Modelling Back Problems from Lifting and Lowering Tasks in Australian Construction Industry

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Abstract - *Most of the work related musculoskeletal disorders (MSDs) in the construction industry are associated with manual handling (MH) tasks such as lifting and lowering. Among all serious work related MSD claims from the year 2000 to 2013 in Australia, around 40% of the injuries/ disorders are lower/ upper back problems, which are mainly associated with body stressing in daily tasks. This paper presents a model to predict the likelihood of acute and chronic back problems from lifting and lowering tasks in construction works. Using a structured questionnaire survey, data collected from workers engaged in manual handling works in Australia based construction industry organisations. Multinomial logistic regression based predictive modelling considered: (a) personal attributes such as body mass index (BMI) and physical abilities; and (b) job requirements such as postures and frequencies of lifting/ lowering different weights in daily routines. Chi-Square test results and R-square values indicate good feasibility of the predictive models. Kruskal-Wallis tests indicate the distribution of work related upper and lower back MSDs are: (i) the same across gender and occupation categories; and (ii) different across age categories. The predictive models will be useful for mitigating risks and ergonomic MH job designs in the construction industry.*

Key Words: **upper back; lower back; musculoskeletal disorder; manual handling; health and safety; risk; ergonomics; construction industry**

1.INTRODUCTION

Manual handling (MH) tasks such as lifting/ lowering of different weights along with associated demands of repetition (frequency) and postural requirements are the leading causes for work related musculoskeletal disorders (MSDs) [1, 2]. The occupational health risks of lifting/ lowering MH tasks are mainly associated with the musculoskeletal system of individuals, which often lead to various MSD problems and injuries to body parts such as bones, discs, joints, ligaments, muscles, nerves and tendons in arm, back, elbow, knee, neck, shoulder, wrist. Among all serious work related MSD claims from the year 2000 to 2013 in Australia, around 40% are lower/ upper back problems. According to 2013-2014 Australian Workers' Compensation Statistics, body stressing in daily tasks is the leading root cause [3].

Physical demands of manual handling tasks and work related MSD problems are extensive in several trade occupations of the construction industry [4,5]. Moreover, the construction industry employs significant workforce in several regions around the world. For example, 9% of workforce (i.e. 1.026 million persons) in Australia are employed in construction industries that include 1.597 billion hours worked by employees in this sector in 2013-2014. Also, the statistics from 2000 to 2014 indicates that incident rate of serious claims per 1000 employees and the frequency rate of serious claims per million hours worked are one of the top across all industries in Australia [3].Work related lower/ upper back MSD problems from lifting/ lowering MH tasks are associated with muscular stress from loads/ torques handled, extent of lifting/ lowering (e.g. floor to knuckle, above shoulder), effects of frequent repetitions in daily routines, hazardous awkward postures and durations [6,7]. The root causes of lifting/ lowering tasks based MSDs are related to the object being handled in the job, MH task demands, personal abilities and the environment [8]. In addition to acute condition of MH work related MSDs and effects (e.g. absenteeism, claims, injuries, discomforts) and the chronic conditions and effects (e.g. long-term disabilities, loss/ change of job) are also significant in the industry [9]. Models to predict the work related back problems and investigate the effects will be useful for both prevention controls and mitigation measures in the construction industry [10,11]. Hence, this study is focused on developing a model to predict both acute and chronic lower and upper back MSDs from MH tasks in the construction industries. The research paper presents details of multinomial logistic regression models considered: (a) personal attributes such as body mass index (BMI) and physical abilities; and (b) job requirements such as postures and frequencies of lifting/ lowering different weights in daily routines.

2.MATERIALS AND METHOD

2.1 Data Collection Procedure

In line with the National Statement on Ethical Conduct in Human Research in Australia, this research been approved by Swinburne's Human Research Ethics Committee (approval number SHR Project 2015/138). A structured questionnaire survey was conducted for data collection. The target respondents are workers engaged in lifting and lowering related MH tasks in their daily works. From the Australian B2B database 3123 organisations in the construction and manufacturing industries were identified. The human resources manager or director in those organisations were contacted with a request letter to identify relevant persons in their organisations and distribute the invitation, survey questionnaire and the consent information. Informed consent was noted by the survey participation. This paper presents only the modelling of back problems from lifting/ lowering related MH works in the construction industry. The details of modelling manufacturing industries are not covered in this paper.

2.2 Data summary

After discarding all incomplete/ irrelevant participations, the total number of valid responses from Australia based construction industry organisations is 432, which include: 155 carpenters, 107 bricklayers, 93 plumbers, 33 wall and floor tilers, 23 roof slaters/ tilers, 13 plasterers, and 8 structural steel welders. Table 1 shows the age and experience details of the participants in this cross sectional research.

Table -1: Summary of participants

Category	Sub-category	Number		Total
		Male	Female	
Age (years)	Less than 40	122	26	148
	40 to 59	109	17	126
	60 and above	115	43	158
Experience (years)	Less than or equal to 10	63	10	73
	11 to 20	219	43	262
	More than 20	64	33	97

2.3 Variables and measure

Through focused literature review [12-35] and brainstorming discussions with six occupational health and safety domain experts in Victoria, the research exercise reported in this paper has identified a set of personal and job related parameters and variables for modelling the upper and lower back MSD problems from lifting/ lowering MH tasks in the construction industry.

2.3.1 Personal attributes

2.3.1.1 Body Mass Index (BMI)

Participants provided their height (in centimetres) and weight (in kilograms) information. The BMI is calculated by the formula: BMI = Weight (in kilograms)/ [Height (in meters) x Height (in meters)].

2.3.1.2 Physical Abilities

Using a 5-point scale (i.e. 'Very poor', 'Poor', 'Moderate', 'Good', and 'Very good'), the participants provided information regarding following ten physical abilities for MH tasks in their occupation in construction industry:

- a1 : Manual dexterity – i.e. ability to use hand and arm, for example to grasp, manipulate, or assemble objects.
- a2 : Static strength – i.e. ability to perform manual handling tasks such as lifting and carrying objects.
- a3 : Dynamic strength – i.e. ability to perform the manual handling tasks repeatedly or continuously over time.
- a4 : Trunk strength – i.e. ability to safely use trunk to support the manual handling tasks.
- a5 : Flexibility – i.e. ability to bend, stretch, twist, or reach with body, arms, and/or legs.
- a6 : Body equilibrium – i.e. ability to keep or regain body balance or stay upright during manual handling tasks.
- a7 : Stamina – i.e. ability to exert physically without getting winded or out of breath.
- a8 : Arm hand steadiness – i.e. ability to keep hand and arm steady while performing manual handing tasks.
- a9 : Finger dexterity – i.e. ability to perform coordinated movements of the fingers of one or both hands, for example to grasp, manipulate or assemble small objects.
- a10 : Multi limb coordination – i.e. ability to coordinate limbs (for example, two arms, two legs, or one leg and one arm) while performing manual handling tasks.

2.3.2 MH Job Requirements

2.3.2.1 Loads, Repetition and Extent of Lifting/ Lowering

The information regarding frequency (i.e. repetition) of lifting/ lowering manual handling (MH) requirements in daily job routines of paricipats were collected for following loads:

- f1 : Less than 5 kg
- f2 : 6 to 10 kg
- f3 : 11 to 15 kg
- f4 : 16 to 20 kg

Also, the information regarding the extent of lifting/ lowering of challenging weights in daily job routines were collected for: (a) floor to knuckle; (b) knuckle to chest; (c) chest to shoulder; and (d) above shoulder ranges.

2.3.2.2 Posture During Lifting/ Lowering

Postures during lifting/ lowering MH tasks have siginificant association with work related MSD problems. Table 2 portrays three common postures (i.e. extent of back bending) considered in this research study. The participants provided information regarding: (a) repeition requirements for forward spine bending during lifting/ lowering tasks in daily job routines and (b) the duration of these postures in their most challenging MH tasks.

Table -2: Back postures during lifting/ lowering MH tasks

ID	Pose	Description
t_1		Neutral – i.e. almost nil (less than 20 degrees)
t_2		Moderate – i.e. moderately flexed (20 to 60 degrees)
t_3		Extreme – i.e. extremely flexed (more than 60 degrees)

2.3.3 Work Related MSD Problems and Injuries

Overall, the research exercise covered work related MSD symptoms and conditions in 11 body parts, i.e. neck, left shoulder, right shoulder, upper back, lower back, left upper arm, right upper arm, left wrist, right wrist, left knee and right knee. This paper covers only details of modelling upper back and lower back MSD problems, which are significant.

2.4 Statistical Analysis

In this study, the predictor variables are categorical (e.g. stamina, trunk strength) or continuous (e.g. BMI) and the outcome variables (i.e. low and upper back MSD) are categorical. Moreover, for each MSD it is required to predict membership of more than two categories – i.e. Nil, Acute, Chronic. Hence, multinominal logistic regression analysis was used to evaluate the effects of specific person attributes and routine job requirements of lifting and lowering MH tasks on MSD occurrences in lower and upper back. For checking association of predictor variables with outcome variables, odds ratio values were calculated with 95% confidence interval and significant level $p<.05$. Kruskal-Wallis tests (and Jonckheere-Terpstra tests for ordered alternatives) with 95% confidence interval and significance level $p< 0.01$ were conducted for grouping categories such as age, gender and occupation.

3. RESULTS AND DISCUSSIONS

3.1 Hypothesis Testing

The participants are from different groups with respect to age (i.e. less than 40, 40 to 59, 60 and above), gender (i.e. male, female), and occupations (i.e. brick layers, carpenters, plasterers, plumbers, roof slaters/ tilers, roof slaters/ tilers, structural steel welders, wall and floor tilers). To ascertain the differences between several independent groups of participants, following six null hypotheses were verified by Kruskal-Wallis test with significance level 0.01:

- H1: The distribution of lower back MSD is same across categories of age (years)
- H2: The distribution of upper back MSD is same across categories of age (years)
- H3: The distribution of lower back MSD is same across categories of gender
- H4: The distribution of upper back MSD is same across categories of gender
- H5: The distribution of lower back MSD is same across categories of occupation
- H6: The distribution of upper back MSD is same across categories of occupation

Table -3: Summary of independent samples hypothesis test

MSD	Group details	Kruskal-Wallis test			Hypothesis test outcome
		Test statistic	df	Asymptotic Sig. (2-sided test)	
Low back	Age (years)	67.537	2	.000	Reject the null hypothesis (H1): The distribution of Lower back MSD is same across categories of Age (years)
	Gender	6.588	1	0.010	Retain the null hypothesis (H3): The distribution of Lower back MSD is same across categories of Gender
	Occupation	7.006	6	0.320	Retain the null hypothesis (H5): The distribution of Lower back MSD is same across categories of Occupation
Upper back	Age (years)	100.527	2	.000	Reject the null hypothesis (H2): The distribution of Lower back MSD is same across categories of Age (years)
	Gender	1.304	1	0.254	Retain the null hypothesis (H4): The distribution of Lower back MSD is same across categories of Gender
	Occupation	13.752	6	0.033	Retain the null hypothesis (H6): The distribution of Lower back MSD is same across categories of Occupation

As presented in Table 3, all hypotheses except those related to age (i.e. H1 and H2) have been retained accourding to the Kruscall-Wallis test results. Also, the hypotheses findings are same as per Jonckheere-Terpstra Test for Ordered Alternatives for testing the trends. Although the physical capacities are generally depleting with ageing, the physical demands of work in most jobs have not changed [35,8]. Also, the findings of this research revealed that potentials for acute and chronic MSD problems are noted as higher among older workers.

3.2 Multinomial Logistic Regression

Using the data from 432 participants, a multinomial regression modelling has been developed to predict the probability of occurrence of work related MSD problems. In this modeling, the code/ notation of MSD for upper back problem is "1" (i.e. k = 1) and lower back problem is "2" (i.e. k =2)

Probability of occurrence of a musculoskeletal problem/ disorder (P_{ik})

$$P_{ik} = \frac{1}{1 + e^{-(b_{0k} + \sum_{a=1}^{A}(b_{ak} \times X_{ia}) + \sum_{f=1}^{F}(b_{fk} \times X_{if}) + \sum_{t=1}^{T}(b_{tk} \times X_{it}) + (b_{mk} \times X_{im}))}}$$

in which,

i Reference identifier for a person

k MSD problem index

b_{0k} Model intercept for each k

A Total number of predictors related to physical abilities

a Indices for predictors related to physical abilities, with set $a = \{1, 2, 3, \dots, A\}$

X_{ia} Input of predictors related to physical abilities for $a \in A$, i, and $X_{ia} = \{1,2,3,4,5\}$

b_{ak} Coefficient value of the predictors related to physical abilities for $a \in A, and\ k$

F Total number of predictors for frequency (i.e. repetition) of lifting/ lowering MH tasks

f Indices for predictors of frequency of lifting/ lowering MH requirement; $f = \{1, 2, 3, \dots, F\}$

X_{if} Input of predictors related to frequency of lifting/ lowering; $f \in F$, i, and $X_{if} = \{1,2,3,4\}$

b_{fk} Coefficient value of the predictors related to frequency of lifting/ lowering tasks; $f \in F, and\ k$

T Total number of predictors related to back postures repetition during lifting/ lowering

t Indices for predictors related to back postures repetition during lifting/ lowering; $t = \{1, 2, \dots, T\}$

X_{it} Input of predictors related to back postures repetition during lifting/ lowering; $t \in T$, i, and $X_{it} = \{1,2,3,4\}$

b_{tk} Coefficient value of the predictors related to back postures repetition during lifting/ lowering; $t \in T, and\ k$

m Index for predictor related to the Body Mass Index (BMI) of a person

w_i Weight of a person i, in which w_i is in kilograms

h_i Height of a person i, in which h_i is in meters

X_{im} Input of predictor related to the BMI of a person i, where $X_{im} = \{(w_i)/(h_i^2)\}$

b_{mk} Coefficient value of the predictor related to the BMI of a person $and\ k$

P_{ik} Probability of occurrence of a musculoskeletal problem/ disorder 'k' for $i, a \in A$, $f \in F, t \in T$, m and k

The model intercepts and coefficient values of predictors of the multinomial logistic regression modeling are consolidated in Tables 4 to 8. The parameters with negative coefficients decrease the likelihood of that response category (i.e., acute/ chronic back MSD problems) and likewise, the parameters with positive coefficients increase the likelihood of that response category.

Table -4: Model intercept (b_{0k}) values for musculoskeletal problem/ disorder (k)

MSD (k)	Acute*	Chronic*
1 Upper Back	-53.11	-15.92
2 Low Back	-19.61	54.23

** No MSD problem is the reference benchmark*

Table -5: Coefficient (b_{mk}) values of BMI for each musculoskeletal problem/ disorder (k)

MSD (k)	Acute*	Chronic*
1 Upper Back	.062	.031
2 Lower Back	-.418	-.425

** No MSD problem is the reference benchmark*

Table -6: Coefficient (b_{ak}) values of predictor variables related to physical abilities

A	Upper back		Lower back	
	Acute $X_{iu} = \{1,2,3,4$	Chronic $X_{iu} = \{1,2,3,4$	Acute $X_{iu} = \{1,2,3,4$	Chronic $X_{iu} = \{1,2,3,4$
1	20.62, 0.15, -1.72, 0.75, 0c	23.51, -2.17, -1.68, -1.96, 0c	4.46, 4.14, 3.94, -0.14, 0c	4.32, 1.95, 2.68, -2.62, 0c
2	23.92, 3.83, 6.09, 2.91, 0c	11.20, 5.93, 7.99, 5.48, 0c	-21.43, -4.21, -0.12, -0.91, 0c	-41.54, -0.61, 3.92, 3.47, 0c
3	4.98, 1.18, -1.02, -1.95, 0c	4.81, 3.64, 1.47, 1.38, 0c	4.15, 1.66, -1.21, 1.63, 0c	4.94, 2.08, -0.87, -1.01 0c
4	1.71, -0.86, -0.04, 2.21, 0c	1.5, -0.36, -0.81, 0.43, 0c	1.81, -0.4, 4.27, 2.17, 0c	3.65, 1.41, 5.57, 1.31, 0c
5	-3.21, 0.99, 0.32, 2.3, 0c	-2.63, 2.31, 0.08, 2.88, 0c	1.68, 1.78, 2.29, 0.13, 0c	6.93, 6.26, 3.92, 2.39, 0c
6	5.23, 2.87, 1.17, 1.25, 0c	4.38, 1.77, -0.02, 1.11, 0c	1.43, -0.8, 1.53, 1.1, 0c	-2.26, -5.11, -2.51, -1.24, 0c
7	-1.52, -1.87, 1.02, 1.8, 0c	-0.91, -2.18, -0.03, 1.36, 0c	0, -0.75, -0.63, 1.44, 0c	-1.93, -3.75, -2.78, -0.48, 0c
8	0.42, 1.01, 1.25, 0.73, 0c	0.31, 1.9, 1.25, 0.46, 0c	3.73, 3.77, 4.55, 2.24, 0c	2.49, 4.69, 3.88, 4.71, 0c
9	-0.08, 3.51, 3.82, 1.1, 0c	-0.52, 4.16, 5.2, 2.54, 0c	6.07, -0.21, 1.31, -0.49, 0c	2.25, -2.03, -1.9, -0.52, 0c
10	-2.72, -0.61, -0.56, 0.31, 0c	-1.48, -1.29, -1.58, -0.54, 0c	10.68, -4.65, -5.23, -1.56, 0c	14.87, -4.16, -3.45, -0.84, 0c

[c] This is set as the reference benchmark

Table -7: Coefficient (b_{fk}) values of predictors related to frequency of lifting/ lowering requirements

F	Upper back		Lower back	
	Acute $X_{if} = \{1,2,3$	Chronic $X_{if} = \{1,2,3$	Acute $X_{if} = \{1,2,3$	Chronic $X_{if} = \{1,2,3$
1	-18.19,-16.47,-11.82,0c	-13.27,-11.51,-9.47,0c	-21.02,-17.03,-16.91,0c	-27.19,-22.95,-20.41,0c
2	66.04,65.77,69.72,0c	76.87,79.88,83.85,0c	-9.61,-8.33,-10.34,0c	-18.41,-15,-22.09,0c
3	-25.99,-26.46,2.31,0c	-27.44,-28.71,-0.28,0c	12.36,13.18,6.4,0c	8.08,8.79,-26.64,0c
4	29.06,28.95,47.62,0c	29.47,29.33,48.81,0c	4.18,3.34,-2.3,0c	-3.26,-3.13,-8.04,0c

[c] This is set as the reference benchmark

Table -8: Coefficient (b_{ft}) values of predictors of back posture repetitions in lifting/ lowering tasks

T	Upper back		Lower back	
	Acute $X_{it} = \{1,2,3$	Chronic $X_{it} = \{1,2,3$	Acute $X_{it} = \{1,2,3$	Chronic $X_{it} = \{1,2,3$
1	1.66,-5.11,-5.71,0c	0.45,-4.5,-5.49,0c	-10.76,-14.28,-7.38,0c	-8.42,-14.02,-8.23,0c
2	-37.06,-36.54,-36,0c	-39.17,-40.48,-40.48,0c	20.6,19.36,23.99,0c	-24.26,-26.43,-20.02,0c
3	-35.5,-36.49,-27.82,0c	-34.7,-36.52,-30.77,0c	-0.03,0.08,5.39,0c	-2.94,-3.52,0.46,0c

[c] This is set as the reference benchmark

The model fitting summaries are consolidated in Table 8 (all age groups), Table 9 (less than 40 years' age group), Table 10 (40 to 59 years' age group) and Table 11 (old age workers above 60 years of age). The decrease in unexplained variance of work related acute/ chronic MSD problems in upper back or lower back, i.e. from the baseline model to the final model has been tested by using chi-square test. These changes (decrease) are significant, which means that our final model explains a significant amount of the variability (in other words, it is a better fit than the original model). The goodness of fit values of the models have been verified by the estimates of Person's and Deviance's measures (i.e. Pearson's chi-square statistic/ degrees of freedom and Deviance's likelihood ratio chi-square statistic/ degrees of freedom respectively). Also, Cox and Snell's R-Square (R^2_{cs}) and Nagelkerke R-Square (R^2_n) have been used to verify the predictive capabilities of the multinomial logistic regression models. The Cox and Snell's R-Squared is based on the log-likelihood of the model (LL_{new}) and the log-likelihood of the original model ($LL_{baseline}$), i.e. for the sample size "n":

$$R^2_{cs} = 1 - e^{[-\frac{2}{n}(LL_{new} - LL_{baseline})]}$$

Similarly, the Nagelkerke R-Square (R^2_n) is computed by:

$$R_n^2 = \frac{R_{cs}^2}{1 - e^{\left[\frac{2(LL_{baseline})}{n}\right]}}$$

Table -9: Model fitting summary for all age groups

MSD	Model fitting criteria (-2 Log Likelihood)		Likelihood ratio tests			Goodness of fit		R-Square	
	Intercept only	Final	Chi-Square	df	Sig.	Pearson	Deviance	Cox and Snell	Nagelkerke
Lower Back	740.681	230.487	510.194	124	.000	.516	1.000	.708	.850
Upper Back	827.087	265.633	561.454	124	.000	1.000	1.000	.745	.859

Table -10: Model fitting summary for age <40 years

MSD	Model fitting criteria (-2 Log Likelihood)		Likelihood ratio tests			Goodness of fit		R-Square	
	Intercept only	Final	Chi-Square	df	Sig.	Pearson	Deviance	Cox and Snell	Nagelkerke
Lower Back	159.510	25.315	134.194	54	.000	1.000	1.000	.599	.904
Upper Back	210.581	38.628	171.953	54	.000	1.000	1.000	.690	.906

Table -11: Model fitting summary for age between 40 and 60 years

MSD	Model fitting criteria (-2 Log Likelihood)		Likelihood ratio tests			Goodness of fit		R-Square	
	Intercept only	Final	Chi-Square	df	Sig.	Pearson	Deviance	Cox and Snell	Nagelkerke
Lower Back	205.277	70.274	135.003	62	.000	1.000	1.000	.663	.818
Upper Back	213.832	39.067	174.765	60	.000	1.000	1.000	.761	.919

Table -12: Model fitting summary for age >60 years

MSD	Model fitting criteria (-2 Log Likelihood)		Likelihood ratio tests			Goodness of fit		R-Square	
	Intercept only	Final	Chi-Square	df	Sig.	Pearson	Deviance	Cox and Snell	Nagelkerke
Lower Back	276.810	74.190	202.620	124	.000	1.000	1.000	.755	.885
Upper Back	281.266	63.700	217.526	124	.000	1.000	1.000	.784	.909

Strong associations and significant interactions between outcome variables (i.e. MSD problems in upper back, and lower back) and predictor variables (such as BMI, physical abilities, load, frequency, back posture and repetition requirements for routine lifting lowering MH tasks) have been noted. The model fitting summaries indicate these are good models of predicting the probabilities for work related lower or upper back MSD problems from lifting and lowering tasks in the construction industry, e.g. the R-square values for the 'more than 60 years' cohort is 0.893 (Cox and Snell) and 0.970 (Nagelkerke).

Predicting probabilities for work related MSD problems will be useful for enhancing occupational health and safety and mitigate risks from lifting and lowering MH tasks in the construction industry. The findings are limited to the cross-sectional research that modelled data of 432 participants from the construction industry in Australia. As the nature of MH tasks and MSD risks are potentially relevant in most regions, the model framework and outcomes can be widely useful. As such the current model framework does not include: (i) environment factors such as heat and vibration, (ii) psychological factors, (iii) other root causes for MSD problems e.g. race and anthropometry, genetic and pharmacodynamics. Suitably integrating biomechanical modelling (e.g. [36]), incorporating other parameters (e.g. vibrations) and longitudinal studies with medical observations will be valuable for firmer generalisations and practical ergonomic applications.

4. CONCLUSIONS

MSD problems associated with lower and upper back are significant among serious claims by the workforce in Australia. Lifting and lowering tasks associated acute and chronic back problems in certain construction industry occupations are investigated through a structured questionnaire based cross-sectional research study. The dataset of valid and complete responses from 432 participants have been analyzed to understand the patterns and associations of selected predictors and targeted outcome variables.

The results of Kruscall-Wallis tests and Jonckheere-Terpstra test for ordered alternatives (at significance level 0.01) indicate that the distribution of both upper and lower back MSD problems are same across all categories of gender and occupations. However, the null hypothesis is rejected for age categories and indicate that aging has notable effect on potentials for work related MSD problems from lifting and lowering MH tasks in the construction industry.

A multinomial logistic regression framework has been developed for predicting the probabilities potential MSD occurrences such as acute low back, chronic low back, acute upper back, chronic upper back problems from lifting and lowering tasks. Predictor variables considered in the logistic regression modelling include: body mass index (BMI), ten physical abilities (i.e. manual dexterity, static strength, dynamic strength, trunk strength, flexibility, body equilibrium, stamina, arm-hand steadiness, finger dexterity, multi-limb coordination), loads and extent lifted, postures as well as durations and repetitions of lifting in daily job routines. The model fit summaries including R-Square values indicate good predictability outcomes throughout different age groups. Such prediction of probabilities for work related MSD problems will be useful for enhancing occupational health and safety through improved selection of people and teams as well as suitable job designs/ redesigns in occupations involving significant MH tasks of lifting and lowering.

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