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Original Article

Evaluation of Related Risk Factors in Number of Musculoskeletal Disorders Among Carpet Weavers in Iran

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ABSTRACT

Background: Musculoskeletal disorders (MSDs) are a common problem among carpet weavers. This study was undertaken to introduce affecting personal and occupational factors in developing the number of MSDs among carpet weavers.

Methods: A cross-sectional study was performed among 862 weavers in seven towns with regard to workhouse location in urban or rural regions. Data were collected by using questionnaires that contain personal, workplace, and information tools and the modified Nordic MSDs questionnaire. Statistical analysis was performed by applying Poisson and negative binomial mixed models using a full Bayesian hierarchical approach. The deviance information criterion was used for comparison between models and model selection.

Results: The majority of weavers (72%) were female and carpet weaving was the main job of 85.2% of workers. The negative binomial mixed model with lowest deviance information criterion was selected as the best model. The criteria showed the convergence of chains. Based on 95% Bayesian credible interval, the main job and weaving type variables statistically affected the number of MSDs, but variables age, sex, weaving comb, work experience, and carpet weaving looms were not significant.

Conclusion: According to the results of this study, it can be concluded that occupational factors are associated with the number of MSDs developing among carpet weavers. Thus, using standard tools and decreasing hours of work per day can reduce frequency of MSDs among carpet weavers.

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1. Introduction

Carpet hand weaving is common in many countries such as Iran, Pakistan, Afghanistan, India, Turkey, China, Egypt, Russia, and Nepal. Production of hand-woven carpets is one of the most important parts of small-scale industry [1]. About 12.2% of Iranian households gain more than 40% of their total earnings by carpet weaving [2]. Carpet weaving is a monotonous profession that requires long hours of static work. Because of the awkward posture, repetitive movements, contact stress, and long working time, it is a high-risk occupation for developing musculoskeletal disorders (MSDs) [3,4].

MSDs are a common health problem and a main cause of disability in the world. The economic loss from MSDs affects individuals and societies [5]. MSDs related to work are an essential problem in developing countries [4]. Prevalence of MSDs in Iranian carpet weavers is higher than in the general population in Iran and outbreaks of symptoms in upper limbs are higher than other limbs [6]. Many such as psychosocial, personal, occupational, and social factors are important in MSD prevalence [7,8].

In recent years, researchers have investigated related risk factors with developing MSDs. The effect of work station design in prevention of MSDs was examined in the carpet hand-weaving industry [5] and also the prevalence of upper limb problems associated with hand tools design among carpet weavers was studied [9]. Also, the association between sex difference and work stressor with the MSDs prevalence were explored in weavers [4]. Factors associated with upper limbs MSDs among female carpet

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weavers were examined by logistic regression [3] and the relationship of the MSDs among carpet weavers with working condition was examined [1]. In another study, MSDs among clerical workers were investigated [10]. Recently, the continuous assessment of the upper arm and back postures and estimation of biomechanical load subtasks using inclinometers were studied [11] and the prevalence of musculoskeletal pain and its association with psychosocial factors were determined among rural hand-woven carpet weavers in Iran [8]. The impact of the traditional and ergonomically designed workstations on trunk posture and cumulative compression load were evaluated in carpet weavers [12]; the researcher tried to estimate prevalence of MSDs or any relation between the MSDs and many factors.

The relationships of certain occupational and individual factors with the number of occupational injuries were evaluated by using random effects zero-inflated Poisson regression [13]. Poisson regression models with random intercept were fitted to explore prevalence of musculoskeletal pain by considering personal, occupational, and social characteristics in 28 countries [7].

Thus identification of related factors to reduce these disorders among carpet weavers is important. In the previous study [3], we found no research that identifies types of factors cause to decrease or increase the number of body parts MSDs among carpet weavers using count models. The objective of the current research is to investigate personal and occupational factors in developing the MSDs to introduce affecting factors in the frequency of MSDs among Iranian carpet weavers.

2. Materials and methods

2.1. Data

Data of this cross-sectional study were randomly selected from a list that included the name and address of weavers. Sample size was 862, and samples were selected using stratified random sampling from seven towns (Tabriz, Marand, Herris, Kashan, Nain, Golpayegan, and Kerman) with regard to workhouse location in urban or rural regions [3]. A questionnaire that consists of personal, workplace, and tools information and a modified Nordic MSDs questionnaire with seven questions about pain existence in upper limbs, including shoulder, wrist, forearm, arm, hand, finger, and elbow was used to collect data.

Choobineh et al investigated the reliability and validity of the Nordic questionnaire [14]. Mokhtarinia et al evaluated the reliability and validity of Persian version of this questionnaire [15]. They reported that all the items of the questionnaire had acceptable face validity. The intraclass correlation coefficient (> 0.7) and the standard error of measurement (0.56–1.76) were reported as acceptable and the Kappa coefficient was calculated as 0.78–1.00 [15].

2.2. Variables

For all studied individuals in this research, factors such as age (years), sex (0, female; 1, male), main job (0, no; 1, yes), work experience (years), carpet-weaving loom (0, moving vertical; 1, fixed vertical), weaving style (0, Turkish; 1, Persian), weaving comb (0, metallic; 1, wooden), were independent variables. The frequency of body parts involving the MSDs is a dependent variable ranging from 0 to 7.

2.3. Statistical analysis

In the data set related to the MSDs among carpet weavers in the towns, Y_{ij} is the number of MSDs in the i^{th} person and j^{th} town. The frequency of MSDs has count property among carpet weavers. We consider Y_{ij} as an independent random variable for an available event in any time and the occurrence of each event in each period, then, Y_{ij} has a Poisson distribution [16].

For appropriateness of this distribution is that the mean and variance are equal. If this assumption is not valid, the other distribution such as negative binomial (NB) may be appropriate [17].

The mean and the variance of the NB distribution are $E(y_{ij}) = \mu_{ij}$ and $\text{var}(y_{ij}) = \mu_{ij} + \alpha\mu_{ij}^2$. Then $\alpha = 1/r$ is over-dispersion parameter. When $\alpha \to 0$, the NB converges to Poisson distribution.

To measure association between the number of MSDs and mentioned risk factors in towns, a mixed Poisson regression was used. The mixed Poisson regression models are used for analysis of count data. In this model, it is assumed that random effect has log-normal or gamma distribution [18].

Because of significant over-dispersion parameters in Poisson gamma and Poisson log-normal models, an NB model with normal random effect was used.

In this study, the full Bayes approach is used for all the model parameters estimation. Classical methods for analysis of non-normal data are based on the asymptotic normality assumption that this assumption does not always holds [19]. Compared to the maximum-likelihood estimation, Bayesian methods are able to model the uncertainty of estimation and to incorporate the prior information [20]. Random effect create a hierarchical structure [21] and gets enough attractive for using Bayesian hierarchical approach [21].

The Gibbs sampler based on Markov chain Monte Carlo and noninformative priors were used. In the all-fitted models, the coefficients are modeled using noninformative multivariate normal, $N_\beta - \beta \sim N_k\,(0,10_k)$. It was considered two parallel chains for the variance component of random effect and gamma distribution $\Gamma(0.01,0.01)$ in Poisson log-normal and NB models. Also, it was considered a gamma distribution $\Gamma(0.01,0.01)$ for NB over-dispersion parameter. The prior of over-dispersion parameter was considered as gamma distribution $\Gamma(0.1,0.1)$ in Poisson gamma model. For independence between product samples, number of initial values are considered, such as 5,000, 5,000, and 10,000 and the number of lags of sampling as 30, 40, and 50 in Poisson log-normal, Poisson gamma, and NB models, respectively. Numbers of product samples were 5,000 in three models. Convergence of chains were examined with trace plots, Gelman–Rubin, Geweke, and Raftery–Lewis convergence diagnostics [21]. Bayesian Inference done based on statistical computations such as mean, standard deviation, 95% credible interval. The deviance information criterion (DIC) was used for comparison between models and model selection. Pearson Chi-square statistics were used for examination goodness of fit. The parameters of models were estimated using Open BUGS [22] and R [23] software. OpenBUGS (Bayesian inference Using Gibbs Sampling) is a computer software that analyses complex statistical models based on Markov chain Monte Carlo methods and it is the open source variant of WinBUGS that can run under Windows as well as from inside the R statistical package.

3. Results

For this study, mean (SD) of age, history, and the number of MSDs was 36.01 (14.80) years, 21.81 (15.37) years, and 2.54 (2.39), respectively (Table 1). The majority of participants (72%) were female. Carpet weaving was the main job of 85.2% of participants in this study. A metallic comb was used by 50.5% of carpet weavers and 49.5% used a wooden comb. The majority (67.5%) of carpet weavers used Persian weaving and others used Turkish weaving.

Table 1
Summary statistics of quantitative variables in models

Variable	Mean	SD	Max	Min
Number of MSDs	2.54	2.40	7	0
Age (y)	36.0	14.8	82	13
Work experience (y)	21.2	15.38	50	1

MSDs, musculoskeletal disorders; SD, standard deviation.

Fixed vertical and moving vertical looms were used by 32.4% and 67.6%, respectively (Table 2).

No MSDs symptoms were reported by 22.4% of the study sample; 20.5% reported symptoms in one region, 16.5% in two regions, 10.8% in three regions, 6.1% in four regions, 7.5% in five regions, 6.6% in six regions, and 9.5% in all seven regions.

Poisson models with gamma and log-normal random effect fitted for specific effects in towns. Best model selected by DIC. Values of DIC were 3,766.0, 3,768.0, and 3,531.0 for Poisson log-normal, Poisson gamma, and NB models, respectively. The NB mixed model has lowest DIC. The Geweke statistics were between −2 and 2 for all models. Gelman−Rubin statistics estimated close to 1 and dependence factor based on Gelman−Rubin diagnostic equal to one for all parameters. All convergence plots of Open BUGS indicated good mixing of chains. Thus, the criteria show convergency of three models. Based on 95% Bayesian credible interval, the main job and weaving type variables were significant, because the zero value did not lie within the credible interval. The main job variable had a positive effect on the number of MSDs. If the main job was weaver, this increased the number of MSDs by $\exp(0.304) = 1.355$ units. Also, the weaving type had a positive effect on MSDs. Using a Persian weaving cause $\exp(0.867) = 2.379$ increased the number of MSDs. Age, sex, weaving comb, work experience, carpet weaving looms were not significant. Because of heterogeneity of disorder among inhabitant people in the towns, the variance of random effect (sigma) was estimated at 0.204 in this model, which is statistically significant (95% credible interval = 0.217, 0.426; Table 3).

4. Discussion

According to the analysis, a random effect NB has the best goodness of fit on this data set, as deviance statistics of this model was the lowest (3521.0). There were more female than male carpet weavers. One of the important results in this study is the significance of weaving style on MSD occurrence, as workers who used Turkish weaving were exposed to MSD less than those who used Persian weaving. This result is similar to Motamedzade and Moghimbeigi [3], but it is in contrast with Choobineh et al's study [24]. Motamedzade and Moghimbeigi suggested that the reason for this paradox is the use of combs with lower weight in Turkish-style weavers [3]. The main job is also one of the most significant and important factor in the number of MSDs. This finding also is similar to Motamedzade and Moghimbeigi's study [3]. People whose main job was carpet weaver had greater risk of MSDs.

Choobineh et al showed that weaving comb is a risk factor for developing MSDs [5], but our study did not conclude that. Afshari et al showed that weaving comb for short periods results small increases the compression load on the lower back [12]. Afshari et al also mentioned using weaving comb as a risk factor for development of disorders in the shoulder region among carpet weavers [11].

In this study, people whose their main job is carpet weaving were in the majority (85.2%). These people want to find more income and be assigned more hours to this work. Allocating long hours to work and repeated movement to weave 30 nodes are risk factors for developing MSDs. This amount of work was 8 hours in 60% of weaving workers [24,25]. Afshari et al mentioned that the median of trunk flexion angle in weavers during knotting and compacting subtasks was 18° and 13°, respectively and for 4.5% of the working time, the weavers worked with arms elevated by > 45° [11].

Specific effect of every town is considered in the fitted models. Random effect is significant. This can be because of various conditions in every town that affect the MSDs [17].

One of the limitations in this study is that data collected with weaver self-reporting about MSDs. Furthermore, some variables aren't significant in comparison with other studies and it may be because of using different models in this study.

According to the results of this study, it can be concluded that occupational factors such as weaving style and main job are associated with developing the number of MSD among carpet weavers. The majorities of these problems are due to poor ergonomics and work posture and long hours of static working condition in the carpet industry. Thus, using standard tools and methods, and reducing hours of work per day can decrease the number of the MSDs among carpet weavers.

Table 2
Summary statistics of qualitative variables in models

Variable		Frequency	%
Sex	Female	638	77.2
	Male	224	27.1
Main job	Yes	734	85.2
	No	128	14.8
Weaving comb	Metallic	435	50.5
	Wooden	427	49.5
Weaving style	Persian	582	67.5
	Turkish	280	32.5
Carpet-weaving loom	Fixed vertical	279	32.4
	Moving vertical	583	67.6

Table 3
The negative binomial random effect model

Parameters	Mean	SD	MC_error	2/5%	97/5%
Intercept	0.2189	0.003148	0.004222	−0.1221	0.5428
Age (y)	0.04505	3.118	0.04294	−5.958	6.148
Sex (female = 1)	0.1137	0.08972	0.001127	−0.06188	0.2904
Work experience (y)	0.007971	3.143	0.04264	−6.025	6.193
Main job (yes = 1)	0.304	0.09911	0.00126	0.3037	0.4999
Carpet-weaving loom (Fixed vertical = 1)	−0.3102	0.1916	0.003675	−0.7244	0.04633
Weaving style (Persian = 1)	0.8668	0.2584	0.005168	0.415	1.439
Weaving comb (wooden = 1)	−0.2595	0.1453	0.002232	−0.5481	0.01574
Sigma	0.2036	0.1049	0.001958	0.07953	0.4691
r	0.4611	0.04883	0.04808	0.3709	0.5609

SD, standard deviation.

Conflicts of interest

Conflicts of interest all contributing authors declare no conflicts of interest.

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