ANNEXURE- I

General Health Assessment Questionnaire

(Structured version 2.0)

Adopted partially from:
Status of Occupational Health in India Questionnaire. Indian Journal of Occupational and Environmental Medicine 2003; 7 (1): 45-48.

Health Questionnaire for Goldsmiths

Code: _____ Date: _____

Name of the Industry: (Optional): _____

Location: City: _____ State: _____

Total Number of Employees:

Permanent : _____

Contract/Temporary : _____

Number of Employees working in Hazardous Operations :

Permanent : _____

Contract/Temporary : _____

Details of Occupational Health Services

1. Pre-placement check up	Done	not done	
2. Periodic Medical check up	Done	not done	
3. Executive Health check up	Done	not done	
4. Health records	Maintained	not maintained	
5. Ambulance service	None	Own	
6. Number of trained First – Aiders	1:50	1:100	1:150
7. Statutory Examination for hazardous work:	Done	not done	

Potential Occupational Health Problems/Disease in your type of industry:

Occupational Health Problems			Approx. No. of workers at potential risk
Heat stress	Y	N	
Noise	Y	N	
Vibration	Y	N	
Lighting,	Y	N	
. Radiation	Y	N	
Ventilation Problems	Y	N	
Ergonomic issues – (Low Backache, CTD/MSD)	Y	N	
Dust related problems	Y	N	
Chemical Exposure	Y	N	
Dermatitis	Y	N	
Respiratory Problems	Y	N	
Hematological Problems	Y	N	
Renal ,,	Y	N	

Liver	"	Y	N
CNS	"	Y	N
CVS	"	Y	N
Occupational Cancers		Y	N
Stress		Y	N
Others if any, specify.			

Habit	No. of workers	Prevalence (For office use)
Smokers		
Tobacco Chewers		
Alcoholism		
Drug addiction		

ANNEXURE- II

WHO-Quality of Life (WHO-QoL)-100 for Field trials

(MNH/PSF/95.1.D.Rev.1)

Source:
WHO (World Health Organization). Field Trial WHOQOL-100. Geneva: 1995.

Field Trial

WHOQOL-100

February 1995

Instructions

This questionnaire asks how you feel about your quality of life, health, and other areas of your life. Please answer all the questions. If you are unsure about which response to give to a question, please choose the one that appears most appropriate. This can often be your first response.

Please keep in mind your standards, hopes, pleasures and concerns. We ask that you think about your life in the **last two weeks**.

For example, thinking about the last two weeks, a question might ask:

How much do you worry about your health?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

You should circle the number that best fits how much you have worried about your health over the last two weeks. So you would circle the number 4 if you worried about your health "Very much", or circle number 1 if you have worried "Not at all" about your health. Please read each question, assess your feelings, and circle the number on the scale for each question that gives the best answer for you.

Thank you for your help

The following questions ask about **how much** you have experienced certain things in the last two weeks, for example, positive feelings such as happiness or contentment. If you have experienced these things an extreme amount circle the number next to "An extreme amount". If you have not experienced these things at all, circle the number next to "Not at all". You should circle one of the numbers in between if you wish to indicate your answer lies somewhere between "Not at all" and "Extremely". Questions refer to the last two weeks.

F1.2 (F1.2.1)* Do you worry about your pain or discomfort?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F1.3 (F1.2.3) How difficult is it for you to handle any pain or discomfort?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F1.4 (F1.2.5) To what extent do you feel that (physical) pain prevents you from doing what you need to do?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F2.2(F2.1.3) How easily do you get tired?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F2.4 (F2.2.4) How much are you bothered by fatigue?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F3.2 (F4.1.3) Do you have any difficulties with sleeping?

None at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F3.4 (F4.2.3) How much do any sleep problems worry you?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

* The numbers in brackets refer to the number of the question in the pilot question pool. National versions must be constructed using that same question taken from national version of the pilot questionnaire.

F4.1 (F6.1.2) How much do you enjoy life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F4.3 (F6.1.4) How positive do you feel about the future?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F4.4 (F6.1.6) How much do you experience positive feelings in your life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F5.3 (F7.1.6) How well are you able to concentrate?

Not at all	Slightly	Moderately	Very well	Extremely
1	2	3	4	5

F6.1 (F8.1.1) How much do you value yourself?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F6.2 (F8.1.3) How much confidence do you have in yourself?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F7.2 (F9.1.3) Do you feel inhibited by your looks?

Not at all	Slightly	Moderately	Very much	Extremely
1	2	3	4	5

F7.3 (F9.1.4) Is there any part of your appearance which makes you feel uncomfortable?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F8.2 (F10.1.3) How worried do you feel?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F8.3 (F10.2.2) How much do any feelings of sadness or depression interfere with your everyday functioning?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F8.4 (F10.2.3) How much do any feelings of depression bother you?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F10.2 (F12.1.3)To what extent do you have difficulty in performing your routine activities?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F10.4 (F12.2.4)How much are you bothered by any limitations in performing everyday living activities?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F11.2 (F13.1.3)How much do you need any medication to function in your daily life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F11.3 (F13.1.4)How much do you need any medical treatment to function in your daily life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F11.4(F13.2.2) To what extent does your quality of life depend on the use of medical substances or medical aids?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F13.1(F17.1.3)How alone do you feel in your life?

Not at all	Slightly	Moderately	Very much	Extremely
1	2	3	4	5

F15.2 (F3.1.2) How well are your sexual needs fulfilled?

Not at all	Slightly	Moderately	Very much	Extremely
1	2	3	4	5

F15.4 (F3.2.3) Are you bothered by any difficulties in your sex life?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F16.1(F20.1.2)How safe do you feel in your daily life?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F16.2(F20.1.3)Do you feel you are living in a safe and secure environment?

Not at all	Slightly	Moderately	Very much	Extremely
1	2	3	4	5

F16.3(F20.2.2)How much do you worry about your safety and security?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

*F17.1(F21.1.1)How comfortable is the place where you live?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F17.4(F21.2.4)How much do you like it where you live?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F18.2(F23.1.5)Do you have financial difficulties?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F18.4(F23.2.4)How much do you worry about money?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F19.1(F24.1.1)How easily are you able to get good medical care?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F21.3(F26.2.2)How much do you enjoy your free time?

Not at all	A little	Moderately	Very much	An extreme amount
1	2	3	4	5

*F22.1(F27.1.2)How healthy is your physical environment?

Not at all	Slightly	Moderately	Very	Extremely
1	2	3	4	5

F22.2(F27.2.4)How concerned are you with the noise in the area you live in?

Not at all	A little	Moderately	Very much	An extreme amount
1	2	3	4	5

F23.2(F28.1.4)To what extent do you have problems with transport?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F23.4(F28.2.3)How much do difficulties with transport restrict your life?

Not at all	A little	A moderate amount	Very much	An extreme amount

1	2	3	4	5

* Note: These questions were inappropriately given a capacity response scale in the pilot version. They are to be given an intensity scale in the WHOQOL-100.

The following questions ask about **how completely** you experience or were able to do certain things in the last two weeks, for example activities of daily living such as washing, dressing or eating. If you have been able to do these things completely, circle the number next to "Completely". If you have not been able to do these things at all, circle the number next to "Not at all". You should circle one of the numbers in between if you wish to indicate your answer lies somewhere between "Not at all" and "Completely". Questions refer to the last two weeks.

F2.1(F2.1.1) Do you have enough energy for everyday life?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F7.1(F9.1.2) Are you able to accept your bodily appearance?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F10.1(F12.1.1)To what extent are you able to carry out your daily activities?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F11.1(F13.1.1)How dependent are you on medications?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F14.1(F18.1.2)Do you get the kind of support from others that you need?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F14.2(F18.1.5)To what extent can you count on your friends when you need them?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F17.2(F21.1.2)To what degree does the quality of your home meet your needs?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F18.1(F23.1.1)Have you enough money to meet your needs?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F20.1(F25.1.1)How available to you is the information that you need in your day-to-day life?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F20.2(F25.1.2)To what extent do you have opportunities for acquiring the information that you feel you need?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F21.1(F26.1.2)To what extent do you have the opportunity for leisure activities?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F21.2(F26.1.3)How much are you able to relax and enjoy yourself?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F23.1(F28.1.2)To what extent do you have adequate means of transport?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

The following questions ask you to say how **satisfied, happy or good** you have felt about various aspects of your life over the last two weeks . For example, about your family life or the energy that you have. Decide how satisfied or dissatisfied you are with each aspect of your life and circle the number that best fits how you feel about this. Questions refer to the last two weeks.

G2 (G2.1) How satisfied are you with the quality of your life?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

G3 (G2.2) In general, how satisfied are you with your life?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

G4 (G2.3) How satisfied are you with your health?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F2.3 (F2.2.1) How satisfied are you with the energy that you have?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F3.3(F4.2.2) How satisfied are you with your sleep?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F5.2 (F7.2.1) How satisfied are you with your ability to learn new information?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F5.4 (F7.2.3) How satisfied are you with your ability to make decisions?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F6.3(F8.2.1) How satisfied are you with yourself?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F6.4(F8.2.2) How satisfied are you with your abilities?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F7.4(F9.2.3) How satisfied are you with the way your body looks?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F10.3(F12.2.3)How satisfied are you with your ability to perform your daily living activities?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F13.3(F17.2.3)How satisfied are you with your personal relationships?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F15.3(F3.2.1) How satisfied are you with your sex life?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied

1	2	3	4	5

F14.3(F18.2.2)How satisfied are you with the support you get from your family?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F14.4(F18.2.5)How satisfied are you with the support you get from your friends?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F13.4(F19.2.1)How satisfied are you with your ability to provide for or support others?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F16.4(F20.2.3)How satisfied are you with your physical safety and security?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F17.3(F21.2.2)How satisfied are you with the conditions of your living place?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F18.3(F23.2.3)How satisfied are you with your financial situation?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F19.3(F24.2.1)How satisfied are you with your access to health services?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F19.4(F24.2.5)How satisfied are you with the social care services?

Very dissatisfied	Dissatisfied	Neither satisfied nor	Satisfied	Very satisfied

1	2	dissatisfied 3	4	5

F20.3(F25.2.1)How satisfied are you with your opportunities for acquiring new skills?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F20.4(F25.2.2)How satisfied are you with your opportunities to learn new information?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F21.4(F26.2.3)How satisfied are you with the way you spend your spare time?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F22.3(F27.2.1)How satisfied are you with your physical environment (e.g. pollution, climate, noise, attractiveness)?

Very dissatisfied 1	Dissatisfied 2	Neither satisfied nor dissatisfied 3	Satisfied 4	Very satisfied 5

F22.4(F27.2.3)How satisfied are you with the climate of the place where you live?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F23.3(F28.2.2)How satisfied are you with your transport?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F13.2(F17.2.1)Do you feel happy about your relationship with your family members?

Very unhappy	Unhappy	Neither happy nor unhappy	Happy	Very happy
1	2	3	4	5

G1(G1.1) How would you rate your quality of life?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

F15.1(F3.1.1) How would you rate your sex life?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

F3.1(F4.1.1) How well do you sleep?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

F5.1(F7.1.3) How would you rate your memory?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

F19.2(F24.1.5)How would you rate the quality of social services available to you?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

The following questions refer to **how often** you have felt or experienced certain things, for example the support of your family or friends or negative experiences such as feeling unsafe. If you have not experienced these things at all in the last two weeks, circle the number next to the response "never". If you have experienced these things, decide how often and circle the appropriate number. So for example if you have experienced pain all the time in the last two weeks circle the number next to "Always". Questions refer to the last two weeks.

F1.1 (F1.1.1) How often do you suffer (physical) pain?

Never	Seldom	Quite often	Very often	Always
1	2	3	4	5

F4.2 (F6.1.3) Do you generally feel content?

Never	Seldom	Quite often	Very often	Always
1	2	3	4	5

F8.1 (F10.1.2) How often do you have negative feelings, such as blue mood, despair, anxiety, depression?

Never	Seldom	Quite often	Very often	Always
1	2	3	4	5

The following questions refer to any "**work**" that you do. Work here means any major activity that you do. This includes voluntary work, studying full-time, taking care of the home, taking care of children, paid work or unpaid work. So work, as it is used here, means the activities you feel take up a major part of your time and energy. Questions refer to the last two weeks.

F12.1 (F16.1.1)Are you able to work?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F12.2 (F16.1.2)Do you feel able to carry out your duties?

Not at all	A little	Moderately	Mostly	Completely
1	2	3	4	5

F12.4(F16.2.1)How satisfied are you with your capacity for work?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

F12.3(F16.1.3)How would you rate your ability to work?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

The next few questions ask about **how well you were able to move around**, in the last two weeks. This refers to your physical ability to move your body in such a way as to allow you to move about and do the things you would like to do, as well as the things that you need to do.

F9.1(F11.1.1) How well are you able to get around?

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

F9.3(F11.2.2) How much do any difficulties in mobility bother you?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F9.4(F11.2.3) To what extent do any difficulties in movement affect your way of life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F9.2(F11.2.1) How satisfied are you with your ability to move around?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5

The following few questions are concerned with **your personal beliefs**, and how these affect your quality of life. These questions refer to religion, spirituality and any other beliefs you may hold. Once again these questions refer to the last two weeks.

F24.1(F29.1.1)Do your personal beliefs give meaning to your life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F24.2(F29.1.3)To what extent do you feel your life to be meaningful?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F24.3(F29.2.2)To what extent do your personal beliefs give you the strength to face difficulties?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

F24.4(F29.2.3)To what extent do your personal beliefs help you to understand difficulties in life?

Not at all	A little	A moderate amount	Very much	An extreme amount
1	2	3	4	5

ABOUT YOU

What is your gender?

Male
Female

What is your date of birth?

_____/_____/_____
DAY / MONTH / YEAR

What is highest education you received?

Primary school
Secondary school
University
Post-graduate

What is your marital status?

Single
Married
Living as married
Separated
Divorced
Widowed

How is your health? (G1.2)**

Very poor	Poor	Neither poor nor good	Good	Very good
1	2	3	4	5

What health problems do you have at the moment? (TICK NEXT TO THOSE THAT APPLY TO YOU)

Heart trouble

High blood pressure

Arthritis or Rheumatism

Cancer

Emphysema or chronic bronchitis

Diabetes

A cataract

Stroke

Broken or fractured bone

Chronic nervous or emotional problems

Chronic foot trouble (bunions, ingrowing toenails)

Rectal growth or rectal bleeding

** This question was originally in the body of rated questions in the pilot questionnaire.

Parkinson's disease

Other (please describe)

Are you currently ill?

If yes, what is your diagnosis? _____

Do you have any comments about the questionnaire?

THANK YOU FOR YOUR HELP

ANNEXURE- III

Mini-Nutritional Assessment (MNA©) Questionnaire

(By Nestlé Nutrition Institute)

Sources:

Vellas B, Villars H, Abellan G, Soto ME, Rolland Y, Guigoz Y, Morley JE, Chumlea W, Salva A, Rubenstein LZ, Garry P. Overview of MNA® - Its History and Challenges. Journal of Nutrition, Health and Aging 2006; 10: 456-465.

Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF). Journal of Gerontology 2001; 56A: M366-377.

Guigoz Y. The Mini-Nutritional Assessment (MNA®) Review of the Literature – What does it tell us? Journal of Nutrition, Health and Aging 2006; 10: 466-487.

Nestlé
NutritionInstitute

Mini Nutritional Assessment MNA©

Last name:			First name:	
Sex:	Age:	Weight, kg:	Height, cm:	Date:

Complete the screen by filling in the boxes with the appropriate numbers. Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake

B Weight loss during the last 3 months
0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out 2 = goes out

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems

F Body Mass Index (BMI) (weight in kg) / (height in m^2)
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater

Screening score (subtotal max. 14 points)

12-14 points: Normal nutritional status
8-11 points: At risk of malnutrition
0-7 points: Malnourished

For a more in-depth assessment, continue with questions G-R

Assessment

G Lives independently (not in nursing home or hospital)
1 = yes 0 = no

H Takes more than 3 prescription drugs per day
0 = yes 1 = no

I Pressure sores or skin ulcers
0 = yes 1 = no

J How many full meals does the patient eat daily?
0 = 1 meal
1 = 2 meals
2 = 3 meals

K Selected consumption markers for protein intake

- At least one serving of dairy products (milk, cheese, yoghurt) per day — yes no
- Two or more servings of legumes or eggs per week — yes no
- Meat, fish or poultry every day — yes no

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes .

L Consumes two or more servings of fruit or vegetables per day?
0 = no 1 = yes

M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups .

N Mode of feeding
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem

O Self view of nutritional status
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem

P In comparison with other people of the same age, how does the patient consider his / her health status?
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better .

Q Mid-arm circumference (MAC) in cm
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC 22 or greater .

R Calf circumference (CC) in cm
0 = CC less than 31
1= CC 31 or greater

Malnutrition Indicator score

24-30 points:	Normal nutritional status
17-23.5 points:	At risk of malnutrition
Less than 17 points:	Malnourished

ANNEXURE- IV

The Nordic Musculoskeletal Questionnaire (NMQ)

Main Questionnaire

Source:
Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics 1987; 18 (3): 233-237.

Date: Subject ID:

PERSONAL DETAILS: *PART – I*

1. Sex
2. Date of Birth
3. What is your weight? …….. Kg
4. What is your height? …….. cm
5. Are you right or left-handed?
6. Waist circumference: ……cm.
7. Hip circumference: ……cm.

INFORMATION ABOUT THE PRESENT WORK TYPE: *PART - II*

1. How many years and months have you been doing your present type of work?

   …….Years …….Months/ If less than one month, how many weeks?

2. Have you worked out this type of job in other field? 1. Yes 2. No

   If yes, what is the total length of time you worked?

   …….Years …….Months/ If less than one month, how many weeks?

3. Do you have any other paid job other than this? 1. Yes 2. No

   If yes, then what type of work? ……

4. No. of working days/ week:
5. Working hours/ day
6. Any overtime? 1. Yes 2. No If Yes, then how many hours?
7. Off days/ week:
8. No. of breaks within the working hours:
9. Duration of breaks:
10. Do you work in shifts? 1. Yes 2. No

    If yes, then how does the shift change?

    1. *Every day* 2. *Every week* 3. *Every fortnight* 4. *Every month*

11. Type of work (i): 1. *Contractual* 2. *Part time* 3. *Permanent*
12. Type of work (ii): 1. *Machine operator* 2. *Fully manual*
13. Type of work (iii): 1. *Multiple* 2. *Fixed*
14. If multiple, then how does the work change?

1. According to the demanding situation 2. Every day 3. Every alternate day

15. Working behaviour: 1. In groups 2. Individually

16. Loads lifted: ……..kg/ Day.

17. Lifting frequency: ……..times/ hour.

18. Lifting type 1. Individually 2. Assistive.

19. What is the level of lifting?

1. Ground to head 2. Ground to back 3. Ground to shoulder
4. Shoulder to head 5. Knee to head 6. Waist to head
7. Ground to waist 8. Ground to knee 9. Waist to shoulder

20. Mode of lifting 1. In one hand 2. In both the hands 3. By any instrument

If by any instrument, then its description: …….

21. In which posture do you remain most of the time?

1. Standing 2. Sitting on the ground 3. Sitting on a chair/ stool
4. Walking 5. Half-sit.

22. How long do you remain in that above said posture? Minutes..... Hours.....

23. Does your posture change frequently? 1. Yes 2. No

24. Is your work repetitive in nature? 1. Yes 2. No

INFORMATION ABOUT THE PAST WORK TYPE (IF ANY):

PART - III

1. How many years and months did you work?

…….Years ……Months, If less than one month, how many weeks?

2. Have you worked out the past type of job in other field? 1. No 2. Yes

If yes, what is the total length of time you worked?

….....Years ……Months, If less than one month, how many weeks?

4. No. of working days/ week:

5. Working hours/ day:

6. Any overtime: 1. Yes 2. No. If Yes, then how many hours

7. Off days/ week:

8. No. of breaks within the working hours:

9. Duration of breaks:

10. Did you work in shifts? 1. Yes 2. No.

If yes, then how does the shift change?

1. Every day 2. Every week 3. Every fortnight 4. Every month

11. Type of work (i): 1. Contractual 2. Per time 3. Permanent

12. Type of work (ii): 1. Machine operator 2. Fully manual

13. Type of work (iii): 1. Multiple 2. Fixed

14. If multiple, then how does the work change?

1. According to the demanding situation 2. Every day 3. Every alternate day

15. Working behaviour 1. In groups 2. Individually

16. Loads lifted: …….kg/ Day.

17. Lifting frequency: ……times/ hour.

18. Lifting type 1. Individually 2. Assistive.

19. What was the level of lifting?

1. Ground to head 2. Ground to back 3. Ground to shoulder

4. Shoulder to head 5. Knee to head 6. Waist to head

7. Ground to waist 8. Ground to knee 9. Waist to shoulder

20. Mode of lifting: 1. In one hand 2. In both the hands 3. By any instrument

If by any instrument, then its description: …….

21. In which posture did you remain most of the time?

1. Standing 2. Sitting on the ground 3. Sitting on a chair/ stool

4. Walking 5. Half-sit.

22. How long did you remain in that above said posture? ….....Minutes .....Hours.

23. Did your posture change frequently? 1. Yes 2. No

24. Was your work repetitive in nature? 1. Yes 2. No

INFORMATION OF THE HOUSEHOLD ACTIVITIES: *PART – IV*

1. Please √ the type (s) of work done in the house:

a) MALES:

1. Shaving 2. Marketing 3. Cycling 4. Cutting wood 5. Gardening

6. Sports 7. Other Entertainment 8. Agricultural work 9. Others.

b) FEMALES:

1. Cooking 2. Cutting vegetables 3. Washing clothes

4. Washing utensils 5. Sweeping 6. Preparing bed 7. Water storage

8. Baby upbringing 9. Agricultural work 10. Entertainments 11. Others

c) GENERAL:

1. Bathing 2. Eating 3. Toilet activities 4. Studying

2. What type of work do you do most of the time?

……..

3. How long do you spend in the above-said work? …….Minutes ……Hours.

INFORMATION OF THE PAIN/ DISCOMFORT FELT: *PART – V*

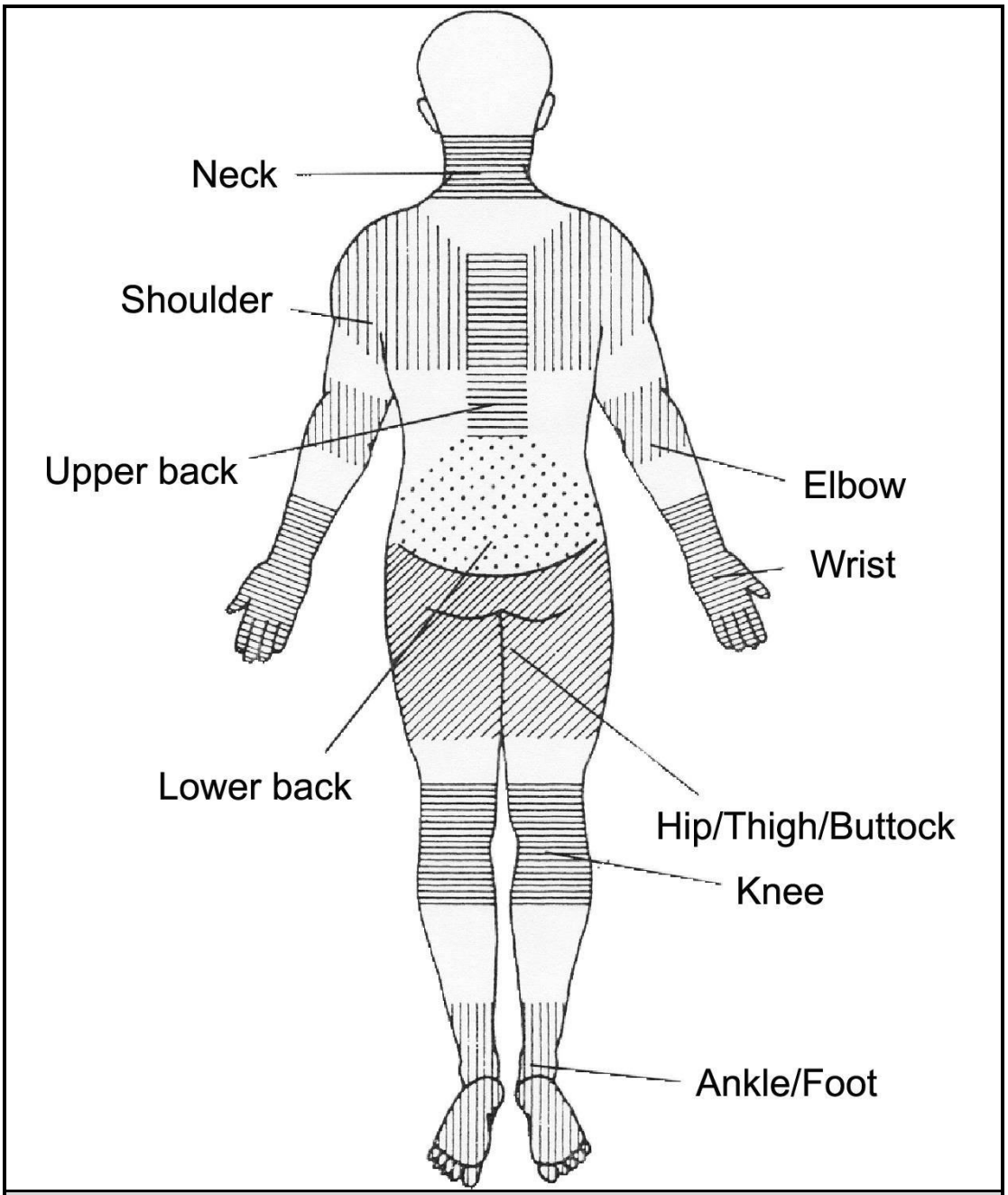


Figure: This picture shows how the body has been divided. Please answer the three questions shown on next page for each body area. Body sections are not sharply defined and certain parts overlap. You should decide for yourself which part (if any) is or has been affected.

Please answer by using the tick boxes – *one tick for each question*
Please note that this part of the questionnaire should be answered, even if you have never had trouble in any parts of our body.

Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness etc.) in:	Have you had trouble during the last 7 days:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, house-work, hobbies) because of this trouble:
1 *Neck* No 1 ☐ Yes 2 ☐	2 *Neck* No 1 ☐ Yes 2 ☐	3 *Neck* No 1 ☐ Yes 2 ☐
4 *Shoulders* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	5 *Shoulders* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	6 *Shoulders (both/either)* No 1 ☐ Yes 2 ☐
7 *Elbows* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	8 *Elbows* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	9 *Elbows (both/either)* No 1 ☐ Yes 2 ☐
10 *Wrists/hands* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	11 *Wrists/hands* No 1 ☐ Yes 2 ☐ right 3 ☐ left 4 ☐ both	12 *Wrists/hands (both/either)* No 1 ☐ Yes 2 ☐
13 *Upper Back* No 1 ☐ Yes 2 ☐	14 *Upper Back* No 1 ☐ Yes 2 ☐	15 *Upper Back* No 1 ☐ Yes 2 ☐
16 *Lower Back* No 1 ☐ Yes 2 ☐	16 *Lower Back* No 1 ☐ Yes 2 ☐	16 *Lower Back* No 1 ☐ Yes 2 ☐
19 *One or both Hips/Thighs/Buttocks* No 1 ☐ Yes 2 ☐	20 *One or both Hips/Thighs/Buttocks* No 1 ☐ Yes 2 ☐	21 *One or both Hips/Thighs/Buttocks* No 1 ☐ Yes 2 ☐
22 *One or both Knees* No 1 ☐ Yes 2 ☐	23 *One or both Knees* No 1 ☐ Yes 2 ☐	24 *One or both Knees* No 1 ☐ Yes 2 ☐
25 *One or both Ankles/Feet* No 1 ☐ Yes 2 ☐	26 *One or both Ankles/Feet* No 1 ☐ Yes 2 ☐	27 *One or both Ankles/Feet* No 1 ☐ Yes 2 ☐

A. Neck Trouble

How to answer the questionnaire:
By neck trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any neck trouble (ache, pain, numbness or discomfort)?
   1. Yes 2. No

   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***shoulder trouble***.

2. Have you ever hurt your neck in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of neck trouble?
   1. Yes 2. No

4. What do you think brought on this problem with your neck?
   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have neck troubles?
   (b) What year was your worst neck trouble?

6. How bad was the pain during the worst episode?
   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of neck trouble?
   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with neck trouble in total?.....

   7c. How many days have you been absent from work with neck trouble in the last 12 months?

8. How often do you get or have you had neck trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years

6. One episode of trouble only

9. What is the total length of time that you had neck trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has neck trouble caused you to reduce your activity during the last 12 months?

    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that neck trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of neck trouble during the last 12 months? 1. Yes 2. No If the answer is 'NO', please go on to the next section.

    If 'YES':

    Where? (More than one can be ticked):

    1. Medical centre at work 2. GP 3. Hospital

    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details.

B. *Shoulder Trouble*

How to answer the questionnaire:
By shoulder trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick √ boxes - one tick for each answer.

1. Have you ever had any shoulder trouble (ache, pain, numbness or discomfort)?
   1. Yes 2. No

   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***upper back trouble***.

2. Have you ever hurt your shoulder in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No

   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of shoulder trouble?

   2. Yes 2. No

4. What do you think brought on this problem with your shoulder?

   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have shoulder troubles?
   (b) What year was your worst shoulder trouble?

6. How bad was the pain during the worst episode?

   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of shoulder trouble?

   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with shoulder trouble in total?.....

   7c. How many days have you been absent from work with shoulder trouble in the last 12 months?

8. How often do you get or have you had shoulder trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had shoulder trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has shoulder trouble caused you to reduce your activity during the last 12 months?
    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that shoulder trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?

    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of shoulder trouble during the last 12 months? 1. Yes 2. No If the answer is 'NO', please go on to the next section.

If 'YES': Where? (More than one can be ticked):

1. Medical centre at work 2. GP 3. Hospital

4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details

C. *Upper Back Trouble*

How to answer the questionnaire:
By upper back trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any upper back trouble (ache, pain, numbness or discomfort)? 1. Yes 2. No
   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***lower back trouble***.

2. Have you ever hurt your upper back in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of upper back trouble?

   1. Yes 2. No

4. What do you think brought on this problem with your upper back?

   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have upper back troubles?
   (b) What year was your worst upper back trouble?

6. How bad was the pain during the worst episode?

   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of upper back trouble?

   1. Yes 2. No

If the answer is 'NO', please go on to Question 8.

If 'YES': 7a. How many times? …….

7b. How many days have you been absent from work with upper back trouble in total?.....

7c. How many days have you been absent from work with upper back trouble in the last 12 months?

8. How often do you get or have you had upper back trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had upper back trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has upper back trouble caused you to reduce your activity during the last 12 months?
    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that upper back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of upper back trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):
    1. Medical centre at work 2. GP 3. Hospital
    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details

D. *Lower Back Trouble*

How to answer the questionnaire:
By lower back trouble it means pain, ache or discomfort in the shaded area

only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any lower back trouble (ache, pain, numbness or discomfort)? 1. Yes 2. No

   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***wrist/hand trouble***.

2. Have you ever hurt your lower back in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of lower back trouble?

   2. Yes 2. No

4. What do you think brought on this problem with your lower back?

   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have lower back troubles?
   (b) What year was your worst lower back trouble?

6. How bad was the pain during the worst episode?

   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of lower back trouble?

   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with lower back trouble in total?.....

   7c. How many days have you been absent from work with lower back trouble in the last 12 months?

8. How often do you get or have you had lower back trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years

6. One episode of trouble only

9. What is the total length of time that you had lower back trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has lower back trouble caused you to reduce your activity during the last 12 months?

    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that lower back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of lower back trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):

    1. Medical centre at work 2. GP 3. Hospital

    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details

E. *Wrist/ hand Trouble*

How to answer the questionnaire:
By wrist/hand trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any wrist/hand trouble (ache, pain, numbness or discomfort)? 1. Yes 2. No
   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***hip/thigh/buttock trouble***.

2. Have you ever hurt your wrist/hand in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of wrist/hand trouble?

3. Yes 2. No

4. What do you think brought on this problem with your wrist/hand?

   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have wrist/hand troubles?
   (b) What year was your worst wrist/hand trouble?

6. How bad was the pain during the worst episode?

   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of wrist/hand trouble?

   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with wrist/hand trouble in total?.....

   7c. How many days have you been absent from work with wrist/hand trouble in the last 12 months?

8. How often do you get or have you had wrist/hand trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had wrist/hand trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has wrist/hand trouble caused you to reduce your activity during the last 12 months?

    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that wrist/hand trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30

days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of wrist/hand trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):

    1. Medical centre at work 2. GP 3. Hospital

    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details

F. *Hip/ Thigh/ Buttock Trouble*

How to answer the questionnaire:
By hip/thigh/buttock trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any hip/thigh/buttock trouble (ache, pain, numbness or discomfort)? 1. Yes 2. No
   If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***knee trouble***.
2. Have you ever hurt your hip/thigh/buttock in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of hip/thigh/buttock trouble? 1. Yes 2. No
4. What do you think brought on this problem with your hip/thigh/buttock?
   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)
5. (a) What year did you first have hip/thigh/buttock troubles?
   (b) What year was your worst hip/thigh/buttock trouble?
6. How bad was the pain during the worst episode?
   1. Mild 2. Severe 3. Very Very Severe
7. Have you ever been absent from work because of hip/thigh/buttock trouble?

   1. Yes 2. No

If the answer is 'NO', please go on to Question 8.

If 'YES': 7a. How many times? …….

7b. How many days have you been absent from work with hip/thigh/buttock trouble in total?.....

7c. How many days have you been absent from work with hip/thigh/buttock trouble in the last 12 months?

8. How often do you get or have you had hip/thigh/buttock trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had hip/thigh/buttock trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has hip/thigh/buttock trouble caused you to reduce your activity during the last 12 months?

    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that hip/thigh/buttock trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of hip/thigh/buttock trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):

    1. Medical centre at work 2. GP 3. Hospital

    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details.

G. *Knee Trouble*

How to answer the questionnaire:
By knee trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any knee trouble (ache, pain, numbness or discomfort)?

1. Yes 2. No

If you have answered 'NO' to this question, do not answer questions 2-12 but please go to the section on ***ankle/foot trouble***.

2. Have you ever hurt your knee in an accident? 1. Yes 2. No

   If the answer is 'NO', please go on to Question 3.

   If 'YES': 2a. was the accident at work? 1. Yes 2. No

   2b. what was the approximate date of the accident?

3. Have you ever had to change duties or jobs because of knee trouble? 1. Yes 2. No

4. What do you think brought on this problem with your knee?

   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)

5. (a) What year did you first have knee troubles?
   (b) What year was your worst knee trouble?

6. How bad was the pain during the worst episode?

   1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of knee trouble?

   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with knee trouble in total?.....

   7c. How many days have you been absent from work with knee trouble in the last 12 months?

8. How often do you get or have you had knee trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had knee trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has knee trouble caused you to reduce your activity during the last 12 months?

(a) Work activity (at home or away from home): 1. Yes 2. No
(b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that knee trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of knee trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):
    1. Medical centre at work 2. GP 3. Hospital
    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details.

H. *Ankle/Foot Trouble*

How to answer the questionnaire:
By ankle/foot trouble it means pain, ache or discomfort in the shaded area only.
Please answer by using the tick boxes √ - one tick for each answer.

1. Have you ever had any ankle/foot trouble (ache, pain, numbness or discomfort)? 1. Yes 2. No
   If you have answered 'NO' to this question, do not answer questions
2. Have you ever hurt your ankle/foot in an accident? 1. Yes 2. No
   If the answer is 'NO', please go on to Question 3.
   If 'YES': 2a. was the accident at work? 1. Yes 2. No
   2b. what was the approximate date of the accident?
3. Have you ever had to change duties or jobs because of ankle/foot trouble?
   1. Yes 2. No
4. What do you think brought on this problem with your ankle/foot?
   1. Accident 2. Sporting activity 3. Activity at home 4. Activity at work
   5. Other (please specify)
5. (a) What year did you first have ankle/foot troubles?
   (b) What year was your worst ankle/foot trouble?
6. How bad was the pain during the worst episode?

1. Mild 2. Severe 3. Very Very Severe

7. Have you ever been absent from work because of ankle/foot trouble?

   1. Yes 2. No

   If the answer is 'NO', please go on to Question 8.

   If 'YES': 7a. How many times? …….

   7b. How many days have you been absent from work with ankle/foot trouble in total?.....

   7c. How many days have you been absent from work with ankle/foot trouble in the last 12 months?

8. How often do you get or have you had ankle/foot trouble?
   1. Daily 2. One or more times a week 3. One or more times a month
   4. One or more times a year 5. One or more times every few years
   6. One episode of trouble only

9. What is the total length of time that you had ankle/foot trouble during the last 12 months?
   1. 0 days 2. 1-7 days 3. 8-30 days 4. More than 30 days, but not every day 5. Every day

10. Has ankle/foot trouble caused you to reduce your activity during the last 12 months?

    (a) Work activity (at home or away from home): 1. Yes 2. No
    (b) Leisure activity: 1. Yes 2. No

11. What is the total length of time that ankle/foot trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?
    (1) 0 days (2) 1-7 days (3) 8-30 days (4) More than 30 days

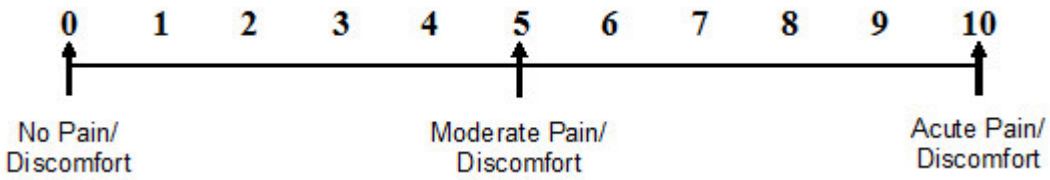
12. Have you been seen by a doctor, physiotherapist, chiropractor, or other such person because of ankle/foot trouble during the last 12 months?
    1. Yes 2. No If the answer is 'NO', please go on to the next section.
    If 'YES': Where? (More than one can be ticked):

    1. Medical centre at work 2. GP 3. Hospital

    4. Private Doctor 5. Osteopathor chiropractor 6. Other*

If you have ticked *other* please give details.

Assessment of Discomfort/Pain by Body Part Discomfort (BPD) Scale:
PART - VI



1. Name:
……..

2. Sex:
……..

3. Height:
……..

4. Weight:
……..

5. Type of Job:
……..

6. Duration:
……..

7. Type of Pain:
……..

8. Duration of Pain:
……..

9. Area of Pain:
……..

10. Occurrence of Pain:
……..

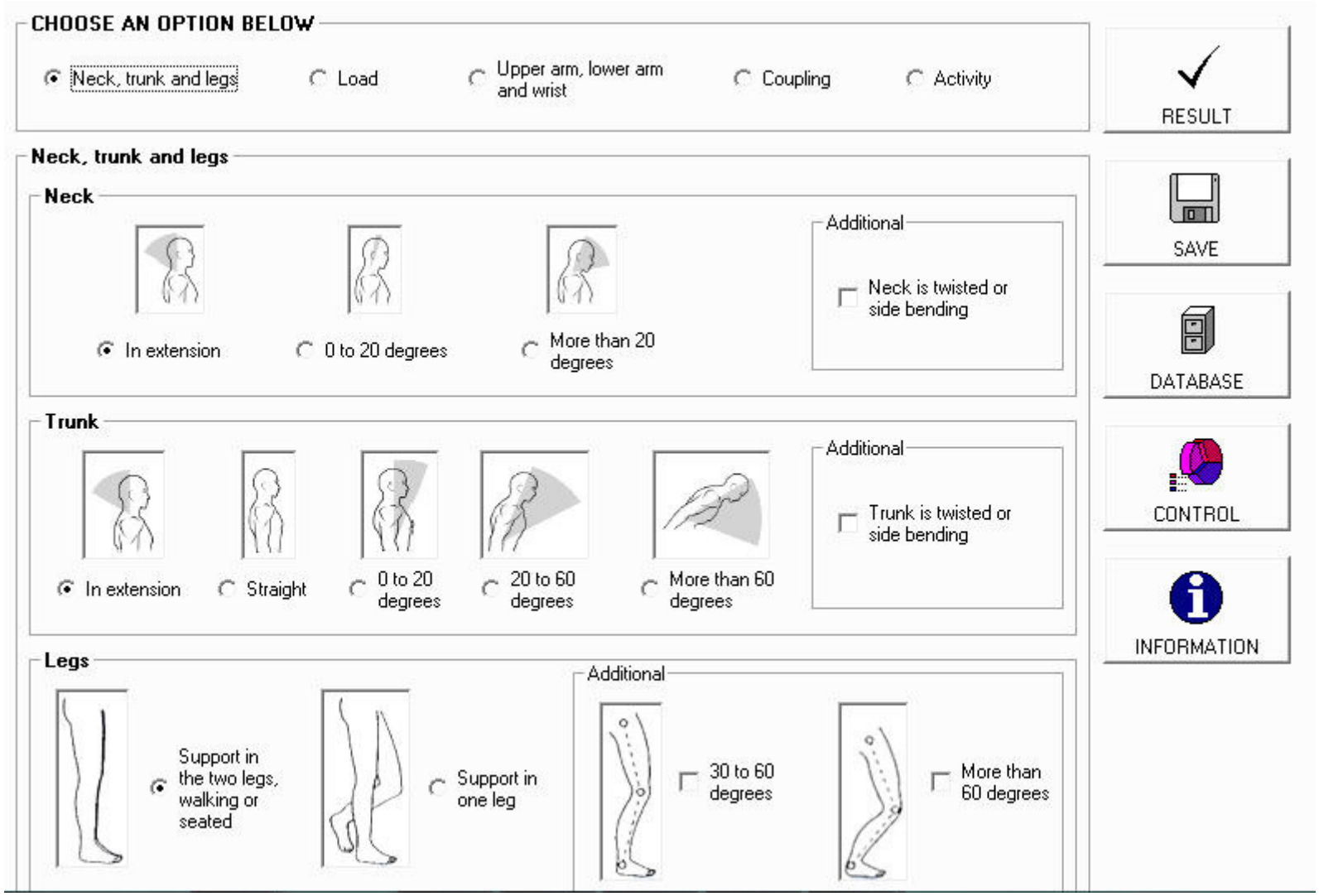
11. Persistence of Pain:
……..

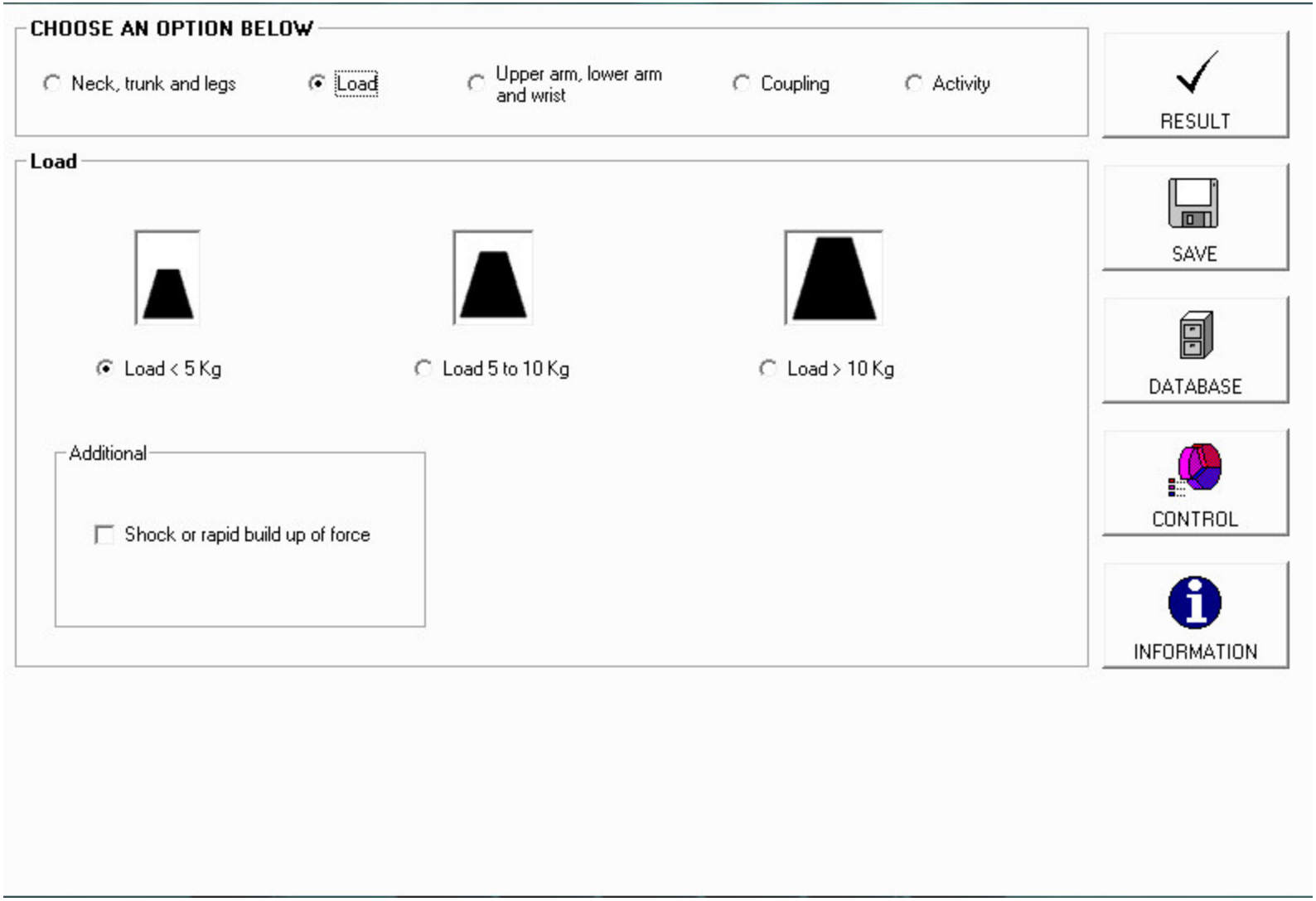
ANNEXURE- V

Rapid Entire Body Assessment (REBA) Score sheet

(via ErgoFellow Software, version 2.0)

Source:
Hignett S, McAtamney L. Rapid Entire Body Assessment (REBA). Applied Ergonomics 2000; 31: 201-205.


CHOOSE AN OPTION BELOW
Neck, trunk and legs
Load
Upper arm, lower arm and wrist
Coupling
Activity
RESULT
Neck, trunk and legs
Neck
In extension
0 to 20 degrees
More than 20 degrees
Additional
Neck is twisted or side bending
SAVE
DATABASE
Trunk
In extension
Straight
0 to 20 degrees
20 to 60 degrees
More than 60 degrees
Additional
Trunk is twisted or side bending
CONTROL
INFORMATION
Legs
Support in the two legs, walking or seated
Support in one leg
Additional
30 to 60 degrees
More than 60 degrees


CHOOSE AN OPTION BELOW
Neck, trunk and legs
Load
Upper arm, lower arm and wrist
Coupling
Activity
RESULT
Load
SAVE
DATABASE
Load < 5 Kg
Load 5 to 10 Kg
Load > 10 Kg
CONTROL
Additional
Shock or rapid build up of force
INFORMATION

CHOOSE AN OPTION BELOW

- ○ Neck, trunk and legs
- ○ Load
- ◉ Upper arm, lower arm and wrist
- ○ Coupling
- ○ Activity

Upper arm, lower arm and wrist

Upper arm

- ○ In extension more than 20 degrees
- ○ - 20 to 20 degrees
- ○ 20 to 45 degrees
- ○ 45 to 90 degrees
- ○ More than 90 degrees

Additional

- ☐ Upper arm is abducted
- ☐ Shoulder is raised
- ☐ Arm is supported or person is leaning

Lower arm

- ○ 60 to 100 degrees
- ○ 0 to 60 degrees or more than 100 degrees

Wrist

- ○ Between 15 degrees up and 15 degrees down
- ○ More than 15 degrees up or more than 15 degrees down

Additional

- ☐ Wrist is bent from midline or twisted

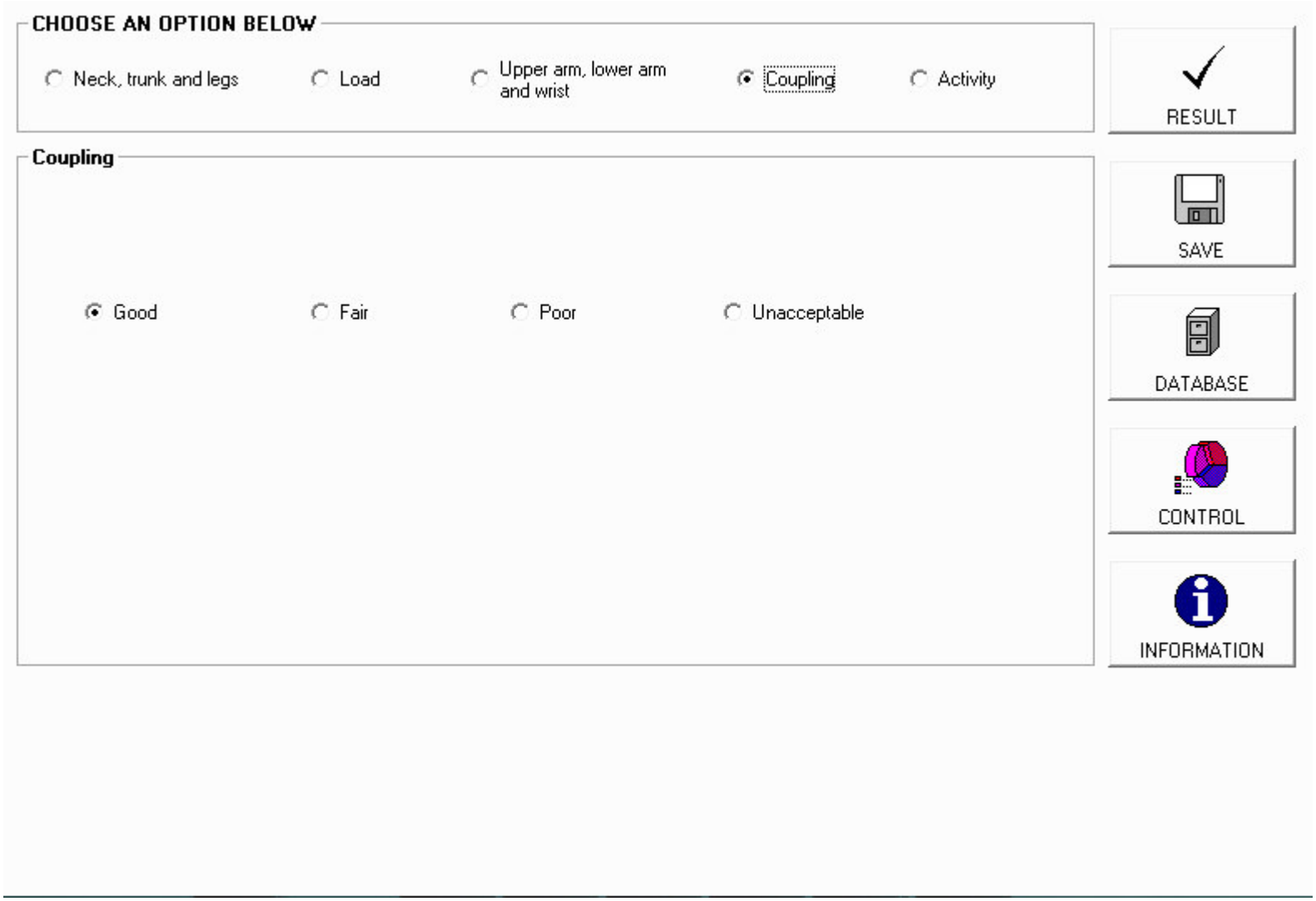
RESULT

SAVE

DATABASE

CONTROL

INFORMATION


CHOOSE AN OPTION BELOW
Neck, trunk and legs
Load
Upper arm, lower arm and wrist
Coupling
Activity
Coupling
Good
Fair
Poor
Unacceptable
RESULT
SAVE
DATABASE
CONTROL
INFORMATION

CHOOSE AN OPTION BELOW

- ○ Neck, trunk and legs
- ○ Load
- ○ Upper arm, lower arm and wrist
- ○ Coupling
- ◉ Activity

Activity

- ☐ One or more body parts are held for longer than 1 minute (static)
- ☐ Repeated small range actions (more than 4x per minute)
- ☐ Action causes rapid large range changes in postures or unstable base

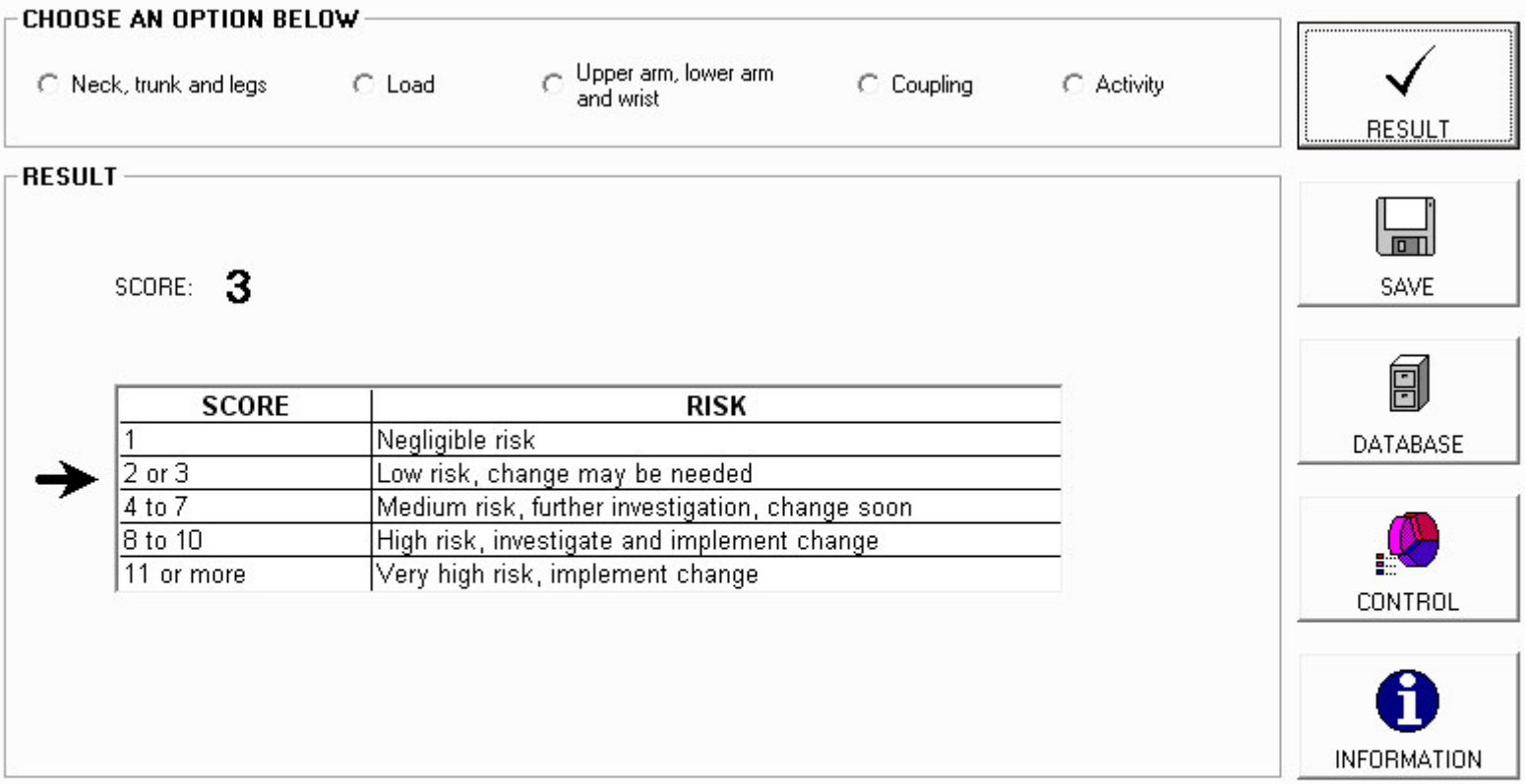
RESULT

SAVE

DATABASE

CONTROL

INFORMATION



SCORE	RISK
1	Negligible risk
2 or 3	Low risk, change may be needed
4 to 7	Medium risk, further investigation, change soon
8 to 10	High risk, investigate and implement change
11 or more	Very high risk, implement change

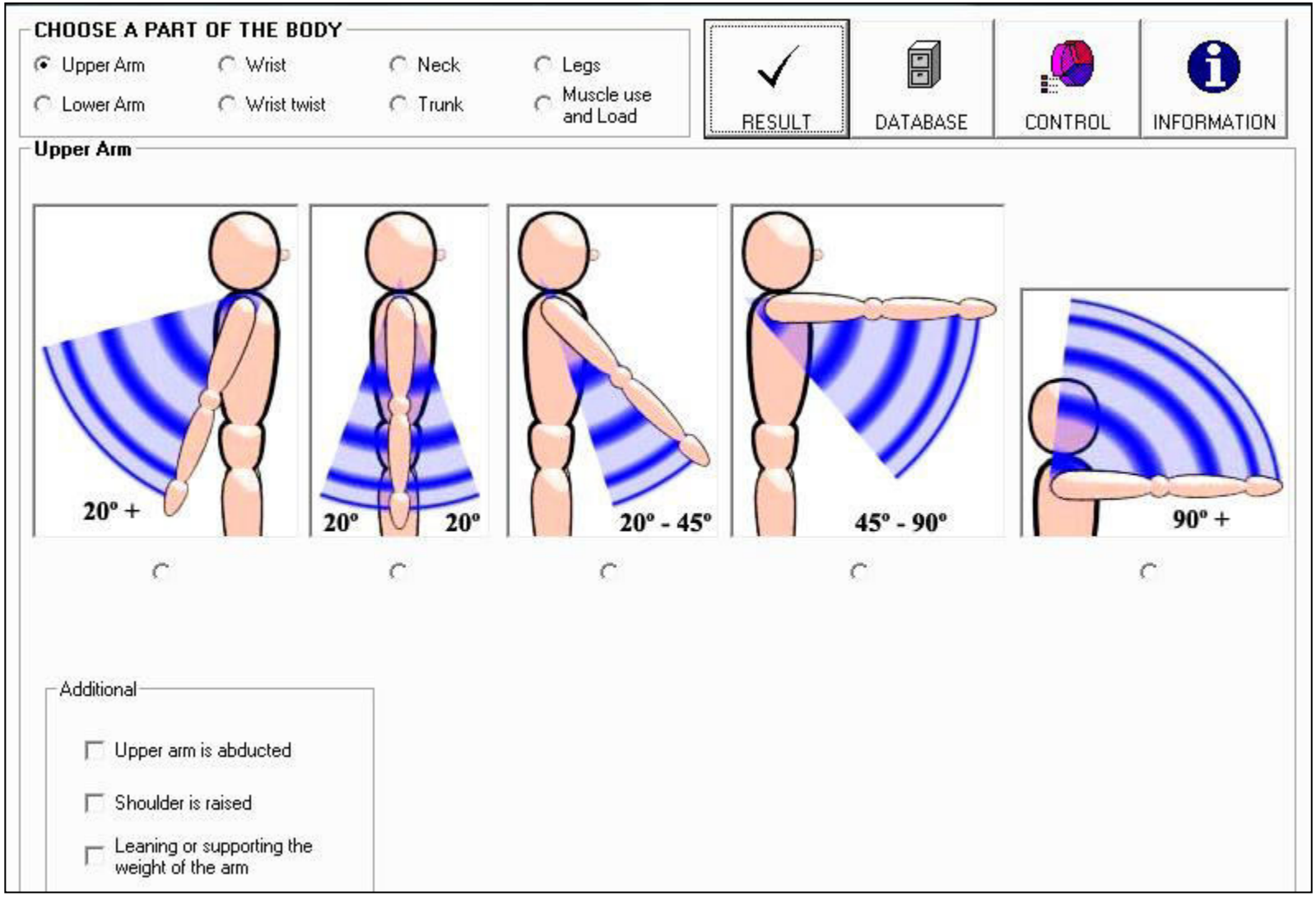
Sample Result

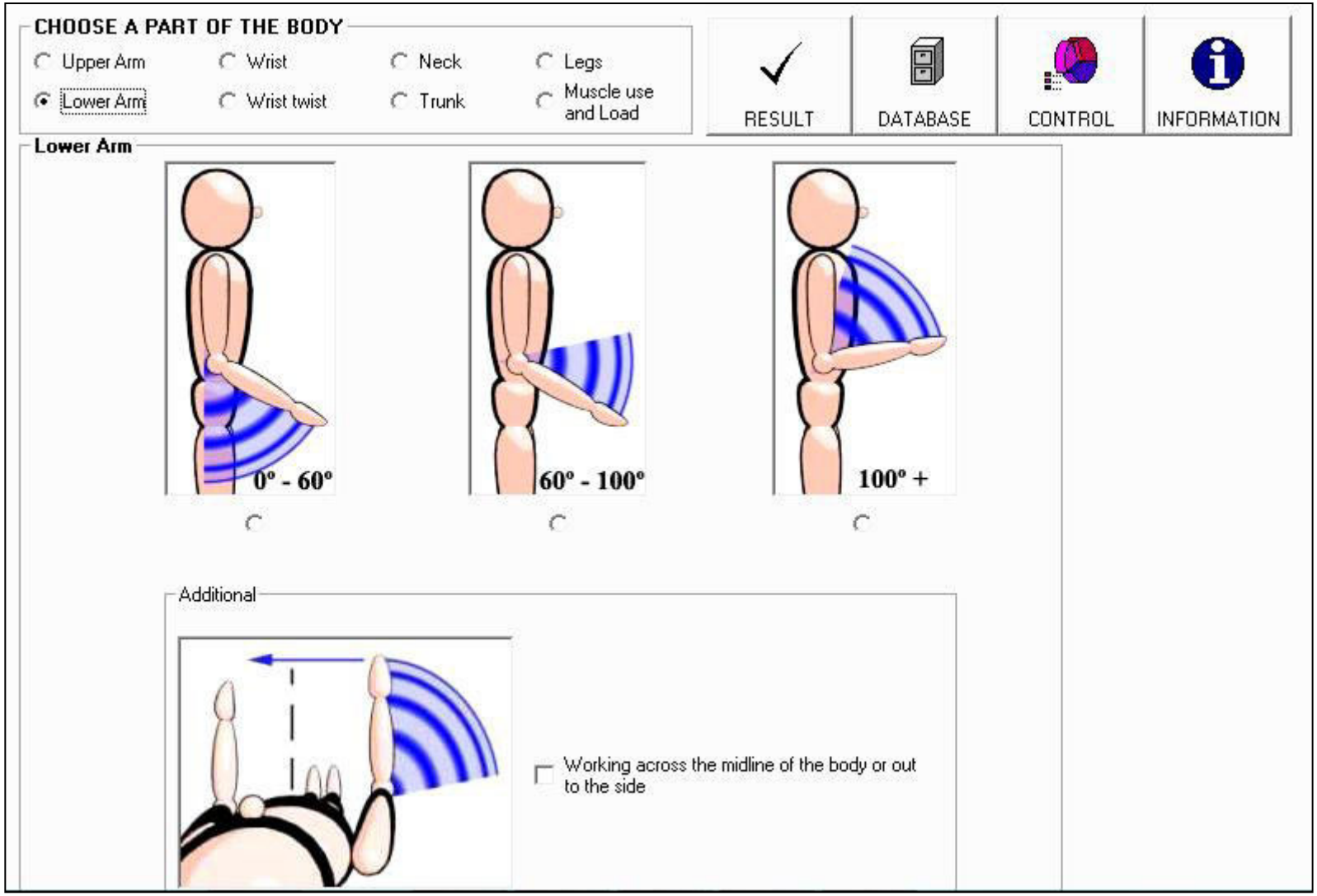
ANNEXURE- VI

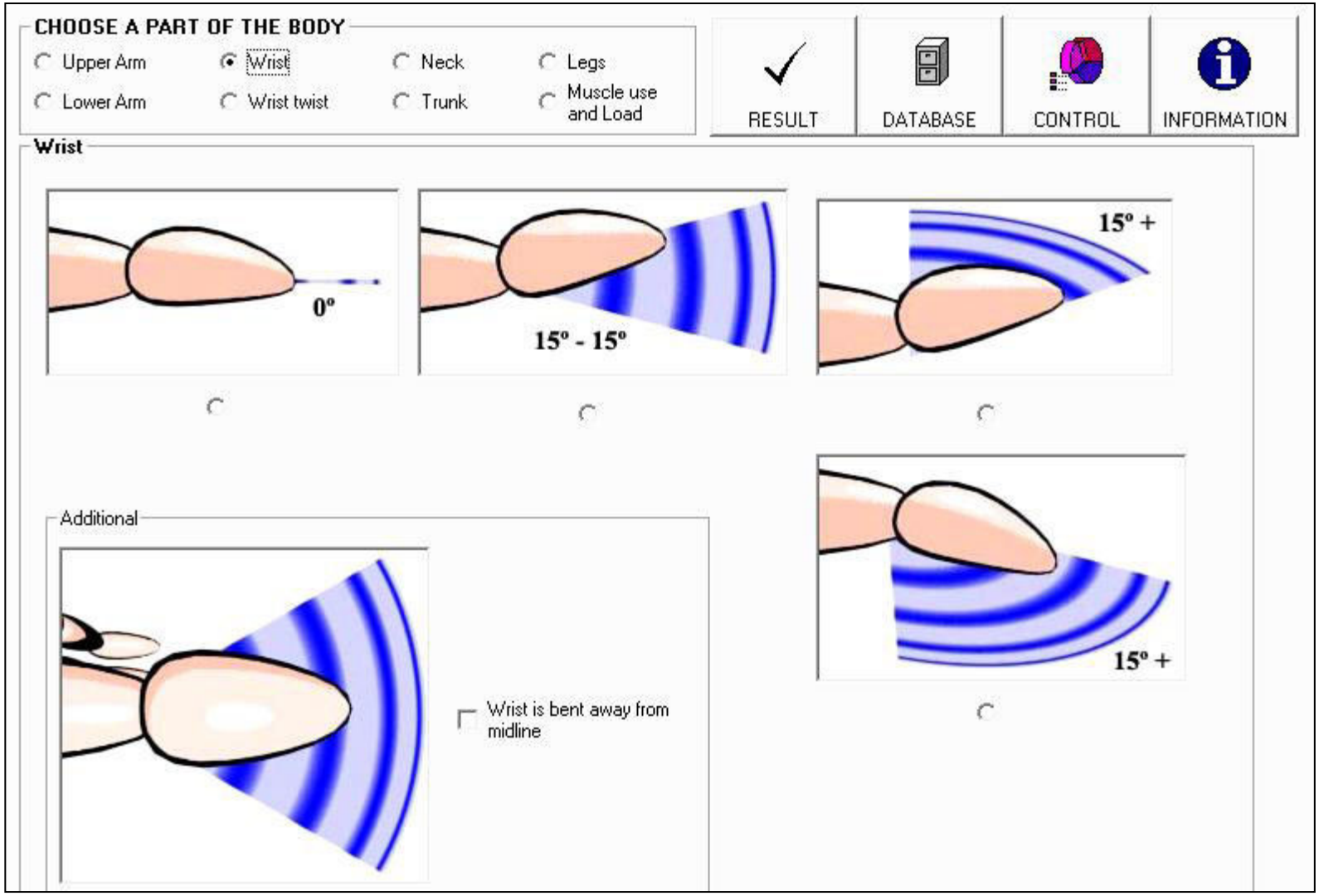
Rapid Upper Limb Assessment (RULA) Score sheet

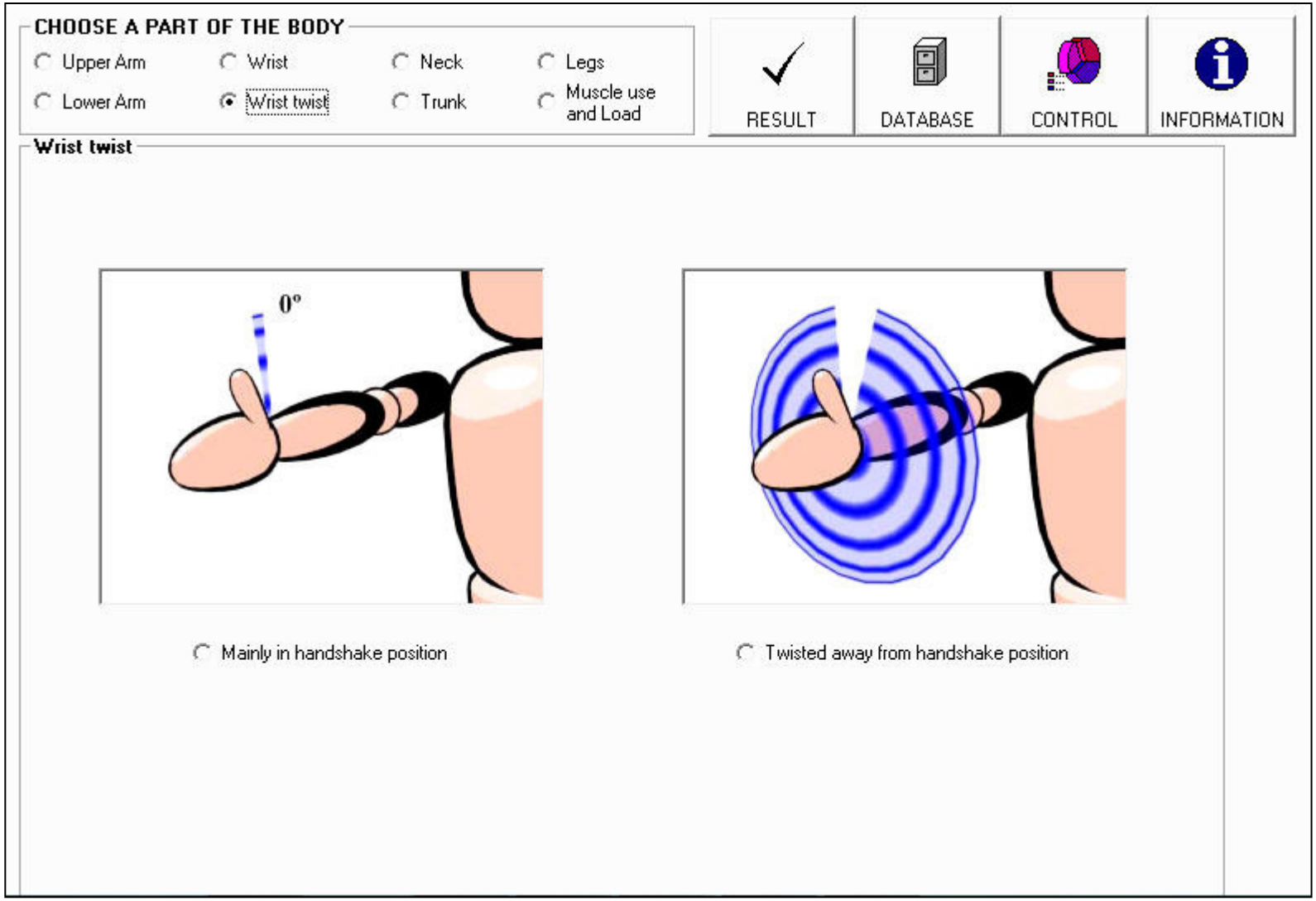
(via ErgoFellow Software, version 2.0)

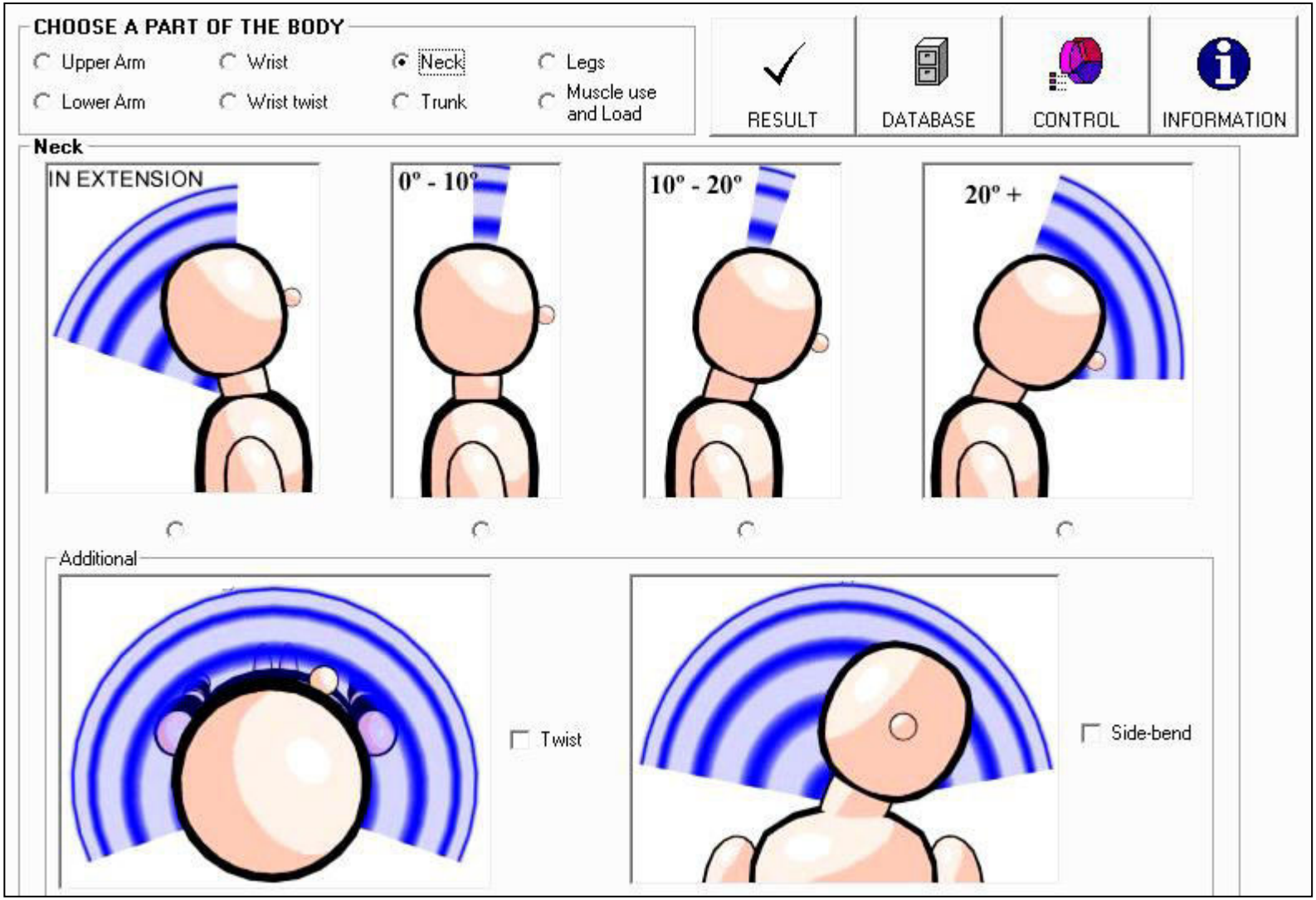
Source:
McAtamney L, Corlett EN. RULA: a survey method for the investigation of work related upper limb disorders. Applied Ergonomics 1993; 24 (2): 91-99.

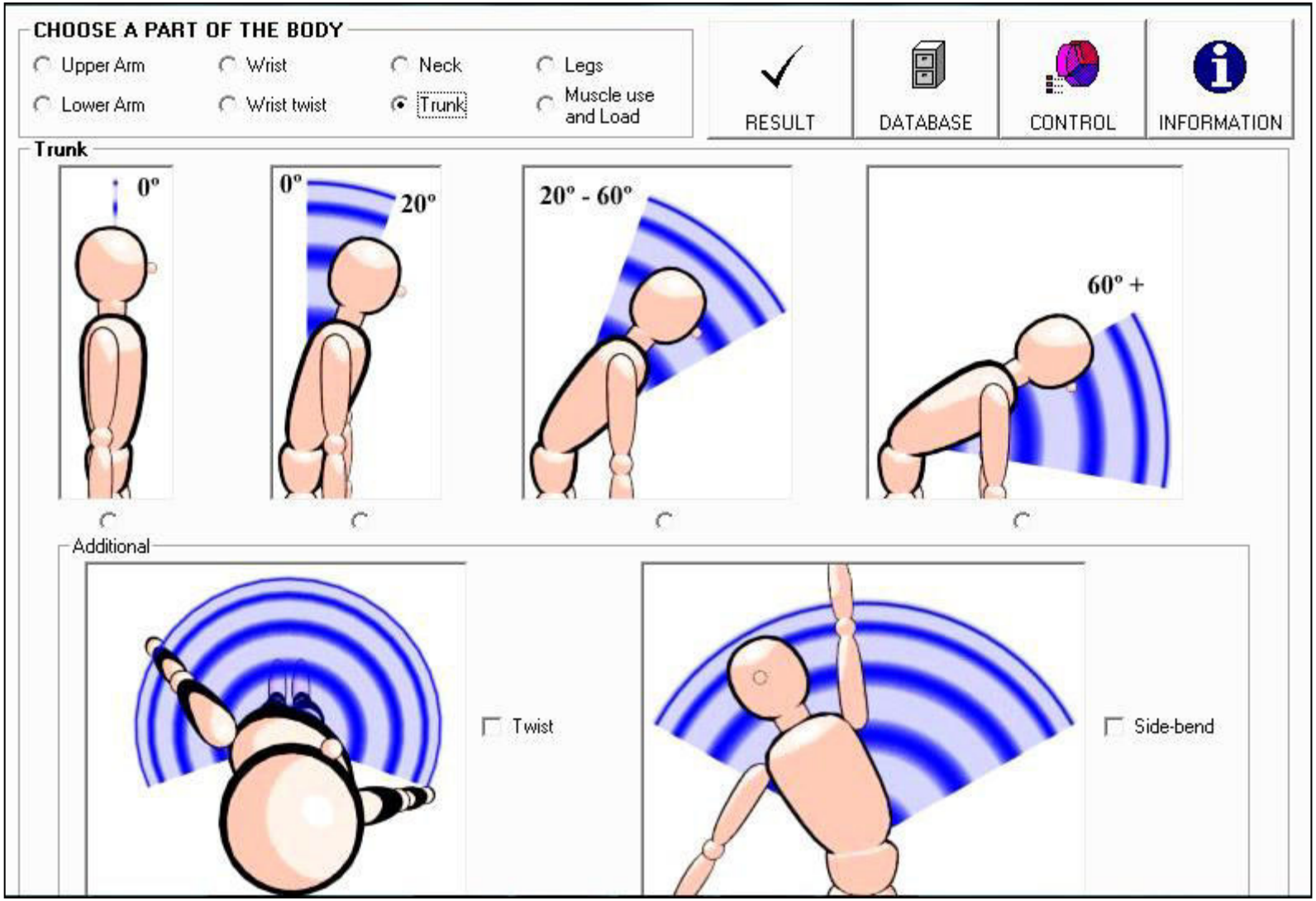

CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Upper Arm
20° +
20°
20°
20° - 45°
45° - 90°
90° +
Additional
Upper arm is abducted
Shoulder is raised
Leaning or supporting the weight of the arm

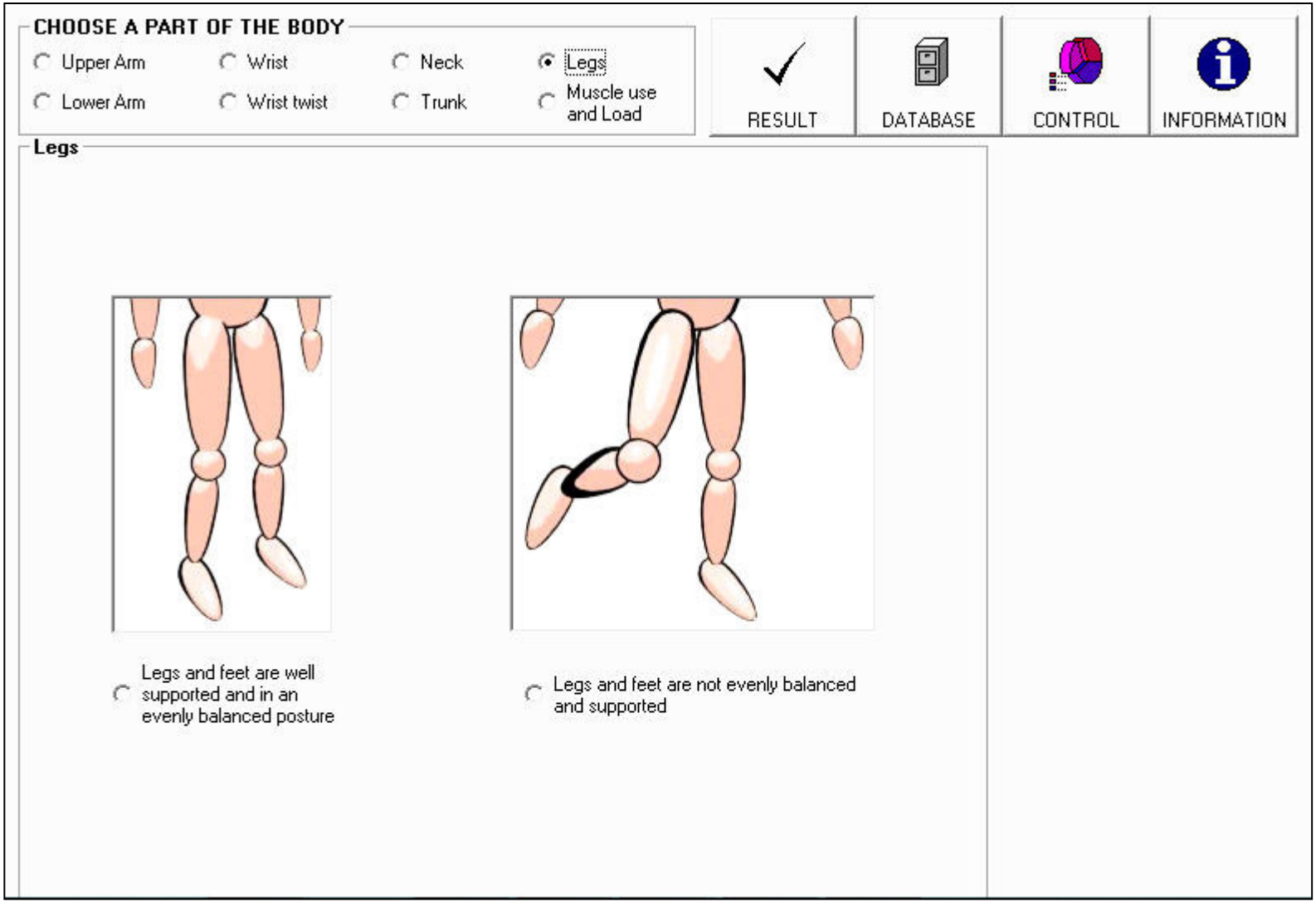

CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Lower Arm
0º - 60º
60º - 100º
100º +
Additional
Working across the midline of the body or out to the side


CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Wrist
0º
15º - 15º
15º +
15º +
Additional
Wrist is bent away from midline


CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Wrist twist
0°
Mainly in handshake position
Twisted away from handshake position


CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Neck
IN EXTENSION
0° - 10°
10° - 20°
20° +
Additional
Twist
Side-bend


CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Trunk
0°
0°
20°
20° - 60°
60° +
Additional
Twist
Side-bend


CHOOSE A PART OF THE BODY
Upper Arm
Wrist
Neck
Legs
Lower Arm
Wrist twist
Trunk
Muscle use and Load
RESULT
DATABASE
CONTROL
INFORMATION
Legs
Legs and feet are well supported and in an evenly balanced posture
Legs and feet are not evenly balanced and supported

CHOOSE A PART OF THE BODY

- Upper Arm
- Wrist
- Neck
- Legs
- Lower Arm
- Wrist twist
- Trunk
- Muscle use and Load

RESULT | DATABASE | CONTROL | INFORMATION

Muscle use and Load

GROUP A - Upper Arm, Lower Arm and Wrist

Muscle use

- [ ] Posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per minute

Load

- Less than 2kg intermittent load
- 2 to 10 kg intermittent load
- 2 to 10 kg static load or repeated loads
- 10 kg or more intermittent load
- 10 kg or more static load or repeated loads
- Shock or forces with rapid build up

GROUP B - Neck, trunk and legs

Muscle use

- [ ] Posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per minute

Load

- Less than 2kg intermittent load
- 2 to 10 kg intermittent load
- 2 to 10 kg static load or repeated loads
- 10 kg or more intermittent load
- 10 kg or more static load or repeated loads
- Shock or forces with rapid build up

CHOOSE A PART OF THE BODY

Upper Arm | Wrist | Neck | Legs
Lower Arm | Wrist twist | Trunk | Muscle use and Load

RESULT | DATABASE | CONTROL | INFORMATION

RESULT

SCORE: **7**

SCORE	ACTION LEVEL	INTERVENTION
1or 2	1	Posture is acceptable if it is not maintained or repeated for long periods.
3 or 4	2	Further investigation is needed and changes may be required.
5 or 6	3	Investigation and changes are required soon.
7	4	Investigation and changes are required immediately.

SAVE

Sample Result

ANNEXURE- VII

European Community Respiratory Health Survey (ECRHS) Questionnaire

(Modified Version)

Note: This modification was carried out for Indian perspective with written permission from the authors of the ECRHS-II Main questionnaire. This questionnaire was compiled using items from the ECRHS-II Main questionnaire and Burden of Obstructive Lung Diseases (BOLD) Core questionnaire (version 3.10, 2005).

Participant's ID: _____ Date: ___ ___/___ ___/___ ___ ___ ___
d d m m y y y y

Demographics

1. *What is the participant's sex?* Male ❑ Female ❑

2. What is your race? _____

3. What is your date of birth? ____ ____/____ ____/____ ____ ____ ____
d d m m y y y y

Respiratory Symptoms and Disorders

These questions pertain mainly to your chest. Please answer yes or no if possible. If you are in doubt about whether your answer is yes or no, please answer no.

Cough

4. Do you usually cough when you don't have a cold? Yes ❑ No ❑

*[If **yes**, continue with Question 4A; If **no**, skip to Question 5]*

4A. Are there months in which you cough on most days? Yes ❑ No ❑

*[If **yes**, ask both Questions 4B & 4C; If **no**, skip to Question 5]*

4B. Do you cough on most days for as much as three months each year? Yes ❑ No ❑

4C. For how many years have you had this cough? Less than 2 years ❑ 2-5 years ❑ More than 5 years ❑

Phlegm

5. Do you usually bring up phlegm from your chest, or do you usually have phlegm in your chest that is difficult to bring up when you don't have a cold? Yes ❑ No ❑

*[If **yes**, continue with Question 5A; If **no**, skip to Question 6]*

5A. Are there months in which you have this phlegm on most days? Yes ❑ No ❑

*[If **yes**, ask both Questions 5B & 5C; If **no**, skip to Question 6]*

5B. Do you bring up this phlegm on most days for as much as three months each year? Yes ❑ No ❑

5C. For how many years have you had this phlegm? Less than 2 years ❑ 2-5 years ❑ More than 5 years ❑

Wheezing/Whistling

6. Have you had wheezing or whistling in your chest at any time in the last 12 months? Yes ❑ No ❑

*[If **yes**, ask both Questions 6A & 6B; If **no**, skip to Question 7]*

6A. In the last 12 months, have you had this wheezing or whistling only when you have a cold? Yes ❑ No ❑

6B. In the last 12 months, have you ever had an attack of wheezing or whistling that has made you feel short of breath? Yes ❑ No ❑

Breathlessness

7. Are you unable to walk due to a condition other than shortness of breath? Yes ❑ No ❑

[*If **yes** to Question 7, please describe this condition on the line below and then skip to Question 9. If **no*** or unsure*, go directly to Question 8.]*

Nature of condition(s): _____

8. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill? Yes ❑ No ❑

*[If **yes**, ask Question 8A through 8D; If **no**, skip to Question 9]*

8A. Do you have to walk slower than people of your age on level ground because of shortness of breath? Yes ❑ No ❑ Does not apply ❑

8B. Do you ever have to stop for breath when walking at your own pace on level ground? Yes ❑ No ❑ Does not apply ❑

8C. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on level ground? Yes ❑ No ❑ Does not apply ❑

8D. Are you too short of breath to leave the house or short of breath on dressing or undressing? Yes ❑ No ❑ Does not apply ❑

9. Has a doctor or other health care provider ever told you that you have emphysema? Yes ❑ No ❑

10. Has a doctor or other health care provider ever told you that you have asthma, asthmatic bronchitis or allergic bronchitis? Yes ❑ No ❑

*[If **yes**, ask Question 10A. If **no**, skip to Question 11]*

10A. Do you still have asthma, asthmatic bronchitis or Yes ❑

allergic bronchitis? No ❑

11. Has a doctor or other health care provider ever told you that you have chronic bronchitis? Yes ❑ No ❑

*[If **yes**, ask Question 11A. If **no**, skip to Question 12]*

11A. Do you still have chronic bronchitis? Yes ❑ No ❑

12. Has a doctor or other health care provider ever told you that you have chronic obstructive pulmonary disease (COPD)? Yes ❑ No ❑

13. Nature of fuel used at home for cooking……..

14. Do you have any pets in your home? If yes, what kind of pets?

15. **Cattle/poultry Livestock**

16) Do you have cattle livestock in your house? Yes ❑ No ❑

If yes, 16a) Does the cattle livestock stays

a. Mostly inside the house ❑
b. Mostly outside the house ❑
c. Outside the house in the morning but taken in the house in evenings ❑

ANNEXURE- VIII

European Community Respiratory Health Survey (ECRHS)-II Questionnaire

(Main Questionnaire)

Source:
Jarvis D, Chinn S, Luczynska C, Burney P. The association of smoking with sensitization to common environmental allergens: results from the European Community Respiratory Health Survey. J Allergy Clin Immunol 1999;104:934-40.

ECRHS APPENDIX B 1 Main Questionnaire

Area number		1-3
Personal number		4-8
Sample		9
Date	DAY MONTH YEAR	10-15

I AM GOING TO ASK YOU SOME QUESTIONS. AT FIRST THESE WILL BE MOSTLY ABOUT YOUR BREATHING. WHEREVER POSSIBLE, I WOULD LIKE YOU TO ANSWER 'YES' OR 'NO'.

Wheeze and tightness in the chest — CARD 2

1. Have you had wheezing or whistling in your chest at any time in the last ***12 months***? NO ☐ YES ☐ 16

IF 'NO' GO TO QUESTION 2, IF 'YES':

1.1 Have you been at all breathless when the wheezing noise was present? NO ☐ YES ☐ 17

1.2. Have you had this wheezing or whistling when you did ***not*** have a cold? NO ☐ YES ☐ 18

2. Have you woken up with a feeling of tightness in your chest at any time in the last ***12 months***? NO ☐ YES ☐ 19

Shortness of breath

3. Have you had an attack of shortness of breath that came on during the day when you were at rest at any time in the last ***12 months***? NO ☐ YES ☐ 20

4. Have you had an attack of shortness of breath that came on ***following*** strenuous activity at any time in the last ***12 months***? NO ☐ YES ☐ 21

5. Have you been woken by an attack of shortness of breath at any time in the last ***12 months***? NO ☐ YES ☐ 22

Cough and phlegm from the chest

6. Have you been woken by an attack of coughing at any time in the last ***12 months***? NO ☐ YES ☐ 23

7. Do you ***usually*** cough first thing in the morning in the winter? NO ☐ YES ☐ 24

[IF DOUBTFUL, USE QUESTION 8.1 TO CONFIRM]

8. Do you ***usually*** cough during the day, or at night, in the winter? NO ☐ YES ☐ 25

IF 'NO' GO TO QUESTION 9, IF 'YES':

8.1 Do you cough like this on most days for as much as three months each year? NO ☐ YES ☐ 26

9. Do you ***usually*** bring up any phlegm from your chest first thing in the morning in the winter? **[IF DOUBTFUL, USE QUESTION 10.1 TO CONFIRM]** NO ☐ YES ☐ 27

10. Do you ***usually*** bring up any phlegm from your chest during the day, or at night, in the winter? NO ☐ YES ☐ 28

IF 'NO' GO TO QUESTION 11, IF 'YES':

10.1 Do you bring up phlegm like this on most days for as much as three months each year? NO ☐ YES ☐ 29

Breathing

11. Do you ever have trouble with your breathing? NO ☐ YES ☐ 30

IF 'NO' GO TO QUESTION 12, IF 'YES':

11.1 Do you have this trouble

TICK ONE BOX ONLY

a) continuously so that your breathing is never quite right? 1 ☐

b) repeatedly, but it always gets completely better? 2 ☐

c) only rarely? 3 ☐ 31

12. Are you disabled from walking by a condition ***other than*** heart or lung disease? NO ☐ YES ☐ 32

IF 'YES' STATE CONDITION _____ AND GO TO QUESTION 13, IF 'NO':

12.1 Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? NO ☐ YES ☐ 33

IF 'NO' GO TO QUESTION 13, IF 'YES':

12.1.1 Do you get short of breath walking with other people of your own age on level ground? NO ☐ YES ☐ 34

IF 'NO' GO TO QUESTION 13, IF 'YES':

12.1.1.1 Do you have to stop for breath when walking at your own pace on level ground? NO ☐ YES ☐ 35

Asthma

13. Have you ever had asthma? NO ☐ YES ☐ 36

IF 'NO' GO TO QUESTION 14, IF 'YES':

13.1 Was this confirmed by a doctor? NO ☐ YES ☐ 37

13.2 How old were you when you had your first attack of asthma? YEARS [ ][ ] 38-39

13.3 How old were you when you had your most recent attack of asthma? YEARS [ ][ ] 40-41

13.4.1-6 Which months of the year do you usually have attacks of asthma?

	NO	YES	
13.4.1 January / February			42
13.4.2 March / April			43
13.4.3 May / June			44
13.4.4 July / August			45
13.4.5 September / October			46
13.4.6 November / December			47

13.5 Have you had an attack of asthma in the last ***12 months***? NO [ ] YES [ ] 48

IF 'NO' GO TO QUESTION 13.6, IF 'YES':

13.5.1 How many attacks of asthma have you had in the last ***12 months***? NUMBER [ ][ ] 49-50

13.6 Are you currently taking any medicines, including inhalers, aerosols or tablets, for asthma? NO [ ] YES [ ] 51

Other conditions

14. Do you have any nasal allergies, including hay fever? NO [ ] YES [ ] 52

15. Have you ever had eczema or any kind of skin allergy? NO [ ] YES [ ] 53

16. Are you allergic to any insect stings or bites? NO [ ] YES [ ] 54

IF 'NO' GO TO QUESTION 17, IF 'YES':

16.1 Which insect? _____ [ ][ ] 55-56

16.2.1-3 What kind of reaction do you have?

	NO	YES	
16.2.1 breathing difficulty, feeling faint, nausea or fever			57
16.2.2 redness, itching or swelling at the site of the sting			58
16.2.3 other: _____			59

17. Have you ever had any difficulty with your breathing after taking medicines? NO [ ] YES [ ] 60

IF 'NO' GO TO QUESTION 18, IF 'YES':

17.1 Which medicines? _____ 1 ☐ 61
2 ☐ 62

Your parents' smoking

	NO	YES	DON'T KNOW	
18. Did your father ever smoke regularly during your childhood?	☐	☐	☐	63
19. Did your mother ever smoke regularly during your childhood, or before you were born?	☐	☐	☐	64

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 20, IF 'YES':

19.1 When your mother was pregnant, in particular with you, did she — TICK ONE BOX ONLY

a) stop smoking before pregnancy? 1 ☐
b) cut down or stop during pregnancy? 2 ☐
c) smoke as usual during pregnancy? 3 ☐
d) don't know 4 ☐ 65

More about yourself

20. When were you born? DAY ☐☐ MONTH ☐☐ YEAR ☐☐ 66-71

21. What country were you born in? _____ ☐☐☐ 72-74

22. Are you male or female? MALE ☐ FEMALE ☐ 75

23. How many brothers do or did you have? NUMBER ☐☐ 76-77

INTERVIEW TYPE? — TICK ONE BOX ONLY

At centre face to face 1 ☐
At home face to face 2 ☐
By telephone 3 ☐ 78

23. continued... CARD NUMBER ☐☐ 79-80
CARD 3
DUPLICATE 1-9

IF 'NONE' GO TO QUESTION 24, IF 'YES':

	NUMBER	
23.1 How many ***older*** brothers?	☐☐	10-11
23.2 How many ***younger*** brothers?	☐☐	12-13
23.3 How many of your brothers ever had asthma?	☐☐	14-15
23.4 How many of your ***other*** brothers ever had eczema, skin or nasal allergy or hay fever?	☐☐	16-17

NUMBER

24. How many sisters do or did you have? [ ][ ] 18-19

IF 'NONE' GO TO QUESTION 25, IF 'YES':

NUMBER

24.1 How many ***older*** sisters? [ ][ ] 20-21

24.2 How many ***younger*** sisters? [ ][ ] 22-23

24.3 How many of your sisters ever had asthma? [ ][ ] 24-25

24.4 How many of your ***other*** sisters ever had eczema, skin or nasal allergy or hay fever? NUMBER [ ][ ] 26-27

	NO	YES	DON'T KNOW	
25. Did your mother ever have asthma?	☐	☐	☐	28
26. Did your mother ever have eczema, skin or nasal allergy or hay fever?	☐	☐	☐	29
27. Did your father ever have asthma?	☐	☐	☐	30
28. Did your father ever have eczema, skin or nasal allergy or hay fever?	☐	☐	☐	31
29. Did you regularly share your bedroom with any ***older*** children before the age of five years?	☐	☐	☐	32
30. Did you go to a school, play-school or nursery with ***older*** children before the age of five years?	☐	☐	☐	33
31. Did you have a serious respiratory infection before the age of five years?	☐	☐	☐	34

32. Are you a full time student? NO ☐ YES ☐ 35

IF 'YES' GO TO QUESTION 32.7, IF 'NO':

32.1 At what age did you complete full time education? YEARS [ ][ ] 36-37

32.2 Are you currently employed or self-employed? NO ☐ YES ☐ 38

IF 'YES' GO TO QUESTION 32.3, IF 'NO':

32.2.1 Are you currently looking for a job? NO ☐ YES ☐ 39

32.3 What is you current or most recent job? [Be as precise as possible]

_____ [ ][ ][ ] 40-42

32.4 Are you or were you TICK ONE BOX ONLY

a) a manager working for an employer? 1 ☐
b) a foreman or supervisor working for an employer? 2 ☐
c) working for an employer, but neither a manager, supervisor or foreman? 3 ☐
d) self-employed? 4 ☐ 43

32.5 Does being at work ever make your chest tight or wheezy? NO ☐ YES ☐ 44

32.6 Have you ever had to change or leave your job because it affected your breathing? NO ☐ YES ☐ 45

IF 'NO' GO TO QUESTION 32.7 IF 'YES':

32.6.1 What was this job? [Be as precise as possible]

_____ ☐☐☐ 46-48

32.7 Have you ever worked in a job which exposed you to vapours, gas, dust or fumes? NO ☐ YES ☐ 49

IF 'NO' GO TO QUESTION 33, IF 'YES':

32.7.1 What was or is this job? [Be as precise as possible]
If current job write 'current job'

_____ ☐☐☐ 50-52

Your home

33. How many years have you lived in your present home? YEARS ☐☐ 53-54

34. How many years have you lived in _____? [Insert area name] YEARS ☐☐ 55-56

35. When was your present home built? TICK ONE BOX ONLY

a) before 1960? 1 ☐
b) 1961-1970? 2 ☐
c) 1971-1980? 3 ☐
d) 1981 or later? 4 ☐
e) don't know 5 ☐ 57

36. Which best describes the building in which you live? TICK ONE BOX ONLY

a) a mobile home or trailer? 1 ☐
b) a one family house detached from any other house? 2 ☐
c) a one family house attached to one or more houses? 3 ☐
d) a building for two families? 4 ☐

e) a building for three or four families?	5	☐	
f) a building for five or more families?	6	☐	
g) a boat, tent or van	7	☐	
e) other: _____	8	☐	58

37.1-3 Does your home have any of the following?

	NO	YES	
37.1 central heating	☐	☐	59
37.2 ducted air heating	☐	☐	60
37.3 air conditioning	☐	☐	61

38.1-7 Which of the following fuels do you use for heating or for hot water?

	NO	YES	
38.1 open coal, coke or wood fire	☐	☐	62
38.2 open gas fire	☐	☐	63
38.3 electric heater	☐	☐	64
38.4 paraffin heater	☐	☐	65
38.5 gas-fired boiler	☐	☐	66
38.6 oil-fired boiler	☐	☐	67
38.7 other: _____	☐	☐	68

39. What kind of stove do you ***mostly*** use for cooking?

		TICK ONE BOX ONLY	
a) coal, coke or wood (solid fuel)?	1	☐	
b) gas?	2	☐	
c) electric?	3	☐	
d) paraffin?	4	☐	
e) other: _____	5	☐	69

	NO	YES	DON'T KNOW	
40. Do you have an extractor fan over the cooker?	☐	☐	☐	70

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 41, IF 'YES':

40.1 When cooking, do you use the fan

		TICK ONE BOX ONLY	
a) all of the time?	1	☐	
b) some of the time?	2	☐	
c) none of the time?	3	☐	71

	NO	YES	DON'T KNOW	
40.2 Does the fan take the fumes outside the house?	☐	☐	☐	72

41.1-5 Does the room which you use most at home during the day

	NO	YES	
41.1 have fitted carpets covering the whole floor?	☐	☐	73

41.2 contain rugs? ☐ ☐ 74
41.3 have double glazing? ☐ ☐ 75
41.4 have curtains? ☐ ☐ 76
41.5 have upholstered or soft furnishings? ☐ ☐ 77
BLANK 78
CARD NUMBER ☐☐ 79-80
CARD 4
DUPLICATE 1-9

42.1-5 Does your bedroom

	NO	YES	
42.1 have fitted carpets covering the whole floor?	☐	☐	10
42.2 contain rugs?	☐	☐	11
42.3 have double glazing?	☐	☐	12

42. continued...

	NO	YES	
42.4 have curtains?	☐	☐	13
42.5 have upholstered or soft furnishings?	☐	☐	14

If 'NO' ask: Do you have a conventional mattress?
If 'YES': ***code 'YES'***

	NO	YES	
43. Do you sleep with the windows open at night during winter?	☐	☐	15

IF 'NO' GO TO QUESTION 44, IF 'YES':

43.1 Do you sleep with the windows open

	TICK ONE BOX ONLY		
a) all of the time?	1	☐	
b) sometimes?	2	☐	
c) only occasionally?	3	☐	16

	NO	YES	DON'T KNOW	
44. Has there ever been any water damage to the building or its contents, for example, from broken pipes, leaks or floods?	☐	☐	☐	17

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 45, IF 'YES':

	NO	YES	DON'T KNOW	
44.1 Has there been any water damage in the last ***12 months***?	☐	☐	☐	18

	NO	YES	
45. Do you have a basement or cellar?	☐	☐	19

IF 'NO' GO TO QUESTION 46, IF 'YES':

	NO	YES	DON'T KNOW	
45.1 Does water ever collect on the basement floor?	☐	☐	☐	20

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 46, IF 'YES':

	NO	YES	
45.1.1 Has this happened in the last ***12 months***?	☐	☐	21

	NO	YES	DON'T KNOW
46. Has there ever been any mould or mildew on any surface, other than			

food, inside the home? ☐ ☐ ☐ 22

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 47, IF 'YES':

46.1.1-6 Which rooms have been affected?

	NO	YES	
46.1.1 bathroom(s)	☐	☐	23
46.1.2 bedroom(s)	☐	☐	24
46.1.3 living area(s)	☐	☐	25
46.1.4 kitchen	☐	☐	26
46.1.5 basement or attic	☐	☐	27
46.1.6 other: _____	☐	☐	28

46.2 Has there been mould or mildew on any surfaces inside the home in the last ***12 months***? NO ☐ YES ☐ 29

47. Do you use a humidifier, including any humidifier built into your heating system? NO ☐ YES ☐ DON'T KNOW ☐ 30

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 48, IF 'YES':

47.1 What kind of humidifier do you use?

	TICK ONE BOX ONLY		
a) humidifier built into heating system	1	☐	
b) portable cold mist (ultrasonic or spinning disc)	2	☐	
c) portable hot mist vaporiser	3	☐	
d) other: _____	4	☐	31

47.2 Under what circumstances do you use your humidifier? TICK ONE

	TICK BOX ONLY		
a) only when someone is ill - in their room	1	☐	
b) to humidify the house	2	☐	
d) other: _____	3	☐	32

<u>Animals, dust and feathers</u>

48. Do you keep a cat? NO ☐ YES ☐ 33

IF 'NO' GO TO QUESTION 49, IF 'YES':

	NO	YES	
48.1 Is your cat ever allowed into your bedroom?	☐	☐	34
48.2 Do all your cats stay outside the house?	☐	☐	35

49. Do you keep a dog? NO ☐ YES ☐ 36

IF 'NO' GO TO QUESTION 50, IF 'YES':

NO YES

49.1 Is your dog ever allowed into your bedroom?			37
49.2 Do all your dogs stay outside the house?			38
	NO	YES	
50. Do you keep any birds?			39

IF 'NO' GO TO QUESTION 51, IF 'YES':

	NO	YES	
50.1 Are any of these birds kept inside the house?			40

51.1-12 When you were a child did anyone in your household keep any of the following pets?

	NO	YES	
51.1 cats			41
51.2 dogs			42
51.3 horses			43
51.4 birds			44
51.5 guinea pigs			45
51.6 hamsters			46

51. continued...

	NO	YES	
51.7 mice			47
51.8 rats			48
51.9 rabbits			49
51.10 gerbils			50
51.11 ferrets			51
51.12 other: _____			52

52.1-6 When you are near animals, such as cats, dogs or horses, near feathers, including pillows, quilts or duvets, or in a dusty part of the house, do you ***ever***

	NO	YES	
52.1 start to cough?			53
52.2 start to wheeze?			54
52.3 get a feeling of tightness in your chest?			55
52.4 start to feel short of breath?			56
52.5 get a runny or stuffy nose or start to sneeze?			57
52.6 get itchy or watering eyes?			58

<u>Trees, grass, plants, flowers and pollen</u>

53.1-6 When you are near trees, grass or flowers, or when there is a lot of pollen about, do you ***ever***

	NO	YES	
53.1 start to cough?			59
53.2 start to wheeze?			60
53.3 get a feeling of tightness in your chest?			61

53.4 start to feel short of breath?	☐	☐	62
53.5 get a runny or stuffy nose or start to sneeze?	☐	☐	63
53.6 get itchy or watering eyes?	☐	☐	64

IF 'YES' TO ANY OF THE ABOVE:

53.1.1-4 Which time of year does this happen?

	NO	YES	
53.1.1 winter	☐	☐	65
53.1.2 spring	☐	☐	66
53.1.3 summer	☐	☐	67
53.1.4 autumn	☐	☐	68

Diet

54. How often do you eat pre-packaged food, such as tinned food or pre-prepared frozen meals?

	TICK ONE BOX ONLY		
a) every day or most days	1	☐	
b) at least once a week	2	☐	
c) less than once a week	3	☐	69

55. How often do you drink sweet fizzy drinks?

	TICK ONE BOX ONLY		
a) every day or most days	1	☐	
b) at least once a week	2	☐	
c) less than once a week	3	☐	70

	NO	YES	
56. Do you take snacks between meals?	☐	☐	71

IF 'NO' GO TO QUESTION 57, IF 'YES':

56.1-3 Which of the following would you have as a snack at least ***once a week***?

	NO	YES	
56.1 savoury biscuits or crisps	☐	☐	72
56.2 sweets, chocolates or sweet biscuits	☐	☐	73
56.3 fruit or vegetables	☐	☐	74

	NO	YES	
57. Have you ever had an illness or trouble caused by eating a ***particular*** food or foods?	☐	☐	75

IF 'NO' GO TO QUESTION 58, IF 'YES':

	NO	YES	
57.1 Have you nearly always had the same illness or trouble after eating this type of food?	☐	☐	76

BLANK 77-78

CARD NUMBER [ ][ ] 79-80

IF 'NO' GO TO QUESTION 58, IF 'YES':

CARD 5
DUPLICATE 1-9

57.1.1 What type of food was this? [List up to 3]

_____ [ ][ ] 10-11

_____ [ ][ ] 12-13

_____ [ ][ ] 14-15

57.1.2.1-6 Did this illness or trouble include

	NO	YES	
57.1.2.1 a rash or itchy skin?	[ ]	[ ]	16
57.1.2.2 diarrhoea or vomiting?	[ ]	[ ]	17
57.1.2.3 runny or stuffy nose?	[ ]	[ ]	18
57.1.2.4 severe headaches?	[ ]	[ ]	19
57.1.2.5 breathlessness?	[ ]	[ ]	20
57.1.2.6 other: _____	[ ]	[ ]	21

Smoking

	NO	YES	
58. Have you ever smoked for as long as a year?	[ ]	[ ]	22

['YES' means at least 20 packs of cigarettes or 12 oz (360 grams) of tobacco in a lifetime, or at least one cigarette per day or one cigar a week for one year]

IF 'NO' GO TO QUESTION 59, IF 'YES':

58.1 How old were you when you started smoking? YEARS [ ][ ] 23-24

58.2 Do you **now** smoke, as of ***one month ago***? NO [ ] YES [ ] 25

IF 'NO' GO TO QUESTION 58.3.1, IF 'YES':

58.2.1-4 How much do you ***now*** smoke on average

	NUMBER	
58.2.1 number of cigarettes per day	[ ][ ]	26-27
58.2.2 number of cigarillos per day	[ ][ ]	28-29
58.2.3 number of cigars a week	[ ][ ]	30-31
58.2.4 pipe tobacco in a) ounces / week	[ ][ ]	32-33
b) grams / week	[ ][ ][ ]	34-36

58.3 Have you stopped or cut down smoking? NO [ ] YES [ ] 37

IF 'NO' GO TO QUESTION 58.4, IF 'YES':

58.3.1 How old were you when you stopped or cut down smoking? YEARS [ ][ ] 38-39

58.3.2.1-4 ***On average*** of the entire time you smoked, before you stopped or cut down, how much did you smoke?

	NUMBER	
58.3.2.1 number of cigarettes per day	[ ][ ]	40-41
58.3.2.2 number of cigarillos per day	[ ][ ]	42-43
58.3.2.3 number of cigars a week	[ ][ ]	44-45
58.3.2.4 pipe tobacco in a) ounces / week	[ ][ ]	46-47
b) grams / week	[ ][ ][ ]	48-50

58.4 Do you or did you inhale the smoke? NO [ ] YES [ ] 51

59. Have you been **regularly** exposed to tobacco smoke in the last ***12 months***? ['Regularly' means on most days or nights] NO [ ] YES [ ] 52

IF 'NO' GO TO QUESTION 60, IF 'YES':

59.1 Not counting yourself, how many people in your household smoke regularly? NUMBER [ ][ ] 53-54

59.2 Do people smoke regularly in the room where you work? NO [ ] YES [ ] 55

59.3 How many hours per day are you exposed to ***other people's*** tobacco smoke? HOURS [ ][ ] 56-57

Medicines and inhalers

60. Have you used any **inhaled** medicines to help your breathing at any time in the last ***12 months***? NO ☐ YES ☐ 58

IF 'NO' GO TO QUESTION 61, IF 'YES':

60.1-6 Which of the following have you used in the last ***12 months***?

60.1 **beta-2-agonist inhalers** NO ☐ YES ☐ 59

60.1.1 If used, which one? _____ ☐☐ 60-61

60.2 **non-specific adrenoreceptor agonist inhalers** NO ☐ YES ☐ 62

60.2.1 If used, which one? _____ ☐ 63

60.3 **anti-muscarinic inhalers** NO ☐ YES ☐ 64

60.3.1 If used, which one? _____ ☐ 65

60.4 **inhaled steroids** NO ☐ YES ☐ 66

60.4.1 If used, which one? _____ ☐ 67

60.5 **other inhalers (non-steroid, single drug)** NO ☐ YES ☐ 68

60.5.1 If used, which one? _____ ☐ 69

60.6 **inhaled compound inhalers** NO ☐ YES ☐ 70

60.6.1 If used, which one? _____ ☐ 71

61. Have you used any **pills**, **capsules**, **tablets** or **medicines**, other than inhaled medicines, to help your breathing at any time in the last ***12 months***? NO ☐ YES ☐ 72

IF 'NO' GO TO QUESTION 62, IF 'YES':

61.1-6 Which of the following have you used in the last ***12 months***?

61.1 **oral specific beta-2-agonists** NO ☐ YES ☐ 73

61.1.1 If used, which one? _____ ☐ 74

61.2 **oral non-specific adrenoreceptor agonists** NO ☐ YES ☐ 75

61.2.1 If used, which one? _____ ☐ 76

61.3 **oral anti-muscarinic drugs** NO ☐ YES ☐ 77

61.3.1 If used, which one? _____ ☐ 78

CARD NUMBER [ ][ ] 79-80
CARD 6
DUPLICATE 1-9

	NO	YES	
61.4 **oral methylxanthines**	[ ]	[ ]	10
60.4.1 If used, which one? _____		[ ]	11
61.5 **oral steroids**	[ ]	[ ]	12
61.5.1 If used, which one? _____		[ ][ ]	13-14
61.6 **oral antihistamines**	[ ]	[ ]	15
61.6.1 If used, which one? _____		[ ]	16
61.7 **oral compound bronchodilators (no sedatives)**	[ ]	[ ]	17
61.7.1 If used, which one? _____		[ ]	18
61.8 **oral compound bronchodilators with sedatives**	[ ]	[ ]	19
61.8.1 If used, which one? _____		[ ]	20
61.9 **other oral medications**	[ ]	[ ]	21
61.9.1 If used, which one? _____		[ ]	22

	NO	YES	DON'T KNOW	
62. Have you ever been vaccinated for allergy at any time in your life?	[ ]	[ ]	[ ]	23

IF 'NO' OR 'DON'T KNOW' GO TO QUESTION 63, IF 'YES':

	NO	YES	
62.1 Have you been vaccinated for allergy in the last ***12 months***?	[ ]	[ ]	24

	NO	YES	
63. Have you had any other **injections** to help your breathing at any time in the last ***12 months***?	[ ]	[ ]	25

IF 'NO' GO TO QUESTION 64, IF 'YES':

63.1 What injections? _____ [ ] 26
_____ [ ] 27

	NO	YES	
64. Have you had any suppositories to help your breathing at any time in the last ***12 months***?	[ ]	[ ]	28

IF 'NO' GO TO QUESTION 65, IF 'YES':

64.1 What suppositories? _____ ☐ 29

_____ ☐ 30

65. Have you used any other **remedies** to help your breathing at any time in the last ***12 months***? NO ☐ YES ☐ 31

IF 'NO' GO TO QUESTION 66, IF 'YES':

65.1 What remedies? _____ ☐ 32

_____ ☐ 33

_____ ☐ 34

66. Do you take drugs every day to help your breathing even if you don't feel short of breath? NO ☐ YES ☐ 35

IF 'NO' GO TO QUESTION 67, IF 'YES':

66.1 Which drugs? _____ ☐☐ 36-37

_____ ☐☐ 38-39

_____ ☐☐ 40-41

_____ ☐☐ 42-43

_____ ☐☐ 44-45

_____ ☐☐ 46-47

_____ ☐☐ 48-49

_____ ☐☐ 50-51

67. Do you take any drugs ***only*** for attacks of breathlessness? NO ☐ YES ☐ 52

IF 'NO' GO TO QUESTION 68, IF 'YES':

67.1 Which drugs? _____ ☐☐ 53-54

_____ ☐☐ 55-56

_____ ☐☐ 57-58

_____ ☐☐ 59-60

_____ ☐☐ 61-62

_____ ☐☐ 63-64

67.2 Do you take these drugs TICK ONE BOX ONLY

a) at the onset of the attack? 1 ☐

b) only when the attack becomes more severe? 2 ☐ 65

68. Has your doctor ever prescribed medicines, including inhalers, for your breathing? NO ☐ YES ☐ 66

IF 'NO' GO TO QUESTION 69, IF 'YES':

68.1 If you are prescribed medicines for your breathing, do you ***normally*** take

TICK ONE BOX ONLY

a) all of the medicine? 1 ☐
b) most of the medicine? 2 ☐
c) some of the medicine? 3 ☐
d) none of the medicine? 4 ☐ 67

68.2 ***When your breathing gets worse***, and you are prescribed medicines for your breathing, do you normally take

TICK ONE BOX ONLY

a) all of the medicine? 1 ☐
b) most of the medicine? 2 ☐
c) some of the medicine? 3 ☐
d) none of the medicine? 4 ☐ 68

68.3 Do you think it is bad for you to take medicines all the time to help your breathing? NO ☐ YES ☐ 69

68.4 Do you think you should take as much medicine as you need to get rid of ***all*** your breathing problems? NO ☐ YES ☐ 70

69. Have you ever visited a hospital casualty department or emergency room because of breathing problems? NO ☐ YES ☐ 71

70. Have you ever spent a night in hospital because of breathing problems? NO ☐ YES ☐ 72

IF 'NO' GO TO QUESTION 71, IF 'YES':

70.1 How many times in the last ***12 months***? NUMBER ☐☐ 73-74

71. Have you ever been seen by a doctor because of breathing problems or because of shortness of breath? NO ☐ YES ☐ 75

IF 'NO' GO TO END, IF 'YES':

71.1 When was the last time you were seen by a doctor because of breathing problems or because of shortness of breath?

TICK ONE BOX ONLY

a) within the last seven days 1 ☐
b) more than seven days ago but within the last four weeks 2 ☐
c) more than four weeks ago but within the last 12 months 3 ☐
d) more than a year ago 4 ☐ 76

71.2 ***Where*** were you seen?

TICK ONE BOX ONLY

a) by a GP at home	1	☐	
b) by a GP in his office or surgery	2	☐	
c) by a specialist at home	3	☐	
d) by a specialist in his office or hospital outpatients department	4	☐	
e) in a casualty department or emergency room	5	☐	
f) admitted to a hospital ward	6	☐	77

END

FIELDWORKER NUMBER	☐	78
CARD NUMBER	☐☐	79-80

ANNEXURE- IX

List of Publications

(Full Papers)

(a) **Moitra S,** Maity SG, Sahu S. Assessment of the musculoskeletal problems of the goldsmiths working in unorganized sectors in West Bengal. ***Journal of Environmental Physiology*** 2011; 4 (1&2): 34-39

(b) Sahu S, Roy B, **Moitra S.** Assessment of the lung function status of the goldsmiths working in unorganised sector of India. ***Lung India*** 2013; 30 (1): 33-37

(c) **Moitra S,** Blanc PD, Sahu S. Adverse respiratory effects associated with cadmium exposure in small-scale jewellery workshops in India. ***Thorax*** 2013; 68 (6): 565-570

(d) **Moitra S,** Brashier BB, Sahu S. Occupational cadmium exposure-associated oxidative stress and erythrocyte fragility among jewelry workers in India. ***American Journal of Industrial Medicine*** 2014. DOI: 10.1002/ajim.22336. (EPub: ahead of print)

(e) Moitra S, Chakraborty K, Bhattacharyya A, Sahu S. Assessment of sputum cell profile and its relation with lung function among occupationally cadmium exposed Indian goldsmiths. ***International Archives of Occupational and Environmental Health***. 2014 (Communicated)

Journal of Environmental Physiology (2011): 4(1, 2), 34-39

Assessment of the Musculoskeletal Problems of the Goldsmiths Working in Unorganized Sectors in West Bengal

SUBHABRATA MOITRA, SANTI GOPAL MAITY AND SUBHASHIS SAHU*
Ergonomics & Occupational Physiology Laboratory,
Department of Physiology, University of Kalyani,
Kalyani- 741235, West Bengal
*Corresponding Author
e-mail: skcsahu@yahoo.co.in

Abstract

Work related musculoskeletal disorders were very common in the unorganized sectors especially in India. The jewellery industry is one of those unorganized sectors on which very few reports are available. The main purpose of this study was to investigate the musculoskeletal problems due to the working postures they have adopted. The postures were analysed using rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) and their stresses were ranked using the body parts discomfort scale. A modified version of the Nordic questionnaire of musculoskeletal disorders was used to get information about the feeling of pain in different body parts.The results showed that the postures they have adopted were strenuous and were responsible for musculoskeletal disorders of the workers.
Key words : REBA, RULA, MSDs, Goldsmiths

Introduction

The workers from organized sectors comprise only 7% of the total workforce of India while the rest (93%) belongs to the unorganized sectors (Venkata Ratnam, 2006). Jewellery manufacturing industries in India belongs mainly to the unorganized sectors. Although some of them belong to the organized sectors but the numbers are very small. Many people are directly or indirectly dependent on this industry. It was reported by the National Institute of Occupational Safety and Health (NIOSH) that the prevalence of low back pain is mainly due to inappropriate workplace (NIOSH, 1997) and recent studies had also demonstrated that the rates of low back disorders vary greatly by industry, occupation and job type within a given industry or facility (Ong et al., 1993). The work related

musculoskeletal disorders (WMSDs) had alarmingly increased in today's world due to inappropriate workstation or lack of knowledge among the workers (Joshi et al., 2001). According to Acheson (1972), it also was observed that the discomfort increases with the advancement of age as aged people refuses to undertake new ideas of a modern workplace (Acheson, 1972). Not only that, the knowledge of proper material handling as well as the physiologically suitable posture is lacking in the developing countries and therefore the prevalence of musculoskeletal disorders is very obvious (Asogwa, 1987).

The workers engaged in this job have adopted the traditional sitting postures for the performance. However, very few reports are available to highlight the probabilities of work related musculoskeletal disorders among the goldsmiths by job type.

Methods

Subjects

One hundred and twenty male workers engaged in jewellery industries were randomly selected for the study from different workplaces. According to the job type, they were grouped in two categories, *the manufacturers* and *the polishing staffs*. The job types were interdependent however not interchangeable, i.e. the manufacturers never perform polishing and vice versa.

Physical characteristics

Height and weight of the subjects were measured by anthropometric rod and weighing machine respectively. Body mass index (BMI) and body surface area (BSA) were calculated after Weisell (2002) and Banerjee et al. (1955) respectively.

Questionnaire study

A modified Nordic musculoskeletal disorder questionnaire (Sett and Sahu, 2010) was applied to seek information about work method, work schedule, health problems and other occupational aspects of gold smiths. The intensity of pain/discomfort was assessed using a body parts discomfort (BPD) scale (Jacquelin, 1994).

Assessment of the working posture

The working postures were recorded using video photography and they were later freeze framed. From those freeze framed images, stick diagrams of the working postures were drawn. The postures were analysed by rapid entire body assessment (REBA) (Hignett and McAtamney, 2000) and rapid upper limb assessment (RULA) (McAtamney and Corlett, 1993).

Data analysis

Chi-square test was performed to analyse the difference of localization of pain among the workers of the two separate groups. Level of significance for the test was taken as $p<0.05$.

Results and Analysis

The physical characteristics of the workers according to the job type have been presented in the Table 1. No such difference of those variables was observed between the workers of the two groups.

Table 1 : Physical characteristics of the goldsmiths by job type

Variables	Manufacturers	Polishing Staffs
Age	36.3 ± 2.4	38.6 ± 3.5
Height	167.3 ± 15.4	164.4 ± 10.3
Weight	62.4 ± 5.6	63.5 ± 8.1
BMI	22.1 ± 2.5	23.5 ± 3.7
BSA	1.82 ± 0.26	1.79 ± 0.52

The feeling of discomfort in different body parts was presented in the Table 2. It was observed that there was no significant difference of the feeling of discomfort among the manufacturers and the polishing staffs. It was observed that in case of upper back, lower back and waist, the prevalence of discomfort were much higher than the other body parts among the manufacturers. However, among the polishing staffs, the prevalence of pain was higher only in lower back than the other body parts although no significant difference of the feeling of pain/discomfort was found between those two working groups.

Analyses of the most frequent working postures as assessed by REBA and RULA were represented in Table 3. It was observed from the table-3 that the REBA scores of all of the postures were under risk. However, the same result was obtained in case of RULA. It is noteworthy that the feeling of discomfort as assessed by the BPD scale did not show much elevation, which meant that the feeling of discomfort were not much higher for those postures adopted by the workers.

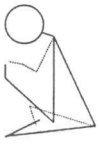
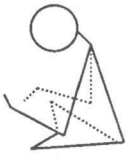
The workers engaged in this industry have to work in a confined workplace and there are not sufficient rooms in those workstations, and as making of jewellery products are very precise works and needs plenty of times, neither can they

Table 2: Analysis of the feeling of discomfort in different body parts of the goldsmiths by job type

Body parts	Feeling of discomfort		X^2 value	p value
	Manufacturers (n=89)	Polishing Staffs (n=31)		
Head	7 (7.8)	4 (12.9)	0.23	0.63
Neck	11 (12.3)	3 (9.6)	0.01	0.92
Shoulder	5 (5.6)	2 (6.4)	0.08	0.77
Upper Back	27 (30.3)	4 (12.9)	2.79	0.09
Lower Back	39 (43.8)	8 (25.8)	2.42	0.11
Waist	28 (31.4)	5 (16.1)	2.00	0.15
Knee	8 (8.9)	2 (6.4)	0.06	0.80

(The numbers do not add up to the respective sample size (n) due to multiple responses. Numbers in the parentheses indicate the percentage.)

Table 3: Analysis of the most frequent working postures

Type of Work	Posture	Stick Diagram	REBA Score	Risk level	RULA Score	Risk level	BPD Scale [Mean ± SD]
Transforming the gold bar into a ring			5	Medium	5	Change necessary	5.59 ± 1.23
Grafting on gold			8	High	3	Change may be needed	4.25 ± 1.20
Making ornaments			7	Medium	3	Change may be needed	3.66 ± 0.59
Pressing gold bar for thinning			10	High	5	Change necessary	4.23 ± 1.12
Pressing gold bar for thinning			9	High	5	Change necessary	2.12 ± 0.46
Polishing the ornaments			7	Medium	3	Change may be needed	4.80 ± 1.52

take sufficient rests during their work. It was observed that the postures the workers had adopted are hazardous. All of the postures were strenuous and the corresponding REBA and RULA scores were high. The impact of these strenuous

(as they work in those postures nearly 8 hours) postures on the workers led to produce WMSDs soon and implied serious health injuries. It was worthy of mentioning that all the postures they adopted were hazardous because of the awkward positioning of the body parts and could impose problems in the areas like vertebral column, bone and joints, which as a result might disturb their work efficiencies and could ultimately damage the productivity.

However, it was noted that the responses of discomfort of different body parts were not significantly related to that of the postures as identified. This could be due to the reason that apart from sitting, nearly all the jobs were of very short period (nearly 15-20 minutes for each cycle, nearly 15-20 cycles per working day). Therefore, the probability of muscular pain or any other type of physiological strain was much less. Although, the responses were minimum the related postures were of high risks and those should be modified for betterment of the workers' health and productivity.

Conclusion

The goldsmiths had to work in very constraint environment with minimum monitoring of workplace safety and as it belonged to an unorganized sector. Therefore, the probable physiological and work related hazards do not come not usually under limelight. Although, the results of these findings depicted that the postures were of high risks, all though the results were not absolutely error free because the methods and tools of postural assessment were not perfectly suitable for analysing the classical Indian sitting postures.

Therefore, a more sophisticated postural assessment tool is necessary for these kinds of assessments. Thus, ergonomic interventions like re-designing of work station, proper postures and avoidance of probable physical stressors are necessary to discard the probable postural stresses of the goldsmiths for the benefit of their physiological health and productivity.

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Original Article

Assessment of the lung function status of the goldsmiths working in an unorganized sector of India

Subhashis Sahu, Biswajit Roy[1], Subhabrata Moitra

Ergonomics and Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani, [1]Department of Statistics, Presidency University, Kolkata, India

ABSTRACT

Context: Exposure to various types of fumes and gases are very common in Jewelery industries. No Report is available regarding the effects of those fumes and gases on the respiratory functions of the goldsmiths. Due to lack of proper monitoring of the workplace environments in these unorganized sectors, workers get very much affected by the occupational exposures to those irritants. **Aims:** The present study aimed to investigate whether the occupational exposures to fumes and gases might alter the lung functions of the goldsmiths. **Materials and Methods:** A total of 118 goldsmiths and 66 unexposed control subjects were taken randomly for the study. The goldsmiths were further classified in 3 groups according to duration (year) of exposures in the work environment, ETA_1 (less than 5 years), ETA_2 (more than 5 years but less than 10 years), and ETA_3 (more than 10 years). Peak expiratory flow rates (PEFR), forced vital capacity (FVC), and forced expiratory flow rates of different intervals ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, $FEF_{25-75\%}$) were measured using computerized Spirometer (Maestros Mediline, India). The statistical analyses were carried out using Minitab software version 3. **Results:** Lung functions of the goldsmiths significantly ($P < 0.01$) decreased from that of the control group. Inter-group comparison also showed the deteriorations of lung functions was associated with exposure time, and more exposed workers had significantly less ($P < 0.01$) efficiencies of lung functions. **Conclusions:** Workplace fumes and gases were responsible for deterioration of the lung function status of the goldsmiths.

KEY WORDS: Lung function, fumes, metals

Address for correspondence: Dr. Subhashis Sahu, Ergonomics and Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani, West Bengal, India. E-mail: skcsahu@yahoo.co.in

INTRODUCTION

Occupation-induced respiratory disturbances have been reported in many studies.[1-5] But, apart from the study of Murgia *et al*.,[6] no study was reported, which could show the occupation-induced physiological changes, especially respiratory changes amongst the goldsmiths. Some reports showed that the mortality rates of the workers of jewelery industries increased due to cancer.[7,8] Reports stated that continuous exposure to acidic air and nitrogen and sulfur oxides can cause carcinogenicity in the lung tissues.[9-17] But, no study has been reported, which could highlight the occupation-induced respiratory hazards of the goldsmiths in India, especially in the unorganized sectors.

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DOI: 10.4103/0970-2113.106131

MATERIALS AND METHODS

Study population

A total of 184 subjects were taken in the study. Amongst them, 118 were goldsmiths who have been engaged in the jewelery industries for at least 1 year. According to experience in that particular sector, they were categorized in 3 subgroups; exposure having less than 5 years (ETA_1), more than 5 years but less than 10 years (ETA_2) and more than 10 years (ETA_3). 66 persons were taken as a reference group for subjective analysis purpose. They were mainly the storekeepers, managers, and front desk office workers of the same industry. The Departmental Research Committee of the University of Kalyani approved the study, and all subjects signed written consent form before participating

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in the study. All the reference subjects were non-smokers, and only 11 of the goldsmiths were smokers.

Measurement of physiological profiles

Height (in cm) and weight (in kg) of the subjects were measured using anthropometric rod and weighing machine, respectively. Body mass index (BMI) was calculated from height and weight according to the method of Weisell.[18]

Questionnaire study

A slightly modified ECRHS (European Community Respiratory Health Survey) questionnaire was applied to the subjects for the assessment of respiratory disturbances.[19] The questionnaires were translated into regional languages for easy communications and were translated back to English to validate the outcomes.

Spirometry

A computerized Spirometer (Maestros Mediline Systems Limited, India) was used to assess the respiratory health of the participants. Guidelines of the American Thoracic Society (ATS) and European Respiratory Society (ERS) were followed during spirometry. All the participants were thoroughly informed about the processes of spirometric tests. Forced vital capacity (FVC) and forced expiratory flows of 4 intervals ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, and $FEF_{25-75\%}$) of the subjects were measured. Peak expiratory flow rate was measured using Peak expiratory flow meter (Medicare Equipments, India). Every test for each participant was performed 3 times, and the best value was taken. The values of forced vital capacity and forced expiratory flow of different percentages were expressed as the percentage of their respective predicted values.

Assessment of the components of workplace fumes and gases

Concentrations of sulfur oxides (SOx), nitrogen oxides (NOx), suspended particulate matters (SPM), carbon monoxide (CO), and carbon dioxide (CO_2) of the workplaces were measured using a portable air monitoring kit (LaMotte, USA). Those concentrations were compared with the maximum limiting values proposed by the Pollution Control Board of the Government of West Bengal.[20]

Statistical analyses

One-way ANOVA was used to analyze the effect of exposure of the goldsmiths in respect of each of the study variables from that of the reference group. To observe the patterns of changes of the lung functions due to exposure duration, one-way ANOVA was performed. Odd ratio was performed to observe whether the outcomes of respiratory disturbances of the goldsmiths differed from that of the reference group. As the percent predicted value of $FEF_{25-75\%}$, PEFR and FVC were reported to be more crucial marker for detection of lung functions over the other study variables ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$), regression analyses of those 3 study variables (PEFR, FVC, and percent predicted value of $FEF_{25-75\%}$) were performed taking time of exposure as predictor to observe whether the predictor had any influence on the changes of those study variables. Two-tailed levels of significance were taken as $P < 0.01$ for all variables under study, and Minitab version 3 (USA) was used for the analysis purpose.

RESULTS

The mean values of age, height, weight, and body mass index (BMI) were presented in Table 1. There were no significant differences between the mean ages of the workers and the subjects of the control group, and there were not much deviation of the other physiological variables like height, weight, and BMI.

In Table 2, the levels of concentrations of different components of the workplace fumes were presented. The ranges of those pollutants vary according to seasonal and occasional changes. When there is a huge demand of ornaments, especially during festivals or social occasions, the work load increases and also the workplace environment changes.

The values of PEFR, FVC, $FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, and $FEF_{25-75\%}$ were compared between the reference group and the goldsmiths using one-way ANOVA and are presented in Table 3. It can be observed that the *F* values of each of the variables decreased in the exposed group from the reference group.

One-way ANOVA of the different exposed groups (ETA_1, ETA_2, and ETA_3) was presented in Table 4, and the results showed that the changes of the variables were significant between the groups. It can be said that the changes of the pulmonary variables were due to exposure to the hazardous work environment as constant exposure to that environment deteriorated the pulmonary health of the workers. The patterns of changes of the variables were dependent on the exposure duration as more exposed workers had lower levels of PEFR, FVC, $FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, and $FEF_{25\%-75\%}$ compared to that of the less exposed workers. The results showed that the workers having

Table 1: Mean Age, height, weight, and body mass index (BMI) between the control and exposed groups

Variables	Control (n = 66)	Exposure		
		ETA_1 (n = 28)	ETA_2 (n = 34)	ETA_3 (n = 56)
Age (Years)	35.24±3.40	32.85±4.52	35.42±2.42	35.46±3.16
Height (cm)	168.28±9.56	171.15±10.56	168.56±6.45	170.51±7.56
Weight (Kg)	60.75±5.29	62.43±4.96	61.05±4.25	62.56±3.54
BMI (kg/m^2)	23.34±2.81	23.42±1.86	22.38±2.37	23.69±3.24

Values shown are Mean ± SD

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Table 2: Assessment of different components of the workplace air

Components	Range at workplace
Oxides of sulfur (SOx)	118.4-140.3 μg/m^3
Oxides of nitrogen (NOx)	102.4-128.2 μg/m^3
Suspended particulate matters (SPM)	69.3-100.2 μg/m^3
Carbon monoxide (CO)	0.72-0.98 mg/m^3
Carbon dioxide (CO_2)	0.01-0.02 mg/m^3

Table 3: Comparison of spirometric values between goldsmiths (exposed) and the reference (unexposed) groups (*n* = 184)

Variables	Control	Goldsmiths	*F* value	*P* value
PEFR (L/Sec)	458.18±4.18	314.24±49.79	223.38	< 0.01
FVC (% Pred)	95.49±5.50	83.22±5.66	198.92	< 0.01
$FEF_{25\%}$ (% Pred)	83.91±1.41	54.57±12.61	167.97	< 0.01
$FEF_{50\%}$ (% Pred)	144.17±3.19	109.67±19.43	69.08	< 0.01
$FEF_{75\%}$ (% Pred)	270.34±7.91	192.85±38.52	77.32	< 0.01
$FEF_{25-75\%}$ (% Pred)	153.67±3.82	92.22±24.18	167.92	< 0.01

Overall difference is based on one-way ANOVA, $P < 0.01$. *F* values in ANOVA are significant at $P < 0.01$

exposure less than 5 years (ETA_1) had better lung functions than the workers having exposure more than 5 years and more than 10 years (ETA_2 and ETA_3). As the duration of exposure increased, the lung functions decreased.

The outcomes of the respiratory disturbances of the exposed and unexposed subjects were analyzed using odds ratio, and the results showed that the positive outcomes were much higher ($P < 0.01$) in the exposed group than that of the unexposed counterpart [Table 5].

Regression analysis of PEFR, FVC, and $FEF_{25-75\%}$ with the duration exposure as predictor showed that more deterioration of that study variable was influenced by the predictor, and the influence was significant. The patterns of changes of those study variables were nearly same as the duration of exposure increased. Changes of PEFR, ($r = -0.819$, $P < 0.001$), FVC ($r = -0.81$, $P < 0.001$), and $FEF_{25-75\%}$ ($r = -0.80$, $P < 0.001$) were presented [Figure 1a-c].

DISCUSSION

In the present context, particularly in Indian perspectives, as there are huge numbers of unorganized sectors, assessment of workers' health is somewhat impossible neither the quality of the work environment can be tested. Lack of proper knowledge about workplace environment makes the workers affected more and the tendency of work-related injuries and accident increases.

The assessment of workplace fumes indicated that there were apparently higher concentrations of SOx and NOx than the proposed limit in the workplaces. According to the proposed permissible exposure levels of the Pollution Control Board of the Government of West Bengal, the concentrations of SOx and NOx were higher in the workplaces than the recommended values (PEL for SOx- 60 μg/m^3; PEL for NOx- 60 μg/m^3).[20] Sulfuric and nitric acids when come in contact with high temperature and various metals, various oxides of sulfur and nitrogen are produced in gaseous forms and as those acids and fumes are very hygroscopic, they produce mists in the workplaces. The concentration of SPM was less in the workplaces (PEL: SPM- 140 μg/m^3) because those places were free from dusts and other associated particles. Carbon monoxide, which is produced during incomplete combustion of carbon, was also much less in the manufacturing sectors (PEL: 2 mg/m^3) although a very small amount of coal is used in those units.

Data reported that decrease in forced expiratory flow could diagnose reduced pulmonary efficiencies, and it was also reported that altered value $FEF_{25-75\%}$ could be a marker for identifying obstructive type lung diseases. According to the results, peak expiratory flow rate and forced expiratory flow of different percentages decreased significantly ($P < 0.01$) with the exposure duration. In recent days, the concept of vital capacity no longer exists, and concept of measuring forced vital capacity has come.

The fumes of various metals, acids, and gases were associated with the deterioration of the pulmonary efficiencies of the goldsmiths, and the results obtained were similar with that of the findings of other authors.[16] In this study, the mean ages of the workers were not related with the differences of exposures because the workers of more exposure joined the industry at very young ages and the workers with less exposure joined the industry relatively later. As there were no significant differences in ages and the body mass indices between the workers and the control subjects, it could be stated that the alterations of the pulmonary variables were neither mediated by malnutrition nor by age of the workers. Assessment of the secondary exposures of the total study population revealed that there were no significant risk factors, which could lead to malfunction of the respiratory system of the workers. Apart from the work stress, no factor was observed, which could make any influence over the normal functions of the lung. So, a clear conception can be obtained that secondary exposures were not much associated with the altered outcomes of lung function tests.

The inter-group analyses showed that the alteration of respiratory indices were dependent upon the duration of exposure to the hazardous fumes and gases. As the exposure increased, the tendency of respiratory obstructions also increased. The study found that a total of 56 goldsmiths had percent predicted values of $FEF_{25-75\%}$ lower than 70% of the predicted and amongst them, 12 were suspected to be suffered from airways obstructions. Chattopadhyay *et al.*[2] showed that constant exposure to fumes and gaseous pollutants were associated with reduced forced vital capacity and peak expiratory flow rates, which could cause an alteration of respiratory health. The validity of assessment of PEFR over the other standard PFT (Pulmonary Function Test) indices lies in the context that the other indices (e.g. FEV_1) are more sensitive in assessing bronchoconstriction of the

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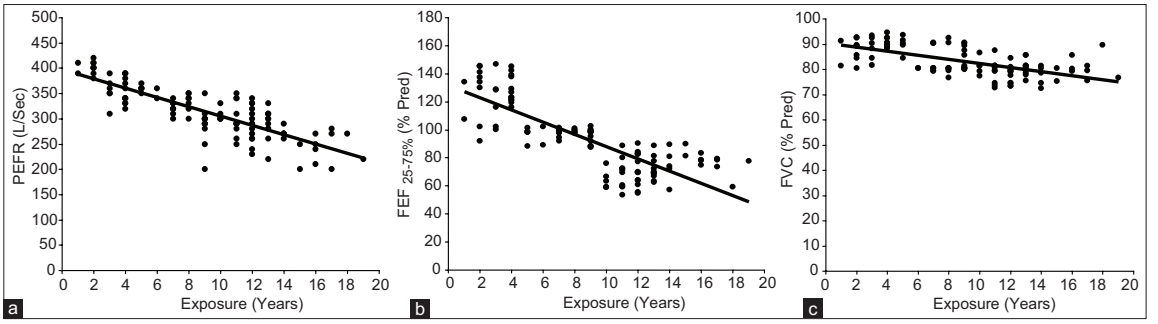

Figure 1: (a) Linear regression of PEFR with the durations of exposures. The durations of exposures and PEFR values of the goldsmiths (n = 118) were pooled, and the analysis was performed by taking PEFR and exposure durations as study variable and predictor respectively (95% CI: -0.87-0.75). (b) Linear regression of FVC (% Pred) with the durations of exposures. The durations of exposures and percent predicted values of FVC of the goldsmiths were pooled, and the analysis was performed by taking FVC (% Pred) and exposure durations as study variable and predictor respectively (95% CI: -0.73-0.51). (c) Linear regression of FEF25-75% (% Pred) with the durations of exposures. The durations of exposures and percent predicted values of FEF25-75% of the goldsmiths were pooled, and the analysis was performed by taking FEF25-75% (% Pred) and exposure durations as study variable and predictor respectively (95% CI: -0.88-0.73)

Table 4: Inter-group comparison of spirometric values of the goldsmiths according to the duration of exposure (years)

Variables	Goldsmiths (*n* = 118)			*F* value	*P* value
	ETA_1 (*n* = 28)	ETA_2 (*n* = 34)	ETA_3 (*n* = 56)		
PEFR (L/Sec)	372.14±5.80	319.41±6.01	282.14±4.82	63.72	< 0.01
FVC (% Pred)	89.07±3.69	84.19±5.14	80.18±4.47	49.82	< 0.01
$FEF_{25\%}$ (% Pred)	69.95±2.10	53.68±1.66	47.43±0.937	60.03	< 0.01
$FEF_{50\%}$ (% Pred)	129.30±3.19	112.19±2.04	98.32±2.10	40.35	< 0.01
$FEF_{75\%}$ (% Pred)	229.34±6.53	209.93±4.30	164.23±2.99	66.41	< 0.01
$FEF_{25-75\%}$ (% Pred)	126.40±2.88	97.13±0.752	72.16±1.33	261.57	< 0.01

Data are presented as the respective *F* values for the analysis of variance for each variable. The *F* values of the ANOVA are significant at $P < 0.01$

Table 5: Outcome of the secondary exposure to respiratory hazards of the total study group

Respiratory symptoms	Positive outcome		Odd ratio	95% CI
	Control (*n* = 66)	Goldsmiths (*n* = 118)		
Chronic cough	4	26	4.38*	1.45-13.17
Sneezing	8	40	3.72*	1.62-8.54
Whistling	2	11	3.29*	0.71-15.31
Breathing trouble	2	23	7.75*	1.76-34.00

*Values of the ORs are significant at $P < 0.01$

airways while PEFR can be an effective measure for home monitoring of lung function,[21] and Litonjua *et al.*[22] showed that $FEF_{25-75\%}$ could be an effective way to identify the pulmonary health, and alteration of $FEF_{25-75\%}$ was associated with obstructive types of pulmonary diseases.

Alteration of peak expiratory flow rates showed significant changes with the duration of exposure, and the results were similar with that of the percent predicted values of forced expiratory flow rates of 25-75%. For long-term exposure to the polluted environment, the lung tissues of the goldsmiths faced great challenge as cytotoxicity due to fumes and gases could alter the proportionate growth of the lung tissues. Sheel *et al.*[23] launched a term "dysanaptic," which they meant the disproportionate growth. They reported that restriction to the alveoli and parts of the upper respiratory tracts might be caused by disproportionate growth of the airways and the lung parenchyma and that dysanaptic growth could lead to the development of different types of lung diseases. Alteration of the $FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$, $FEF_{25-75\%}$, FVC, and PEFR henceforth might indicate reduced "cross-talks" between the lung parenchyma and the airways, which could lead to the development of complicated pulmonary diseases.

Our study had some limitations. First, the main restriction of this study was that there were no available data about the workplace environment and status of the air qualities in the unorganized sectors so as in the jewelery industries. It also varies from one workplace to another. In the jewelery industries, smoke and fumes generate by various means. So, it was not possible to evaluate the effect of single identity on respiratory health. Second, the study population was from the unorganized sectors where there is no proper maintenance of work schedules and assessment of hazardous substances of the workplaces.

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Therefore, it is necessary to be cautious when generalizing our results. Finally, as the workers rarely work in a specific workplace for a long period, understanding the pulmonary status of the workers working at a constant location for a long time (e.g. more than 25 or 30 years) were not possible.

CONCLUSIONS

In conclusion, long exposures to workplace gases and fumes were significant risk factor for pulmonary fitness amongst the goldsmiths of Indian unorganized sectors. Our results suggested that long exposure to those pollutants abruptly altered the lung functions of the workers. Some measures that can be adopted are as follows:

1. Regular investigation of the workplaces should be performed.
2. The workers should use preventive measures such as masks as many times as possible.
3. The use of chimneys and other exhaust techniques should be provided to the workers.
4. Regular check-up of the workers should be encouraged for their health education.

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How to cite this article: Sahu S, Roy B, Moitra S. Assessment of the lung function status of the goldsmiths working in an unorganized sector of India. Lung India 2013;30:33-7.

Source of Support: This work has been partially supported by the grants of the INSPIRE fellowship awarded to Subhabrata Moitra by the Department of Science and Technology, Govt. of India (Sanction letter No. DST/INSPIRE FELLOWSHIP/302).
Conflict of Interest: None declared.

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ORIGINAL ARTICLE

Adverse respiratory effects associated with cadmium exposure in small-scale jewellery workshops in India

Subhabrata Moitra,[1] Paul D Blanc,[2] Subhashis Sahu[1]

[1]Ergonomics and Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani, West Bengal, India
[2]Division of Occupational and Environmental Medicine, University of California San Francisco, San Francisco, California, USA

Correspondence to
Dr Subhashis Sahu, Ergonomics and Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani-741235, West Bengal, India; skcsahu@yahoo.co.in

Received 23 November 2012
Revised 8 February 2013
Accepted 14 February 2013
Published Online First 6 March 2013

ABSTRACT

Background Cadmium (Cd) is an important metal with both common occupational and environmental sources of exposure. Although it is likely to cause adverse respiratory effects, relevant human data are relatively sparse.

Methods A cross-sectional study of 133 workers in jewellery workshops using Cd under poor hygienic conditions and 54 referent jewellery sales staffs was performed. We assessed symptoms, performed spirometry, measured urinary Cd levels in all study subjects and quantified airborne total oxidant contents for 35 job areas in which the studied workforce was employed. We tested the association of symptoms with exposure relative to the unexposed referents using logistic regression analysis, and tested the association between urinary Cd levels and lung function using multiple regression analysis, adjusting for demographics, smoking and area-level airborne oxidants.

Results Exposed workers had 10 times higher urinary Cd values than referents (geometric mean 5.8 vs 0.41 μg/dl; p<0.01). Of the exposed subjects, 75% reported respiratory tract symptoms compared with 33% of the referents (OR=3.1, 95% CI 1.4 to 7.3). Forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1) were also lower among the exposed workers than the referents (>600 ml decrement for each, p<0.001). For every 1 μg increase in urinary Cd there was a 34 ml decrement in FVC and a 39 ml decrement in FEV_1 (p<0.01), taking into account other covariates including workplace airborne oxidant concentrations.

Conclusions This cohort of heavily exposed jewellery workers experienced frequent respiratory symptoms and manifested a marked deficit in lung function, demonstrating a strong response to Cd exposure.

Key messages

What is the key question?
- Is occupational cadmium exposure associated with pulmonary function impairment?

What is the bottom line?
- The poor hygienic conditions in Indian jewellery making workshops that entail cadmium overexposure linked to clinically relevant lung function deficits.

Why read on?
- Past data on this topic have been mixed; this study provides convincing support for the adverse target organ effects of chronic cadmium inhalation.

INTRODUCTION

The process of making gold-containing ornamental metal jewellery and related objects comprises three stages: alloying metal for its intended use; fabricating the intended object, which can include soldering or brazing; and polishing or buffing the completed piece. Each of these stages of the production process can lead to various metallic (eg, cadmium (Cd)) and non-metallic (eg, fume) exposures of potential health concern.

Cd metal is one such exposure. Cd is a component of certain metal solders, including so-called 'gold carat' solders used in jewellery fabrication. In addition, Cd can be employed as a metal additive in jewellery alloying, combined with gold and silver to produce what is sometimes called 'green gold'. Cd is a well-established respiratory toxin.[1] Acute high-level human inhalation exposure, typically through flame cutting or brazing Cd-containing materials, is associated with acute lung injury and diffuse alveolar damage.[2 3] In experimental animal models, repeated Cd inhalation causes emphysema.[4 5] There is also evidence that human exposure can have a similar adverse effect. Indeed, the natural Cd content of cigarettes or environmental Cd exposure interactions with cigarette smoking may be mechanisms underlying obstructive lung disease caused by smoking.[6 7]

Thus, delineating the respiratory effects of subacute and chronic inhalation of Cd is of both occupational and wider public health importance. To date, the seminal report of Davison and colleagues has best described a heavily Cd-exposed cohort,[8] although there have been other limited investigations of this topic, some of which have shown an adverse respiratory effect[9–12] while other studies have not.[13–15] We report our findings among a group of Cd-exposed jewellery workers in whom Cd levels and lung function data were systematically analysed.

METHODS

Overall study design and subject participation

We performed a cross-sectional study among workers engaged in manufacturing gold jewellery that involved the use of Cd-containing solder, including persons with varying duties and a range of anticipated exposure levels. A total of 233 men were screened from 276 potential study participants randomly identified among a total workforce estimated to be 350 in 35 working areas. Women are not employed in this industry in the region studied. The

To cite: Moitra S, Blanc PD, Sahu S. *Thorax* 2013;**68**:565–570.

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Table 1 Baseline characteristics of the participants

Characteristic	Referent (n=54)	Exposed (n=133)	p Value
Age (years)	37.6 (5.6)	35.7 (4.7)	0.39
Body mass index (kg/m^2)	23.4 (3.2)	22.5 (2.8)	0.54
Height (m)	1.71 (0.14)	1.68 (0.12)	0.62
Ever smoker	14 (25.9%)	43 (32.3%)	0.49
Regular exposure to SHS	16 (29.6%)	49 (36.8%)	0.44
Parental asthma	3 (5.5%)	7 (5.3%)	0.94

Data are presented as mean (SD) or n (%).
SHS, second-hand smoke.

workshops were located within a 200 km radius of Kolkata, West Bengal. The study was carried out between late February and early April 2012.

Of the 276 workers screened for participation, we excluded subjects for the following reasons: current antibiotic therapy; being under the supervision of a healthcare provider for an active medical condition; or failing to perform spirometry successfully. After excluding 22 potential jewellery sales staffs and 67 exposed workers, 187 (80% of the recruited group) remained. The mean age was similar in the excluded participants and the included group (35.7±5.9 years vs 36.2 ±5.0 years; p=0.38). There were proportionally fewer ever smokers among the excluded group than among those included (16.9% vs 30.5%; p<0.05). Of the 187 participants included in the final analysis, 133 (71%) worked in active production and 54 (29%) were personnel associated with sales of the jewellery products that had been manufactured (the referent category in this analysis). The exposed group was further subcategorised by job type: metal melting/alloying (n=32); design and fabrication including flame cutting metal pieces and soldering/brazing (n=61); and jewellery buffing and polishing (n=40). Metal melting was generally carried out with charcoal burning in ceramic vessels. Flame cutting and brazing employed liquefied petroleum gas and a manual blow pipe. Buffing and polishing used predominantly manual tools with acid solutions for cleaning. The workers did not move among these three subcategories of employment.

Questionnaire assessment

We administered a structured questionnaire containing items on respiratory health, occupational exposure and lifestyle factors. This questionnaire was modified from the European Community Respiratory Health Survey[16] and translated into Bengali. An English back-translation was used for validation. Subjective respiratory complaints in the previous 12 months by questionnaire were categorised by symptom group. These included: (1) acute/current or chronic/prolonged cough; (2) acute or chronic wheezing or whistling of the chest; (3) production of phlegm; (4) breathing trouble; (5) nasal problems (irritation in nose, dryness or stuffy nose, sneezing, runny or blocked nose); (6) eye problems; (7) nasal problems with watery eyes; and (8) skin symptoms such as dryness, rashes, patchiness, irritation, dark spots, burns or swelling.

Lung function

We measured lung function using a computerised spirometer (Maestros Mediline Systems Ltd., India), consistent with American Thoracic Society guidelines,[17] using the best of three values for forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1). Predicted values used Indian population values.[18] Spirometry was performed at sites removed from the workshops studied to avoid concomitant acute irritant exposures.

Measurement of urinary cadmium level

The first morning urine sample was collected by subjects in a standard glass container (Borosil, India) at home before coming to work. The concentration of Cd in the urine samples was quantified using atomic absorption spectroscopy (PerkinElmer, USA). Urine creatinine was not measured.

Measurement of total airborne oxidants in the workplace

We measured area-level total airborne oxidants (TAO) using a portable air monitor sampling pump employing impinger collection and a phenolphthalein-based colorimetric assay (LaMotte, USA), consistent with methods initially developed by Haagen-Smit and Brunelle to assess ambient air pollution.[19] Concentrations are quantified in parts per million (ppm) total oxidant content. Air quality was monitored in the workshops as well as in the shops. Different workstations of the three different subcategories of tasks (melting, fabrication and polishing) were sampled. When more than one subcategory existed at a single employment site, the areas were not open to each other although some cross-contamination was possible. Sampling for referents was performed in their work offices. A minimum of four recordings of 10 min sampling duration at 1 litre flow rate was made at each work site studied and the mean value was calculated. The area-level measurement was assigned as the exposure level for all of the workers in that area. Measurements were made for the work areas of all the participants included in the analysis.

Table 2 Comparison of urinary cadmium levels between referents and exposed workers and among the exposure subcategories

Exposure group comparisons	Geometric mean±SD	Median	25th–75th percentile	Range
Referent vs exposed workers				
Referent (n=54)	0.41±0.11	0.43	0.29–0.54	0.18–0.78
Total exposed (n=133)	5.80±0.38	5.91	4.17–8.18	2.74–9.89
Across exposure subcategories				
Melting/alloying (n=32)	4.85±0.19	4.93	4.16–5.76	3.17–7.33
Fabricating (n=61)	8.31±0.10	8.32	7.83–8.99	6.22–9.89
Buffing/polishing (n=40)	3.87±0.15	3.91	3.52–4.37	2.74–5.90

All units are μg cadmium/dl urine.
p<0.01 for all pairwise differences.

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Table 3 Area-level total airborne oxidants by exposure category

Exposure category (sample n)	Median	Range
Referent vs exposed workers		
Referent workplaces (n=13)	85.3	68.1–92.4
Total exposed workplaces (n=22)	270.3	138.3–510.0
Across exposure subcategories		
Melting/alloying areas (n=10)	271.3	210.7–310.7
Fabricating areas (n=7)	150.0	138.3–175.3
Buffing/polishing areas (n=5)	450.0	420.0–510.0

All units are expressed in parts per million total oxidants in that area. Each measure represents the average value of at least four measurements made (see Methods section).

Data analysis

To graphically display urine Cd values, they were transformed into the natural logarithm of 1 plus the observed value (to avoid negative values for concentrations <1.0 μg/dl). To test differences between the exposed and referent groups we used the χ^2 or unpaired t test. Differences in spirometric data among groups were tested using one-way analysis of variance. To test differences between urinary Cd (expressed as the geometric mean) among the referents compared with all the exposed workers as a group, we used the Mann–Whitney U test. To test differences in pairwise comparisons of urinary Cd between the different exposure subgroups we used the Tukey modified t test.

Logistic regression analysis was used to test the association between exposure and respiratory symptom-based categorical outcomes expressed as ORs and 95% CIs. The models tested included the covariates of age (continuous), parental asthma/atopy (yes/no), smoking status (ever smoker=yes, never-smoker=no) and regular exposure to second-hand smoke (SHS) at home and/or at work (yes/no). The effect of exposure on lung function was analysed using multiple linear regression. Separate models were tested for each of five outcomes: FVC, FEV_1, FVC% predicted, FEV_1% predicted and FEV_1/FVC ratio. Models of FVC, FEV_1 and FEV_1/FVC were adjusted for age, height, smoking status, SHS exposure, parental atopy/asthma and TAO for the work area of each subject. Models for FVC% predicted and FEV_1% predicted included the variables other than age and height (already accounted for in the lung function prediction equation). All analyses were performed in SPSS V.20.

RESULTS

The baseline characteristics of the study participants are presented in table 1. Overall, the referent jewellery sales group was slightly older and had a higher mean body mass index than the exposed production workers, although these differences were not statistically significant (p>0.20). Cigarette smoking (32% vs 26%; p>0.20) and regular SHS exposure (37% vs 30%; p=0.44) were slightly more prevalent among the exposed workers, although these were present in a minority of participants in both groups and the differences were not statistically significant.

Urinary Cd levels are shown in table 2. The urinary Cd level among the exposed group overall was 10 times higher than in the referent group (geometric mean 5.8±2.2 μg/dl vs 0.41 ±0.15 μg/dl; p<0.001). Among the three exposure subcategories there was a twofold difference between the highest exposure group (fabricating) and the lowest exposure group (buffing/polishing) (geometric mean 8.3±0.7 μg/dl vs 3.87±0.72 μg/dl). All three exposed groups differed significantly from each other in pairwise comparisons (p<0.01).

We obtained 22 area-level averaged measures of TAO for clusters of exposed workers in the three job task subcategories ranging from 138 to 510 ppm, as well as 14 averaged measures of the workstations of the referents (range 68–92 ppm). The concentrations of TAO by overall exposure and by subcategory are presented in table 3. The median TAO level for the exposed group was nearly threefold greater than for the referents. Within the exposure subcategories, buffing and polishing tasks were associated with the highest median TAO levels and fabricating with the lowest.

The frequencies of respiratory symptoms by exposure categories are presented in table 4. Overall, being in the exposed group was associated with substantially increased odds of reporting any respiratory symptom (OR 3.1; 95% CI 1.4 to 7.3). The exposed workers reported a threefold higher prevalence of cough, wheezing and phlegm (18.8%, 17.3% and 23.3%, respectively) compared with the referent group (5.5%, 5.5% and 7.4%, respectively). Taking into account the covariates, the odds of each of the individual symptoms shown in table 4 were significantly elevated in the exposure group, except for eye irritation (in isolation from nasal symptoms).

Table 5 shows the spirometric findings for the referent and exposed groups. There were marked deficits in lung function associated with exposure. Overall, there was a 600 ml mean

Table 4 Occurrence of respiratory symptoms in the study population

Symptoms	Referents (n=54)	Exposed (n=133)	OR (95% CI)	p Value
Any respiratory tract symptom	18 (33.3)	99 (75.9)	3.13 (1.37 to 7.28)	0.019
Prolonged cough	3 (5.5)	25 (18.8)	4.93 (1.26 to 19.22)	0.021
Wheezing or whistling in chest	3 (5.5)	23 (17.3)	3.65 (1.05 to 12.74)	0.042
Phlegm in chest	4 (7.4)	31 (23.3)	3.92 (1.26 to 12.12)	0.017
Breathing trouble	5 (9.2)	30 (22.5)	2.90 (1.03 to 8.16)	0.043
Nasal allergy	10 (11.1)	56 (27.8)	3.49 (1.58 to 7.72)	0.002
Nasal problems with watery eyes	2 (3.7)	27 (20.3)	4.55 (1.30 to 15.92)	0.017
Other symptoms				
Eye problems	5 (9.2)	15 (11.3)	1.21 (0.41 to 3.54)	0.726
Skin problems	4 (7.4)	33 (24.8)	4.16 (1.38 to 12.58)	0.011

ORs (referent symptom prevalence=1.0) are adjusted for parental atopy or asthma, smoking and exposure to second-hand smoke at work and/or at home. Values for the respiratory symptoms do not add up to 100% due to multiple non-exclusive response categories.

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Table 5 Lung function by exposure among 133 jewellery production workers and 54 referents

	Parameters				
	FVC	FVC (% predicted)	FEV_1	FEV_1 (% predicted)	FEV_1/FVC
Referent vs total exposed					
Referent (n=54)	3.49±0.29	92.7±4.6	3.04±0.24	92.2±2.8	0.87±0.03
Total exposed (n=133)	2.89±0.29	83.9±5.9	2.40±0.27	81.8±5.9	0.83±0.06
Within exposure subcategories					
Melting (n=32)	3.00±0.25	86.1±6.6	2.61±0.21	85.6±5.5	0.87±0.07
Fabricating (n=61)	2.99±0.22	84.9±4.2	2.47±0.20	82.4±4.5	0.83±0.05
Polishing/buffing (n=40)	2.64±0.27	80.5±6.5	2.12±0.18	77.6±5.7	0.81±0.06

Data are presented as mean±SD.
FVC, forced vital capacity in litres; FEV_1, forced expiratory volume in 1 s in litres.
Referent vs exposed group differences p<0.01 for all lung function variables shown. Polishing vs melting and polishing vs fabricating differences in all lung function variables p<0.01. Melting vs fabricating differences in FEV_1 and FEV_1/FVC, p<0.01 and FEV_1% predicted, p<0.05; differences in FVC and FVC% predicted were not significant between the melting and fabricating groups.

exposure-associated difference in both FVC and FEV_1 (all differences were significant at p<0.01). As a percentage of predicted values, the exposed group had lung function values 84% and 82% of predicted for FVC and FEV_1, respectively. Overall, 51 (38%) of the exposed workers had FEV_1 values less than 80% age and height predicted. The mean FEV_1/FVC ratio was also significantly lower among the exposed group than in the referents (p<0.01). Within the subcategories of exposure, all the lung function variables were significantly (p<0.001) lower among the polishing workers compared with those engaged in melting or fabrication. Compared with workers engaged in melting, the fabricators had lower mean FEV_1 and FEV_1/FVC values whereas the mean FVC values were similar between these two groups.

The relationship between urinary Cd concentrations and FEV_1 is shown in figure 1. This scatterplot shows that, although there is considerable variability, there is minimal overlap for both parameters between referents and the exposed group.

As shown in table 6, higher urinary Cd concentrations were associated with poorer lung function for each of the spirometric measures studied. Among the group as a whole (n=187), for each increase in Cd of 1 μg/dl we observed a 34 ml decrement in FVC and a 39 ml decrement in FEV_1, with a decline in the FEV_1/FVC ratio by 3% for the same unit increase in urinary Cd. The analyses within the exposed group alone (ie, excluding the referents) demonstrated a similar exposure response, albeit more pronounced (FVC deficit of 40 ml and FEV_1 deficit of 65 ml per 1 μg/dl urinary Cd).

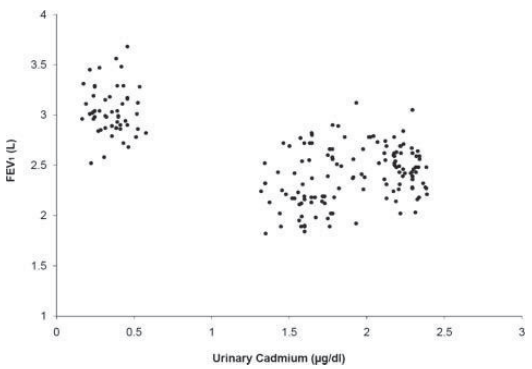

Figure 1 Forced expiratory volume in 1 s (FEV_1) in relation to urinary cadmium (Cd) levels among referents (cluster to upper left) and exposed workers (cluster to lower right). The urinary Cd values have been transformed, taking the natural logarithm of 1 plus the observed value.

DISCUSSION

We observed large and clinically relevant decrements in lung function associated with a Cd exposure response. This relationship takes into account airborne oxidant co-exposures, which were highest among the polishing workers, the group with a lower Cd exposure. The lung function decrement and symptom prevalence in this cohort underscores the clinical impact of the multifactorial poor hygienic conditions experienced by these jewellery workers.

The urinary Cd levels were highest among the fabricating workers, which is consistent with Cd-containing solder as the principal exposure source. A recent Indian press report highlighted the use of Cd-containing solder in gold jewellery.[20] Acute Cd inhalation toxicity from solder brazing has been documented in case reports from silver jewellery making in India.[21 22] Subacute to chronic Cd exposure from 'silver solder' has been well-recognised in jewellery fabrication and in other industrial brazing applications.[23 24] Cd overexposure from gold and silver alloying with Cd has also been reported.[25]

Cd is toxic to various biological systems.[26–31] Among these, the respiratory tract is a key target organ with emphysema being a particularly important endpoint. An investigation of 101 Cd-exposed workers showing lung function decrements including lung carbon monoxide transfer factor (TLCO), a marker of emphysema, is especially noteworthy.[8] Other occupational studies of respiratory effects due to Cd have yielded mixed results. Three studies (total exposed n=120) have shown Cd-associated adverse lung function deficits[9 10 12] while another observed an increased risk of respiratory mortality.[11] In contrast, three other studies of Cd-exposed workers (total exposed n=205) did not observe lung function decrements.[13–15] In the only study of jewellery workers using Cd-containing solder, only 8 of 25 workers with brazing fume exposure had detectable urine levels (>0.4 μg/dl); pulmonary function was described as 'normal' in all but one worker with asthma.[23] The current study adds substantially to this pool of data and drives the balance of findings in support of Cd-associated adverse effects on lung function in humans.

Limitations of our study include its cross-sectional design and the possibility that acute and subacute effects were

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Table 6 Effect (β) of occupational exposure on lung function

Parameters	β value (95% CI) All subjects (n=187)	Exposed workers only (n=133)
FVC (l)	−0.034 (−0.044 to −0.023)	−0.04 (−0.07 to −0.009)
FVC % predicted	−0.84 (−1.08 to −0.60)	−1.53 (−2.31 to −0.76)
FEV_1 (l)	−0.039 (−0.033 to −0.044)	−0.065 (−0.08 to −0.05)
FEV_1% predicted	−1.00 (−1.21 to −0.79)	−1.99 (−2.69 to −1.28)
FEV_1/FVC	−0.003 (−0.006 to −0.001)	−0.011 (−0.02 to −0.003)

All models included area-level TAO, parental atopy or asthma, smoking and exposure to second-hand smoke at work and/or at home. Models for FVC, FEV_1 and FEV_1/FVC also include height and age. All β values are statistically significant (p<0.01).
FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; TAO, total airborne oxidants.

superimposed on a cumulative impairment. One controlled study of toxic Cd exposure showed an acute decrement in FEV_1, FVC and TLCO 24 h after intentional exposure followed by at least partial recovery at 48 h.[32] We did not measure TLCO in our study, although this is likely to be an important endpoint in Cd toxicity.[8] Although our urinary measurements were not adjusted for creatinine concentration, such measurement imprecision is likely to have been non-systematic, although a recent study of child labourers manufacturing surgical instruments in Pakistan found that exposure-related differences in urine chromium levels were actually even greater with creatinine adjustment.[33] It is important, too, to emphasise that Cd was not the only relevant exposure in the jewellery workshops that we studied. We took airborne TAO into account but did not characterise this exposure further. One source may have been nitric acid (such exposure has been reported in the Indian jewellery industry[34]), and other oxidants may have been produced by charcoal-fuelled metal alloying or flame torch-based brazing. An independent negative effect of concomitant TAO exposure on lung function is consistent with the greatest decrement in lung function occurring in polishers who had the highest TAO values yet relatively lower Cd levels (albeit substantially higher than the referents). Although we took this effect into account in our analysis, our study was not designed or powered to assess potential multiplicative interactions among combined risk factors. Furthermore, we did not measure area-level or personal airborne Cd or other particulates. Based on standard industrial hygiene principles, the working conditions were consistent with airborne Cd fume inhalation being the salient route of exposure, but we cannot exclude concomitant Cd exposure via ingestion. There were potential selection effects in that those excluded from the study were less likely to be ever smokers. Nonetheless, the proportion of ever smokers in the study group was not high and we took active smoking and SHS exposure into account in our multivariate analysis. There could have been other unmeasured confounders that we did not assess. Socioeconomic status probably differed between the referents and exposed groups, but there should not have been a gradient within the exposed subcategories, all of whom were drawn from multiple small worksites not typically recruited into occupational studies.

The adverse exposure effects we found underscore the deplorable conditions experienced by the jewellery workers that we studied. Clearly, there is a serious need for systematic surveillance of respiratory status in this population and enforcement of adequate protective measures.

Acknowledgements The authors thank Professor Pulok Mukherjee, Department of Pharmaceutical Technology, Jadavpur University, Kolkata, India for providing the AAS facility and Mr Neelesh Nema for assisting in the assay.

Contributors SM designed the study, collected and analysed data. PDB analysed and interpreted the data and wrote the manuscript. SS designed and supervised the study and took the final decision to submit the manuscript.

Funding The study was partially financed by INSPIRE fellowship grants (Sanction Letter No-DST/INSPIRE FELLOWSHIP/2010/302) awarded by the Department of Science and Technology of the Government of India to SM and the DST PURSE Programme (Government of India) of University of Kalyani to SS.

Competing interests None.

Ethics approval Ethical approval was obtained from the Departmental Research Committee of the Department of Physiology, University of Kalyani and participants provided signed consent.

Provenance and peer review Not commissioned; internally peer reviewed.

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THORAX

Adverse respiratory effects associated with cadmium exposure in small-scale jewellery workshops in India

Subhabrata Moitra, Paul D Blanc and Subhashis Sahu

Thorax 2013 68: 565-570 originally published online March 6, 2013
doi: 10.1136/thoraxjnl-2012-203029

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Occupational Cadmium Exposure-Associated Oxidative Stress and Erythrocyte Fragility Among Jewelry Workers in India

Subhabrata Moitra, MSc,[1,2] Bill B. Brashier, MD,[2] and Subhashis Sahu, PhD[1]*

Background *Cadmium-induced pulmonary and renal target organ effects are well-established although its association with oxidative stress and associated hematological effects for human toxicity remain understudied.*
Methods *In a population of cadmium-exposed male jewelry manufacturing workers (n = 32) and referents without direct exposure (n = 21), all with urinary cadmium quantification, we measured plasma antioxidant enzymes (catalase, superoxide dismutase), lipid peroxidation (malondialdehyde), erythrocyte fragility, and surface irregularity of the erythrocyte membrane.*
Results *Compared to referents, exposed workers manifested significantly lower plasma antioxidant enzymes, and increased malondialdehyde and erythrocyte fragility (for all, $P < 0.01$). Consistent with the exposure subcategories, activities of superoxide dismutase and catalase were reduced and lipid peroxidation and erythrocyte fragility were enhanced ($P < 0.01$ for all) in terms of Cd-effect indicating a strong impact on hematological system and oxidative stress.*
Conclusion *Cd exposure contributes to oxidative stress and related erythrocyte effects thus making the hematological system another end-organ target for chronic Cd toxicity. Am. J. Ind. Med.* *© 2014 Wiley Periodicals, Inc.*

KEY WORDS: atomic force microscopy; oxidative stress; cadmium toxicity; jewelry industry; erythrocyte roughness; occupational exposure

INTRODUCTION

Cadmium (Cd) posses an important occupational exposure risk in the jewelry industries in India. This toxic metal is used predominantly in soldering gold, with additional applications in so-called "Gold-KDM" alloys [Moitra et al., 2013]. Human end-organ damage is well established from acute and chronic Cd exposure, adversely affecting the renal, cardiovascular systems, and respiratory systems. The latter is particularly vulnerable to Cd toxicity.

In a previous analysis of a population of Cd exposed Indian jewelry workers, we observed a Cd dose-response for adverse pulmonary effects [Moitra et al., 2013]. Apart from the effects on the lungs, the nephrotoxic effects of Cd have been documented. A recent report of a case of renal impairment in a heavily cadmium exposed Indian jewelry worker underscores the hazards of this heavy metal in that industry [Chakraborty et al., 2013].

A presumed common pathway for multi-organ adverse effects from Cd is its role in generating free radicals, ultimately increasing oxidative stress and inhibiting antioxidant enzyme function both extracellularly and intracellularly [Yang et al.,

[1]Ergonomics & Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani, India
[2]Chest Research Foundation, Pune, India
Contract grant sponsor: Department of Science & Technology of the Government of India and DST-PURSE Program.
The work was performed at Ergonomics & Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani, India.
Disclosure Statement: The authors report no conflicts of interests.
*Correspondece to: Dr. Subhashis Sahu, PhD, Ergonomics & Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani-741235, West Bengal, India. E-mail: skcsahu@yahoo.co.in

Accepted 30 March 2014
DOI 10.1002/ajim.22336. Published online in Wiley Online Library (wileyonlinelibrary.com).

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2003; Li et al., 2004]. Cd is toxic to the cells because of its potential to alter the balance of intracellular free radical scavenging enzyme, superoxide dismutase (SOD). It is well-documented that Cd has inhibitory effect on the activity of SOD [Babu et al., 2006; Arslan et al., 2011; Conterato et al., 2011]. Alteration of the activity of SOD is also dependent on the degree of exposure. Recent researches on occupational Cd exposure and oxidative stress have re-established the strong negative impact of Cd on the activities of plasma antioxidants [Henkler et al., 2010; Awodele et al., 2013; Nair et al., 2013]. It has been documented that SOD activity increases after low-level exposure to Cd followed by a defense mechanism to minimize the oxidative stress [Wąsowicz et al., 2001; Wieloch et al., 2012; Hambach et al., 2013]. However, results of Cd-associated oxidative stress have been mixed, which indeed supposed an unclear understanding of the mechanism of Cd toxicity. Also consistent with this pathway, Cd has inhibitory effects on the peroxide scavengers such as glutathione/glutathione peroxidase, catalase, and ascorbate peroxidase, thus facilitating peroxide accumulation [Filipič and Hei, 2004]. Moreover, Cd has been shown to replace copper and iron from cytoplasmic and membrane proteins; these displaced metal ions can accelerate the breakdown of hydrogen peroxide, generating free radicals through a Fenton reaction [Watjen and Beyersmann, 2004]. The oxidant-antioxidant equilibrium is largely dependent on glutathione pools; this is also an important factor in the detoxification of metals by accelerating the formation of metal-metallothionine additives [O'Brien and Salacinski, 1998; Nigam et al., 1999; Ercal et al., 2001; Garçon et al., 2004]. In this regard, Cd has been shown to significantly reduce the function of glutathione [Gong and Hart, 1997; O'Brien and Salacinski, 1998; Nigam et al., 1999; Ognjanović et al., 2003; Arslan et al., 2011; Nair et al., 2013].

Potentially related to oxidative stress, Cd also exerts strong adverse effects on the red blood cells (RBCs). The RBCs contain high amounts of unsaturated fatty acids in the cell membrane and thus are highly susceptible to free radical induced peroxidation [Kanter et al., 2009]. Being a strong thiol reducing metal, Cd can also compromise RBC membrane proteins though that mechanism [Kunimoto and Miura, 1986]. RBCs can actively take up Cd through membrane-based ion exchange potentially adding a further exposure burden [Lou et al., 1991]. The destruction of erythrocyte membranes has been shown following experimental Cd exposure [Zikić et al., 2001; Ognjanović et al., 2003]. Other experimental models have shown a Cd-associated reduction in total erythrocyte count, hemoglobin, and hematocrit [Kostić et al., 1993; Kanter et al., 2009].

Despite these experimental findings data are limited on oxidant pathway and RBC effects in humans following acute or chronic Cd exposure. The data that are available, however, indicate that effects similar to experimental models are likely to be manifested in humans with substantial Cd exposure in particular from occupational sources [Järup et al., 1998; Mason et al., 1999; Conterato et al., 2011]. In addition to these, there is also no substantial information about the normative value of urinary Cd among the Indians as this greatly varies depending upon demographic features, pollution and ground water Cd concentration. Very recently Akerstrom et al. (2013) have found a mean of 0.012 μg Cd per 100 ml of urine among 15 nonsmokers, normotensive adult males (range: <detection limit to 0.11 μg/100 ml urine), which has however, provided some useful data in this aspect. Consistent with our previous findings of higher urinary Cd among Indian jewelry workers, we hypothesized a fall of antioxidant defense mechanism among these heavily exposed jewelry manufacturing workers. To test our assumption, in the current analysis, we investigated markers of oxidative stress and erythrocyte status in a population of Indian jewelry workers with well-characterized heavy exposure to Cd. We systematically measured urinary Cd, quantified plasma antioxidant enzyme activity and erythrocyte numbers and morphology in this population and studied the associations among these variables and between them and Cd exposure.

MATERIAL AND METHODS

Study Population

For this analysis we recruited a subset of participants from a larger cross-sectional study of workers engaged in jewelry manufacturing with potential exposure to cadmium, along with a supplemental group of referent workers without direct occupational cadmium exposure. Details of parent study population recruitment have been reported previously [Moitra et al., 2013]. In brief, we recruited 187 male participants out of a preliminary screened pool of 276 workers, of whom 133 were engaged in active production of jewelry and 54 were referent workers who were not in direct contact with the exposure (mainly sales persons of the jewelry products). The subset of participants included in the current analysis represents a convenience sample of persons who were willing to provide a blood sample over and above the basic components of the parent study protocol (e.g., lung function testing and urine sampling). We performed this study in a subset of our previously selected sites where we could use conveniently the facilities of a nearby pathology laboratory to avoid transportation related hemolysis of red blood cells. The only exclusion criterion for those otherwise logistically accessible in this way was a history of blood donation in the previous two months. In total, we recruited 32 participants from among 133 exposed workers and 21 participants from among 54 referents in the parent study. The characteristics of the participants who provided blood samples compared to the remained of the subjects in the parent study are presented in Table I. As shown, those who did and did not participate in this additional protocol were similar in demographics and

TABLE I. Baseline Characteristics of the Participants Based on Study Inclusion and Cadmium Exposure Status

	Main study cohort (n = 187)			
	Referents (n = 54)		Exposed (n = 133)	
Characteristics	**Included (n = 21)**	**Excluded (n = 33)**	**Included (n = 32)**	**Excluded (n = 101)**
Age (years), mean (SD)	36.4 (3.3)	37.9 (5.4)	35.7 (4.6)	34.9 (4.9)
Height (meters), mean (SD)	1.8 (0.04)	1.7 (0.07)	1.8 (0.04)	1.7 (0.04)
Ever smoker, n (%)	4 (19.1)	10 (30.3)	10 (31.3)	33 (32.7)
Urinary cadmium (μg/dl), geometric mean (SD)	0.40 (0.14)	0.44 (0.16)	4.44 (1.11)†	6.72 (2.22)*
Workplace TAO (ppm), mean (SD)	83.3 (7.7)	87.0 (6.2)*	162.0 (14.9)†	245.3 (128.7)*

TAO, total airborne oxidants; ppm, parts per million.
*$P < 0.05$, included versus excluded subjects (by referent or exposure status).
†$P < 0.05$ exposed versus referent (included subjects only).

smoking status. Among the exposed group, however, urinary cadmium and airborne oxidant levels were lower than among those who did not participate in this protocol. We obtained signed informed consent form from all participants before recruiting them in the study. The Board of Research Studies (BRS) of the University of Kalyani approved the study.

Demographics and Measurement of Urinary Cadmium and Airborne Oxidants of the Worksites

We administered a questionnaire to all the participants. The questionnaire comprised items elicited demographics and smoking habits. Participants were categorized as current smokers and never smokers based on their smoking habits. The smokers in this population generally use "Bidi" consistent with consumption patterns of lower socioeconomic status in India. Bidi is a very small stick of tobacco encapsulated in a dried leaf and the amount of tobacco, thus approximately one tenth that of a standard cigarette. The number of bidi taken per day by the smoker participants ranged between 8 and 20/day (equivalent to 1–2 cigarettes). Data of participants' urinary cadmium and the workplace airborne oxidants were obtained from our large population reported previously [Moitra et al., 2013]. In brief first urine of the morning was collected in standard glass container (Borosil, India) for measuring the metal concentration. All samples were assayed using atomic absorption spectroscopy (Perkin Elmer, Waltham, MA) and concentration of cadmium in the urine samples were expressed as microgram (μg) per dl of sample.

The workplace air used to be full of different fumes generating from various acids (hydrochloric and nitric), metals (mainly Cd, very little from zinc), wood and coal. These all are responsible for oxidative stress and were considered as total airborne oxidants (TAO) of the workplace in this present study. We measured concentration of TAO of the workplaces included using a portable air monitor-sampling pump (LaMotte, Chestertown, MD) to assess ambient workplace pollution according to the methods described previously [Moitra et al., 2013]. In brief, we measured the ambient TAO in the working stations (in each worksite) for the exposed workers while sampling for referents was performed in their work offices. We recorded a minimum of four recordings of 10 min sampling duration at 1 L flow rate for each worksite and the mean value was calculated. Concentrations of the total oxidants were in parts per million (ppm). The 53 subjects included in this analysis were employed at 10 separate worksites where the area level TAO was measured (maximum subjects at the same site = 17).

Blood Collection and Preparation

Five milliliters of blood were collected from each study participant and placed in a vial containing EDTA. Plasma and red blood cells were separated using HiSep LSM (Leucocyte separation media, Himedia, India) according to the manufacturer's instructions. Following this protocol, 1.5 ml media was poured into the tube and 5 ml blood mixed with EDTA was slowly poured over it so that it did not mix with the medium. The tube was then centrifuged at 3,000 rpm for 10: min. After centrifugation, plasma was separated and stored separately. The leukocyte pellet was discarded and the erythrocytes were isolated. The RBCs were washed 20 times with isotonic phosphate buffer saline (pH 7.4). We measured the total erythrocyte count and hemoglobin content using a hemocytometer and Sahli's hemoglobinometer respectively. We derived the mean corpuscular hemoglobin (MCH) from these two values.

Osmotic Fragility of Erythrocytes

Erythrocyte fragility was measured using gradient decrease of concentration of sodium chloride (NaCl) solution according to the standard method [Pal and Pal, 2001]. In brief, a series of NaCl containing test tubes were used

in which hypotonicity was increased up to 0.1% starting from isotonic solution (0.9% NaCl). One drop of freshly collected blood mixed with anticoagulant was poured into each tube and observed for 60 min. The set point of hemolysis was determined by the concentration (%) of NaCl in the solution.

Antioxidant Enzyme and Lipid Peroxidation Assays From Plasma

Activity of plasma Cu^{++}/Zn^{++} superoxide dismutase (Cu^{++}/Zn^{++}-SOD) was measured according to the pyrogallol auto-oxidation method and measured at 420 nm wavelength. One unit (U) of SOD was defined as the enzyme activity that inhibited the auto-oxidation of pyrogallol by 50% [Marklund and Marklund, 1974].

We measured plasma catalase activity as previously described [Aebi, 1984]. Hydrogen peroxide was used as substrate and the activity was measured at 240 nm wavelengths.

Plasma glutathione S-transferase (GST) activity was measured according to Habig et al. (1974) taking 1-chloro-2,4-dinitrobenzene (CDNB) as substrate. The activity was measured at 340 nm wavelengths.

Glutathione reductase (GR) converts oxidized glutathione to its reduced form in physiological system in the presence of reduced nicotinamide adenine di-nucleotide phosphate (NADPH). We measured the activity of GR in plasma according to David and Richard (1983) by adding NADPH-Na_4 as the proton donor. Measurements were taken at 340 nm wavelengths of a dual beam spectrophotometer.

The activity of plasma reduced glutathione (GSH) was measured using 5,5′-dithiobis-2-nitrobenzoic acid (DTNB) as an oxidizing agent [Moron et al., 1979]. The formation of 5-thio-2-nitrobenzoic acid (TNB) was measured quantitatively at 405 nm wavelengths.

We measured the activity of plasma glutathione peroxidise (GPx) according to Paglia and Valentine (1967). Activity was measured at 340 nm wavelengths of a dual beam spectrophotometer.

Plasma lipid peroxidation was measured spectrophotometrically as the concentration of thiobarbituric acid reactive substance malondialdehyde according to Ohkawa et al. (1979). Malondialdehyde concentration was measured at 532 nm wavelengths.

Total protein content of plasma was measured according to Lowry et al. (1951).All of the parameters above were adjusted per mg protein of plasma.

Measurements of all plasma biomarkers were performed in a dual beam UV-Vis spectrophotometer (Systronics, Ahmedabad, Gujarat, India). The instrument was calibrated every time before the measurement and all tests were triplicated to minimize inter-test variability of the results.

Determination of Erythrocyte Morphology

Sample preparation

The RBC smear for atomic force microscopy was prepared according to the method described by Nowakowski and Luckham (2002). The red blood cells were immobilized on cover slides by the following procedures. First, the cover slides were cleaned with standard cleaning solution and dried. The slides were coated with 0.1% aqueous poly L-lysine (Sigma–Aldrich, St Louis, MO). Ten microliters from washed RBC pellets was dissolved in PBS. Twenty microliters glutaraldehyde was added to it and the final volume was made up to 2 ml. From the final concentration, 1 μl was placed on the lysine-coated slides and dried.

Atomic force microscopy

We carried out all AFM studies of the red blood cells with Veeco Multimode V7.0 atomic force microscope (Veeco, Santa Barbara, CA). We recorded the images in tapping mode to observe the cell surface with the use of a silicon cantilever with a resonant frequency of 40 Hz. Higher resolution images were used to collect data of roughness. All measurements were carried out with the help of the software, SPMLabAnalysis (Santa Barbara, CA). Three principal roughness indicators, arithmetical mean deviation/average roughness (Ra), maximum peak height (Rp), and total height (Rt) were measured. A number of small surfaces of the cells were analyzed to ensure that the measurements did not skew the cellular morphology. 2D-Fast Fourier Transform (2D-FFT) was performed to characterize the surface pattern of the membranes. The atomic force photomicrographs of the red blood cells can be found in the supplementary files.

Statistical Analysis

Descriptive statistics are presented as the frequencies and percentages of categorical variables or the mean and standard deviation for continuous variables of demographics and exposure. We used the chi square and *t*-test to test the differences between subjects included and excluded in the analysis by referent or exposure status and to test the differences between the referents and exposure subjects ultimately studied. To test the differences between plasma and RBC variables (all expressed in geometric mean ± SD) among the exposed compared to referents, we used Mann–Whitney *U* test. We performed Pearson correlation to assess the associations among the principal markers of oxidative stress (SOD, CAT, GSH, and MDA) and RBC indices (fragility, total count, and average membrane roughness) in the entire study group (exposed and referents combined) (all variables were log-transformed). We further analyzed the

correlations among these same oxidative stress and RBC indices and the urinary Cd and TAO), stratified by exposure versus referent status. For the variables for which there was a statistical correlation ($P \leq 0.05$) with both Cd and TAO (SOD, CAT, MDA, and fragility), we used multiple regression modeling to estimate the association between each of these dependent study variables and Cd and TAO. All analyses were performed using SPSS version 20.

RESULTS

The baseline characteristics, urinary cadmium concentration and workplace total airborne oxidants of the study participants included in this analysis by exposure vs. referent status are shown in Table I. Although there were no statistical differences in age, height or the prevalence of smoking, the two exposure parameters were higher among the exposed subjects. There was more than tenfold increase in urinary cadmium level among the exposed persons compared to the referents (4.4 vs. 0.4 μg/dl, $P < 0.05$) and an approximate twofold difference in TAO (245.29 vs. 83.3 ppm, $P < 0.05$).

Oxidative stress and RBC indices by exposure status have been presented in Table II. Antioxidant enzymes, including superoxide dismutase, catalase, and glutathione derivatives, were all significantly lower and the malondialdehyde significantly higher (all $P < 0.001$) among the exposed compared to referents. In addition, RBC osmotic fragility was increased among the exposed groups, as was the mean indices of erythrocyte membrane roughness and maximum and total peak height were also significantly greater in the exposed group ($P < 0.001$). Of all the parameters analyzed, only the total RBC did not differ statistically by exposure status.

The correlations among the key plasma antioxidant enzymes, malondialdehyde, and erythrocyte indices are presented in Table III. With the exception of the total RBC count, all of these parameters were highly inter-correlated in the anticipated directions (e.g., SOD, CAT, and SGH positively correlated with one another and natively correlated with MDA, fragility, and roughness). Only the total erythrocyte count was poorly correlated with all of the other parameters. All the other parameters shown in Table II although not included in Table III demonstrated similar inter-correlations (data not shown).

We studied the correlations among these selected antioxidants (SOD, CAT, and GSH), MDA and RBC indices and the two exposure variables of interest, stratified by exposure vs. referent status (Table IV). Among the exposed, higher urinary Cd was strongly and inversely correlated with antioxidant status (SOD, CAT, and GSH; r −0.84 to −0.89, $P < 0.001$) and positively correlated with MDA, RBC fragility, and Ra (r 0.64 to 0.5, $P < 0.001$). There were similar patterns of correlations between Cd and these variables in the referent group, with the exception of RBC average roughness (Ra), which was poorly correlated with Cd in this group. In contrast, TAO was not statistically correlated with any of these parameters among the exposure group (Table IV) although there were statistical correlations with SOD and RBC fragility (r 0.47 and −0.49, $P < 0.05$).

TABLE II. Comparison of Evaluated Plasma Stress Biomarkers and Urinary Cadmium Level Between the Referents and Exposed Workers

Parameters	Geometric mean (SD) Referents (n = 21)	Geometric mean (SD) Exposed (n = 32)	*P* value
Plasma profile			
SOD (U mg^{-1})	6.90 (1.40)	2.80 (0.40)	<0.001
CAT (nM H_2O_2 decomposed min^{-1} mg^{-1})	5.46 (0.75)	1.97 (0.47)	<0.001
GSH (μM mg^{-1})	0.33 (0.05)	0.19 (0.05)	<0.001
GR (nM NADPH consumed min^{-1} mg^{-1})	3.58 (0.22)	2.92 (0.26)	<0.001
GST (nM min^{-1} mg^{-1})	3.14 (0.33)	1.77 (0.15)	<0.001
GPx (U mg^{-1})	4.20 (0.68)	2.05 (0.56)	<0.001
MDA (nM mg^{-1})	74.74 (8.76)	97.91 (10.19)	<0.001
Erythrocyte profile			
Total RBC count (million/mm^3)	5.21 (0.29)	5.29 (0.39)	0.35
Hemoglobin (g/dl)	14.74 (0.79)	13.10 (1.13)	<0.001
MCH (pg)	28.29 (1.43)	24.73 (3.37)	<0.001
Osmotic fragility (NaCl %)	0.59 (0.03)	0.69 (0.04)	<0.001
Average roughness (Ra) (μm)	0.09 (0.03)	0.25 (0.06)	<0.001
Maximum peak height (Rp) (μm)	0.15 (0.06)	0.35 (0.11)	<0.001
Total height (Rt) (μm)	0.45 (0.14)	1.12 (0.25)	<0.001

SOD, superoxide dismutase; CAT, catalase; GSH, glutathione; GR, glutathione reductase; GST, glutathione S-transferase; GPx, glutathione peroxidase; MDA, malondialdehyde; RBC, red blood cell; MCH, Mean corpuscular haemoglobin.
All values are presented as geometric mean (SD). All pair-wise comparisons were significant at $P < 0.05$ except Total RBC count ($P = 0.35$).
Activities of all plasma variables were expressed per mg of protein.

Table V presents the results of a multiple linear regression analysis of the joint effects of Cd and TAO separately for the exposed and for the entire study group. Taking into account TAO, Cd was associated with significantly lower antioxidant enzyme activity (SOD and CAT) and elevation in plasma MDA and RBC fragility. Although TAO was considered separately as a probable factor of causing oxidative stress, we did not observe significant exposure response for the oxidative stress and erythrocyte markers with each stratum analyzed separately or for the group as a whole.

DISCUSSION

Unregulated occupational exposure to cadmium appears to be endemic in the Indian jewelry industry [Baker et al., 1979; Moitra et al., 2013]. This unfortunate situation provides a unique opportunity to systematically study the adverse

TABLE III. Correlations Among Plasma and Erythrocyte Oxidative Stress Markers and Related Variables

	Total participants (n = 53)						
	SOD	**CAT**	**GSH**	**MDA**	**Fragility**	**TC**	**Ra**
SOD	1.0	0.989 (<0.001)	0.945 (<0.001)	−0.900 (<0.001)	−0.895 (<0.001)	−0.086 (0.54)	−0.840 (<0.001)
CAT		1.0	0.951 (<0.001)	−0.915 (<0.001)	−0.920 (<0.001)	−0.098 (0.48)	−0.869 (<0.001)
GSH			1.0	−0.975 (<0.001)	−0.967 (<0.001)	−0.048 (0.73)	−0.861 (<0.001)
MDA				1.0	0.979 (<0.001)	0.067 (0.63)	0.841 (<0.001)
Fragility					1.0	0.080 (0.68)	0.862 (<0.001)
TC						1.0	0.109 (0.44)
Ra							1.0

SOD, superoxide dismutase; CAT, catalase; GSH, glutathione; MDA, malondialdehyde; Fragility, red blood cell [RBC] fragility; TC, total RBC count; Ra, average roughness of the erythrocyte membrane.
Values presented are Pearson correlation coefficients; Values in the parentheses indicate the respective significance levels (see Table II for units).

effects of Cd that may be mediated through oxidative stress pathways.

Our findings of impaired antioxidant enzyme activity and related effects underscore the imbalance of free radical scavenging defenses in persons with heavy cadmium exposure. We also found relatively lower amount of cadmium in the urine of the referent workers also who had no direct exposure to the metal. We approximated this event as an effect of cross-contamination through air, food, water and fabricated products coming out of the workplaces to the shops. Our findings of strong, inverse association between the burden of Cd based on urinary excretion and two principal antioxidant enzymes, superoxide dismutase and catalase were consistent with the anticipated effects of peroxide and free radical over-production. These findings were also similar to some other previously published reports of cadmium-exposed population where reductions in these antioxidant enzymes also were observed [Morselt, 1991; Casalino et al., 2002; Conterato et al., 2011]. The higher concentration of plasma malondialdehyde we observed is also consistent with an elevation of free radicals such as $HO^{\cdot}$ and $O^{\cdot}{}_2^{-}$. Glutathione, which is a critical plasma antioxidant, also manifested reduced activity. Moreover, the strong

TABLE IV. Correlations Between Selected Indices of Oxidative Stress Markers and RBC Function and Exposure to Cadmium and Airborne Oxidants by Exposure and Referent Status

	Factors	
Variables	**Cd**	**TAO**
Exposed (n = 32)		
Superoxide dismutase (SOD)	−0.84 (<0.001)	−0.09 (0.62)
Catalase (CAT)	−0.88 (<0.001)	−0.07 (0.71)
Reduced glutathione (GSH)	−0.89 (<0.001)	−0.002 (0.99)
Malondialdehyde (MDA)	0.83 (<0.001)	−0.01 (0.93)
RBC fragility	0.85 (<0.001)	−0.03 (0.86)
Total RBC count (TC)	0.07 (0.69)	0.10 (0.58)
Average roughness (Ra)	0.64 (<0.001)	−0.22 (0.23)
Referents (n = 21)		
Superoxide dismutase (SOD)	−0.78 (<0.001)	0.47 (0.03)
Catalase (CAT)	−0.76 (<0.001)	0.44 (0.05)
Reduced glutathione (GSH)	−0.67 (0.001)	0.36 (0.10)
Malondialdehyde (MDA)	0.72 (<0.001)	−0.43 (0.05)
Fragility	0.74 (<0.001)	−0.49 (0.02)
Total RBC count (TC)	0.19 (0.42)	0.19 (0.42)
Average roughness (Ra)	0.15 (0.52)	−0.33 (0.14)

Cd, cadmium; TAO, total airborne oxidants.
Values presented as Pearson correlation coefficients (r); values in the parentheses indicate the respective significance levels (see Table II for units).

TABLE V. Multiple Linear Regression Analysis: The Combined Effects of Cadmium and Airborne Oxidant Exposure on Oxidative Stress Markers and RBC Stability

Dependent variables	**Independent predictors included in multivariate modeling**			
	Cd	***P*-value**	**TAO**	***P*-value**
Exposed (n = 32)				
SOD	-0.31 ± 0.04	<0.001	$1 \times 10^{-4} \pm 5 \times 10^{-3}$	0.98
CAT	-0.37 ± 0.04	<0.001	$1 \times 10^{-3} \pm 6 \times 10^{-3}$	0.91
MDA	7.74 ± 1.00	<0.001	-0.09 ± 0.14	0.53
Fragility	0.03 ± 0.004	<0.001	$-3 \times 10^{-4} \pm 1 \times 10^{-3}$	0.59
All (n = 53)				
SOD	-0.94 ± 0.06	<0.001	-0.05 ± 0.004	<0.001
CAT	-0.78 ± 0.04	<0.001	-0.04 ± 0.003	<0.001
MDA	6.06 ± 0.41	<0.001	0.27 ± 0.04	<0.001
Fragility	0.02 ± 0.001	<0.001	$1 \times 10^{-3} \pm 2 \times 10^{-4}$	<0.001

SOD, superoxide dismutase; CAT, catalase; MDA, malondialdehyde; Fragility, red blood cell (RBC) fragility; Cd, cadmium; TAO, total airborne oxidants.
Values presented as regression coefficient $\beta \pm$ SE. Values were adjusted for age and smoking status (see Table II for units).

correlations among all of these parameters support the interpretation that they reflect an inter-related process. We observed strong exposure response for Cd in terms of antioxidant enzymes (SOD and CAT), MDA and RBC fragility in the anticipated directions of association. Although the effects were consistent in both the exposed and referent strata, a higher exposure response slope was present among the referents, despite of having much lower urinary cadmium levels as a group compared to those directly exposed. The referent participants were members of the jewelry sales staff. Although the manufacturing staffs produce the jewelry, the sales staffs frequently go onsite into the workshops and in this way are exposed to that ambient environment. This is likely to contribute to lower level but measurable Cd exposure.

The concentrations of two principal antioxidants (SOD and CAT) were higher among the referents with low urinary Cd values, but the associations between them were inversely related. These results are consistent with similar observations made by Conterato et al. [2011]. Other recent reports have reported antioxidant enzyme effects in low-Cd exposed populations where this toxicant was found to be positively associated with SOD and CAT possibly because of a Cd-induced activation of defense mechanisms against oxidative stress [Wieloch et al., 2012; Hambach et al., 2013]. In this study, the association we observed may be due to chronic exposure to a sustained, low Cd level. Further, values of all antioxidants were adjusted for plasma proteins, which may attenuate the relationship. Reduced glutathione (GSH) offers a first line of defense against ROS-induced oxidative damage. Heavy metals may induce alteration of GSH pool in the cell [Dickinson and Forman, 2002]. Reduction of the activity of plasma GSH among the exposed workers may indicate a relative deprivation of the GSH pool in this group. The cytosolic balance of GSH pool depends on the equilibrium between its synthesis and use. GSH functions in a coordinated way with GST. Sustained exposure to Cd may affect in the GSH-mediated transportation of metal-metallothionine additives from the cell (Ercal, 2001; Arslan et al., 2011). Reduced glutathione offers a first line defense against ROS-induced oxidative damage. Heavy metals may induce alteration of GSH pool in the cell [Dickinson and Forman, 2002]. Reduction of the activity of plasma GSH among the exposed workers indicated a marked deprivation of GSH pool in the body due to a sustained exposure to high amount of heavy metal. The cytosolic balance of GSH pool depends on the equilibrium of its synthesis and use. GSH functions in a coordinated way with GST, however, a constant encounter with heavy metals (such as Cd) may affect in the GSH-mediated transportation of metal-metallothionine additives from the cell (Ercal, 2001; Arslan et al., 2011).

The increased fragility and morphological abnormalities in erythrocytes that we observed were also correlated with the key measures of oxidative stress (including MDA) and was related to Cd levels as well. Potentially related to erythrocyte status but independent of oxidative stress, Lauwerys et al. [1973] found that human exposure to cadmium is associated with delineating functional activity of δ-aminolevulinate dehydratase, an enzyme that converts aminolevulenic acid to porphobilinogen and thus interferes in hemoglobin synthesis. More recently, Horiguchi et al. (2011) found that exposure to cadmium might lead to anemia through interdependent progress of hemolysis, body iron accumulation and insufficient erythropoietin production in laboratory animals. We found a significant loss of biconcave shape and lowered cellular hemoglobin content, which could be related to anemia following chronic cadmium exposure. Of note, however, we did not observe a Cd-associated decrease in RBC count or a correlation between this parameter and markers of oxidative stress.

In addition to the inhalable fumes of Cd produced during soldering activities, other potential factors may be present in the workplace. For example, other airborne vapors and particulates may contribute to some of the observed abnormalities. In particular, the use of strong acids (HCl, HNO_3) and bases (KOH) in this industry may lead to exposure to irritant fumes with oxidant potential. Indoor combustion byproducts may further contribute to such stressors. We were not in a position to measure each of these separately.

Our study has limitations that should be kept in view. This was a cross-sectional study and thus cannot assess Cd exposure effects prospectively over time. Further, although urinary cadmium is a standard exposure marker, measurement of Cd in plasma and in red blood cells might have provided additional insights of most recent exposure. Our findings of oxidative stress were compared against urinary Cd values, which indicate a chronic or sub-chronic effect of Cd exposure. We were unable to provide, however, any strong supportive information on potential Cd exposure parameters Although we took into account total airborne oxidant exposure effects, we could not further characterize specific chemical oxidants such as oxides of nitrogen or ozone and other combustion byproducts. Although we performed lipid peroxidation assays to confirm oxidative damage, a direct measurement of the reactive oxygen species (ROS) or investigating protein or nucleic acid oxidation as additional endpoints could have provided additional useful data. Unfortunately, resourced limitations prevented such analyses and we acknowledge that this is a study limitation. The small proportion of participants in this study, who smoked, used "Bidi" for which there is no standard pack per year quantification and which is quite low by Western standards. This limitation means that we were not powered to look at smokers alone or even smoking-related interactions. Further, in our study, only a third of the participants were smokers. This may limit generalizability of our findings to more heavily smoking populations where that may a further contributor to the Cd burden and other exposures; however, the frequency of smoking was similar in the parent study

population. Thus, selection bias is not likely to be a factor in that regard. Ours is a relatively small study group and represents only a subset of a larger population that we have analyzed previously. Small study size, however, would not explain the associations that we did observe. Moreover, those included in this analysis from the larger population appeared to less heavily Cd-exposed than those excluded, which if anything should have blunted the associations we observed.

In conclusion, our findings indicate that oxidative stress is a relevant mechanism of Cd toxicity in humans. Further, the adverse erythrocyte effects indicate that the hematological system is likely to be another end-organ target for toxicity from this heavy metal. In addition to this, the oxidative stress is probably one of the import mechanisms of pulmonary and renal dysfunction and/or damage. This added dimension of toxicity further underscores the importance of adequate workplace controls to reduce occupational sources of Cd exposure.

ACKNOWLEDGMENTS

The authors thank Professor Pulok Mukherjee, Department of Pharmaceutical Technology, Jadavpur University, Kolkata for providing the AAS facility and Mr. Neelesh Nema for assisting in the assay. The authors also thank Professor Tarakdas Basu, Department of Biochemistry and Biophysics of University of Kalyani for assisting with AFM facility and Mr. Arijit Chatterjee for his technical help in the microscopy. The authors thankfully acknowledge Professor Paul D. Blanc, Division of Occupational and Environmental Medicine, University of California San Francisco for his help in drafting and critical evaluation of this article. The study was partially financed by INSPIRE fellowship grants awarded by Department of Science & Technology of the Government of India and DST-PURSE Program. *Grant Sanction Letter No*: DST/INSPIRE FELLOWSHIP/2010/302.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web-site.

ANNEXURE- X

List of Publications

(Abstracts & Conference Proceedings)

(a) **Moitra S,** Sahu S. Exposure to workplace fumes alters the forced expiratory flow of different intervals and peak expiratory flow rate of the goldsmiths. ***Proceedings of the XXIII Annual National Conference of the Physiological Society of India (Physicon2011)*** 2011; Vijayawada, 21-23 December 2011.

(b) **Moitra S,** Sahu S. Exposure to workplace acid mists alters the lung functions of the goldsmiths working in unorganized sectors of India. ***7th International Conference on Science of Exposure Assessment (X2012).*** Edinburgh (UK), 2-5 July 2012

(c) **Moitra S,** Maity SG, Haldar P, Pandit AK, Sahu S. Trawler fuel exhaust and respiratory impairments; a cross sectional study in Indian fishermen. ***European Respiratory Journal*** 2012; 40(Supp 56): 737s

(d) **Moitra S,** Sahu S. Respiratory symptoms and lung function tests among the goldsmith engaged in jewellery manufacturing industries in India. ***European Respiratory Journal*** 2012; 40(Supp 56): 183s

(e) Chakraborty S, **Moitra S,** Bhattacharyya A, Sahu S. Deterioration of lung function is perturbed by sputum neutrophilia and lung cell DNA damage among occupationally cadmium-exposed Indian goldsmiths. [Accepted for presentation in the ERS International Congress 2014]