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Physiological Aspects of Cordillera Weaving in the Philippines

Jennifer G. Inovero[1]*, **Analyn Salvador-Amores**[2], and **Jeffrey C. Pagaduan**[3]

[1]Human Kinetics Program
[2] Department of Anthropology, Sociology, and Psychology
University of the Philippines Baguio, Benguet 2600 Philippines
[3]College of Health and Medicine, School of Health and Sciences
University of Tasmania, Australia

This novel study examined the physiological aspects of weaving among 20 female weavers from the Cordillera Region of Northern Luzon, Philippines. Demographic profile and anthropometric measures were gathered, heart rate (HR) and posture were continuously monitored while the weavers performed a 30-min weaving task. Data were analyzed using mean ± standard deviation and Pearson's correlation coefficient to identify any relationship. Analysis was conducted using a commercial statistical package (SPSS version 25, IBM, Chicago, IL) with alpha set at 0.05 level. Data revealed that the weavers' blood pressure is at the prehypertension stage, body fat percentage relative to age is average, BMI value is classified as overweight, and WHR value showed that they are at risk from metabolic disorders. Results also showed that the occupational demands of weaving presented low cardiovascular workload and increased task difficulty resulted to more forward lean among weavers. Additionally, there was a linear relationship between HR and posture. These findings suggest the potential for increased risk for musculoskeletal injuries with weaving.

Keywords: Cordillera, physiology, posture, weaving

INTRODUCTION

In Northern Luzon, Philippines, weaving is a practice that is deeply embedded in the culture of the people and community. Weaving is the process of interlacing the "*warp"* (vertical threads) and the "*weft"* (horizontal threads) on a backstrap loom and a foot loom. Traditionally, most of the woven fabrics in the Cordillera are produced through the backstrap loom which entails body tension movement because as the weaver leans back, tension is produced to hold the warp in place. In the tedious weaving process, the women are likely to produce musculoskeletal problems, which were also observed during fieldwork in the Cordillera region.

*Corresponding Author: jginovero@up.edu.ph

Studies have illustrated that somatic symptoms can be traced to various conditions present in the work environment. Poor posture is a risk for musculoskeletal problems of the neck, shoulders, and lower back. Incorrect posture strains the hips and knees; faulty posture and weak and inelastic muscles are the leading causes of chronic low back problems. Dianat and Karimi (2016) noted a high prevalence of musculoskeletal complaints in the neck, lower back, and shoulders among Iranian handicraft workers engaged in different hand sewing tasks. Similarly, Sarkar (2016) also identified back, neck, knee, foot, and joint pain caused by the long working hours in various harmful positions on traditional looms and instruments of handloom weaving in India. Researchers also identified the link between posture and musculoskeletal disorders (MSDs) among workers in the production process, textile

factory workers, and weavers (Djiono and Noya 2013; Abraha *et al.* 2018; Mallapiang *et al.* 2021). Several other studies which used the rapid upper limb assessment (RULA) method to establish the relationship of work posture and MSDs in broom making, garment, and welding workers have shown that the high prevalence of MSDs is caused by poor working posture (Chaiklieng and Homsombat 2011; Van *et al.* 2015; Promsri 2017; Surahma *et al.* 2020). Moreover, Isler *et al.* (2018) used the rapid entire body assessment (REBA), and both RULA and REBA by Upasana and Deepa Vinay (2017) to analyze working posture and MSDs among workers in the clothing sector and tailors respectively. Upasana and Deepa Vinay (2017) found out that the majority reported a high rate of musculoskeletal discomfort associated with their workstation, tasks, and working postures.

In the Philippines, Miralao and Aguilar (1985) pointed out that the poor working conditions of the weavers in Baguio City and Benguet were directly linked to the low productivity in weaving and, hence, attributed to the low income of the local weavers. Consequently, these have caused the high prevalence of poor physical and health conditions of the weavers such as upper respiratory illnesses, back pain, poor posture, and eye problems, among others.

Up to date, there is no recent study that investigated the physiological indices of weaving in the Philippines. Such an undertaking may provide a better understanding of the working conditions that the weavers face. Thus, the purpose of this study is to identify the physiological aspects of weaving, particularly in this study, the weavers' HR and posture during the weaving task to promote better working conditions, specifically for the weavers in the Cordillera region.

MATERIALS AND METHODS

Participants

Twenty ($N = 20$) female weavers from the Cordillera region, North Luzon volunteered to participate in the study. There were four weavers each from Bontoc and Benguet province, five weavers each from Abra and Kalinga, and two weavers were from Ifugao province. The mean age is 38.6 ± 14.4 yr, where the youngest was 10 yr old from Kalinga province and the oldest is 69 yr old from Ifugao province who are both using the back strap weave. Eighteen weavers were using the foot loom technique.

Written informed consent was collected before further activity. The procedures of this study were approved by the regional office of the National Commission on Indigenous Peoples and do not fall within the purview of the Indigenous Knowledge Systems and Practices and Customary Laws Research and Documentation Guidelines of 2012 and, therefore, a free and prior informed consent process was not required. Further, the protocol of this study is adherence to the Declaration of Helsinki for Human Experimentation.

Procedures

Experimentation was administered for a single session located at the workspace of each weaver, with time-varying according to convenience. The subjects were given instructions to avoid any food intake two hours before experimentation. Demographic and anthropometric measures were gathered first before each weaver performed an actual weaving task for 30 min. During this task, HR and posture measurements were recorded. Since there was only one available piece of equipment used to measure these parameters, the weavers were tested

Figure 1. Backstrap (a) and foot (b) loom techniques.

consecutively. This procedure was patterned from a study made by Borah and Kalita (2016), which evaluated the physiological activity of the weavers during a 30-min weaving task using a chest strap HR monitor.

Measures

Height and weight. With the subject in a standing position, barefoot, and leaning against the steel bar, weight and height measurements were made. A steel stadiometer with a weighing scale (Detecto brand, USA platform type) was used to measure the subjects' weight expressed in kg and height in cm.

Blood pressure (BP). Using an Omron automatic blood pressure monitor (HEM-7200), each weaver was asked to sit on a chair with arms rested on a level armrest or table while measurement was being administered. Three consecutive measurements were recorded for each weaver. Blood pressure was expressed in mm/Hg and the corresponding HR was expressed in beats per minute (bpm). HR was also measured together with BP using the same equipment. A 1-min interval between each measurement was observed to reduce or possibly eliminate other factors, which can influence HR and BP recording. Possible feelings of anxiety over the equipment used with the handcuff slowly tightening over the arms and being excited or nervous about the task ahead were taken into consideration.

Body mass index (BMI). The BMI is based on the concept that a person's weight should be proportional to one's height and is a fairly accurate measure of the health risks of body weight for average people. It is calculated by dividing the weight in kg by the square of the height in m. Obtained values were interpreted using standard norms for BMI.

Waist circumference (WC). The WC assesses potential risk for disease based on intra-abdominal fat content. WC assumes that the total amount of body fat by itself is not the best predictor of increased risk for disease but the location of the fat (Hoeger and Hoeger 2015). WC is a better predictor than BMI of the risk of disease. Using an anthropometric tape, WC was measured at the smallest waist circumference.

Waist-hip ratio (WHR). The WHR is a simple method used to assess body fat distribution and identify individuals with a higher amount of abdominal fat. Health risk increases as WHR increases and the standards for risk vary with age and sex. Using an anthropometric tape, measure the circumference of the waist (above the iliac crest) divided by the circumference of the hips.

HR and posture. The HR and posture were measured using Zephyr Biopatch (Bioharness 3, Zephyr, USA), which was worn against the skin and attached to the center of the chest of each weaver. The weavers used their usual, comfortable clothing, which did not affect their movement. Repetitive forward lean, sweat produced, and probably the weavers' undergarment caused the Biopatch to be displaced in several instances during the 30-min weaving task but was immediately put back in place since this will affect data recording. Clothing was not considered as a potential contributing factor to HR and posture.

HR was measured using two disposable electrocardiogram (ECG) electrodes, where different sets were used for each participant. The Biopatch acts as a data logger that includes a two-lead ECG and tri-axis accelerometer to measure HR and posture respectively. Although the equipment includes a tri-axial accelerometer, the data of X and Z-axes were not available and only one output, dependent on the Y-axis was displayed for posture. Therefore, only Y-axis (degrees) was utilized to determine thoracic posture. Data are recorded continuously for 30 min, extracted offline using commercial software (Omnisense Analysis ver 4.1.6, Zephyr Technologies, USA), and exported to Microsoft Excel for further analysis.

Perceived workload and difficulty of design. A 10-point rating (1 = very, very easy; 10 = maximal) of perceived exertion (Table 1; Borg 1982) was utilized to determine the subjective intensity of work performed for 30 min and the difficulty of weaving design.

The Borg scale was described and explained to each weaver and they subjectively rated workload and difficulty of design accordingly.

Analysis

Data are displayed as mean ± standard deviation. Spearman's rank-order correlation was carried out to identify any relationship. Analysis was conducted using a commercial statistical package (SPSS version 25, IBM, Chicago, IL) with alpha set at 0.05 level.

Table 1. Borg's 10-point perceived exertion scale.

Rating	Description
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

RESULTS AND DISCUSSION

Twenty (20) female weavers from five provinces in the Cordillera region, North Luzon served as the participants of this study. The mean age of the weavers is 38.6 yr, with the youngest weaver at 10 yr old from Kalinga province and the oldest at 69 yr old from Ifugao province, both used the backstrap weave. The other eighteen weavers used the foot loom technique.

Measures

Height and weight. The mean weight and height are 57.7 kg and 148.8 cm, respectively.

Blood pressure. The mean value of the weavers' BP was recorded at 135/80 mmHg categorized at the pre-hypertension stage and 78 bpm average resting heart rate (RHR). Blood pressure measurements were made before the weaving task and, therefore, the weavers are still at rest. However, a high mean value for BP during rest is a serious concern on the health condition of the weavers. This implies chronic high blood pressure (hypertension), where a significantly high BP was recorded from the Bontoc weavers.

BMI. The weavers are classified as overweight with a mean value of 26 kg/m^2 and, therefore, are at increased disease risk.

WC. The mean value for WC is 64.8 cm, categorized as low risk. However, looking at BMI mean value in conjunction with WC, results showed that the weavers are at an increased risk from chronic diseases.

WHR. The WHR as a measure of regional fat distribution is an indicator of health and risk of developing serious health conditions. The weavers' mean value of 0.88 implies that they are at a high risk of suffering from chronic diseases.

Considering that the weavers are relatively young, their mean values for BP, BMI, WC, and WHR indicate poor health conditions. The weavers are already at the pre-hypertension stage, categorized as overweight, and both WC and WHR indicate that they are at high risk of suffering from chronic diseases. Chronic diseases are leading causes of disability and death in most countries and include heart disease, cancer, stroke, and diabetes, among others. The nature and demands of weaving tasks are contributing factors to this. These findings call for serious attention and, if not addressed immediately, the weaving tradition in the Cordillera may not be sustained.

HR. The mean HR of the weavers during the 30-min weaving task was 89.9 ± 2.15 bpm. Figure 2 displays the HR of the weavers during this task.

According to the American Heart Association, the average RHR is between 60–100 bpm. During work or exercise, HR is expected to increase. The mean HR of the weavers before the weaving task was 78 bpm and increased to 90 bpm during the 30-min weaving activity. This implies that weaving only entailed a low cardiovascular workload among weavers. In fact, their HR during the weaving task still falls within the range of average RHR.

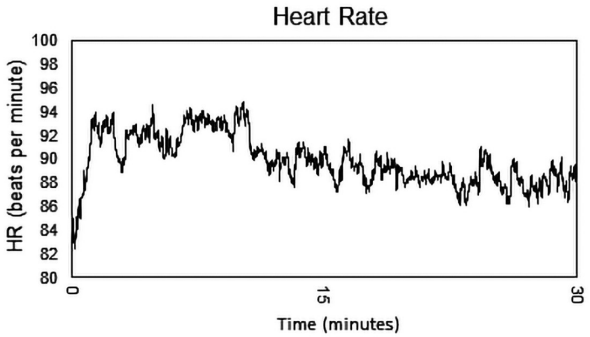

Figure 2. HR of weavers during the 30-minute weaving task.

A small increase in the HR of weavers from rest to activity may be explained by their RPE on the task itself and design, rated as "moderate" to "somewhat hard," respectively. Weaving requires the weaver to assume a sitting position. The metabolic equivalent of weaving is approximately 1.5 MET, which is considered a low-intensity activity (Choi et al. 2019). However, weaving entails prolonged sitting, where most weavers spend an average of 6–7 h/d, depending on orders placed, other household chores they need to do, or other work they are also engaged in. Some Ifugao weavers also work as farmers. Moreover, limb movements during the weaving task are repetitive, require meticulous hand-eye coordination, and have the lower back remain unsupported. Prolonged sitting with the back unsupported and repetitive limb movements may result in MSDs among weavers.

Posture. Figure 3 depicts the posture of the weavers during the 30-min weaving task, with a mean value of 2.96 ± 4.83 degrees.

The posture graph recorded using **Biopatch** was utilized to exhibit the postural trend in weaving, wherein the zero value demonstrates upright trunk position. Results showed dominant forward lean with weaving. This coincides with the findings of Borah and Kalita (2016), which demonstrated increased lumbosacral range of motion with the weaving task. The increased forward lean can be attributed to the nature of the weaving task itself and the design or pattern of the fabric where a more complex design may require more forward lean. Moreover, the forward lean may also be related to the weaving equipment (Borah and Kalita 2016). Traditional looms do not have

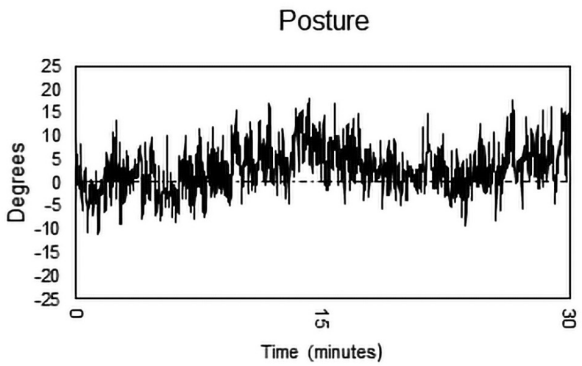

Figure 3. Postural deviation of weavers during the 30-min weaving task.

a backrest to support the back during the task while backstrap weaving involves sitting on the floor with the strap tied to the weaver's waist. This work-related postural deviation may potentially contribute to an increased risk of MSDs (Bori 2016; Durlov *et al.* 2014; Miralao and Aguilar 1985; Andersen *et al.* 2007; Dianat and Karimi 2016; Picavet *et al.* 2016; Sarkar 2016).

The weaving task involves prolonged sitting and repetitive limb movements. Common postural problems identified by the weavers in this study include prolonged back pain, lower back pain, cramps (hands), pain/stress in the shoulders, buttocks, feet, eyes, darkening of the skin in the buttock, formation of callus in the buttocks, knee pain, and pain in the arms due to the shifting of the shuttle. In the Ifugao foot loom (standing), pain in the feet, hips, shoulders, and arms was also pointed out.

Perceived workload and design. The RPE for workload and design were 3.50 ± 1.27 and 3.80 ± 2.50, respectively. These low scores in RPE suggest familiarization with the task and design executed by the weavers. It is important to note that the design and pattern of each weave are different for each province, and each weaver within a province also weaves a different design.

Relationship of Variables in the Study

The table below (Table 2) depicts the relationship between HR, posture, and RPE of both design and workload of the weaving process. Spearman's correlation revealed a significant relationship between HR and posture, $\rho = 0.48$, $p = 0.03$. The increasing HR response with the forward lean may be related to vestibulo-sympathetic responses with weaving (Yates *et al.* 2015).

In addition to physiological aspects of weaving, other problems pointed out by the weavers include low income and poor working conditions that they experience such as exposure to dust, fabric, and hot weather, particularly in the province of Abra. Weavers from Abra stressed that their income is not commensurate to the hard work they put in, which is one of the reasons why the younger generation is discouraged from weaving. As the family's main source of income, an exception to this is the weavers from Kalinga province, where all five children in a family are engaged in weaving to help augment the family's expenses. At a young age, they are already able to provide for their personal needs and their parents pay for their tuition fee only.

The weavers' income varies depending on demand from the market, rolls of fabric produced, and their pace in weaving. For Bontoc weavers, for example, they can produce two rolls/mo, and each roll has 100 yards of fabric. Each yard costs PHP 250, which has a total of PHP 25,000 less the cost of thread and labor. Labor costs PHP 55 for each yard. Bontoc weavers, however, do not have a direct market to sell their produce. This means that the weavers have to wait for purchases to be made before they can get a hand in their earnings. On average, they spend 10 h each day weaving. Weavers from Abra, Kalinga, and Ifugao – on the other hand – earn approximately PHP 200–300/d. Some Kalinga weavers weave based on orders and thus are being paid once their products are delivered. Miralao and Aguilar (1985) cited poor working conditions of weavers in Baguio City and Benguet as causes of low productivity attributed to the low income of the local weavers. Unfortunately, the same conditions are still faced by our weavers at present.

Due to the tedious process of weaving, health and postural problems raised, the young generation seems to be discouraged to continue the weaving tradition in some parts of the Cordillera. Such conditions also brought the decrease of the weaving industry in the region, primarily because of old age and the poor health of the weavers.

Table 2. Relationship of HR, posture, and RPE during weaving task.

	HR	Posture	RPE -workload	RPE-design
HR		0.48*	0.28	0.24
Posture	0.48*		0.08	0.30
RPE-workload	0.28	0.08		0.30
RPE-design	0.21	0.30	0.30	

*Significant at 0.05 level
**Significant at 0.01 level

Limitations

Limitations of the current study are acknowledged. First, the generalizability of results should be avoided as the results are only applicable to the participants of this study. Second, the weaving task only lasted 30 min. Physiological recording for a longer duration may elucidate information on the daily metabolic workload of weaving and provide more information on the cardiovascular and postural indices among weavers. Lastly, the use of the RULA, REBA, and other non-invasive methods to assess postural problems and determine physiological mechanisms can help explain increased health risks among weavers.

CONCLUSION

The purpose of this novel study was to identify the physiological profile of weaving tasks among female weavers in the Philippines. The findings showed that the occupational demands of weaving presented a low cardiovascular workload and increased forward lean among weavers. Anthropometric measures further indicated that the weavers are also at risk from suffering from chronic diseases. Future studies should warrant the reduction of work-related health risk among this population to be able to sustain Cordillera weaving.

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