

October 2011

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### Recommended Citation

Bangar, Ajay; Joshi, Vikrant; ., Neetu; and Arora, K.C. (2011) "Analysis of Recommended Weight Limit to Mitigate the Lower Back Pain in Manual Material Handling Task," *International Journal of Mechanical and Industrial Engineering*: Vol. 1 : Iss. 2 , Article 13.

Available at: <https://www.interscience.in/ijmie/vol1/iss2/13>

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# Analysis of Recommended Weight Limit to Mitigate the Lower Back Pain in Manual Material Handling Task

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**Abstract** - In this paper Authors have tried to calculate the revised Recommended Weight Limit (RWL) on the basis of revised Load constant (LC), Horizontal Multiplier (HM), Vertical Multiplier (VM) which are calculated according to the collected data from industry. While their average value had been considered in National institute for occupational safety & health (NIOSH) lifting equation. Thought behind this was that person's age, obesity and height can not be taken constant Authors have applied the new approaches for setting limits of LC, HM, VM for optimizing the value of RWL of workers who work in industry. The approach may probably lead to calculate the safe weight for lifting and lowering in manual material handling task. It is expected that such an approach may be more protective for workers in manual material handling.

**Keyword:** Recommended Weight Limit (RWL), Horizontal Multiplier (HM), Vertical Multiplier (VM), Load Lifting, Safe Weight, Load Constant (LC).

## I. INTRODUCTION

### A. Literature History

The NIOSH (National institute for occupational safety & health) lifting equation was designed to evaluate RWL to avoid the risk of lifting task with respect to low back injury (water, puts, Anderson, gargandfine 1993). The equation is widely accepted and used through out in industry insetting acceptable lift limits for workers. It was revised in 1991.

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM.$$

This equation is used for calculating the value of RWL Here

DM = Distance Multiplier

AM = Asymmetric Multiplier

FM = Frequency Multiplier

CM = Coupling Multiplier

The values they had taken

Load constant (LC) taken =23kg

Horizontal Multiplier (HM) taken as shown in table I where H is horizontal location of load.

TABLE-I : HORIZONTAL MULTIPLIER ACCORDING TO NIOSH

H In	HM	H cm	HM
≤10	1.00	≤25	1.00
11	.91	28	.89
12	.83	30	.83
13	.77	32	.78
14	.71	34	.74
15	.67	36	.69
16	.63	38	.66
17	.59	40	.63
18	.56	42	.60
19	.53	44	.57
20	.50	46	.54
21	.48	48	.52
22	.46	50	.50
23	.44	52	.48
24	.42	54	.46
25	.40	56	.45
>25	.00	58	.43
		60	.42
		63	.40
		>63	.00

Vertical Multiplier (VM) taken as shown in table II where V is vertical location of load

TABLE – II : Vertical Multiplier according to NIOSH

V	VM	V	VM
In		cm	
0	.78	0	.78
5	.81	10	.81
10	.85	20	.84
15	.89	30	.87
20	.93	40	.90
25	.96	50	.93
30	1.00	60	.96
35	.76	70	.99
4	.93	80	.99
45	.89	90	.96
50	.85	100	.93
55	.81	110	.90
60	.78	120	.87
65	.74	130	.84
70	.70	140	.81
>70	.00	150	.78
		160	.75
		170	.72
		175	.70
		>175	.00

Distance Multiplier (DM) taken= 1 (here distance travel by job from origin to destination position is taken less then 10inches.)

Asymmetry Multiplier (AM) taken=1(here angle of asymmetry is taken zero.)

Frequency Multiplier (FM) taken= 1(here working time taken is less than one hour)

Coupling Multiplier (CM) taken= 1(here coupling type taken is fair and  $V \geq 30$  inches)

**A. Problem Identification**

Authors thought that the values of LC, HM, VM is not constant, but it varies with various parameters of workers with age, obesity and height. The rest factors are same as NIOSH equation. To obtain the appropriate values of LC, HM and VM, authors have taken data from industry and tried to estimate the optimal LC, HM, and VM for each age group of worker according to their obesity and height.

**II. DATA ANALYSIS**

**A. Data Collection**

Sl. No	Name	Age in Yr.	Weight (Kg)	Height (C Ms)	Job Weight (Kg)	Distance Of Weight (Horizontal) (Inches) H	Ht. Of Job from Ground (Inches) V	Vertical distance (inches) D
01	MAHESH CHAWLE	44	64.8	158	10.7	11	40	$\geq 10$
02	BALRAM	50	60	169	5.8	13	42	$\geq 10$
03	RAJENDRA	30	77	177	6.1	14	45	$\geq 10$
04	SHIVDAYA L	38	61	163	10.5	12	39	$\geq 10$
05	S.M. SHARMA	47	64.8	166	13.4	11	42	$\geq 10$
06	RAM PRASAD	36	76.4	177	12.7	13	39	$\geq 10$
07	M.L.DALA L	45	68.7	166	8.9	12	38	$\geq 10$
08	MAHESH	48	60.3	170	11.5	15	39	$\geq 10$
09	P. CHAND	43	68	170	13.4	15	54	$\geq 10$
10	AJAY	32	64	164	14.2	14	39	$\geq 10$
11	VIKRAM	35	63	169	3.1	13	39	$\geq 10$
12	C.S.CHAUHAN	34	79.7	163	2.9	11	39	$\geq 10$
13	SANDEEP SINGH	35	67	173	2.9	13	39	$\geq 10$
14	MANGILA L	24	65	175	6.1	14	39	$\geq 10$
15	VASANT	23	61	165	7.5	12	42	$\geq 10$

**B. Horizontal Multiplier (HM)**

The Horizontal Multiplier (HM) is  $10/H$ , or  $H$  measured in inches, and  $HM$  is  $25/H$ , for  $H$  measured in centimeters. If  $H$  is less than or equal to 10 inches (25 cm), then the multiplier is 1.0  $HM$  decreases with an increase in  $H$  value. The multiplier for  $H$  is reduced to 0.4 when  $H$  is 25 inches (63 cm). If  $H$  is greater than 25 inches, then  $HM = 0$ . The  $HM$  value can be computer directly or determined from Table 1 (evaluate the risk of lifting task with respect to low back injury by water, puts, Anderson, Gargandfine 1993) . Now author thought the horizontal distance changed due to obesity of workers. So for this purpose author take the data from the industry and calculate  $HM$  for different group of obesity of person.

*HM Calculation according to Author*

$$HM=10/H$$

When

Waist =30 inches then  $H=10$  inches,  $H$ =distance from C.G.  $HM=1$

Waist =32 inches then  $H=10.66(10/30=32/H)$  than

$$HM=.93$$

Waist =30 inches then  $H=11$  inches

$$HM=.90$$

Waist =32 inches then  $H=11.66(10/30=32/H)$  than

$$HM=.85$$

**TABLE -IV : HORIZONTAL MULTIPLIER ACCORDING TO AUTHOR**

Distance From C.G. (inches) H	Horizontal Multiplier(HM)										
	Waist (inches)										
	30	32	34	36	38	40	42	44	46	48	50
≤10	1.00	.93	.88	.83	.78	.75	.71	.68	.65	.62	.60
11	.90	.85	.81	.76	.73	.69	.66	.63	.61	.58	.56
12	.83	.78	.75	.71	.68	.65	.62	.60	.57	.55	.53
13	.76	.73	.69	.66	.63	.61	.58	.56	.54	.52	.50
14	.71	.68	.65	.62	.60	.57	.55	.53	.51	.50	.48
15	.66	.63	.61	.58	.56	.54	.52	.50	.49	.47	.46

**C Vertical Multiplier (VM)**

To determine the vertical multiplier (VM) the absolute value or deviation of V from an optimum height of 30 inches (75cm) is calculated a height of 30 inches above floor level is considered waist height for a worker of average height 66inches or 165cm. The vertical multiplier is  $[1-(.0075|V-30|)]$  for V measured in inches (evaluate the risk of lifting task with respect to low back injury by water, puts, Anderson, Gargandfine 1993).

But the author thought that the average height can not give the accurate value so he took the deviations of height as height ranges ≤66, 66-68, 68-70, and 70-72 inches. Due to the change in height, the waist height of worker will change. According to the height change the waist height is calculated ( $66/30=68/x=30.90$ ) and shown in table

**TABLE - V : FORMULA FOR VM**

SR. NO.	Height (inches)	Waist height (inches)	Formula For VM
1.	66	30.00	$[1-(.0075 V-30.00 )]$
2.	68	30.90	$[1-(.0075 V-30.90 )]$
3.	70	31.81	$[1-(.0075 V-31.81 )]$
4.	72	32.72	$[1-(.0075 V-32.72 )]$

So according to these formulas VM is calculated and shown in table no. VI.

**TABLE-VI : VERTICAL MULTIPLIER ACCORDING TO AUTHOR**

Vertical distance (inches) V	Vertical Multiplier(VM)			
	Height ≤66	66<Height ≤68	68<Height ≤70	70<Height ≤72
0	.78	.76	.76	.75
5	.81	.80	.79	.79
10	.85	.84	.83	.82
15	.89	.88	.87	.86
20	.93	.92	.91	.90
25	.96	.95	.94	.94
30	1.00	.99	.98	.97
35	.96	.96	.97	.98
40	.93	.93	.93	.94
45	.89	.89	.90	.90
50	.85	.85	.86	.86
55	.81	.81	.82	.83
60	.78	.78	.78	.79
65	.74	.74	.75	.75
70	.70	.70	.71	.72
>70	0.00	0.00	0.00	0.00

**D Load Constant (LC)**

For the calculation of load constant for different age groups of workers, we have applied FUZZY LOGIC APPROACH and find out the LC according to age groups results are shown in table no VII

Load Constant (LC) with Reference of Paper(3)

**TABLE-LOAD CONST. ACCORDING TO AGE GROUP**

Age (year)	Load Const.(LC) in kg		
	Low capacity (lc) = 23	Medium capacity (mc) = 28	High capacity (hc) = 33
20	10	13.48	17.97
25	15	17.97	21.59
30	20	21.59	26.35
35	15	17.97	21.57
40	10	13.48	17.97
45	5	8.07	13.48
50	5	8.07	13.48

### III. CASE STUDY

#### A. Case 1

Name of worker –Mahesh Chawala  
 Age-44, Wt= 64.8 kg, height= 63.2 inches  
 Job  
 Weight= 10.7, H=11, V=40, D≤10, A= 0°,  
 F≤0.2 (v≥30) (Hour≤1)  
 Where H=horizontal location of job  
 V= vertical location of job  
 D=distance travel

According to NIOSH

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 23 \times .91 \times .91 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 19.4649 \text{ kg} \end{aligned}$$

According to authors

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 17.97 \times .66 \times .93 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 11.0299 \text{ kg} \end{aligned}$$

Where LC is taken on higher capacity

Waist of worker=42 inches

#### B. Case 2

Name of worker – Balram  
 Age-50, Wt= 60 kg, height= 67.6 inches  
 Job  
 Weight= 5.8, H=13, V=42, D≤10, A= 0°,  
 F≤0.2 (v≥30) (Hour≤1)

According to NIOSH

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 23 \times .77 \times .91 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 16.116 \text{ kg} \end{aligned}$$

According to authors

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 13.48 \times .61 \times .91 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 7.4 \text{ kg} \end{aligned}$$

Where LC is taken on higher capacity

Waist of worker=40 inches

#### C. Case 3

Name of worker – Sandeep  
 Age-35, Wt= 67 kg, height= 69.5 inches  
 Job  
 Weight= 2.9, H=13, V=39, D≤10, A= 0°,  
 F≤0.2 (v≥30) (Hour≤1)  
 According to NIOSH

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 23 \times .77 \times .94 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 16.64 \text{ kg} \end{aligned}$$

According to authors

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 21.57 \times .63 \times .95 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 12.90 \text{ kg} \end{aligned}$$

Where LC is taken on higher capacity

Waist of worker=38 inches

#### D. Case 4

Name of worker – Rajendra  
 Age-30, Wt= 77 kg, height= 70.8 inches,  
 Job  
 Weight= 6.1, H=14, V=45, D≤10, A= 0°,  
 F≤0.2 (v≥30) (Hour≤1)

According to NIOSH

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 23 \times .71 \times .89 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 14.53 \text{ kg} \end{aligned}$$

According to authors

$$\begin{aligned} \text{RWL} &= \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \\ \text{RWL} &= 26.35 \times .62 \times .90 \times 1 \times 1 \times 1 \times 1 \\ \text{RWL} &= 14.70 \text{ kg} \end{aligned}$$

Where LC is taken on higher capacity

Waist of worker=36 inches

#### E. Case 5

Name of worker – Vasant  
 Age-23, Wt= 61 kg, height= 66 inches  
 Job  
 Weight= 7.5, H=12, V=42, D≤10, A= 0°,

$F \leq 0.2$  ( $v \geq 30$ ) (Hour  $\leq 1$ )

According to NIOSH

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

$$RWL = 23 \times .83 \times .91 \times 1 \times 1 \times 1 \times 1$$

$$RWL = 17.31 \text{ kg}$$

According to authors

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

$$RWL = 17.97 \times .71 \times .91 \times 1 \times 1 \times 1 \times 1$$

$$RWL = 11.610 \text{ kg}$$

Where LC is taken on higher capacity

Waist of worker = 36 inches

#### IV. RESULTS

The variables in NIOSH Lifting equation may vary according to various parameters of workers. Author identifies these parameters and calculates feasible values of RWL. The comparative chart for different of values of RWL according to NIOSH and according to author for different cases is as shown follows

**TABLE - VIII : RESULTS FOR DIFFERENT CASES**

SL no	Case study	According to NIOSH			According to Author			RWL according to NIOSH	RWL according to Author
		LC	HM	VM	LC	HM	VM		
1.	Case1	23	.91	.91	17.97	.66	.93	19.46	11.03
2.	Case2	23	.77	.91	13.48	.61	.91	16.12	7.40
3.	Case3	23	.77	.94	21.57	.63	.95	16.64	12.90
4.	Case4	23	.71	.89	26.35	.62	.90	14.53	14.70
5.	Case5	23	.83	.91	17.97	.71	.91	17.31	11.61

#### ACKNOWLEDGEMENT

We gratefully acknowledge the inspiration provided by Professor V. M. Sahai, (Principal), Professor G.S.Tomar (Advisor), Professor Sanjay Goyal, and Professor A.K. Saxena, Professor Ashish Sastri, Professor Rajan Sharma of M.P.C.T.Gwalior to complete this research. Partial support for this research from the GAJARA GEAR Ltd. is deeply appreciated.

At last but not least we are very thankful to God who has blessed us to accomplish this work.

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