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Design, implementation and evaluation of a participatory ergonomics program among home-based Mapuche weavers

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ABSTRACT
The Mapuche comprise 80% of the indigenous population of Chile. The Araucanía has the highest concentration of Mapuche peoples and is also the poorest region of the country. The region's proximity to a large tourist sector provides opportunities for weavers to work from home and sell their products as a primary or secondary income source. The adverse health effects related to craft production and home-based work are significant and not well described in the literature. Participatory ergonomics (PE), an approach that emphasizes the input and participation of individuals directly impacted by the work being studied, is a strong fit for this population. This article describes a PE project among 33 Mapuche weavers that characterizes the hazards, risks and perceived adverse health effects associated with home-based weaving and the identification, implementation and evaluation of three ergonomic interventions. This project can inform the development of sustainable ergonomics health programs for home-based artisans.

KEYWORDS
Indigenous; artisans; weaving; participatory ergonomics; hazards; community-based participatory research; interventions

1. Introduction

1.1. Mapuche people

The Mapuche account for roughly 80% of the indigenous population in Chile, or roughly 1.7 million people [1]. The Araucanía region of Chile, being the heart of Mapuche homelands and territory, has the highest concentration of the Mapuche peoples; their struggles in the region are well documented. During the Pacification of the Araucanía (1861–1883) the Chilean army stripped the Mapuche of their extensive lands used for subsistence farming and husbandry, and relocated them to reservations, or *reducciones*, negatively altering their way of life and forcing many to rely on small plots and temporary or seasonal work [2,3]. Today, the Araucanía is the poorest region of the country, in which over half of the Mapuche families live in rural areas in the *reducciones*, now considered 'communities'. They continue to farm small plots of land with limited access to water, continuous vulnerability to harsh climates and weak infrastructure [4–6]. The region's proximity to a large tourist sector, the Lake District, provides opportunities for artisans, including weavers, to work from home and sell their products as a primary or secondary income source [7,8]. The art of textiles is a foundation of their culture and economic activity, often led by the women.

1.2. The crafts sector and Mapuche textiles

According to the Alliance for Artisan Enterprise, the craft sector is valued at over USD 32000 million per year [9]. However, given the informal nature of this sector, workforce data are limited, often failing to capture home-based, part-time and rural workers, especially women [10]. In general, this workforce is predominantly made up of people in low and middle-income countries, who often pass skills from generation to generation, while providing additional subsistence work in the informal economy [11]. The craft sector is, in large part, home-based, and serves as an important income generator for women worldwide [12–15]. In 2006, the *Encuesta de Caracterizacion Socioeconomica Nacional* estimated there were 40,713 artisans in Chile, with 18% or 7500 identifying as weavers and roughly one-third of artisans residing in the southern region of Chile, where the Araucanía is located [16]. The craft sector consists of Mapuche artisans and tradespeople that produce handmade items such as textiles, ceramics, jewelry and decorative arts, some of which are livelihoods that have existed for hundreds of years. Indigenous Mapuche crafts are characterized by the use of materials that are locally accessible (e.g., plants, vegetables, wool) and provide a utilitarian need (e.g., baskets, shawls, bowls) while also serving as a form of cultural expression [17,18]. Mapuche textiles are entirely handmade using traditional mediums such as natural and synthetic dyes and Mapuche symbols. Many weavers and family members assist with wool production and wool dying activities.

Among Mapuche weavers, vertical handloom weaving is the most common type of weaving work [19]. Figure 1 illustrates a vertical loom and the associated tools.

Among this group, weaving steps include the following:

(1) Setting up the loom (*witral*): the loom is made up of two vertical wooden poles and two horizontal wooden boards, or *kilwos*, that can be adjusted depending on the width and height of the piece. The poles and boards are held together with ties, or *tientos* [19,20].
(2) Creating the warp: the warp acts as the foundation of the piece. The wool is wrapped around the posts or the posts and the *kilwos* in a loop or figure-eight fashion, resulting in front and back wool pairings [19,20].

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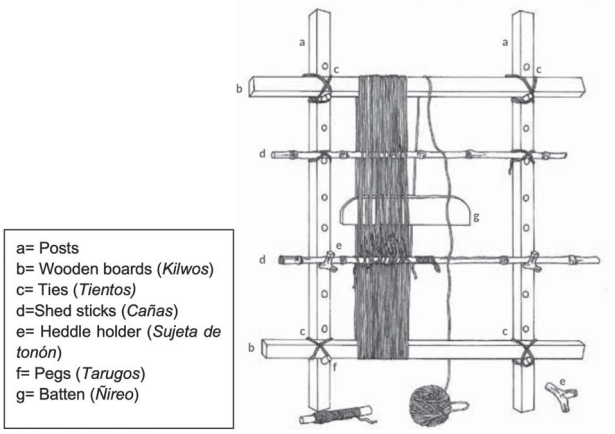

Figure 1. Vertical loom.
Note: Re-created with permission from Javiera Naranjo.

(3) Making the heddle holder (*tonón*): the heddle holder, usually a string of yarn, helps the weaver easily divide the front and back wool pairings by grouping and tying sets of the front pairings together. If there are several *tonóns* (e.g., the textile is wide), they are tied to a shed stick (*caña*) so they can be pulled at the same time [20].
(4) Inserting the *huachique* stitch: the *huachique* stitch helps stabilize the warp before creating the weft. It is a strand of wool that wraps around every one to two pieces of warp wool [20].
(5) Creating the weft and weaving: passing the wool lengthwise, across the opening created by the *tonón*, creates the weft. Many weavers use a batten, or *ñireo*, a wooden tool shaped like a half-circle, that separates out the front and back pairs and tightens the piece after each cycle [19,20]. One cycle can be defined as passing the wool through the opening of the front and back pairs and then crossing the warp so that the back pairs become the front pairs [19]. At the beginning, the weavers may be hunched over for long periods, and then gradually make their way to a seated or standing position.
(6) Finishing the piece: weavers typically finish the piece by hand with a needle [20].

1.3. Home-based work

Home-based crafters are predominantly female and include self-employed, small enterprise and piece-rate workers who are important contributors to family incomes [15,21]. They typically work independently or in small groups and depend on family members to help with work and/or home responsibilities [15,22–24]. This arrangement allows for flexible work hours and workday organization, but is also associated with long work hours, multi-tasking, isolation, cancelled orders, delayed payments, work-related costs and health hazards [15,21,23–28]. Examples of work-related costs include purchasing equipment, tools and materials, workspace upkeep and transportation for any work-related activities [15]. Given the informal nature of this work, workers are susceptible to hazardous working conditions including awkward postures, dusty and noisy spaces, poor lighting and ventilation, extreme temperatures, long working hours and stress [15,27–29]. This type of work is also associated with having high demands, low job security, low control and low wages as well as erratic hours [26,28,30]. The home workspace itself also poses challenges as work is often done in small shared spaces with distractions and limited space, which can negatively impact the workload and productivity [21]. A study of 447 home-based workers in India, Thailand and Pakistan, e.g., explored the range of challenges of this workforce including infrastructure, transportation and market access [28]. Participants identified crowded workspaces, power outages and flooding as infrastructure barriers that forced them to increase productivity and work longer hours to make up for lost work time [28]. Transportation also impacted work time as participants traveled to markets, to purchase supplies and deliver products, via inconsistent and costly public transport that caused them to miss deadlines [28]. Most studies demonstrate hardships and challenges faced by workers in urban settings, but few studies are available for craft workers in rural settings where other challenges, not mentioned, may arise.

1.4. Ergonomic features

Among the most commonly cited ergonomic hazards in weaving are awkward postures, repetitive movements and poor lighting [22,31–34]. Awkward postures include sitting, standing and bending for long periods, resulting in back, forearm and leg strain [22,32,35]. Moreover, weaving above the elbow can cause excessive shoulder and upper arm flexion, while weaving at or below the elbow can cause neck and back strain [31,36,37]. Repetitive movements, such as creating the warp and weft (vertical and horizontal components of a fabric), completing cycles and making designs can lead to tendon strain and soft tissue tears [32,38]. Psychosocial hazards such as stress, workload, job control, decision-making ability and job satisfaction are associated with adverse musculoskeletal effects [22,39,40]. For instance, a study of 546 rural home-based carpet weavers found an association between self-identified back, shoulder, wrist and hand pain with age, lack of time, low social support and low job satisfaction [40].

1.5. Community-based participatory research and participatory ergonomics

Community-based participatory research (CBPR) is a research methodology that includes participation of those who are affected by the issue or problem for the purposes of creating both new knowledge and social change, with a focus on benefiting the community involved [41]. This inclusion of community members provides a much-needed perspective in public health research that creates a deeper understanding of the various social, cultural and economic factors that shape experience and inform the development of interventions [41,42]. Moreover, this approach seeks to ensure that groups that are under-represented or marginalized, such as indigenous populations, are active participants, co-designers and decision-makers in these studies. Some of the key components of CBPR include: leveraging pre-existing resources within the community; continuous involvement of community members throughout the study; a reciprocal exchange of knowledge between researchers and community members with the intent of improving the well-being of the community; and sharing research knowledge and findings with community members [41]. A key asset of the CBPR approach is the emphasis on using a mixed-methods approach and adapting or creating new tools to meet the needs of study population [42,43].

Participatory ergonomics (PE) is grounded in principles of CBPR and can be best understood as 'the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals' (p.490) [44]. In addition to community members, PE studies typically include an ergonomics specialist as well as staff and management from the organization, if applicable [43]. Research linking PE and home-based work or the craft sector is very limited; however, research has yielded valuable insights that can be applied to this workforce. Several studies have stressed the importance of having a strong understanding of the risk factors, buy-in from management and workers, streamlined communication, education and training, and ongoing evaluations as part of an effective PE approach [45–49].

2. Materials and methods

2.1. Research setting

This study used a PE approach, including observations, surveys, semi structured interviews, audio recordings, photographs and visual aids. A combination of validated tools adapted for this population and newly developed tools co-designed and approved by a weaver participants was created for this study. A culturally appropriate, tailored approach allowed the study team to facilitate an ongoing dialog between the PE team and participants regarding health issues and potential interventions; to better understand the interplay between work and home responsibilities; and to identify the range of hazards associated with home and work responsibilities. This resulted in a rich relationship-building opportunity and mutual trust. A convenience sample of 33 home-based Mapuche women weavers were identified with the assistance of a non-governmental organization (NGO) that was created in 2012. The goal of the NGO is to protect the values and improve the economic conditions of indigenous women by assisting them in designing and producing high-end textiles, while preserving intergenerational Mapuche weaving techniques and patrimonial designs. On a monthly basis, the weavers, who reside in eight communities in southern Chile (Imperial, Carahue, Padre Las Casas, Ercilla, Pitrufquen, Puerto Saveedra, Temuco and Labranza), traveled to the NGO's office to pick up and drop off their products, as well as attend meetings and workshops. It was important to gain their trust before the fieldwork even began. Weavers were approached during each phase of the study by the principal investigator (PI) and asked whether they would be interested in participating. The study was described to the weavers and written informed consent was obtained by the PI prior to the interviews, in accordance with the University of Illinois Chicago (UIC) Institutional Review Board (IRB) (Protocol #2015-0833). The 33 weavers who agreed to participate ranged in age from 23 to 60 years, with a mean of 26 years of weaving experience. In addition to working with the NGO, most participants worked under contract with other weaving organizations and also sold their weaving products independently.

2.2. Project components

Like CBPR, PE requires consensus-building around the design of the research. In order to obtain a comprehensive understanding of the historical, social, cultural and economic factors that impact the health issues of home-based rural Mapuche weavers, the study team adapted and developed a mix of quantitative and qualitative tools with extensive feedback from participants. They are described in detail in the following sections.

2.2.1. Establishing relationships with collaborators and participants (December 2014–September 2016)

Using a community-based participatory approach is key and requires long-term dialog to develop consensus around the weavers' participation in the study. Developing relationships was a multi-year process that involved finding a Chile-based weaving NGO and a researcher with expertise in community-based research who, in turn, could act as intermediary between the weavers and the research team; finding a local IRB in Chile to support the study; establishing the PE team; and partnering with a local company to provide products (headlamps) and a local organization to provide services (eye examinations). Many of these activities were a result of design elements that emerged from the weavers in the different phases of the study. Figure 2 shows a timeline depiction of these relationships.

2.2.2. Understanding the for-profit NGO

Located in Labranza, Chile, the NGO office is located centrally to the most densely populated communities of weavers employed by the NGO. Additionally, several weavers serve as NGO Board members and, currently, one weaver serves as the Quality Control Director. The weavers collaborate with the NGO to preserve and incorporate Mapuche cultural symbolism and weaving techniques in a range of sheep and alpaca wool textiles and clothing sold all over the world [50]. Individuals who want to join must be recommended by a current NGO weaver. Their work is assessed by completing an already designed sample for the NGO based on a specification sheet. If the sample meets the criteria (correct final measurements, no dangling or orphan threads, finished to specifications), then the weaver is contracted by the NGO. Weavers are paid monthly based on the number of products they commit to weave and whether the products pass quality control inspection. Because weavers have other obligations, they are given the flexibility to decide how much work to complete each month. Additionally, it is not uncommon for weavers to take 1–3 months off from working with the NGO to focus on their farms, host family members, travel or rest.

The following is an overview of a typical month working for the NGO:

- Picking up work: weavers take one or two buses, mostly from rural areas, traveling for 1–2 h to the office where they meet with the Quality Control Director or Operations Director to discuss the type (with design vs without design; item type and hours) of work they will be responsible for that month. Each item has a specification sheet that includes an item description and illustration as well as measurement information and design and finishing details that is reviewed with the weavers. NGO staff give weavers the corresponding amount of wool for the products and they jointly decide on a due date.
- Weavers work and are in communication with the NGO staff regarding questions, issues and upcoming due dates.

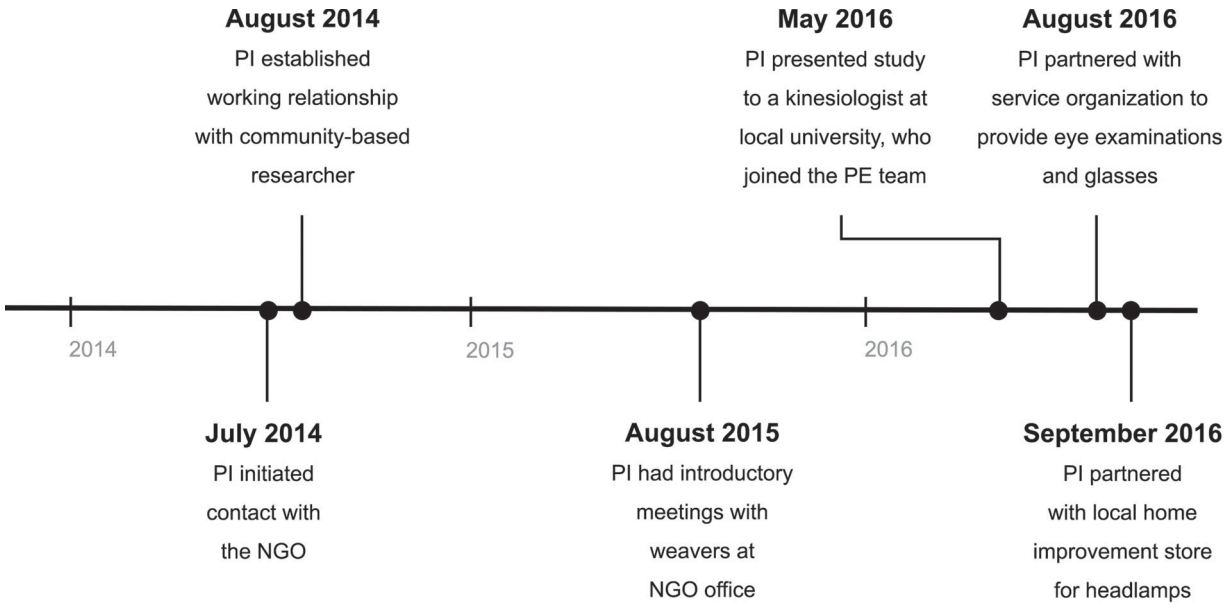

Figure 2. Timeline of study relationships.

Note: NGO = non-governmental organization; PE = participatory ergonomics; PI = principal investigator.

- Delivering products: weavers travel to the office, as already described, to meet with the Quality Control Director. If the woven piece is approved, it is accepted as a final product, and the weavers receive payment at the end of the month. If there are problems with the item, the Director reviews the issues with the weavers and the weaver has the option of addressing the issues and bringing the item back at a later date or leaving the product as is. If the weaver decides to address the issue, she is only compensated for the previously agreed-upon price of the final product and not the unforeseen extra time required to finish the piece appropriately.
- Payment: all weavers are paid at the end of the month for the products they deliver.

2.2.3. Developing, testing and administering the study protocol (February 2016–August 2017)

The study fieldwork took place between December 2015 and August 2017 during which time cognitive testing was also conducted on all of the study tools. Table 1 presents an overview of the study tools that will be discussed in the following sections.

Table 1. Overview of data collection tools and interventions.

Study tool	Sample (*n*)	Data collection time period
Work and health survey	33	February–June 2016
Workplace characterizations	6	April–May 2016
Contextual interviews	10	April–June 2016
Intervention 1: headlamps	40	September–October 2016
Intervention 2: kinesiologist workshop	23	October 2016
Intervention 3: eye examinations	32	February 2017
Evaluation survey	20	July–December 2017

2.2.4. Work and health survey tool

The work and health survey tool was adapted from the work of Terry Snyder, a senior ergonomist at PS Associates [51]. As part of the PE approach, the PI added new questions regarding weaving experience, tasks and seasonal variation in work based on interviews with the weavers and a literature review. The full survey included questions about workday organization, weaving tasks and weaving injuries, as well as workspace characteristics and demographic information. Given the limited educational backgrounds of many weavers, especially the more senior members, visual aids including a body outline and drawings representing different types of work were used to help them answer questions about health issues and seasonal variations in work. The survey was pilot tested among eight participants at the NGO office and modified based on feedback. The Spanish language survey was developed and administered through Qualtrics (2018) when Internet access was available and on paper when it was not [52]. The survey was administered orally in Spanish by the PI and took approximately 20–25 min to complete. The survey responses were exported from Qualtrics into a Microsoft Excel spreadsheet (version 16.10.0).

2.2.5. Introductory visits and workplace assessments

To better understand the workspaces, workday organization and environmental and occupational health hazards, the investigators conducted home visits with 16 weavers. NGO staff assisted the investigators in identifying weavers who would allow for capture of variation based on geography (representation from five of the eight communities, rural vs urban), experience, weaving style (design vs no design) and workspace type (dedicated workspace and common area workspaces). The research team – the PI, an NGO weaver (a member of the PE team), the community researcher and an NGO staff member – observed the workspace, took photographs and watched the weaving work. After sharing the results with the weavers through general analysis and statistics, the research team shared this information with the PE team to inform the identification and development of future interventions.

The investigators conducted more in-depth workplace assessments among six of the weavers' homes. This convenience sample included weavers who weave with and without a specified design, weave large and small pieces, and weave in dedicated workspaces and in common areas. The workplace characterization tool was developed based on a literature review of health issues associated with weaving and using two tools to document and analyze the weaving process. The task and hazard identification tool was developed for this study to capture weaving steps, duration, hazards (physical, biomechanical, psychosocial, biological, chemical) and affected body parts [53]. The ergonomic assessment tool was adapted from the quick exposure check (QEC) to analyze each step in more detail, including identifying repetitive tasks, describing the equipment and specific task actions, measuring the cycle length (defined for each step), and light and body angle measurements, where appropriate [54]. The investigators also measured the loom width and height, the seat height and the distance between the loom and the seat. The tool was pilot tested on three weavers and updated based on user feedback.

2.2.6. Contextual interviews

Contextual interviews serve a dual purpose: they allow the researcher to observe subjects working and ask clarifying questions in real time; and they allow subjects to explain, demonstrate and narrate their work [55]. The PI and researcher conducted 10 contextual interviews with a convenience sample of weavers from different communities, weaving experience and workspace types. Based on the findings from the work and health survey tool, the introductory visits and workplace assessments, the investigators developed a Spanish-language interview guide with questions surrounding workday organization, scheduling rationale, weaving skills and experience, workspace, self-identified health issues, perceived causes and potential solutions. Sample questions include: 'How long have you been weaving, either as a hobby or a job?', 'Tell me about your typical workday', 'How would you describe your workspace?' and 'Do you experience any pain or discomfort when you are doing this task?'. The interview guide was pilot tested among five weavers to check for understanding and question clarity. These interviews were audio-recorded and supplemented with photographs, videos and written observations. Each interview took place in the weaver's home and lasted 3–6 h. Data from the contextual interviews were analyzed independently by both the PI and the researcher in Spanish. A codebook was developed and reviewed by both investigators; the audio files were uploaded into Atlas.ti version 7, and the PI transcribed the interviews verbatim in Spanish. Each interview and visual aid were coded independently, followed by a meeting between the PI and the researcher to review and reconcile any coding disagreements.

2.2.7. Developing and implementing the interventions

In accordance with the CBPR approach, the PE team met throughout the study and reviewed data from the baseline survey, workplace assessments and contextual interviews to identify potential interventions to the weavers for their input. The most common and concerning health problems identified by the weavers were eyestrain and shoulder, back, neck and wrist pain. The PE team drafted a number of potential interventions based on their knowledge of ergonomics and experience with weaving, and presented these back to the weavers for their input regarding perceived effectiveness and comfort with, or barriers to, implementation of the proposed intervention. Three selected interventions were: a workshop with a kinesiologist; improved lighting via headlamps; and eye examinations and eye glasses. Each intervention is described in more detail in the following.

2.2.8. Evaluation survey

Once the selected interventions had been implemented for at least 9 months, the research team conducted an evaluation survey, which included health questions previously administered as part of the work and health survey and new questions focused on the individual interventions. However, while the health questions from the work and heath survey were framed around the past year, the evaluation survey questions asked about health problems in the past month. This decision was made to ensure capturing all three interventions, which were launched at different times. The survey consisted of 29 items with specific focus on: participation at each intervention; use of intervention; perceived changes (if any) in one's work for each intervention; and perceived changes (if any) in health for each intervention. The survey was piloted with five weavers at the NGO office to check for understanding and clarity of the new questions and adjusted.

3. Results

3.1. Work and health survey tool

As part of the work and health survey ($N = 33$), participants were first asked about an array of health problems, their potential causes and treatments (if any). Participants were shown a visual aid depicting the front and back of a body to help facilitate the discussion around health problems. Table 2 presents demographic characteristics from this sample. Table 3 provides a summary of these self-identified health problems, causes and treatments. In addition to these health problems, three participants also identified knee pain (9%), followed by kidney pain ($n = 2$) and hand, knuckle, ankle and leg pain ($n = 1$). Other problems identified included fatigue ($n = 1$), diabetes ($n = 1$), hernia ($n = 1$), sinusitis ($n = 1$), allergies ($n = 1$), psoriasis ($n = 1$), dizzy spells ($n = 1$) and depression ($n = 1$).

3.2. Workplace characterizations ($n = 6$)

As part of the workplace characterizations, the investigators observed six weavers in their home workspaces while they were weaving NGO products including a shawl ($n = 2$), manta (shawl) ($n = 1$), a scarf ($n = 1$), a blouse ($n = 1$) and a dress ($n = 1$); with and without design. Figure 3 shows a fieldwork photograph of a weaver applying pressure to the vertical wool strands (warp) in order to pass through the wool horizontally to create the weft. Two of the weavers had dedicated weaving workspaces while the remaining four worked in their respective living/dining room areas. The investigators attempted to observe as much of the weaving work as possible; however, given the distance to the weavers' homes, lack of reliable transportation and roads, the investigators were only able to observe the weavers for 8–10 h as part of the observation. The pieces took between 16 and 56 h, or 2 and 4 days, to complete. For any work the team was not able to observe directly, the weavers were asked to keep track of the time

Table 2. Work and health survey: demographic characteristics of home-based Mapuche weavers ($n = 33$).

Demographic variable	Response
Age (years), mean	46.2
Age range (years), *n* (%)	
23–29	2 (6.1)
30–39	8 (24.2)
40–49	9 (27.3)
50–59	10 (30.3)
60	3 (9.1)
Unspecified	1 (3.0)
Education, *n* (%)	
Basic school	26 (78.8)
High school	4 (12.1)
University	1 (3.0)
Technical school	1 (3.0)
Unspecified	1 (3.0)
Marital status, *n* (%)	
Single	4 (12.1)
Married	19 (57.6)
Long-term relationship	5 (15.2)
Divorced/separated	2 (6.1)
Widowed	1 (3.0)
Unspecified	2 (6.0)
Number of dependents, *n* (%)	
0–1	19 (57.6)
2–3	13 (39.4)
≥ 4	1 (3.0)
Years of weaving experience, mean	26.0
Years working with non-governmental organization, *n* (%)	
≤ 1	14 (42.4)
2–4	10 (30.3)
≥ 5	9 (27.3)

spent on each task and provide that information. Data from each workplace characterization (observations, photographs and videos) were analyzed and summarized to obtain the following: weaving steps; duration of repetitive tasks; weaving hazards; and affected body parts. Table 4 presents a breakdown of this information.

3.3. Contextual interviews ($n = 10$)

The contextual interviews ($n = 10$) provided the opportunity for participants to expand on their health issues, causes and treatments. Throughout the interviews, participants were asked about health problems associated with their work (paid and non-paid) as well as potential causes and treatments. The most commonly cited health problems were eyestrain ($n = 7$), back pain ($n = 6$), shoulder pain ($n = 5$), arm pain ($n = 4$), hand pain ($n = 4$), neck pain ($n = 3$), wrist pain ($n = 3$) and finger pain ($n = 3$). When asked about potential causes, the most common response was weaving-related activities. As part of the contextual interviews, participants cited housework ($n = 10$), farm work ($n = 7$) and childcare ($n = 4$) as the most common types of unpaid work. Housework activities included cooking, cleaning, doing laundry and collecting firewood. The most commonly identified hazards related to non-weaving work were biomechanical in the form of awkward postures, repetitive movements and heavy loads associated with cleaning, doing laundry, cooking, planting fruits and vegetables, and looking after livestock.

For each interview, the investigators and subject developed a 'day in the life' time-wheel visual that captured the different types of work subjects carried out (i.e., paid work, domestic responsibilities, childcare) including start and end times and seasonal variations. This visual was developed at the beginning of the interview to help facilitate conversations around time management health issues, potential causes and treatment. Data from these visual depictions were summarized to calculate total work hours and average hours associated with each task. Figure 4 shows a sample depiction of this visual. Results from this portion of the study will be described in a later publication.

3.4. Interventions

3.4.1. Kinesiology workshop ($n = 23$)

Weaver participants expressed interest in being seen by a kinesiologist to help them address and prevent ergonomic problems. A kinesiologist from a local university (and a member of the PE team) developed a 1-day workshop with four components: an interactive educational presentation; a loom demonstration; individual examinations; and exercises that could be carried out at home. Figure 5 depicts the exercise session led by the kinesiologist. The workshop, presented by four kinesiologists, was held at a co-working space in Temuco, about half an hour from the NGO office. The weavers were provided with free transportation and 23 weavers participated.

3.4.2. Headlamps ($n = 40$)

Many participants described the challenges of weaving due to poor natural and artificial lighting. Electrical outages also occurred frequently enough that participants identified this as a barrier as well. Many weavers suggested using headlamps to address these challenges and the PE team agreed that this intervention to address the identified problems, allowing the weavers to re-direct the beam, would be ergonomically sound. The kinesiologist identified headlamp models that would be a good fit for this population and the PI worked with a local home improvement store to donate 40 battery-powered modifiable headlamps. Proper use of the headlamp was demonstrated as part of the kinesiologist's workshop (Figure 6) and depicted on an educational pamphlet created by the kinesiologist and shared with all the weavers.

3.4.3. Eye examinations and glasses ($n = 32$)

Eyestrain and vision problems were the most commonly cited health problems among participants. As part of the surveys and contextual interviews, several participants shared that they could not see an eye doctor due to long waiting lists (with some participants stating they had been waiting for 2–3 years to be called), not having the funds to cover the examination and eye glasses, and not having access to an eye doctor in their village. The PI reached out to the local Lions Club chapter in Temuco and they agreed to provide eye examinations and eye glasses to participants at a reduced cost that the project funds were able to cover. The optometrists agreed to set up stations at the NGO office to conduct eye examinations and eye-glass fittings (Figure 7). NGO staff provided transportation to weavers who did not have access to transportation while other weavers arrived at the office by bus. In total, 32 eye examinations were completed and 32 eye glasses were prescribed and purchased for the weavers.

Table 3. Self-reported health problems, causes and treatments ($n = 33$).

Health problem	Cause	Treatment
Eyestrain ($n = 22$)	• Weaving ($n = 7$) • Pre-existing health issue ($n = 7$) • Fatigue ($n = 1$) • Need for glasses ($n = 1$)	• Trying to schedule appointment with optometrist ($n = 6$) • Taking breaks ($n = 4$) • Not weaving at night ($n = 3$) • Improved lighting ($n = 2$)
Headache ($n = 22$)	• Pre-existing health issue ($n = 4$) • Fatigue ($n = 3$) • Eyestrain ($n = 2$) • Stress ($n = 2$)	• Aspirin/ibuprofen ($n = 10$) • Physician treatment ($n = 7$) • Rest ($n = 3$)
Back pain ($n = 17$)	• Weaving ($n = 8$) • Fatigue ($n = 3$) • Stress ($n = 2$)	• Physician treatment ($n = 5$) • Rest ($n = 4$) • Stretching ($n = 2$) • Aspirin/ibuprofen ($n = 3$) • Cream ($n = 1$)
Shoulder pain ($n = 15$)	• Weaving ($n = 13$) • Stress ($n = 2$) • Fatigue ($n = 1$)	• Cream ($n = 6$) • Rest ($n = 7$) • Physician treatment ($n = 5$) • Stretching ($n = 1$) • Aspirin/ibuprofen ($n = 2$) • Massaging ($n = 3$)
Neck pain ($n = 7$)	• Weaving ($n = 3$) • Stress ($n = 2$)	• Massage ($n = 1$) • Ibuprofen/aspirin ($n = 1$) • Physician treatment ($n = 1$) • Rest ($n = 1$)
Trouble breathing ($n = 7$)	• Weaving ($n = 3$) • Stress ($n = 1$)	• Physician treatment ($n = 3$) • Mask ($n = 2$) • Rest ($n = 2$) • Inhaler ($n = 1$)
Wrist pain ($n = 6$)	• Weaving ($n = 4$)	• Wrist guard ($n = 2$) • Ibuprofen/aspirin ($n = 1$) • Cream ($n = 2$)
Finger pain ($n = 6$)	• Weaving ($n = 1$)	• Cream ($n = 2$) • Massage ($n = 2$) • Physician treatment ($n = 1$)

Figure 3. Photograph of a weaver applying pressure to separate the wool.
Note: Fieldwork photograph 2016.

3.4.4. Evaluation survey (n = 20)

Nine months after the first intervention was implemented, an evaluation survey was administered to participants. The evaluation survey included previously administered health questions as part of the work and health survey and newly developed questions focused on the interventions, including whether they were maintained throughout the period and barriers to and facilitators of use. Due to project timeline limitations, the study team was only able to survey 20 participants, five of whom had not completed the work and health survey. Overall, participants rated each intervention very positively. The evaluation survey focused on each intervention individually, providing valuable information about how individual interventions are being used, and captured self-reported

Table 4. Summary data from the workplace characterizations ($n = 6$).

Task	Duration	Hazard type	Affected body part(s)
Setting up the loom (*witral*)	0–30 min	Biomechanical ($n = 6$) Physical ($n = 2$) Chemical ($n = 6$)	Whole body
Creating the warp	90–450 min (observed and estimated)	Biomechanical ($n = 6$) Physical ($n = 2$) Biological ($n = 6$) Psychosocial ($n = 6$) Chemical ($n = 6$)	Hand, shoulder, arm, wrist, back, legs, eyes
Making the heddle holder (*tonón*)	8–10 min	Biomechanical ($n = 6$) Chemical ($n = 6$)	Shoulder, arm, hand, wrist, back, neck, eyes
Putting in the *huachique* stitch	6–8 min	Biomechanical ($n = 6$) Chemical ($n = 6$)	Shoulder, arm, hand, wrist, back, neck, eyes
Putting in the batten (*ñireo*)	30–40 s	Biomechanical ($n = 6$) Chemical ($n = 6$)	Eyes wrist, hand
Creating the weft and weaving	14–48 h (observed and estimated)	Biomechanical ($n = 6$) Psychosocial ($n = 6$) Biological ($n = 6$) Chemical ($n = 6$)	Back, neck, hand shoulder, arm, wrist, legs, eyes
Finishing the piece	0–3 h (estimated)	Biomechanical ($n = 4$) Psychosocial ($n = 4$)	Hand, shoulder, arm, wrist, eyes

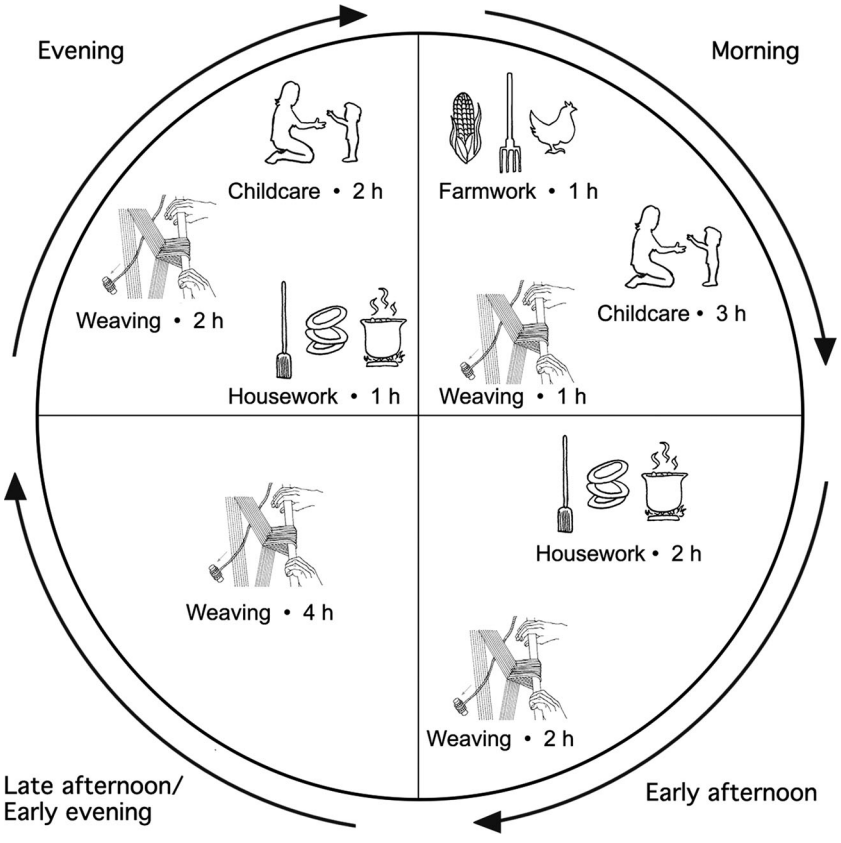

Figure 4. Sample 'day in the life' time-wheel visual.

health and work changes for each intervention. Results from this portion of the study will be described in a later publication.

4. Discussion

This is one of the first studies we are aware of that applies a PE approach to home-based craft workers, and specifically women, both being a large and understudied population in the crafts sector. This study followed participants from ethnographic interviews through a careful ergonomic assessment, planning of interventions, intervention implementation and evaluation of effectiveness. The combination of surveys and observations provided the study team with a comprehensive understanding of the range of weaving and non-weaving factors that could contribute to ergonomic problems. Drawing on others' work, we used the work and health survey [51], observations, measurements and contextual interviews to facilitate discussions around daily work and non-work-related tasks, self-identified health issues, causes, self-administered treatments and attempted interventions. We used this information to develop and evaluate well-known, but also culturally appropriate and acceptable, ergonomic solutions. We examined

Figure 5. Photograph of arm stretching exercise led by the kinesiology team.
Note: Fieldwork photograph 2016.

home-based workspaces via participants' own words, photographs and researchers' notes. A major strength of this study is the ongoing support and collaboration with the NGO that worked directly with participants. This organization is committed to improving the health of the weavers and has identified funding opportunities to ensure that the interventions that result in ergonomic improvements are sustainable.

This work yielded valuable insights and information that can be applied to home-based workers and artisans. First, the work and health survey tool elucidated demographic characteristics of the population as well as data on type of work (paid and unpaid, seasonal vs annual), weaving experience and self-identified health issues, causes and treatments. This information was supplemented with introductory visits and workplace assessments, which provided a deeper understanding and documentation (via notes, photographs and videos) of weaving tasks, weaving tools and weaving hazards. Next, the contextual interviews yielded narrative descriptions of work processes, health issues, causes and potential interventions. The 'day in the life' time-wheel visual developed for each participant facilitated important discussions around workday organization, balancing work and home responsibilities, multitasking and family support. After reviewing data from the surveys, visits, workplace assessments and contextual interviews, the PE team identified and presented potential interventions to participants. The three interventions – a kinesiologist examination and a 1-day workshop; headlamps; and eye examinations and glasses – were implemented and evaluated 9 months later. The evaluation included questions from the baseline survey and tailored questions focused on the interventions, health changes and interest in continuing the interventions. Poor eyesight, headaches, shoulder and back pain are among the most common health problems reported by participants, with weaving as the most recurring reported cause. Participants rated the interventions very positively, and while health problems persisted, participants reported a reduction in eyestrain and neck, wrist and finger pain. Each component described in this article (baseline survey, introductory visits and work assessments, contextual interviews, interventions and evaluations) will be explored in more detail in future publications.

This study also has several limitations. First, this study is made up of a small convenience sample ($n = 33$) of home-based weavers who use horizontal looms, making the generalizability of our findings difficult. For example, we did not capture weavers who worked outside the home or in cooperative settings. Second, the use of home-based workspaces introduced the possibility that non-intervention components may have influenced self-reported health issues, causes and interventions. Examples of these components include other paid work, domestic responsibilities, childcare and exposures or hazards introduced by other family members in the home. We attempted to identify these issues in the baseline and evaluation surveys as well as the contextual interviews by asking about primary and secondary jobs and related exposures. Third, participants were followed over an 18-month period, which can introduce attrition and maturation effects making it difficult to tease apart whether any reported changes in health effects can be attributed to the ergonomic interventions or to normal life events. Relatedly, we proposed implementing

Figure 6. Photograph of a kinesiologist adjusting a headlamp on a weaver.
Note: Fieldwork photograph 2016.

up to three ergonomic interventions at the same time, which made it difficult to attribute the self-reported effects to a single intervention. Next, we obtained self-reported health data as part of the baseline surveys, contextual interviews and evaluation, which could introduce recall issues. The NGO's involvement in the project and general business structure posed a major limitation. While the NGO's wages are higher than their Chilean competitors and weavers are able to work from home and control their workload, quality control is stricter [56]. An observation the research team made was the need to cater job tasks to the specific needs and limitations of the weavers, i.e., weavers with poorer eyesight or with smaller weaving spaces would be provided pieces without designs or symbolisms, while mothers with young children could be tasked with the smaller pieces to finish each piece quicker. Likewise, the company's support and involvement in this project, including introducing the project to the participants, may have biased participants' responses to the surveys and interviews even though participants were informed that their responses would not be shared with the company.

5. Conclusions

A PE approach is well suited to fully capture the range of hazards, health issues and causes that are associated with home-based craft work and address them in a way that is culturally appropriate. Moreover, the adaptation of existing tools and the development of new tools that were pilot tested could be used by other investigators and validated for other populations. Triangulation of findings further validated these survey tools. The participants' attendance and uptake of the interventions selected by the PE team suggests that the selection was on target for addressing critical needs; early results suggest effectiveness of the interventions. Strong collaborations between an NGO committed to the health of the weavers, local professionals (kinesiologists, optometrists) invested in

Figure 7. Photograph of a participant undergoing an eye examination.
Note: Fieldwork photograph 2017.

providing much-needed services and the research team comprising an occupational health expert and a community-based researcher were vital to the success of this study. Specifically, situating these services within a centralized location, accessible to all participants (e.g., the NGO office or a site that was accessible by bus) could contribute to the sustainability of the participants' needs. Finally, the CBPR and PE approaches have proven successful in other settings and this study shows that they are a strong fit for indigenous, home-based and craft workers owing to their emphasis on involving individuals directly impacted by the issues and developing or adapting culturally appropriate tools.

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