of the load on the body has an impact on daily physical activity (Martin & Nelson, 1986). Literature indicates that many factors contribute to higher incidence of injury among females compared to males in doing a work with equipment attributable to males (Ling eta al. 2004). Backpacks are used every day by so many of people for carrying different loads. Carrying heavy loads for long distances is usual with students, military personal, recreational hikers and various types of workers. Such a load condition is a constraint and makes walking difficult (Safikhani eta al. 2012). Various load configurations for healthy men have been examined, but such study on women is scarce. This study examined the changes in gait patterns of healthy women while carrying a 10 Kg (using a backpack) load on the hand, head and diagonally across one shoulder.

METHODS

Nine healthy female sedentary University students of age group 20 to 30 years from Mumbai without any musculoskeletal problems in the spine and legs were selected for this study. All were involved in exercise programs on a regular basis. The mean values and standard deviations for age, height and body mass of the female subjects were calculated as their general information. Written consent was obtained and then a screening examination was conducted to ensure each volunteer was free of musculoskeletal problems in the spine and legs. Thirty six reflective markers were placed on specific locations of each volunteer's legs and pelvic region. The defining markers, which enabled Visual 3D to reconstruct the digital skeleton of the volunteers, included the following: ASIS (anterior superior iliac spine), PSIS (posterior superior iliac spine), greater trochanters, thigh, shanks, lateral and medial side of knee joint line, lateral and medial malleolus, heel marker was placed on the posterior side of the calcaneus of both the legs and two markers were placed on the first and fifth metatarsal bone of both the legs. After the static trial, heel, knee and hip markers were not needed so were removed during the movement trial. An array of six high speed cameras type-OQUS by Qualisys Motion Capture System, Sweden, was used to film the volunteers walking along a 5 meter walkway. Each volunteer first walked on two force plates (Kistler, Switzerland) arranged in a 5 meter walkway at her self-selected speed without any load. This was used to establish a baseline and then, in random order, they walked along the walkway with a 10-kilogram load on the head, across one shoulder and on hand (frontal plane). Each volunteer followed the same protocol for the four testing conditions. The volunteers were allowed to walk. Force plate-1 and force plate-2 were stepped by left foot and right foot respectively. The volunteers were asked to walk for 60 seconds during which 4 trials were recorded by the OQUS infrared digital cameras. The best of the trial were considered for analysis

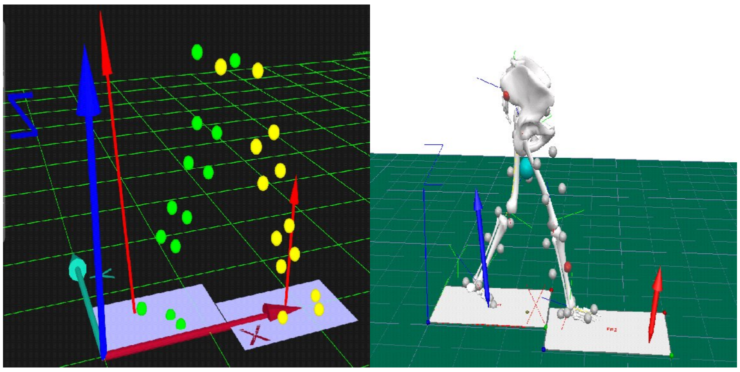

Fig 1: Force Plates

Data-Processing

To record the movement and force plate data the software Qualisys Track Manager was used. It was ensured that the cameras and force plates recorded properly all the three coordinate axis. The best of the trials were considered for analysis. The data was analysed by Visual 3D software (professional version). The Gait report was generated for each volunteers and comparison was made.

Tools used in data collection

The tools used for collecting the data are as follows:

1. Qualysis Motion Capture system with OQUS digital camera
2. Weighing scale used to measure the total body weight of the volunteers.
3. Anthropometric kit was used to measure the physical dimensions of the volunteers. It includes anthropometric, spreading calliper, sliding calliper, anthropometric tape.
4. Flexible measuring tape: used for measuring hip circumference of the volunteers.

RESULTS AND DISCUSSION

Table 1 below summarizes the mean and standard deviation values for each of the demographic variables as measured for each volunteer.

Table 1: Demographic Details of the volunteers

Variables	Age (yr)	Height (cms)	Weight (kg)	BMI (kg/m^2)	Hip Circumference (cms)	Pelvis Depth(cms)
Mean	22.3	157.5	58.5	23.445	96.5	12.77
Standard deviation	1.636	7.424	8.647	3.195	6.124	1.804
Range	20-25	147.7-169	41.5-67.9	17.61-27.65	86-103.5	10.3-16.5

Mean±SD

Table 2 summarizes the mean and standard deviation values for each of the descriptive variables kinematic as measured under each of the experimental load conditions. The stride length was found to decrease (1.1m) while carrying head load. Cycle times and double limb support time taken by the volunteers were almost same for all the modes of load carriage (1.0 sec and 0.2sec respectively). Number of time of double limb support was found to be maximum during carrying shoulder load (13 times approx.). Walking Speed was found to decrease while carrying load on head compared with other modes of load carriage.

Comparisons using a one-way ANOVA with repeated measures were conducted to examine differences between parameters during the load-carrying conditions and normal gait. Values were considered significant at $p< 0.05$. Changes in selected gait parameters was noted while walking with different loads hand, head and shoulder. Future study is needed to examine the effects of the volunteer's height, body mass index, and strength on gait pattern while carrying load. This is in accordance with the results of the study carried out by Connolly et al (2008).

The results found that walking naturally on level ground for about 5 meters did not produce much significant effect on the gait pattern. According to the study conducted by Majumdar et al in 2010, the changes in the spatial parameters were also not significant and the temporal parameter like total limb support and initial double limb support also showed no significant change.

Table 2: Effect of different load carriage modes on selected Gait parameters

Load Pattern	Speed(m/s)	Double support(s)	Cycle time(s)	Double Support-no of times(s)	Stride ln(m)
Free Walk	1.2±0.14	0.3±0.27	0.9±0.31	4.4±1.06	1.3±0.08
Head	1.1±0.17	0.2±0.06	1.0±0.10	9.1±5.33	1.1±0.22
Hand	1.2±0.18	0.2±0.03	1.0±0.06	9.1±3.31	1.2±0.12
Shoulder	1.2±0.14	0.2±0.02	1.0±0.06	12.6±5.68	1.2±0.12

Mean±SD

Therefore, the walking distance selected in this study might not be sufficient. Further experiments, to indicate the effect of different modes of load carriage on gait pattern needs to be conducted using a longer walking distance. Another limitation in this study, was that the walking patterns were recorded when the volunteers were in a non-fatigued state but an evaluation of the influence of fatigue on gait pattern during different modes of load carriage would make a valuable contribution.

CONCLUSION

Results from the analysis revealed that all the modes of load carriage substantially modified the normal walking gait pattern. Interactions between the load conditions and temporal and distal gait metrics were tested using separate one-way ANOVA with repeated measures. Not much significant ordinal interactions as well as significant main effects were found between the different carrying modes for selected gait parameters. Carrying load on head had more impact in deviating normal gait than the other modes of carriage, especially for carrying the heavy load for the age group considered in this experiment. There are no significant changes observed on selected gait parameters during 10kg backpack load carriage.

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