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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× HM×VM× DM× AM× FM× 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 hade 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	HM	H	HM
In		cm	
≤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≥30 inches)

A. Problem Identityfication

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 (CMs)	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	≥10
02	BALRAM	50	60	169	5.8	13	42	≥10
03	RAJENDRA	30	77	177	6.1	14	45	≥10
04	SHIVDAYAL	38	61	163	10.5	12	39	≥10
05	S.M. SHARMA	47	64.8	166	13.4	11	42	≥10
06	RAM PRASAD	36	76.4	177	12.7	13	39	≥10
07	M.L.DALAL	45	68.7	166	8.9	12	38	≥10
08	MAHESH	48	60.3	170	11.5	15	39	≥10
09	P. CHAND	43	68	170	13.4	15	54	≥10
10	AJAY	32	64	164	14.2	14	39	≥10
11	VIKRAM	35	63	169	3.1	13	39	≥10
12	C.S.CHAUHAN	34	79.7	163	2.9	11	39	≥10
13	SANDEEP SINGH	35	67	173	2.9	13	39	≥10
14	MANGILAL	24	65	175	6.1	14	39	≥10
15	VASANT	23	61	165	7.5	12	42	≥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

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 23 × .91 × .91 × 1 × 1 ×1×1

RWL=19.4649 kg

According to authors

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 17.97 × .66 × .93 × 1 × 1 ×1×1

RWL=11.0299 kg

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

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 23 × .77 × .91 × 1 × 1 ×1×1

RWL=16.116 kg

According to authors

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 13.48 × .61 × .91 × 1 × 1 ×1×1

RWL=7.4 kg

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

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 23 × .77 × .94 × 1 × 1 ×1×1

RWL=16.64 kg

According to authors

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 21.57 × .63 × .95 × 1 × 1 ×1×1

RWL=12.90 kg

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

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 23 × .71 × .89 × 1 × 1 ×1×1

RWL=14.53 kg

According to authors

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 26.35 × .62 × .90 × 1 × 1 ×1×1

RWL=14.70 kg

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≤0.2 (v≥30) (Hour≤1)

According to NIOSH

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 23 × .83 × .91 × 1 × 1 ×1×1

RWL=17.31 kg

According to authors

RWL= LC× HM ×VM× DM× AM× FM× CM

RWL= 17.97 × .71 × .91 × 1 × 1 ×1×1

RWL=11.610 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 NOISH			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

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REFERENCES

[1] T.R. Waters, Putz- V. Anderson, A. Garg, Applications manual for The revised NIOSH lifting equation, DHHS (NIOSH) Publication No. 94-110, NIOSH, Cincinnati, 1994.

[2] M.M. Ayoub, N.J. Bethea, S. Deivanayagam, S.S. Asfour, G.M.Bakken, D Liles, Determination and modeling of lifting capacity, Final report,DHHS (NIOSH) Grant No. 5-R01-0H-00545- 02, NIOSH, Cincinnati (1978).

[3] Ajay Bangar, K.C. Arora, Vikrant Joshi, Neetu, Evaluation of Acceptable weight for manual lifting task in industry: A Fuzzy Logic Approach, ICAM, Agra, India, PP 1099, 2011.

[4] M.M. Ayoub, J.L. Selan, B.C. Jiang A mini-guide for lifting, Texas Tech University, Texas. (1983)

[5] S.M. Hsiang, M.M. Ayoub, Development of methodology in Biomechanical simulation of manual lifting. Int. J. Ind Ergon 13, 271 88, 1994.

[6] CJ Lin, MM Ayoub, TM Bernard, Computer motion simulation for sagittal plane lifting activities, Int. J. Ind Ergon 24, 141–55, 1999.

[7] S. L. Sauter, L.M. Schleifer, S.J. Knutson, Work posture, workstation design and musculoskeletal discomfort in a VDT data entry task. Hum Factors 33, 151–67, 1991.

[8] Y-H T Lee, An optimization approach to determine manual lifting motion. Ph.D. Dissertation, Texas Tech University, Texas, 1988.

[9] D.A. Winter, Biomechanics and motor control of human movement, 2nd Ed., 56–7, John Wiley & Sons, New York, 1990.

[10] T.J. Stobbe, The development of a practical strength testing program for industry. Unpublished Ph.D. dissertation, The University of Michigan, Michigan, 1982.

[11] T.R. Waters, V. Putz-Anderson, A. Garg, L.J. Fine, Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics 36, 749–76, 1993.

[12] G. Borg, An introduction to Borg's RPE scale, Movement Publications, New York, 1985.

[13] D.B. Chaffin, G.B.J. Andersson, and BJ Martin, Occupational biomechanics, 3rd Ed., 263, John Wiley and Sons, New York, 1999.

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