Macro-ergonomics and human ability indices at work: Assessment of job groups and workers by using of Relative Stress Index (RSI) and Work Ability Index (WAI)

Jafar Akbari[1], Meghdad Kazemi[2], Shahram Safari[2*], Mohammad Amin Mououdi[3], Behzad Mahaki[4]

1. Department of Occupational Health Engineering, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran
2. Department of Occupational Health Engineering, School of Health, Ilam University of Medical Sciences, Ilam, Iran
3. Department of Occupational Health Engineering, School of Health, Mazandaran University of Medical Sciences, Sari, Iran
4. Department of Statistics, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran

[*] **Corresponding author:** Tel: +98 9189213893; fax: +98 8412227103
Address: Department of Occupational Health Engineering, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran
E-mail: safari.shahram65@gmail.com
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Abstract

Introduction: To reduce occupational accidents and work-related diseases as well as improving satisfaction of working conditions, Assessment to identify risks and control measures are necessary. The aim of this study, applying ergonomic assessment indices to assessed the job groups and ability of textile workers.
Materials and methods: This study was conducted on 194 men employed in the QaemBaft textile company. Relative Stress Index (RSI) was used to assess the textile job groups. Also; Work Ability Index (WAI) was used to assess the personnel's ability.
Results: Results of RSI for 15 job groups showed that all jobs were in the Safe zone. Also results of WAI showed that only "Open "job was to have good level of ability and other job groups were to have intermediate level of ability.
Conclusion: According to the results, Relative Stress Index (RSI) is a tool for macro-ergonomics assessment of job risks. Also, in six categories of tasks of RSI, levels of fitness is determined. But WAI, Ability to work is determined that is a wider earning than the fitness.

Keywords: Relative Stress Index (RSI), Work Ability Index (WAI), macro-ergonomy, risk assessment

Introduction

Workers' health (plural) surveillance should be conducted on the level of company or industry. Comprehensive system of worker's health monitoring includes evaluating individual and social health of workers, recording occupational injuries and diseases, notification of high-risk occupations and occupational investigations (1). Using practical assessments in occupations is necessary for decreasing occupational accidents, work related diseases, major industrial accidents, and enhancement of occupational satisfaction and in this regard ergonomic assessment in workplace cause enhancement of occupational conditions and productivity (2). Occupational conditions and tasks associated with safety and health risk cause negative effects on mental and physical health of individuals as increasing occupational stress (3), circadian variation of heart

beats, increased Cortisol level in the morning (4), increased blood pressure, increased Lipid, over-weighting, smoking, alcohol consumption (5). Furthermore, individual and environmental factors in workplace directly and indirectly effect on human productivity (6). Therefore, practical assessments with the aim of identifying and eliminating workplace risk factors and protecting workers health is a necessary issue.

Macro-ergonomics is an approach for organization design, working systems, and also human-machine, environment- human and user-system interaction (7,8). Using macro-ergonomics in work causes 50% to 90% increase in efficiency of organization and also 200% increase in productivity (9). Different macro-ergonomics models have been used, Macro-ergonomics analysis of structure (MAS), is a mental model for organizational assessment which will evaluate working system structure of organization by evaluating the effects of 3 main social-technical elements which include technological sub-system, employees and external environment sub-system effective on organization (10). Macro-ergonomics analysis and design method (MEAD) which is based on MAS method is according to 10 fundamental steps of an effective model for comprehensive evaluation of system (11). System Analysis Toll method (SAT) is being used more in administrative circumstances. In this method, analysis level is being identified on the level of company or department where the aims and missions of the company will be defined in and personal and group aims will be supported by these missions (12, 13). These methods and other evaluation methods focus on organization structure by ergonomics approach. Relative Stress Index (RSI) will evaluate occupations and identify their risk levels from the viewpoint of macro-ergonomics. This method, by gathering occupational information, completing 6-level risk evaluation, and computing RSI, will evaluate occupations, and task levels and those elements will be defined according to a criterion from 0 to 10. Then based on the defined level occupation status and its modification will be decision (14).

Observing work ability is not only from the aspect of health but also with a multidimensional approach pays attention to merits, values, workplace, and social relationships (15). Studies have shown that working ability index (WAI) is in related to occupational stress factors and stress symptoms (16). This index is also used as a tool for predicting long-term absences from workplace due to illness among young workers (17) and work disability among old workers (18). Poor working conditions like low control over work for heavy physical load, cause increase of absences due to illness (19-22). Therefore, this is an important tool index in occupational health and medicine and can be used as an effective tool for workers health monitoring.

Materials and methods

Subject: This cross-sectional study was conducted among 194 male workers of textile industries QaemBaft textile company (Isfahan, Iran) in Oct. and Nov. 2012 that was selected by census method. The age range of participants was 24-62 years (40.22±6.991). Before starting the study, people's health controlled by interviewing, Having occupational experience more than one year, correct perception of the two indexes questions and exact answering to all questions were the criteria to select the persons for the study.

Assessments: Relative Stress Index (RSI) has been developed according to the comprehensive range principles, practicality, usefulness, reliability and simplicity in reflecting occupation. According to RSI the main structure of evaluating risk includes 3 parts: job description, check lists, and relative stress index (RSI). job description includes general information of interviewee`s

background, job summary, and details related to jobs and relevant tasks. In the 2nd part six categories of tasks for each job has been completed include manual material handling, hand work, posture, senses, environment and personal protective equipment (PPE). These six categories include 64 high risk factors as lifting loads, inappropriate posture, etc. The 3rd part includes occupation needs qualitative evaluation in the form of RSI score. In this level general index of RSI and the elements have been defined by mathematical formula by considering that job variables have the two main and interacted effects (table 1). Final score of RSI was from 0 to 10. Zero indicates that the occupation is dangerous, unsafe, and nonproductive and score 10 indicates non dangerous, safe and productive occupation. Based on the above issues occupation evaluation, task levels, and occupation elements is as follows: RSI score between 0 to 2.5 shows red zone and means it requires immediate action, RSI score between 2.5 to 7.5 shows yellow zone and means, Change are required after taking care of the red zone although change can be made together with those made in red zone. And eventually RSI score equals to 7.5 or more shows green zone and means no changes is required (24). Figure 1 shows schematic format of different categories of relative Stress Index (RSI).

Table 1. RSI scores for different tasks. * task elements in this method are defined according to 1- 4 tasks (24).

Tasks	*Task elements	RSI equations
Manual material handling	1-4	$RSI = \sum_{1=1}^{4} RSI_1/_4$
Hand work	5-6	$RSI = \sum_{1=5}^{6} RSI_1/_2$
posture	7-22	$RSI = \sum_{1=7}^{22} RSI_1/_{16}$
Sensory	23-34	$RSI = \sum_{1=23}^{34} RSI_1/_{12}$
Environment	35-59	$RSI = \sum_{1=35}^{59} RSI_1/_{25}$
Personal protective equipment	60-64	$RSI = \sum_{1=60}^{64} RSI_1/_5$
Total RSI	1-64	$RSI = \sum_{1=1}^{64} RSI_1/_{64}$

Work Ability Index (WAI) includes 7 aspects of present job ability in comparison with the best periods of life, occupational ability in relation to occupation mental and physical needs, numbers of present diseases diagnosed by physician, sick leave during the past 12 months, prediction of the person of his occupational ability in the next two years, mental resources, estimation of work loss due to illness (25). Table 2 shows choices being examined in the working ability index questionnaire. Translating WAI questionnaire into Persian and identifying its reliability and validity in Iran has been done by Abdolalizadeh et al. (26).

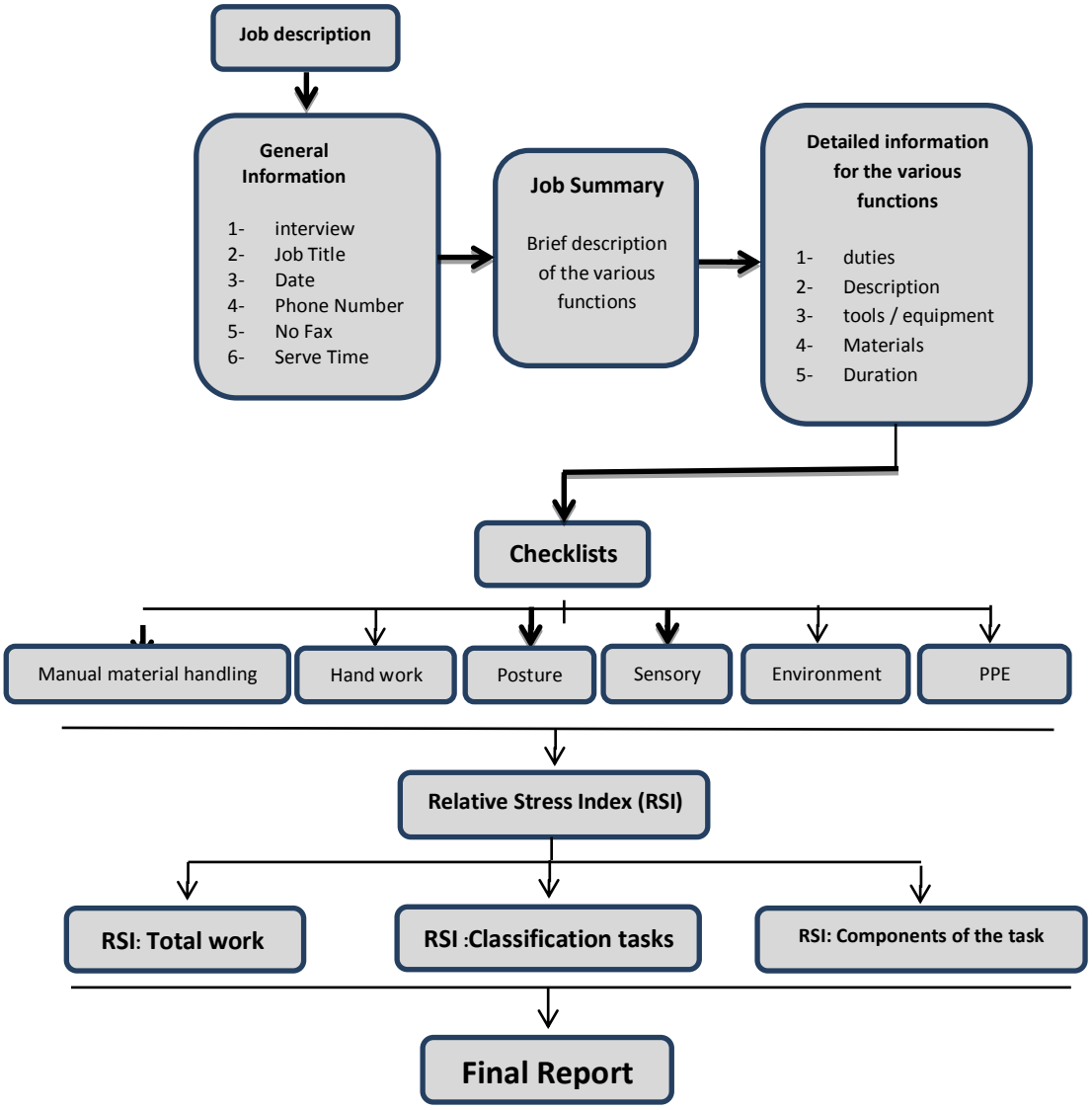

Figure 1. Steps of relative Stress Index (RSI).

Table 2. Options in WAI questionnaire (27).

Item	Scale
(1) Subjective estimation of present work ability compared with lifetime best	1-10
(2) Subjective work ability in relation to both physical and mental demands of the work	2-10
(3) Number of diagnosed diseases	1-7
(4) Subjective estimation of work impairment due to diseases	1-6
(5) Sickness absenteeism during the past year	1-5
(6) Own prognosis of work ability after 2 years	1, 4, 7
(7) Psychological resources (enjoying daily tasks, activity and life spirit, optimistic about the future)	1-4

The study has been conducted on peoples working in 3 shifts. Morning (7am-15pm), evening (15am-23pm), night (23pm-7am) and one rest shift in the summer. After identifying groups the study and its aspect explained for the participants and for being studied a written permission signed by them. How to complete both indexes was based on individual's interview and self-report. At first checklist questions related to RSI index and then WAI questionnaire explained for all individuals and their answers to the questions were recorded. Assessment and decision making in RSI is very time consuming. For accelerating the performance of assessment and decision making in RSI, RSI software designed and used.

Statistics

Standard deviation and meanvaluewere examined for individuals' characteristics and they werecomputed for WAI. Also the mean for each 6 level indexes of RSI and general RSI in each group wereachieved. The gathered information have been analyzed by SPSS software, version 20 and analytical statistics. Moreover, Pearson Correlation Coefficient was used for relationships between indexes (RSI and WAI). A p-value of 0.05 wasconsidered assignificant.

Results

Demographic variables, average of RSI and WAI: In this study 194 men in 3 shifts of a company have been participated. These persons were selected among shift workers with different jobs by examining their periodical examination files. Number of individuals based on 3 shifts of morning, afternoon, evening and rest were 56, 57, 44, and 37, respectively. Furthermore, individual's age average (standard deviation), occupational experience, weight, height, BMI were 22-40 (6.99) years, 15-17 (6.03) years, 73-87 (12.7) kg, 17.3 (7.4) cm, 25.5 (4.1) (kg/m2).In the first step of identifying RSI score for each occupation, related data were gathered by information interview sheet related to each occupation and nature of every occupation. Then, the examined occupations were divided into 15 groups: Ring, Carding, Double twist, Auto Kenner, batting, Open, Weaving, Technical, sizing, shift supervisor, repairing, warp coil, designing, flyer, and services. Also these 15 groups were placed in 4 occupational levels: spinning, weaving, repairing, and shift supervising.

Then, frequency/ time duration (FD), repeating (R), weight (w), distance (TD), horizontal duration (HD), were recorded in checklists for each 64 task elements by individuals' interviewing. After gathering data, tasks RSI 6-level indexes were computed by formula related to RSI indexes. (Table 1). Table 3 shows the average of these indexes for 15 occupational groups. Fig.1 shows the general RSI average for these occupational groups. After gathering information related to RSI index needed information for identifying this index were gathered by using ability index questionnaire and interviewing method. Like RSI index all WAI questionnaire' questions were analyzed and described for the studied individuals, till individuals with different educational level having the same perception of all questions and so the gathered results have high accuracy. After gathering data, the average of WAI final score for each job was computed. Figure 2 shows the average of this index for occupational groups. Examining individual characteristics effects on WAI average score among occupational groups have shown that there was a significant relationships between age ($p < 0.05$, $r = -0.198$) and occupational background ($p<0.05$, $r=-0.204$) with WAI (Figure 3). But there were no significant relationships between WAI with height, weight, and BMI.

Table 3. The RSI average of tasks for 15 job groups (MMH: manual material handling; WH: Hand work and PPE: Personal protective equipment).

	MMH		HW		Posture		Sensory		Environment		PPE	
Job group	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Ring	8.98	0.48	8.6	0.43	7.54	0.44	7.78	0.46	8.62	0.52	7.86	0.45
Carding	8.77	0.4	8.15	1.4	7.37	0.28	7.83	0.56	8.54	0.41	8	0.56
Double twisting	9.02	0.06	8.45	0.48	7.5	0.27	7.98	0.52	8.68	0.47	7.76	0.35
Auto kenner	8.97	0.23	8.20	1.01	7.14	0.44	7.53	0.37	8.67	0.45	8.47	0.42
Batting	8.75	0.29	7.8	1.29	7.34	0.64	8.23	0.83	8.39	0.6	8.17	0.72
Open	8.77	0.00	8.38	0.00	7.50	0.00	8.67	0.00	7.92	0.00	7.60	0.00
Weaving	9.14	0.41	9.02	1.04	7.3	0.3	7.58	0.36	8.61	0.72	7.64	0.24
Technical	8.54	0.21	8.31	0.35	6.99	0.11	7.83	0.77	8.05	0.62	8.16	0.61
Sizing	8.66	0.83	9.06	1.04	7.2	0.48	7.68	0.26	8.61	0.41	8.06	0.64
Supervisor	7.8	0.32	8.38	0.00	7.04	0.24	8.08	1.06	8.24	0.00	8.4	0.00
Repairing	9.00	0.13	9.33	1.16	7.29	0.33	7.50	0.33	8.64	0.55	8.13	0.46
Octoploid twisting	8.76	0.36	8.59	1.30	7.39	0.27	8.22	0.82	8.45	0.48	8.00	0.69
Designing	9.14	0.28	9.19	1.14	7.41	.20	7.75	0.11	8.84	0.16	7.60	0.00
Flyer	8.68	0.35	7.37	0.72	6.94	0.29	7.77	0.82	8.14	0.47	7.97	0.49
Warp coil	9.05	0.43	8.69	1.00	7.29	0.32	7.58	0.37	8.87	0.31	8.33	0.51

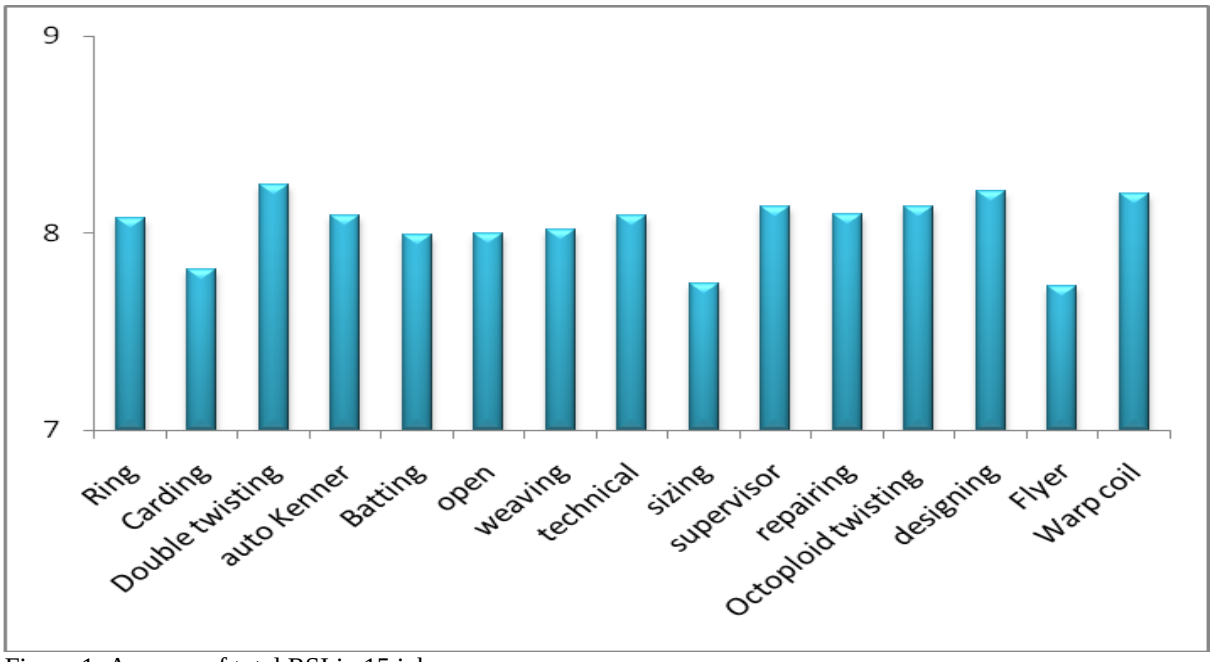

Figure 1. Average of total RSI in 15 job groups.

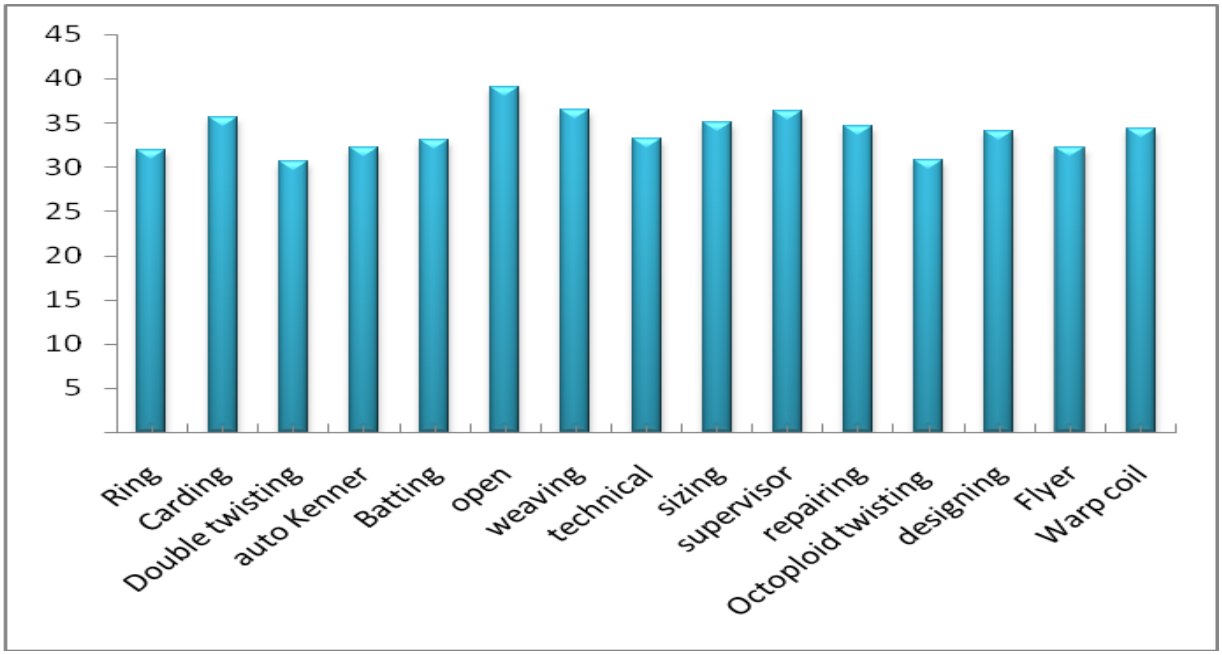

Figure 2. Average of WAI in 15 job groups.

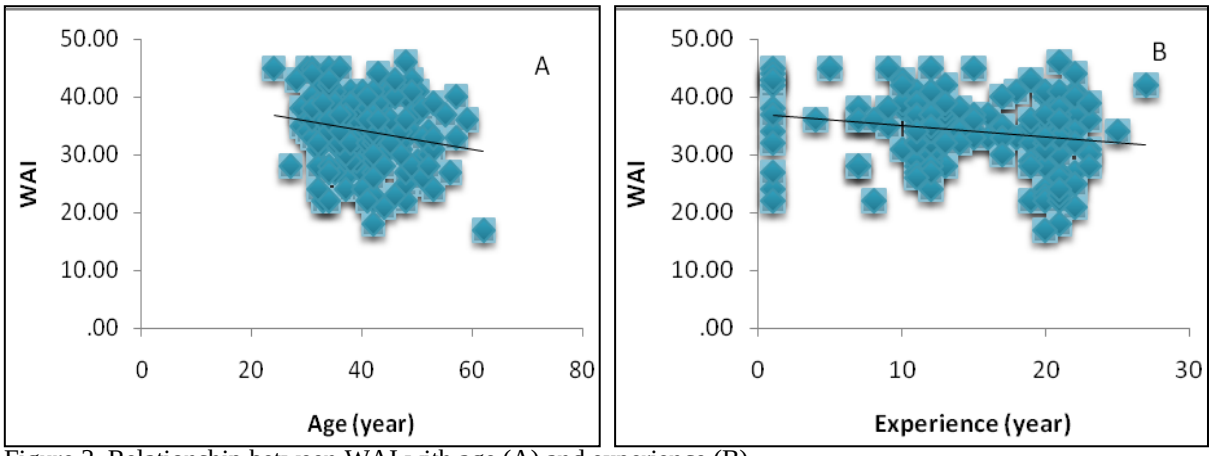

Figure 3. Relationship between WAI with age (A) and experience (B).

Relationships between RSI and WAI in job groups: Pearson Correlation Coefficient in order to relationships between RSI and WAI in different jobs revealed that in none of job groups there were significant relationships between six categories of RSI and total RSIs (RSIt) and work ability index (WAI). This means that there was no significant relationships by increasing or decreasing average score of each section of RSI index with changes in WAI. Table 4 shows results of Pearson Correlation Coefficient analysis for relationships between six categories of RSI with WAI. Also, Figure 4 shows relation between general RSI and WAI.Most bites occurred in rural area which is in line with findings of other studies (4, 6, 9, 10, 31), but it is in contrast with studies in Mashhad (13) and Bushehr cities (32). It seems that most families in rural area have a dog and their dogs do not have dog collar, thus leading to bites increase in this area.

Table 4.relationship between WAI and deferent RSI in job groups (MMH: manual material handling; WH: Hand work and PPE: Personal protective equipment).

		MMH	WH	Posture	Sensory	Environment	PPE
WAI	Pearson Correlation	0.063	-0.168	-0.049	-0.037	-0.040	0.050
	Sig. (2-tailed)	0.537	0.099	0.634	0.718	0.699	0.626
	N	194	194	194	194	194	194

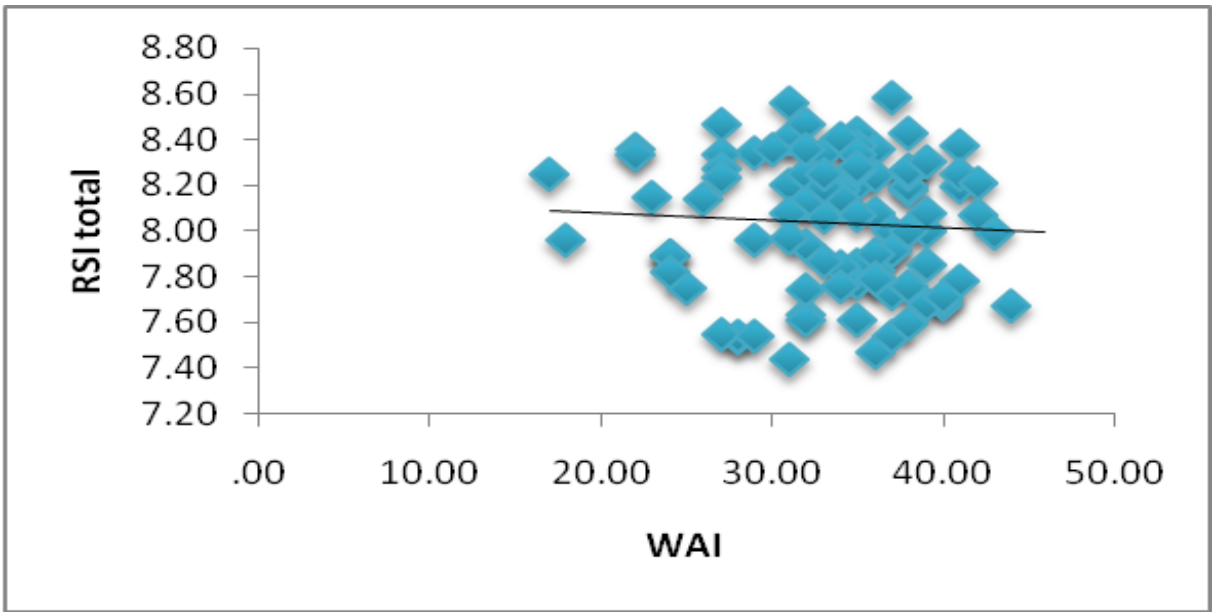

Figure 4. Relationship between total RSIand WAI in deferent job groups.

Discussion

Results of RSI index for 15 occupational groups showedthat all groups were in green zone (RSI larger than 7.6). Double twisting jobhadthe highest score with averageof 8.24±0.06 and Flyer has the lowest score with average and SD of (7.73±0.087) (Figure 1).Also the highest score of RSI was related to the category of manual material handling in designing job (9.19) and the lowest score was related to posture in Flyer (6.94). Therefore, this task in Flyer job placed in yellow zone.

The point worth of considering was that physical posture status in all 15 job groups and also senses status in job groups of octoploid twisting , Auto kenner, weaving, and repairing placed in yellow zone (Table 3). Main risk factors for physical posture includes long-term standing, no sitting and resting, kneeling, hunching, bending, head, body and arm rotation and bending, and also accesses below and above shoulder according to the job. Furthermore, about senses, continuous use of vision and focusing on performance of work is the main risk factors. Based on evaluation and analysis of results it is identified that as occupational groups divided into smaller groups and if decision-making on occupational risk factor being done for each individual separately, the value of occupational macro-ergonomic evaluation will be get higher by this index and one can better refer to its results for controlling occupational risk factors, because in job groups especially vast occupational groups, occupational needs and control and the balanced status between them for each person is different. Furthermore, Index Score Report for each person individually is closer to the occupational evaluation from macro-ergonomic

viewpoint, since macro-ergonomic looks on the balance between human and other elements of organization not human groups. By examining results (table 3 and Figure 1) it is clear that jobs cannot be evaluated based on general RSI since this index has reported green zone for all job groups (with no danger or no risk factor), while senses and posture status in many occupations is located in yellow zone (warning) that may decrease in to the red zone over time. Therefore, referring to the general RSI results produces a pseudo-trust that causes assessor to be careless about RSI of tasks. Also, the most task elements of this index (24.64 or 37.5% of it) is related to the environment section so in industries like textile industry that has not tasks like working in height, underground, and limited circumstances and etc, the average of this index for circumstances is equal to non-dangerous which is not close to the real situation although issues like moisture, noise, vibration and temperature are in the highest amount. So for appropriate usage of this index, general RSI score and environment RSI score are closer to the real situation if tasks non-relevant to the industry be omitted from the index and task elements be amended based on industry .

Another point about RSI index is related to the task element of "Manual material handling". In this part using aids like wheelbarrow for moving loads is not mentioned and since this is an interviewing index, non-analyzing it or non-using of appropriate modification for it, may change worker understanding of loads to the body and may report it more than actual amount. So, for more appropriate usage of this index have been recommended to use" pressure to the body when lifting a load" instead of this general expression.

Results of Work ability index (WAI) showed that the least amount of this score is related to double twisting (average of 30.66) and the most amounts is related to Open (average of 39.00). WAI is characterized based on 4 levels: Weak (7-20 score), mean (28-36 score), good (37-43 score), and excellent (44-49 score) (27). Based on this only occupation group "Open" has the good working ability and other groups have the mean working ability (Figure 3).

Also Pearson correlation Coefficient shows that there was reverse and significant relationships between WAI with age and work experience which means by increase in age and work experience of individuals in occupational groups, the amount of this index will decrease so because of nature of work and apparent decrease of it, physical loads of work will become more than ability of the individual by increasing in their age and the amount must be decreased (28). Work ability index shows their job satisfaction and it considers as an important factor in their work quality and safety, means that individuals having high WAI, have more ability to do their tasks and feel tiredness and disability more lately.

WAI is an index for working ability in relation to occupational needs and can measure balance between work and working ability among workers. This index examines effectiveness of occupational health interferences among workers and also examines workers exposing to working disability risk due to work, individually (29, 30). Therefore, for macro-ergonomic occupation evaluation and identifying their risk levels between individuals considering employees' working ability in each occupation is a necessary task. Work ability is resulted from interaction between individual sources and work. These sources include individual health, functional capacity, individual training, and how to determine the situation; these are influenced by individual ability, attitude, motivation, and job satisfaction. The individual can understand his own resources in his work and as a result organization, workplace, and working mental and physical needs

will be influenced. So as work ability index will evaluate individual ability with a person-centered approach and examine the relation between occupation, workplace and individual understanding and his ability, this is an appropriate tool for evaluating employee ergonomics.

Conclusions

According to RSI result, 15 occupational groups were safe and productive for employees. RSI of physical posture in all the 15 occupational groups and RSI of senses in occupation groups of octoploid twisting, Auto Kenner, weaving and repairing were placed in yellow zone. Therefore, by presenting engineering and management controls like physical posture analysis, ergonomics training, supervising on working process, and resting between work hours, the senses and posture status will be enhanced to green zone.

Based on results of WAI, individuals working in occupational group of "OPEN" had good work ability and other groups had the mean work ability . RSI in evaluating workers only identifies some levels of fitness for work in 6 levels of examination; meaning that it examines merit, fitness, the ability for successful performance of tasks and the most percent of this evaluation (37.5%) is related to the environment evaluation. Work ability index examines concepts beyond "fitness for work". By identifying working ability, this index expresses personal sources relate to social, mental and physical needs in work. Also the amount of working ability is dependent on working organization and management, organizational culture and workplace. Furthermore, based on meaningful results gained between age and occupational experience with working ability index in this study and previous studies, this index can reliably predict working disability , retirement and death rate. It seems that by amending RSI for different industries, detailed look on occupations and also paying more attention to individual ability, we can achieved detailed results by WAI , which final approval needs more study in the future.

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