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Assessment of Ergonomic and Occupational Health-Related Problems Among Female Prawn Seed Collectors of Sunderbans, West Bengal, India

Banibrata Das

South Calcutta Girls' College, University of Calcutta, Kolkata, India

Tirthankar Ghosh

Department of Physiology, Manipal College of Medical Science, Pokhara, Nepal

Somnath Gangopadhyay

University College of Science & Technology, University of Calcutta, Kolkata, India

Sixty female prawn seed collectors and 60 female control subjects from Sajenakhali and Sandeshkhali blocks of Sunderbans, West Bengal, India, were randomly selected to evaluate and compare musculoskeletal disorders and physiological stress. The control group was engaged in domestic work involving minimum hand-intensive activities. The modified Nordic musculoskeletal questionnaire and rapid entire body assessment were used. Most subjects suffered from discomfort in different body parts, especially in the lower back (98%), knees (88%), shoulders (75%), ankles (70%) and feet (67%). This study reveals that female prawn seed collectors suffer from significant physiological load and extreme physiological stress due to prolonged working hours in a standing posture and excessive work pressure. Consequently, all these factors affect female prawn seed collectors' health and work performance.

musculoskeletal disorders physiological stress prawn seed collectors hand grip strength rapid entire body assessment (REBA)

1. INTRODUCTION

Sunderbans is mainly known as the largest river delta as well as the largest mangrove forest in the world. Most people from Sunderbans depend on prawn seed collections, which are treated as the backbone of Sunderbans economy.

Women in rural India play a major role in shaping the country's economy, they are also regarded as the backbone of the rural areas [1]. Female prawn seed collectors are forced to do hard, manual and physically demanding work in prawn seed collection for a prolonged time. Women collect prawn seed to earn money for their families. They perform different activities in prawn seed collection, e.g., dragging a net (forwards and backwards), spreading a net and collecting seed.

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Correspondence and requests for offprints should be sent to Banibrata Das, 100 Biplabi Ganesh Ghosh Sarani, Bhadrakali, Dist-Hooghly, Pin -712232, West Bengal, India. E-mail: dr.banibrata@yahoo.com.

Awkward postures are mainly defined as postures used repetitively or for prolonged periods resulting in increased risk of fatigue, pain or injury [2]. They are sustained either actively by muscle contraction or tensile loads on bones, muscles, tendons, ligaments, etc. [3]. Most activities performed during prawn seed collection are very strenuous, because prawn seed collectors have to work in an awkward posture for a prolonged time in a repetitive manner.

According to Burdorf and Sorock, manual material handling, awkward back postures and heavy physical work are work-related physical risk factors for low back pain [4]. Hoogendoorn, van Poppel, Bongers, et al. state that work-related psychosocial factors, such as low job satisfaction, poor social support at work and high job demands, also cause low back pain [5].

The main aim of this study is to assess the occurrence of musculoskeletal disorders (MSD) among female prawn seed collectors. The study also assesses the collectors' physiological and psychological strain during prawn seed collecting activities.

2. METHODS

2.1. Location

The study took place in Sajenakhali and Sandeshkhali blocks of Sunderbans. The village is in the district of South 24 Parganas, in the extreme southeastern part of the state of West Bengal, India.

2.2. Selection of Subjects

The experimental group consisted of 60 randomly selected female prawn seed collectors. The control group consisted of 60 randomly selected women, who were engaged in domestic work involving minimum hand-intensive activities. Most female prawn seed collectors had 4–20 years of work experience in that occupation.

2.3. Basic Activities of Subjects

During high tide, tiger prawn seed come in a great amount due to the pressure from a sea. However, prawn seed are collected during low tide. Women collecting seed have to travel a long distance dragging a net forwards and backwards through 0.46-metre-deep[1] sticky mud and salty water on the river side. They also have to spread a net to collect tiger prawn seed. The female domestic workers dust and clean floors, wash clothes and clean kitchen, etc.

2.4. Physical Parameters

The height and weight of prawn seed collectors were measured with a Martin anthropometer (Takei, Japan) and a Crown weighing machine (Raymon Surgical, India), respectively. The body mass index (BMI) [4, 7] and the body surface area (BSA) [8] of all the subjects were also computed.

2.5. Questionnaire Study

The modified Nordic musculoskeletal questionnaire includes objective questions with multiple-choice responses [9]. For this study, the questionnaire was further modified. Questions on discomfort of the experimental group at different times (during work, after work, during sleep at night and 24 h after work) were added to make the study more reliable and precise. The questionnaire also included questions on type of work and affected body parts.

2.6. Hand Grip Strength

Collecting prawn seed is generally a hand-intensive activity, during which people drag a hand-operated net in unfavorable working conditions. Hand grip strength was measured before and after prawn seed collection. The physical examination consisted in female prawn seed collectors standing straight, without side bending, with arms at their sides, not touching the body and gripping a hand grip dynamometer (Rolex, India) with full force [10]. There were two measurements a day:

[1] 1.5 ft = 0.46 m

before and just after prawn seed collection. Because the value of grip strength varies in accordance with the elbow position, measures were done at 90° and 180° elbow flexion [11].

2.7. Working Postures

Working postures of the experimental group were analysed with REBA (rapid entire body assessment) to assess work-related risk factors for MSD [12].

2.8. Physiological Parameters

To assess physiological stress, heart rate of the experimental group was measured prior to work and just after work. Before work, heart rate was measured for one minute with a stopwatch from the radial pulse. Heart rate just after work was measured with a 10-beats method from the carotid pulse [13]. Blood pressure of the subjects was measured with a sphygmomanometer and a stethoscope (H. Mukerji & Banerjee Surgical, India) before and just after work.

2.9. Statistical Analysis

Analysis of variance (ANOVA) was performed to calculate the *F* ratio to find out whether there were any significant differences between physical parameters, hand grip strength and physiological stress among the two groups of subjects for the chosen level of significance ($p < .05$). A two-tail χ^2 test of independence was applied to determine whether or not the test item had any significant association with discomfort. The computed χ^2 was then compared with the critical χ^2 values for the chosen level of significance ($p < .05$). The adjusted prevalence odds ratios with 95% confidence intervals indicated the strength of the relation between MSD and the independent variables. Statistical analysis was performed with Primer of Biostatistics version 5.0 (McGraw-Hill).

3. RESULTS

Table 1 presents physical characteristics of the two groups (experimental and control). Data presented in Table 2 show significant differences in hand grip strength measured at 90° and 180° elbow flexion just after work. The control group had comparatively higher hand grip strength than the experimental group.

The questionnaire analysis showed that the experimental group complained of discomfort in different body parts. Most female prawn seed collectors suffered from low back pain (98%) (Table 3). Knees (88%) and shoulders (75%) were the second and third most affected body parts among the experimental group. Over 70% of female prawn seed collectors suffered from discomfort in ankles and 67% suffered from pain in feet; they also reported pain in the upper extremities (elbows, wrists, hands and upper back). This may be due to the fact that female prawn seed collectors have to walk through 0.46-metre-deep sticky mud and salty water for a prolonged time to collect prawn seed.

TABLE 1. Physical Characteristics of Female Prawn Seed Collectors and the Control Group

	Collectors		Control Group			
Characteristics	***M***	***SD***	***M***	***SD***	***F***	***p***
Age (years)	26.00	5.69	26.40	5.32	0.15	.704
Height (cm)	159.60	6.20	159.20	4.91	0.19	.661
Weight (kg)	46.60	6.78	47.20	4.45	0.38	.541
BSA (m^2)	1.43	0.11	1.44	0.07	0.25	.615
BMI (kg/m^2)	18.32	2.83	18.64	1.69	0.57	.454
Working experience (years)	9.66	3.77	10.62	4.38	1.64	.202
Duration of work per day (h)	5.63	1.08	6.00	1.05	3.50	.064
Duration of work per week (days)	6.18	0.77	6.16	0.66	0.02	.899

Notes. BSA = body surface area, BMI = body mass index.

TABLE 2. Differences of Hand Grip Strength Between Prawn Seed Collectors and the Control Group

	Collectors		Control Group			
Hand Grip Strength	***M***	***SD***	***M***	***SD***	***F***	***p***
90° elbow flexion						
resting	40.15	1.63	40.58	2.58	1.20	.275
just after work	38.35	2.06	39.22	2.26	4.80	.030
180° elbow flexion						
resting	40.15	1.63	40.58	2.58	1.20	.275
just after work	37.28	1.95	38.42	2.23	8.73	.004

TABLE 3. Discomfort (Pain) Among Female Prawn Seed Collectors (*n* = 60) and the Control Group (*n* = 60) Affecting Different Body Parts

Body Part	Collectors (%)	Control Group (%)	*OR*	95% CI	χ^2	*p*
Neck	39 (65)	7 (12)	14.06	[5.43, 36.36]	33.87	<.001
Shoulder	45 (75)	10 (17)	15.00	[6.12, 36.73]	38.80	<.001
Elbows	9 (15)	2 (3)	5.11	[1.05, 24.78]	3.60	.058
Wrists	15 (25)	2 (3)	9.66	[2.10, 44.46]	9.86	.002
Hands	31 (52)	13 (22)	3.86	[1.74, 8.56]	10.37	.001
Upper back	37 (62)	12 (20)	6.43	[2.83, 14.59]	19.86	<.001
Lower back	59 (98)	28 (47)	67.42	[8.76, 518.86]	37.61	<.001
Knees	53 (88)	27 (45)	9.25	[3.62, 23.64]	23.43	<.001
Ankles	42 (70)	18 (30)	5.44	[2.49, 11.88]	24.14	<.001
Feet	40 (67)	9 (15)	11.33	[4.65, 27.57]	31.04	<.001

Notes. OR = odds ratio, CI = confidence interval.

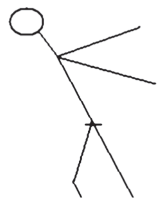
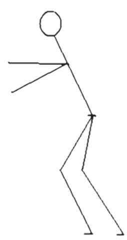
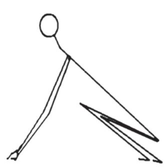
The predominant type of discomfort among the experimental group was pain in different body parts, followed by tingling (85%), numbness (53%), stiffness (38%) and swelling (12%). The control group also suffered from pain (46%), followed by tingling (28.0%), numbness (22.0%), stiffness (18.0%) and swelling (5.0%). An analysis of the questionnaire showed that the experimental group suffered maximum discomfort before and after sleep at night.

The analysis of female prawn seed collectors' body postures showed that most postures adopted during work were awkward and hazardous and required immediate corrective measures (Table 4). Female prawn seed collectors frequently adopted these types of body postures throughout the day.

An analysis of the questionnaire showed that the experimental group complained of discomfort (pain) in different body parts in different times of the day, especially after work and during sleep at night (Figure 1). Data showed that female prawn seed collectors suffered body injuries caused by the accidents at work (Table 5).

Table 6 presents physiological stress of the experimental and control groups. Resting heart rate of both groups did not show any significant change; whereas, just after work, heart rate of both the experimental and control groups showed significant change. Resting blood pressure (systolic and diastolic) of both groups did not show any significant change. However, blood pressure (systolic and diastolic) just after work differed significantly in both groups. There was no significant change in maximal heart rate and heart rate reserve between the experimental and control groups. There were significant changes in net cardiac cost and recovery cost.

TABLE 4. Analysis of Prawn Seed Collectors' Working Posture

Activity	Figure	REBA Score	Risk Level	Action Category
Moving forwards with a net		9	high	necessary soon
Moving backwards with a net		9	high	necessary soon
Spreading and setting a net		7	medium	necessary
Collecting and separating seed		8	high	necessary soon

Notes. REBA = rapid entire body assessment.

TABLE 5. Types of Injuries of Prawn Seed Collectors

Injury	Subjects Affected (%)	Body Parts Affected
Laceration	42 (70.0)	legs
Abrasion	37 (61.7)	hands and legs
Cut	32 (53.3)	legs
Avulsion	20 (33.3)	legs
Sprain	11 (18.3)	legs

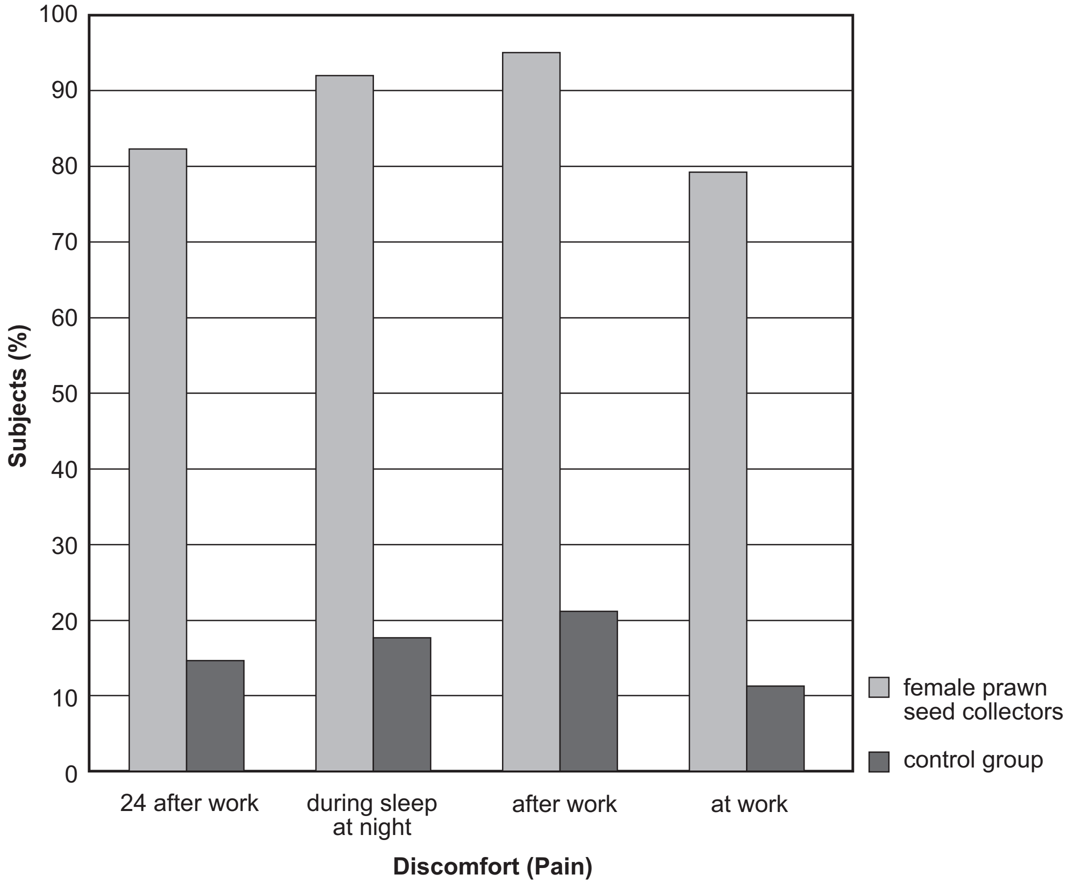


Figure 1. Discomfort (pain) at different times among prawn seed collectors and the control group.

TABLE 6. Physiological and Physical Workload Among Female Prawn Seed Collectors and the Control Group

	Collectors		Control Group			
Physiological Parameter	***M***	***SD***	***M***	***SD***	***F***	***p***
HR (beats/min)						
resting	73.60	6.38	74.7	5.74	0.99	.323
just after work	121.10	12.73	111.7	8.54	22.56	<.001
BP (mm/Hg)						
systolic						
resting	110.00	8.18	111.7	8.90	1.19	.278
just after work	124.80	7.28	114.5	7.75	55.76	<.001
diastolic						
resting	70.50	7.05	70.0	6.95	0.15	.696
just after work	79.40	6.51	77.0	4.88	5.22	.024
HR_{max}	194.00	5.69	193.6	5.32	0.16	.692
HRR	120.40	8.97	118.9	7.72	0.96	.328
NCC	47.50	7.87	37.0	5.72	69.89	<.001
RCC	64.46	8.91	49.8	8.22	88.23	<.001

Notes. HR = heart rate, BP = blood pressure, HR_{max} = maximum heart rate, HRR = heart rate reserve, NCC = net cardiac cost, RCC = relative cardiac cost.

4. DISCUSSION

This study revealed that different awkward postures of the experimental group could cause discomfort (pain). Most female prawn seed collectors had low socio-economic status. Money earned by them depends on the hours spent at work. Almost all subjects suffered from discomfort in different body parts caused by prolonged working hours, constant awkward postures and repetitiveness of the work. Repetitiveness of the work, prolonged working hours and awkward body postures during work may also lead to MSD [14, 15, 16].

From the observation of the working conditions of the experimental group, it is evident that female prawn seed collectors work in unfavorable conditions; they have to travel a long distance dragging hand-operated nets forwards and backwards through 0.46-metre-deep sticky mud and salty water. This may cause discomfort in different body parts, especially in the lower back (98%), knees (88%), shoulders (75%) ankles (70%), feet (67%) and hands (52%). Moreover, spreading a net and collecting seed are very strenuous activities. In most cases, the intensity and frequency of discomfort in different body parts increase with time. Women have to take frequent leave to recover temporarily. They suffer from several types of work-related injuries.

Hand grip strength of both groups was measured at 90° and 180° elbow flexion during rest and just after work. There was a significant difference in hand grip strength just after work between the experimental and control groups. If prawn seed collectors are constantly engaged in hand-intensive activities, they may develop discomfort in the upper body and significant changes in hand grip strength [17].

Several studies proved that work-related MSD were caused by multifactorial operations of various risk factors, such as working posture, repetitive and forceful activities and static muscle load [18, 19, 20, 21, 22]. Other studies reported an association of poor body postures with pain or symptoms of MSD [23, 24, 25, 26, 27, 28]. An analysis of working postures of the experimental group revealed that most postures needed to be changed as indicated in REBA action categories. Thus, it is evident that female prawn seed collectors working in an awkward posture for a prolonged time throughout the day suffer from MSD. According to Kivi and Mattila [29] and Gangopadhyay, Das, Das, et al. [30], awkward working postures are mainly associated with developing MSD.

Chaffin and Anderson [31] and Leskinen [32] argued that the number of forwards bend working postures influenced the compressive forces on vertebral disc and erector spine muscles. The present study shows that forwards bend postures and frequent waist twisting for a prolonged time during prawn seed collection activities are mainly responsible for developing MSD, especially in the low back. Gangopadhyay, Das, Das, et al. stated that MSD were mainly associated with constant awkward bending postures for a prolonged time [33].

This study also revealed that subjects mostly complained of intense discomfort (pain) that led to sleep disturbance, suggesting that sleep disturbance was a regular occurrence. Discomfort (pain) persisted during and after work. The intensity of discomfort was higher among the experimental group than among the control group. This finding suggests that a rigorous work schedule exerts a negative effect on subjects' physical health.

This study showed that during prawn seed collection activities, heart rate becomes high among collectors. According to Kroemer and Grandenjean, heart rate increases linearly with the work performed. Comparatively low heart rate increases quickly to the level appropriate to the effort and then remains constant for the duration of work. Moreover, during more strenuous work, heart rate increases until either the work is interrupted or a worker is forced to stop from exhaustion [18]. According to Shaver, the increase in heart rate is linear with the increase in the intensity of activities [34].

Female prawn seed collectors' heart rate and blood pressure (systolic and diastolic) just after work is high because of constant movement of the body. Moreover, when female prawn seed collectors bend forwards to drag a net, muscles of the abdomen contract and muscles of the back stretch. This contracting and stretching of the muscles require energy. Contracting and stretching of the muscles also take place when dragging and spreading a net and collecting seed in a forwards bend posture; therefore, the heart beats faster and supplies more blood to the muscles [35]. Guyton supported the results of this study: stretching muscles causes muscle vasoconstriction, which results in restricted blood flow and increased systolic blood pressure [36]. This study also revealed that there was a significant change in diastolic blood pressure due to the erect and rigid posture among the experimental group. Guyton also found that diastolic blood pressure increased in certain activities when a posture was erect and rigid [36]. Moreover, blood pooling in any part of the body causes muscle vasodilatation and an increase in diastolic blood pressure.

This study had some limitations. A retrospective study has to identify the long-term physiological and biomechanical stress among the experimental group. The other limitation of this study was that the results of an electromyographic study on dragging a net through 0.46-metre-deep sticky mud and salty water for a prolonged time were not available.

5. CONCLUSION

This study shows that female prawn seed collectors working continuously in a constant forwards and backwards bend posture may suffer from discomfort or pain in different body parts, especially in the low back, knees, shoulders, ankles and feet. The feeling increases if a bend posture is maintained for a prolonged time. Consequently, female prawn seed collectors are exhausted after such strenuous activities; this not only hampers their normal physical activities but also there is a possibility of developing serious MSD.

This study also proves that female prawn seed collectors suffer more pain or discomfort than women, who are mainly involved in household activities. Moreover, prawn seed collecting activities are extremely intense and as a consequence the feeling of discomfort not only prevails during work but also persists after work and during sleep at night.

Thus, it can be concluded that female prawn seed collectors suffer from physiological stress due to the hazardous working conditions and behaviour, which also affects their health and work performance.

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