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## Feasibility of designed MMH technology for carrying agriculture produce using NIOSH Lifting Index

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Agriculture is an occupation framed within the context of family and community. The farm family is the central entity in agricultural production involving every member be it children, women or the elderly. For more than a decade, farming has been rated as one of the most dangerous occupations in the developing countries. A considerable number of adverse health conditions, including musculoskeletal disorders, are linked to agricultural work. Occupational risk factors include static positioning, forward bending, heavy lifting and carrying, kneeling, and vibration.

Manual material handling (MMH) is defined as the unaided moving of objects, often combined with twisting and awkward postures, and contributing to musculoskeletal disorders. Traumatic occurrences (slips, trips, falls, and blows to the body) cause other bodily injuries, pains, and disabilities. Typically, not one specific occurrence but rather the awkward body positions, repetition, force, and duration associated with movement lead to back, neck, and other problems like Cumulative Trauma Disorders (Anonymous, 2007).

Manual material handling is responsible for the appearance of physical fatigue or even injuries, which may occur immediately or through the accumulation of minor traumas apparently of little importance. Both the workers who regularly handle loads and those who do so from time to time may be affected. The most frequent injuries are, inter alia: bruises, cuts, wounds, fractures and, above all, muscle-bone injuries. These injuries may occur to any part of the body but the upper limbs and the back, particularly the dorso-lumbar region, are the most susceptible.

The research work was executed by assessing participation and drudgery involved in various manual material handling tasks in agriculture. On the basis of anthropometric measurements and other ergonomic parameters hand trucks were designed. The physiological cost of work and musculoskeletal disorders was assessed to check the effectiveness of the designed MMH technology (hand truck).

The present study was taken up with the following objective:

1. To evaluate traditional methods and designed manual material handling technology for harvested vegetable crops.

### Methodology

The present study was conducted in villages of Mawali tehsil as the locale was found suitable as per the objectives of the study. For the present study a sample of 100 agricultural workers (50 male and 50 female) engaged in agricultural tasks from last 10 years were selected for collecting data on gender participation in agricultural activities involving manual material handling tasks and to assess Musculoskeletal Disorders (MSDs) experienced. A sub-sample of 30 workers was purposively selected for evaluation of traditional method and field testing of designed technology. For designing of hand trucks various anthropometric data were recorded. Data were collected before and after the designed technology intervention. NIOSH lifting index was calculated using NIOSH software.

In the present paper only the results for NIOSH Lifting Index are presented for evaluation of traditional method and designed MMH technology for transporting harvested vegetable crops.

**Results and Discussions**

The designed MMH technology in the paper is termed as SWHT (Single Wheel Hand Truck) and DWHT (Double Wheel Hand Truck)

**Background information of the respondents**

The background information of the respondents showed that majority of the respondents were in the age group of 35-45 years. The educational status of the respondents was low as that majority of female respondents (82%) and more than half of the male respondents (52 per cent) were illiterate. Majority of the male respondents i.e. 60 per cent and 58 per cent of female respondents belonged to scheduled caste/tribes. The percentages of respondents residing in joint families were marginally more and were having large size families. About half of the male respondents (48 per cent) and about 44 per cent of female respondents had small landholdings and 16 per cent respondents had marginal landholdings and rest possessed large landholdings. Agriculture was the main occupation of cent per cent respondents. About 70 per cent of the respondents were earning their annual income between INR 20001-40,000.

**Anthropometric data of male and female agricultural workers**

The mean weight of both the males and females was taken into consideration while limiting the load to be carried in traditional head loading method. The shoulder height (cm), elbow height (cm), waist height (cm) was considered while designing adjustable handle height of hand trucks. Mean hand breadth (cm) was used for designing handhold width of hand trucks. The 5th, 95th and 50th percentile values of inside grip diameter of male and female agricultural workers as given in Table 3.30 were 4.4, 5.7 & 5.0 cm and 3.9, 5.0 & 4.5 cm; respectively (Rahi, 2003) was used for designing handle grip diameter of hand trucks.

**Designing of Hand Truck**

**Direction of motion:** The manual material handling technology designed i.e., hand trucks were pushing type.

**Handle Grasp:** The handle grasp of SWHT and DWHT was power grasp.

**Handle Grip Diameter:** The handle diameter of the designed manual material handling technology i.e. hand

trucks was taken 4.0 cm.

**Handhold Width (Grip Length):** The grip length was 41.9 cm (16.5 inch) for Double Wheel Hand Truck and 12.7 cm (4.5 inch) for Single Wheel Hand Truck.

**Handle Height:** The handle height of all the hand trucks was kept adjustable according to the requirement of the respondents. For this reason the handle length was 121.9 cm (48.0 inch) for SWHT, 87.6 cm (34.5 inch) minimum and 132.1 cm (52.0 inch) maximum for DWHT.

**Wheel Diameter:** The wheel diameter of designed hand trucks was 30.5 cm (12 inch).

**Wheel composition:** The wheel composition of designed hand trucks was GI pipe for SWHT and synthetic rubber for modified SWHT and DWHT.

**Hand truck weight:** The weight of SWHT was 15kg (approx.) whereas DWHT was 25kg (approx.). The weight of DWHT was higher than SWHT as DWHT has two wheels and platform to carry load is also made up of G.I. pipe and iron net which had more weight than SWHT bag which is made of cloth to carry load.

**Evaluation of traditional method and designed MMH technology of carrying and transporting harvested vegetable crops**

**NIOSH Lifting Index**

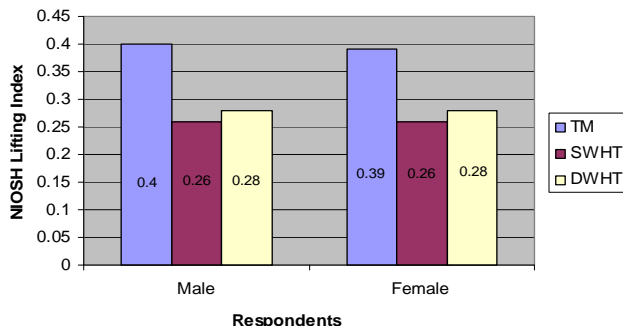
The software Ergo Intelligence Series: Manual Material Handling Assessment Tools 1.3.1 was used to calculate the lifting index. The single task lifting index was below 0.85 for lifting 5 kg and 10 kg weight for both male and female respondents which comes under green zone which means no risk involved in lifting these loads using traditional method and DWHT. The data in Table 1 show that single task lifting index was below 0.85 when both the male and female respondents carried load of 15 kg to fill the basket of DWHT and above 1.00 when they carried load of 20 kg. The NIOSH lifting index was above 1.00 when the male respondents carried weight between 15-20 kg in traditional method.

**Table 1:** NIOSH Lifting Index for respondents lifting loads of various capacities in traditional method and filling SWHT bag and DWHT basket

Load	Frequency (Lift/Minute)	Average NIOSH Lifting Index N=30									
		Pre Intervention		Post Intervention				Change			
		Traditional Method		SWHT		DWHT		SWHT		DWHT	
		Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)
5 Kg	1	0.40	0.39	0.26	0.26	0.28	0.28	0.14	0.13	0.12	0.11
	2	-	-	0.31	0.31	0.36	0.36	-	-	-	-
	3	-	-	0.32	0.32	0.37	0.37	-	-	-	-
	4	-	-	0.33	0.34	0.39	0.39	-	-	-	-
	5	-	-	0.35	0.36	0.41	0.41	-	-	-	-
10Kg	1	0.79	0.79	0.50	0.50	0.55	0.55	0.29	0.29	0.24	0.24
15Kg	1	1.18	1.18	0.70	0.70	0.84	0.84	0.48	0.48	0.66	0.66
20Kg	1	1.58	1.57	0.75	0.75	1.11	1.11	0.83	0.82	0.47	0.46

The NIOSH lifting equation is over estimating the severity of this task before the intervention, but still demonstrates significant improvement. In traditional method the

respondents carried weight either on head/shoulder but after the intervention of designed material handling technology i.e. SWHT and double wheel hand truck they



**Fig 1:** NIOSH Lifting Index for respondents lifting loads of various capacities in traditional method and filling SWHT bag and DWHT basket

carried weight at lesser height for filling the bag (4 inch high) and basket (16 inch). It is clear from Fig.1 that both male and female respondents in post intervention (use of

SWHT and DWHT) was same because they both carried the same weight for same height whereas in pre intervention the head loading was done where male has to lift the weight at a greater height than female respondents due to their heights.

**Disc Compression Force**

The software Ergo Intelligence Series: Manual Material Handling Assessment Tools 1.3.1 calculated the intervertebral disc compression forces for the L5/S1 joint. It is clear from Table 2 that the post intervention analysis (after the use of SWHT and DWHT) shows improvement for the disc compression forces, over pre-intervention values (Traditional Method). The disc compression at L5/S1 joint decreased for both males and females respondents while using the single and double wheel hand truck for carrying weight as the height of lift with weight was reduced.

**Table 2:** Disc Compression Force of respondents lifting loads of various capacities in traditional method and filling SWHT bag and DWHT basket

Load	Frequency (Lift/ Minute)	Average NIOSH Lifting Index N=30					
		Pre Intervention		Post Intervention			
		Traditional Method		SWHT		DWHT	
		Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)
5 Kg	1	2137.91	1797.28	1381.1	1381.1	1769.40	1769.40
	2	-	-	1381.1	1381.1	2126.40	2126.40
	3	-	-	1381.1	1381.1	2126.40	2126.40
	4	-	-	1381.1	1381.1	2126.40	2126.40
	5	-	-	1381.1	1381.1	2126.40	2126.40
10Kg	1	2495.18	2156.16	1517.5	1517.5	2110.17	2110.17
15Kg	1	2854.65	2815.24	1653.8	1653.8	2453.07	2453.07
20Kg	1	3215.59	3189.11	1790.1	1790.1	2797.73	2797.73

Table 2 clearly depicts that the disc compression at L5/S1 joint for male was 2137.91 N while lifting 5 kg of weight in traditional method which was reduced to 1769.40 N when using DWHT for one lift/minute and to 1381.1 N when filling SWHT bag. For female respondents the disc compression at L5/S1 joint was 1797.28 N (traditional method) while lifting 5 kg of weight in traditional method which was reduced to 1769.40 N (double wheel hand truck) and 1381.1 N (single wheel hand truck) for one lift/minute. Joosab et. al. (2005) reported that head loading creates a shift in the degeneration from the fifth intervertebral disc space to higher levels. They also reported that carrying heavy loads on the head alters the pattern of degenerative changes of the cervical spine. An experiment by Kumar (1998) demonstrated that during lifting of a 22 kg box from the ground to a shelf at 1250 mm height, compressive forces of the L5/S1 joint increased with increasing trunk extension from 3600 N at hip level to around 4300 N at the height of the shelf.

The data also portray that the disc compression reduced while carrying 10, 15, 20, 25 kg weight for filling single and double wheel hand truck. In traditional method the respondents carried weight either up to head/ shoulder height but after the intervention i.e. introduction of single and double wheel hand truck they carried weight at lesser height for filling the bag and basket, respectively. The respondents were advised that while filling the hand truck instead of lifting more weight in one lift/minute they were trained to carry 5 kg of weight per lift. It is clear that from the data in

the above table that by decreasing the weight and increasing the number of lifts per minute the disc compression force was significantly reduced.

They should exercise precaution in lifting weight. A load up to 10 kg is safe to lift only up to once/minute, if more than 10 kg is to be lifted; the load should be divided in multiples of 5 kg as lifting 5 kg weight is safe up to 5 lifts/minute. Thus, load up to 25 kg can be lifted in multiples of 5 kg. Graveling et.al (2003) in their research report ‘The principles of good manual handling: Achieving a consensus’ recommended pushing/pulling than lifting, pushing rather than pulling and suggested to carry several small loads rather than one large one.

**Conclusion**

**NIOSH Lifting Index:** The lifting index for lifting 5 kg and 10 kg weight for both male and female respondents was under green zone which means no risk involved in lifting these loads using traditional method and DWHT. The lifting index was below 0.85 when both the male and female respondents carried load of 15 kg to fill the basket of DWHT and above 1.00 when the male respondents carried weight between 15-20 kg in traditional method.

The data for both male and female respondents in post intervention (use of SWHT and DWHT) was same because they both carried the same weight for same height whereas in pre intervention the head loading was done where male has to lift the weight at a greater height than female respondents due to their heights.

**Risk Zone of NIOSH Lifting Index:** Cent per cent of male and female respondents fell in green zone when lifting 5-10 kg of weight by traditional method whereas it was found that both the gender fall in green zone when lifting weight 5 kg to 15 kg for filling basket of double wheel hand truck as the reason was that in this they have to carry weight at lower height (basket height 16 inch from floor) while in the traditional method they carried weight up to head/shoulder. Cent per cent of the male and female respondents were in green zone when they carried load ranging from 5-20 g for filling SWHT bag.

**Disc Compression Force:** The post intervention analysis (after the use of SWHT and DWHT) shows improvement for the disc compression forces, over pre- intervention values (Traditional Method). The disc compression at L5/S1 joint decreased for both males and females respondents while using the single and double wheel hand truck for carrying weight as the height of lift with weight was reduced.

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