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Chronic lower back pain in aquaculture clam farmers: adoption and feasibility of self-management strategies introduced using a rapid prototype participatory ergonomic approach

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Abstract

Background: Lower back pain (LBP) is extremely prevalent in seafood harvesters who often have limited or no access to ergonomic consultation, occupational health support and rehabilitation services.

Purpose: This pilot study aimed to describe a participatory ergonomic approach and determine feasibility and extent of adoption of self-management strategies in clam farmers with LBP.

Methods: A rapid prototype participatory ergonomic approach was used to develop context-specific self-management strategies. Options to adjust lifting and repetitive stress were introduced using video clips, demonstrations and discussions in the workplace. Workers chose and implemented 3 strategies for 8 weeks with weekly reminders. Survey and qualitative data from focus groups were analyzed.

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• All authors have reviewed the article.

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Study was approved by the University of Florida IRB201702245 and registered as a Clinical Trial NCT03524378

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There was no financial interest or benefit to the authors from the direct applications of this research.

Results: Team strategies were the most popular, but individual options were used more often. Strategies were considered feasible, acceptable and relatively easy to use. Strategies were implemented relatively consistently, and most improved productivity with decreased pain. Challenges for uptake included changing habit, culture and team dynamics.

Discussion/Conclusions: Participatory rapid prototyping provided a feasible and efficient option to introduce strategies for clam farmers with small teams, variable work processes and workloads, and time restrictions. Strategies were considered acceptable, easy to use and most increased productivity. These methods show potential for future research.

Keywords

Lower back pain; participatory ergonomics; seafood harvesting; action research; feasibility; acceptability; clam farmers; aquaculture

1. Introduction

Chronic musculoskeletal pain is extremely prevalent in commercial seafood workers, impacted by repetitive processes and heavy lifting required for harvesting, processing and shipping product [1,2]. The incidence and location of injury varies based on the type of fishing, work processes and experience [2,3]. The majority of published data on injury prevention in the fishing industry has focused on fatalities and severe injuries related to trauma, with less emphasis on repetitive strain injuries [4–7]. However, the overall prevalence of musculoskeletal disorders (MSDs) in the commercial fishing industry has been recognized as a priority that needs to be addressed [8]. Musculoskeletal repetitive strain injury prevalence ranges from 21 to 63% in the aquaculture industry [9], while lower back pain (LBP) has been reported by 50–80% of deep sea fishing crews [10,11] and lobstermen [12] and as many as 73% of artisanal shellfish workers [13–15]. There are descriptive and quantitative studies of ergonomic stresses in sectors such as crab pot and gill net fishing [2,16–18], and qualitative studies of worker and manager opinions of factors leading to injury or possible prevention [5–7,19]. There are also prevention tips and ergonomics training programs developed from surveys and focus groups with community participants for commercial fishing [8]. However, there is a limited evidence of the effectiveness of interventions to address repetitive strain musculoskeletal injuries such as LBP in the fishing industry [7] and more specifically in aquaculture farmers.

The aquaculture sector is a diverse and expanding sector where farming of aquatic organisms occurs in a controlled environment and includes both self-employed and employed workers [9,20,21]. Shellfish can be harvested in the natural environment or farmed in an aquaculture process from seed to market-ready maturity. The limited research on work-related MSDs in shellfish workers has focused on female artisanal gatherers using manual techniques to harvest, clean and prepare the shellfish [13–15,22,23]. In Brazil, higher prevalence of pain was found in shellfish harvesters who worked longer than 26 years, worked in a flexed sitting position or used high upper extremity manual forces [13]. In a large study of primarily female shellfish harvesters in Spain (n=929), 65% reported chronic LBP with the extent of disability related to the number of regions of musculoskeletal pain and pain intensity using surveys [14,22,23]. In the only intervention study found, the same authors also described a 16-session therapeutic exercise program improved trunk muscle endurance, pain intensity, and decreased back pain incidence in 19 shellfish gatherers [24].

In an ongoing occupational health and safety surveillance project targeting seafood workers along the Florida Gulf coast, commercial clam (*Mercenaria mercenaria*) farmers identified chronic LBP as a major problem impacting their quality of life and longevity in the industry [25]. Clam aquaculture in Florida is a multi-process operation where lease-holders and growers control reproduction, larval development, and production of young “seed” clams. Production of marketable hard clams in Cedar Key typically takes 12–18 months, with small teams responsible for all tasks from planting to harvesting [26]. Clam farmers typically work in teams with variable job tasks; most workers lift the heavy bags and baskets as well as stand or sit for repetitive tumbling, grading and other tasks. Some larger teams divide tasks with individuals taking responsibility for lifting or more stationary cleaning, sorting and packing. As such, there are multiple positions and movements that can lead to overload, repetitive stress and localized forces in the lower back region. While the nature of physically demanding labor makes complete resolution of pain challenging, preventing exacerbations and functional disability is extremely important for workers who cannot afford to take time off from income-generating activities. There is, therefore, a need to identify options that are feasible in this work environment to reduce cumulative stress and overload while maintaining work productivity. The majority of seafood workers have limited or no access to ergonomic consultation, occupational health support or rehabilitation and work is often prioritized over seeking medical treatment[27]. The aquaculture industry in Cedar Key is no exception with the added barrier of no rehabilitation providers in the local vicinity and limited access to medical providers in this relatively remote and isolated rural area. Independent contractors or small businesses employ 3–12 workers or use temporary workers. Few workers can afford to take time off for medical appointments especially with the need for travel. Therefore, innovative options are necessary to provide sector-specific interventions.

One option to address this problem is a participatory approach designed to engage stakeholders and involve them in identifying solutions to address LBP. Participatory ergonomics is defined as: ‘participation of those performing the work activities using a problem-solving approach to reduce risk factors’ [28,29]. Workers problem-solve and implement new processes or alternatives with varying degrees of guidance or support [30,31] to identify feasible interventions to best address occupational requirements [32] The ownership and interactive nature of the process contributes to adoption of context-specific modifications needed for different work responsibilities. Antle et al. from the SafetyNet Centre for Occupational Health and Safety Research [30] suggest that methods for gathering data include interviews with workers to determine: 1) areas of musculoskeletal pain, 2) workstation, psychological and organizational factors, 3) job tasks and operations. Video recording is recommended for objective analysis of tasks and operations to determine specific movements and postures contributing to loads and accumulation of stress on the body [30].

There are positive outcomes reported from participatory ergonomic programs with increased productivity and improved health outcomes for individuals with MSDs in industry, healthcare and business [28,29,32–36]. However, these methods are not as widely used in agricultural or seafood sectors where physically demanding tasks are the norm and organizational support for prevention is limited. Participatory processes have been proposed as a useful method to address repetitive strain injury in seafood industries [7,27,37]. Kincl et al.[7] suggest that participatory processes could help identify potential factors for cumulative trauma in the Dungeness crab fishing crews, particularly as relative acceptance of overuse injuries as part of the job seems to be common in seafood industries. Fulmer et al.[27] also recommended participatory research methods for future studies in lobster and other seafood industries as a community-driven model for capacity building to prevent future injury. In addition, participatory approaches have been recommended for addressing work-related musculoskeletal conditions experienced by workers in small and medium size groups in remote or rural locations [38]. This approach may therefore be useful for individualized choices for ergonomic self-management.

The National Institute for Occupational Safety and Health (NIOSH) recommends physically removing, replacing or isolating workers from hazards that cause bodily injury as the highest impact solutions for major occupational injury [39]. Ideally re-design of the workplace is preferred rather than modifying behavior, however, workplace adjustment in small teams and businesses in the aquaculture industry are often constrained by costs and limited access to ergonomic consultants. There are also limitations in implementation of industry-wide equipment or workplace modifications for these small teams or independent contractors [8]; as the diverse settings, limited work spaces, unstable boat platforms and wide task variety make standardized recommendations more difficult [8,9]. In some contexts, changing the way people work or adjusting processes may be more feasible than major equipment or workplace modifications. Self-management approaches, including coping strategies, are recommended to reduce disability and manage pain in patients with chronic LBP [40–43], and may be a valuable component of participatory interventions, especially when there are financial constraints for major ergonomic redesign.

Successful participatory ergonomic processes take time to develop based, in part, on the need for comprehensive stakeholder input related to their unique work environment and tasks. Participatory ergonomics are aligned with action research approaches used successfully in rehabilitation [44] and injury prevention [33,36]. This research method involves a reflective cycle of data collection, reflection and action to enable change in short timeframes and integrate information gleaned from understanding implications of culture, context and social relationships [45]. In a similar approach, a working prototype or 'rapid prototyping' model has been used to speed up engineering, education and software design for context-specific strategies and allows improvements from early prototypes [46]. An iterative cycle using an early prototype may be a useful component for participatory ergonomic research to expedite research while ensuring relevance of interventions aimed at influencing behavior [47].

There is therefore a need to investigate the feasibility of strategies that can be implemented individually or in teams for smaller work groups with limited resources such as the aquaculture industry in Cedar Key Florida. This pilot study aimed to: 1) describe the participatory ergonomic approach using a rapid prototyping action research process, 2) determine feasibility, and 3) extent of adoption of self-management strategies in clam aquaculture farmers with LBP.

2. Methods

This pragmatic participatory action research pilot study [47] was implemented in three phases: 1) development of a rapid prototype list of tasks and strategies, 2) Phase I pilot for methods and prioritization of self-management and ergonomic strategies in a small number of participants and 2) Phase II evaluation of feasibility and adoption of self-management strategies in a larger cohort using adjusted research methods and prioritized strategies. Continuous evaluation allowed for prioritization and adjustment of methods and strategies in the rapid prototyping and Phase I phases (Figure 1). The project was approved by the University of Florida Institutional Review Board (IRB201702245) and registered as a Clinical Trial NCT03524378.

2.1 Subjects

Full-time clam workers in Cedar Key, Florida area were recruited through the local Aquaculture Association and enrolled in the study if they reported LBP > 3/10 (*0=no pain, 10/10 most severe pain possible*) for more than 3 months, had no history of hospitalization in the past year or spinal surgery in the past 3 years, were not seeking disability, and were currently working in the seafood industry.

2.2 Instruments (Phase I and II, Table 1)

In both Phase I and II, participants completed a demographic survey and instruments to identify the most problematic work tasks. They rated the level of difficulty with these tasks (Patient Specific Functional Scale. PSFS) [48–51], pain with the work tasks (PSFS Pain), as well as general LBP-related functional difficulty (Oswestry Disability Index, ODI) [35–37], and pain-related affective measures. (Table 1) In Phase II, additional visual analogue scales were used to collect the patient's reported average, least and most pain, work intensity (light, medium, hard) and number of hours worked per week during initial and final data collection. After completing 8 weeks of the self-selected team or individual strategies, participants completed the same instruments as baseline. In the final surveys, participants reported the number of days and percentage of work time they used each strategy and how many weeks (out of 8) they used the used the strategy for more than 50% of the time. They also rated the ease or difficulty of use for each choice and if they felt the strategy impacted their productivity (*yes/no/possibly*). Finally, they commented on whether they would recommend the strategy for other clam farmers with low back pain. In both phases focus groups were conducted at the end of the study to discuss participant opinions of feasibility and opinions of the strategies. Discussions were recorded, transcribed and coded.

2.3 Participatory action phases (Figure 1)

2.3.1 Rapid Prototype Development—Potential strategies were developed from early interviews with a few key stakeholders, workplace observation and review of videotapes of workplace activities collected during previous surveillance research. Investigators reviewed work processes (Tasks analysis for clam aquaculture farming Online supplemental material) using videos collected during the surveillance research study leading to this pilot [25] and developed a preliminary list of tasks and strategies that served as a rapid prototype to initiate discussions with clam farmer teams.

2.3.2 Phase I: Pilot for methods, prioritization of task list and strategies—

Nine eligible workers from 3 clam farmer teams provided informed consent and were enrolled in Phase I. One team of 3 individuals withdrew due to changes in the company ownership prior to completion, with two three-person teams completing the study in Phase I. After discussion of potential strategies to minimize accumulation of lower back stress, participants reviewed the prototype list and indicated whether they considered each potential strategy as feasible (*yes/no/possibly*), likely to be beneficial (*yes/no*), and the frequency they were using possible strategies on an ordinal scale (*0, 25, 50, 75, 100%).* Participants were then asked to select 3 preferred strategies to use for 8 weeks.

On a separate occasion, work teams were videotaped performing their typical work tasks with selected video clips used to stimulate further discussion of the most problematic tasks, as well as options to adjust movement and ergonomic factors. Participants discussed feasibility of strategies including whether they were able to adjust work tasks, use of equipment, processes and movement, and options they found helpful. At the end of Phase I, research methods, video presentations and the list of strategies were evaluated and adjusted based on feedback and input from the participants, and field observations.

2.3.3 Phase II: Evaluation of adoption and feasibility (N=19)

2.3.3.1 Method adjustments after Phase I: Large workload variability due to production deadlines was observed during Phase I, particularly around holidays or when work teams changed, or when workers were absent. Participants reported that these intense work timeframes were often when back pain was more severe. In order to account for variability in work intensity, a within-subject A-B-A design was used in Phase II. Baseline measurements were collected weekly for 4 weeks preceding 8 weeks of intervention and followed by weekly measurements for 2 weeks of final data collection.

In Phase II, baseline weekly surveys were completed for the first 4 weeks. (Table 1) Rather than using open-ended choices, the 9 most common problematic work tasks identified in Phase I were listed in a drop-down choice for the PSFS difficulty and pain with work tasks measures to improve consistency.

The strategy list was reduced with more passive self-care options eliminated to focus on active self-management in the workplace and options provided in a drop-down menu. Prioritized strategies were introduced in the workplace using additional video clips collected during Phase I as well as demonstrations of lifting and movement modification by a research assistant with previous experience in the industry. The participants selected 3 strategies to use in their work activities for 8 weeks from a prioritized list of 12 team and individual options to address work process, equipment, lifting, positioning, movement and pacing after discussion within their teams.

In Phase II, workers were also videotaped early in the intervention phase and received immediate individual feedback using the videos. Participants were encouraged to remind their team partners to use strategies and to work with their team on work process or equipment modification. Each participant received weekly text reminders to continue to use their self-selected strategies and to provide a check-in for questions if needed.

2.3.3.2 Outcome measures Phase II: The focus of Phase II to was to assess the choice of strategy and rate of adoption, and feasibility of implementation, including the barriers and facilitators of adoption. Choice was defined as the number of individuals selecting strategy. The rate of adoption was determined by calculating the frequency of use of strategies including the number of weeks >50% of time worked, days/% time a strategy was used in the past week.

Measures of feasibility included ease of implementation (0=*very easy* to 100=*very difficult*), acceptability (*Would you recommend: yes/no/possibly*). Narrative comments were also collected from final focus group discussions, open-ended comments, and fieldwork observations.

2.4 Analysis

Descriptive statistics are reported for choice, adoption and feasibility of strategies (n=19). Qualitative analysis of the final focus group discussions, open-ended comments and fieldwork observations were used to expand and interpret the responses for feasibility. Summary data were created from the instruments (PSFS, ODI, pain, affective factors) to characterize the participants. Consistent with the pilot study design of this study, no inferential statistics were performed.

3. Results (Phase II: Evaluation of adoption and feasibility)

3.1 Participant characteristics

Twenty-eight individuals from 7 teams (distinct from Phase I participants), met inclusion criteria and provided informed consent in Phase II. Three participants were excluded due to insufficient average pain during the baseline period, 3 withdrew due to unrelated medical issues, and 3 stopped working fulltime in the industry, with 19 completing the study. Phase II participants were mostly male (90%), white (93%), with high school or beyond education (70%). The mean age of the group was 34 with 9.5 years' experience working in the seafood industry. They reported lifting more than 50 pounds for an average of 17.3 hours per week and experiencing back pain for an average of 4 years (range 3 months to 10 years). Participants generally reported mild disability (ODI 16.8%), mild to moderate difficulty with work activities (PSFS 63.5%) and mild to moderate pain (PSFS pain work activity 44.2/100; average pain 42.2/100). On average, fear avoidance was low (1.8/4), self-efficacy was high (8.3/10), and coping was moderate (6.3/12).

3.2 Most difficult tasks (Figure 2)

The most common work activities regarded as difficult due to back pain were moving baskets or boxes (16, 84%), lifting bags onto/off the boat (11, 58%), and standing while working (10, 53%;).

3.3 Choice of strategies (Table 2)

In Phase II, participants selected a mix of team and individual strategies. The 3 most frequent choices involving team strategies were team lifting (58%), rotating tasks in the team (47%), and using mechanical equipment (42%). The most frequent individual strategies chosen were pacing or taking small breaks (42%) and changing lifting position (32%). Participants selected a mix of both familiar and novel options, often considering productivity and time constraints. Of interest, 3 of the top 6 strategies chosen were also reportedly being used frequently at baseline for >50% of the time (team lifting, use of mechanical equipment, positioning for lifting), although this was not always observed in practice. The remaining top choices were not being used routinely prior to the start of the study (rotating tasks, breaking up or switching tasks, small breaks during lifting).

3.4 Adoption of strategies (Table 2)

Participants in Phase II reported using individual strategies for between 3 to 6.5 days per week, and 46–92% of the time. Participants reported using the strategies over 50% of the time for 4 -to 6.9 of the 8 weeks. The most frequently used individual strategy was positioning for lifting (n=6, 6.5 days, 92% of the time, 6 weeks > 50%). Although workers selected more team than individual strategies, the team strategies were used slightly less often. The strategies used the least were using mechanical equipment (n=8, 3.4 days, 53% of time, 5.1 weeks), team lifting (n=11, 4.6 days, 46% of time, 5.1 weeks) and rotating tasks (n=9, 4.4 days, 53% of time, 5.4 weeks) (Table 2).

3.5 Feasibility of strategies (ease of implementation, acceptability, challenges)

3.5.1 Ease of implementation (Phase II)—Participants felt that the strategies were relatively easy to use (average of 30 on a scale of 0=*very easy* to 100=*very difficult*, Table 2). There were multiple comments on the importance of team lifting as being an important strategy embedded into everyday routine: '*Most important or easiest element to decrease pain was helping each other pulling and lifting, especially using two men to dump the nets on the boat.'*

Although they felt that the strategies were practical, they acknowledged that it took time to integrate into regular routines:

> Fairly easy to implement them once we got in the rhythm of using them

> They were easy to implement once I got the workers to make it a habit, we struggled the most with getting started, even though the solutions were easy to implement. Everyone saw the benefits and they were very practical solutions.

Even if the participants were aware of the strategies prior to the research study, they appreciated the support and acknowledged the challenge to remember to use the strategies and change habits:

> The rotating tasks and those kind of things were really helpful. We were already doing them for the most part – but this brought to light to do them more often.

> Biggest problem when you have been doing it for so long is reminding yourself to do those steps and to get into a habit.

3.5.2 Acceptability of strategies (Phase II)—The strategies were recommended by most (74%) or possibly recommended (19%) with only 4 (7%) not recommended. (Table 2) Participants reported general appreciation of the importance of training, with those individuals who had been in the industry for a long time reporting the relevance for their longevity in the industry: *'these solutions are very important, I'm getting old and these are good for your back.'* They also felt that the training would be important for workers starting off in the industry, especially for high school students:

> Very important especially for people starting out or new to the industry. When I was starting out, the crews I was working with thought it was funny not to tell me any of the tips or tricks, I had to learn the hard way.

Workers commented on the accessibility of the methods: *'We could have found all this info online, but it took you coming here for us to find out.'* The videos of themselves or other crews were noted as being very helpful to be able see the positions and movements they were using that could be changed. They also felt that reminders were very helpful, both from the researchers and their team: *'The text and email weekly reminders helped a lot. And we would kind of remind each other watch your back or stand differently.'*

One of the concerns often expressed during initial focus groups was the potential that any change in work process would impact productivity. Participants were asked whether the strategies impacted their productivity in an open-ended question in the final survey. Most strategies were reported to assist productivity (42 strategies, 75%), particularly if there was less pain, and some participants reported that they were able to lift for longer or work faster. There were a few strategies did not change productivity (8 choices, 14%), or slowed down processes (5 choices, 9%). (Table 2)

3.5.3 Challenges—Some participants were more comfortable with their particular routine: *'rotating tasks was easy but a lot of it was us deciding not to because were happier doing the different jobs we do, but we have the option now'*. Team strategies were more difficult to change: *'rotating tasks was difficult because we don't have very many people, we all have what we are good at, and in order to move fast and not be here all day, we kind of have to stick with what we are good at.'*

The culture, ego and team dynamics and attitudes were challenges in some teams and the researchers noted discomfort where individuals did not want to be perceived as not being able to do the job or less capable than others.

> Teaming up seems to be in my eyes beneficial. As a culture, not always looked at positively, takes away a man's pride. People might view that differently, you know how guys when they get together they want to one up the other guy, whether they are teasing "oh you need help".

Some reported that team lifting was impacted by their partners: *'Ego and arrogance got in the way –hey wait for me to lift it and then boom its done',* but participants did comment on positive changes with asking for help: '*not being afraid to have someone help you lift the baskets'.* Time and workflow pace were also mentioned as factors limiting implementation:

> Time management was a barrier but not a real problem - mostly up to the guys to ask for help with lifting baskets.

> They were harder than we thought – everything is moving so fast, so you don't have time to think about it – and if you start thinking about how to do it, you fall behind or by the time you thought of doing it, it's already done.

4. Discussion

LBP has been identified as a major problem for commercial agricultural and seafood workers [22,23,52–54], impacting productivity and longevity in these physically demanding occupations and impacting physical and psychological health [22,23]. Frequent lifting, heavy loads and repetitive work tasks in small teams without the support of occupational health present unique challenges for this subgroup of workers. This study describes the process used to identify self-management strategies using a rapid prototyping participatory process for shellfish aquaculture farmers and aimed to establish if the approach was feasible. The context-specific self-management strategies were considered both feasible and acceptable and this study provides early support for use of participatory methods in this group of highly motivated workers. These results may be useful to inform methods for future participatory action research studies for seafood and agricultural workers.

4.1 Participatory approach

The participatory approach used in this study enabled participants to contribute to identification of context-specific self-management work process and movement strategies and to select multiple strategies that they felt were most applicable for their own work. The rapid prototype participatory research approach in the workplace allowed workers to contribute their opinions and prioritize feasible strategies early in the process while facilitating community buy-in. One of the advantages of participatory approaches is the input from workers for addressing individual risk factors and relevant solutions for the individual work context [55]. In the small aquaculture teams the emphasis and importance of being able to continue to work is different from large organizations where a participatory approach informs change at an organizational level. Smaller teams have some control over their work processes but have limited options to adjust equipment, and both individual movement strategies and team strategies were considered feasible. The individual selection of relevant strategies was supported by active learning using video examples and feedback; a method supported by others who have extensive experience with participatory approaches [30] and the flexibility of choices offered alternatives for individuals or multiple work teams who use slightly different team and work approaches. While these methods may be viable for small teams and independent work crews self-management may or may not be ideal for change in large organizations with limited process flexibility [56].

Another important element was the workplace delivery in an industry with fast-paced and variable deadlines that limit time-off for workers to seek care for low back pain or research study involvement and with no occupational safety support at an organizational level. Worker involvement and strategy acceptability was enhanced by organizing data collection and intervention demonstrations around team availability in their work settings and a relatively low time commitment on the part of the workers.

4.2 Choice and adoption of self-management strategies

Strategies reliant on team processes or equipment were the most popular choices including team lifting, rotating tasks and use of mechanical equipment, followed by individual strategies such as breaking up repetitive tasks, changing position for lifting and pacing. Of interest, there was not always a match between the tasks regarded as the most problematic and strategy choices. For example, if standing was difficult, participants did not always select strategies that would impact the repetitive position directly. In future studies, creating options to link the choices of strategies to work functions and identified difficulties would be useful. Workplace observation or quantitative measurement would be preferred to self-report, but time and funding limitations prohibited use of these research methods.

Use of individual choices encouraged self-management and active coping, and the focus groups and review of video clips created opportunities for discussion and built team cooperation and enhanced the likelihood of adoption. Building capacity using an active learning approach has been advocated for support of adoption [28], while self-management has been strongly emphasized to help with reduction of pain in patients with chronic LBP seen in medical settings [40–43,57]. Of interest, strategies involving team processes were often selected as a first choice rather than individual movement adjustment, but the overall frequency of use was higher for individual strategies. There were occasions where some team members were not amenable to switching tasks or changing processes or were not prepared to wait or help others if they preferred a specific role or task. There were also some members of teams who did not elect to participate in the study or were not eligible due to no back pain and this may have impacted overall team support.

In this study, adjusting workflow, equipment organization or adjustment which are recommended as higher on the NIOSH hierarchy [39] were provided as options but were not chosen by many workers. This may have been due to most teams having already adjusted the equipment as much as possible prior to starting the study or due to financial limitations to implement changes. Equipment adjustments (e.g. tumbler height) were not always possible and space was not always conducive to appropriate ergonomics. While some teams used a winch to assist with harvesting clam bags, some teams believed this took longer than physically rinsing and heaving the bags from the water and over the stern of the boat. There were occasions when participants chose to use mechanical equipment, but frequently resorted to manual lifting if there were equipment malfunctions or if there were fewer workers available.

There was also a discord between the research team observations of efficient lifting and movement strategies and self-reported frequency and awareness reported by workers at the beginning of the study. Lack of awareness of physical performance may have led to individuals not choosing individual strategies, even if this would have been the first recommendation from an external observer. This is a possible limitation of self-selection of strategies without expert advice, however the buy-in for self-identified strategies may be more important for adoption. Individual movement instruction was also challenging given the group delivery and limited time to provide detailed feedback and reinforcement. However, the video recordings of movement along with demonstrations from an assistant with work experience in the industry provided relevant and impactful opportunities for learning and often resulted in immediate changes in movement strategies or positioning. The video tapes of others and their teams were reported by participants as being extremely helpful and were strong recommendations in the focus groups to introduce safe lifting or work habits. There were a number of participants who believed that they were lifting effectively until they watched the videos and made major changes as a result. Use of video recordings for observation of work tasks [30] and for engaging workers has been recommended by others [58]. In this study, the videos were not only used for initial participation but for feedback for implementation and this element of the design was supported strongly in the qualitative comments.

Factors highlighted in the literature impacting adoption include: support from supervisors and team members, resource availability (time), production requirements, easy “low-hanging fruit” changes, workplace climate, personnel turnover, resistance to change and nature of the work [28]. All of these factors impacted teams to different extents, but supervisor and organizational support was critical in these small operations for recruitment and change and has been emphasized in other studies [59,60]. In the teams with leaders who supported and initiated changes, changes in team processes were easier and more obvious buy-in was present. The supervisor’s recognition of the importance of prevention and availability of time during work was highly appreciated by workers. When strong mutual support was observed, reminders and positive encouragement of change was more frequent. In studies where interventions to improve communication and problem solving skills for workers and supervisors have been implemented, reduced work absence due to pain and lower health-care utilization compared to ‘usual’ management has been found in a variety of industries [61]. Future research might consider team dynamics and the importance of leadership in these small teams.

There were contextual factors that are not possible to control. While the workplace climate was very generally very supportive, there were a few isolated members of teams who did not participate in the study, potentially influencing adoption and team processes. There were also some personnel changes that changed both the workload and potential for team-based processes. The variability in work orders for holidays and cyclical nature of harvesting clams does result in periods of highly stressful intense workloads that cannot be adjusted. While the multiple baseline and final measurements was instituted for Phase II in response to the variability, these complexities may need to be considered for future studies.

4.3 Feasibility (ease, acceptability, challenges)

Participants commented positively on the opportunity to manage their LBP as they had not been exposed to any preventive education when starting in the industry. Of importance the strategies were considered relatively easy to use and most reported increased productivity with less impact from pain, resulting in overall acceptability. Some participant's expectations and desire for improvement were influenced positively by family history of major spine pain and disability or negatively by cultural expectations of pushing through the pain. There were also a few participants who showed less enthusiasm for change potentially related to ego or not wanting to be viewed as unable to do the job or regarding pain as being inevitable. Some younger participants commented on an overall 'culture' where new or younger workers would be expected to manage the highest loads and any mention of pain or reticence to perform the rigorous work regarded negatively [11]. Older workers commented on 'not having other options' except to hire younger workers if they were unable to work due to pain.

Participants may have chosen options that were available or familiar rather than options where they did feel comfortable changing or might potentially result in decreased productivity. However, the opportunity to select from a list of potential strategies overall was more acceptable than a prescribed plan. Of interest, although team lifting was a popular choice in comparison to changing individual lifting and movement techniques, individuals who chose the team lifting tended to use the techniques less frequently than those who chose individual modifications, potentially related to difficulty waiting for others to help. The need to coordinate a group of workers to implement team strategies, or wait for others to finish tasks, may account for individual strategies being rated by participants as easier to use than team strategies. Another barrier for use of team or mechanical equipment options was limited financial support for changes in space or equipment. In general, however, the majority of strategies were considered easy to use by participants. This favorable view likely accounted for the high rates of adoption of strategies to modify work-related stressors.

4.4 Strengths

The rapid prototyping approach was efficient and allowed for more definitive choices to be used in Phase II and is supported by others as an option to adjust design and choice of methods suitable for the context. The rapid prototype and action research methods allowed for relatively efficient adjustments in research methods. The Phase I pilot videos from previous research, early stakeholder interviews and focus groups all expedited the research cycle and integrated factors important for the local context. The early implementation and inclusion of multiple forms of input using interviews, observations and videotape analysis along with self-selection of strategies contributed to participant buy-in, as well as an iterative cycle of feedback and adjustment of methods for this pilot study. The active involvement of participants contributed to overall team support and change as well as influencing the research methods in collaboration with the research team [62]. The videotapes provided rich data for analysis, examples for focus groups and feedback and allowed more than one researcher to be involved in analysis. The qualitative comments gleaned from focus groups also supplemented survey data and observations. Data collection, focus groups, presentation of concepts and videotaping all took place in the workplace - a distinct advantage for recruitment, development of trust and validity of the methods. The methods also included instruments reflecting attitudes such as coping, fear avoidance and self-efficacy that have not been reported in many participatory ergonomics studies. Participants viewed the visual feedback as extremely helpful - a recommendation for future studies in similar contexts.

4.5 Limitations

This was a pilot study with small sample size due to resources and number of possible participants in the Cedar Key Florida area. The results presented here are preliminary to the final analysis of effectiveness, limiting any conclusions on outcomes. The impact of internal team dynamics and leadership was observed but not a specific component of this study and would be a future direction for other studies. Additional ethnographic methods including field notes or observations may have allowed further triangulation of data. However, the time for travel, rescheduling if there were unanticipated work requirements and need to avoid interference with work activities impacted the timelines and time in the field.

4.6 Recommendations

The variation in workload was very difficult to anticipate or control. Although a within-subject control was added, research designs will need to take this into account for sample size, length of the baseline and follow-up and frequency of measurements in similar populations. Consideration of overall workload (including total hours, frequency of lifting and loads) should be included in future research. The health burden and subsequent productivity of workers, as well as longevity in the industry require long term studies, although these methods will be challenging given the nature of the work and sometimes fluctuating workforce.

5. Conclusions

Introduction of context-specific, self-management strategies using a participatory ergonomics approach facilitated worker engagement and self-reported adoption of intervention strategies. Use of context specific solutions in the workplace, organization of focus groups in their work settings and around work requirements, text reminders to use the strategies on a weekly basis, and ability to view their own movements using videos all supported use of the individualized interventions and adoption. Participatory methods provided feasible opportunities to introduce, support and build worker responses in the workplace and build team buy-in. Live demonstrations, video clips and workplace videos used for illustration of concepts and feedback, along with weekly reminders, assisted teams with implementation and support.

Overall, participants were receptive and appreciative of opportunities to manage pain and implemented strategies relatively consistently. Team strategies were the most popular choices, but individual options were used more often. Strategies were considered acceptable, relatively easy to use and most increased productivity. Future projects using these methods will need to build strong community linkages, buy-in, and local presence to facilitate workplace intervention and data collection. Participatory approaches provide a viable option to introduce work-related changes for individuals in physically demanding occupations with small teams, variable work processes, time restrictions and workloads, while rapid prototyping provides an option for simultaneous data collection and intervention that is both feasible and acceptable in seafood workers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Task Analysis for Clam Aquaculture Farming (Supplemental Material)

1. Planting clams
2. Cleaning clam bags in the water – one or two clam farmers reduce the amount of mud and sediment by manually shaking bags in the water prior to heaving onto the boat.
3. Pulling bags of market-size clams involves lifting loads in and out of the water, often weighing 120 pounds or more in varying water depths. Some farmers use an overhead winch for retrieval of bags from the water onto the boat.
4. Clam bags are moved on the boat to shore-based processing facilities and clams transferred from bags to fish baskets with handles.
5. Cleaning the clams is accomplished using rotating, inclined tumblers with water jets. Workers lift and dump bags or baskets of clams into the top of a rotating tumbler above waist level or if possible, directly from the boat into the tumbler.
6. One person is responsible for guiding the clams and directing the water jets standing at the top of the tumbler.
7. The person working the bottom of the tumbler typically sits in a flexed position, picking out discards, broken shells and other debris.
8. This person usually lifts the filled baskets to pallets for transport to the sorter.
9. Baskets of clean clams are manually lifted from pallets by one or two people into a mechanical grader that sorts clams by size and automatically counts them into mesh bags for distribution. The apparatus is often above waist height to facilitate the movement of the clams.
10. One person is responsible for guiding the clams at the top of the grader – standing.
11. Others collect the bags of clams, counted and sorted by size, from the bottom of the grader.
12. Small bags are weighed, labeled and packaged.
13. Bags are moved to boxes or pallets and stored in cold storage rooms.
14. Boxes or pallets are moved out of storage rooms and transferred to refrigerated trucks for transport usually using forklifts.

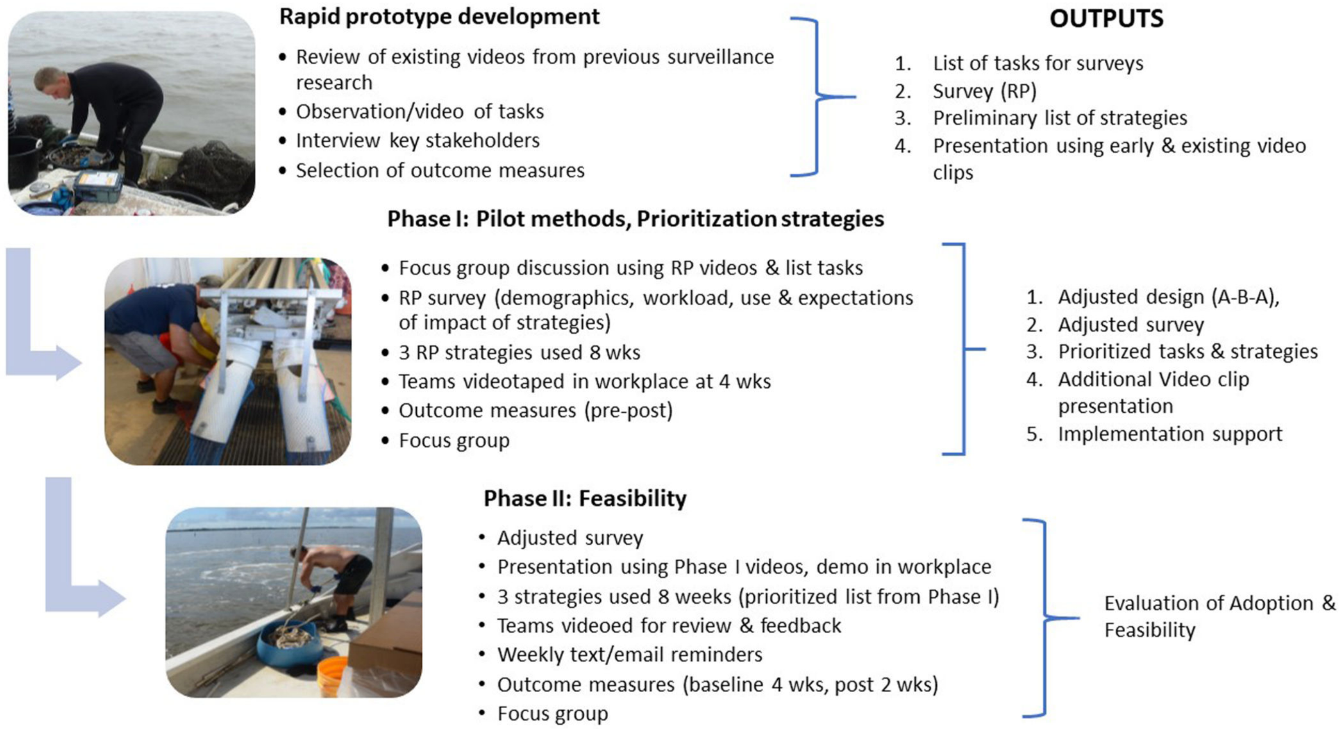

Figure 1. Methods

Note: Rapid Prototype (RP)

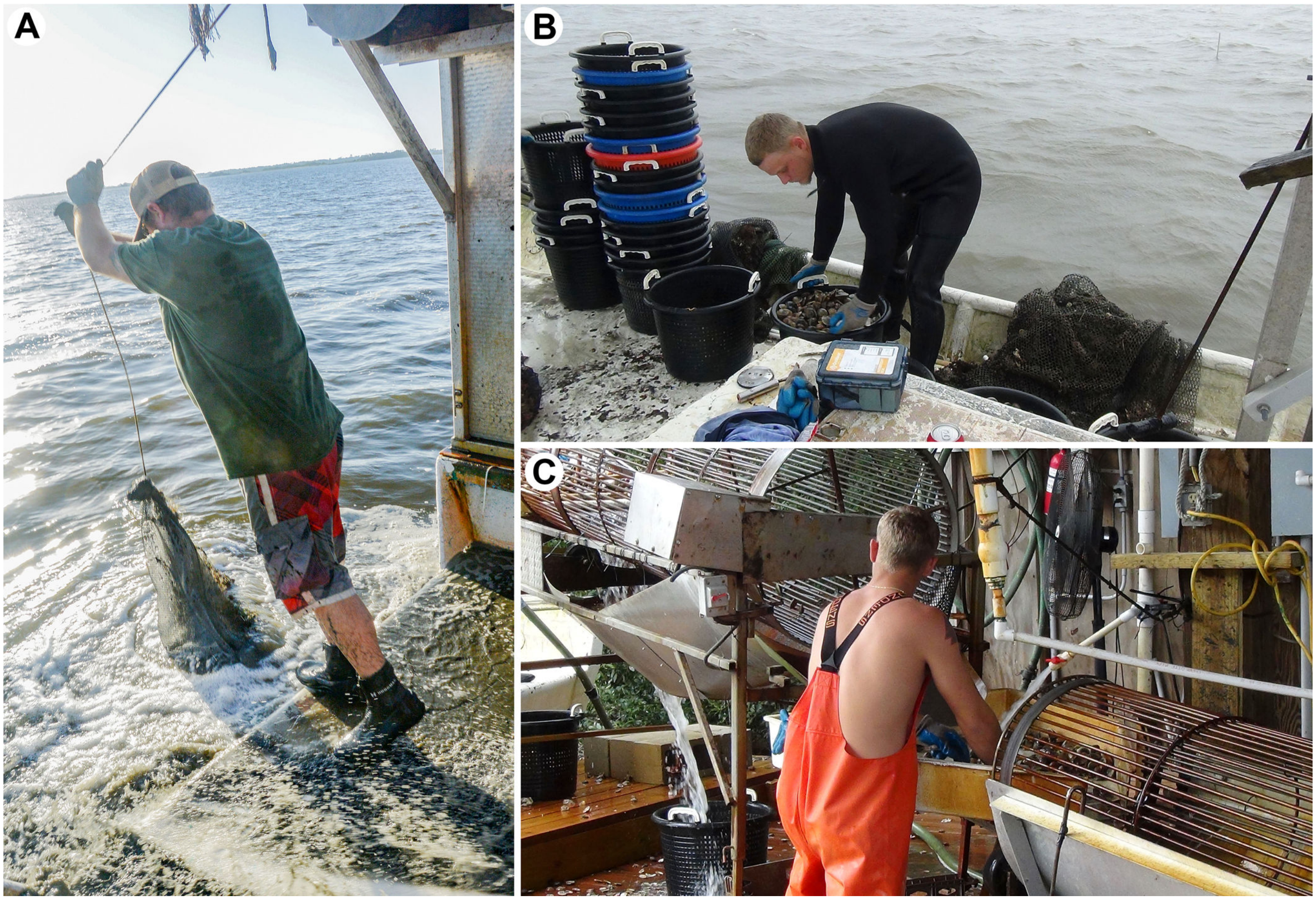

Figure 2. Tasks considered problematic.

Note: The most common work activities regarded as difficult due to back pain were:

A. Lifting bags onto/off the boat (11/19, 58%)

B. moving baskets or boxes (16/19, 84%)

C. standing while working (10/19, 53%).

Table 1

Instruments used in Phase I and Phase II

Instrument	Adjustments from Phase I for Phase II
Demographic survey	Same
Oswestry Disability Index (ODI) [35–37] Functional abilities impacted by back pain.	Same
Patient Specific Functional Scale [48–51] [49,63,64] Ratings of level of difficulty for 3 most problematic work tasks.	Open-ended questions for most problematic work activities in Phase I; Drop-down menu for work task choices identified in Phase II
Patient Specific Functional Scale Pain (PSFS Pain) Pain reported on a visual analogue scale for each of 3 most problematic work activities	Open-ended questions for most problematic work activities in Phase I Drop-down menu for work task choices identified in Phase II
Visual Analogue Pain Mean of average, most and least pain (0–100, 0=no pain, 100=most excruciating pain possible)	Only collected in Phase II
Pain anxiety symptom scale 20 (PASS) [65] 20 statements with 4 subscales reflecting psychological constructs related to pain: cognitive, escape/ avoidance, fear, physiological anxiety items	Same
Fear avoidance (short form 1 item FAQ) [66] Single item FAQ was rated on a 0–4 scale for agreement with: “I should not do physical activities that might make my pain worse”	Same
Short form Self-efficacy Questionnaire (PSEQ-2) Confidence in ability to work and live normal lifestyle [67,68]	Same
Coping Strategies Questionnaire (CSQ) Ability to cope or deal with pain 1) cope with pain or 2) ability to decrease pain (without medication)? [69,70]	Same
Work intensity & number of hours worked per week	Only collected in Phase II
Feasibility/acceptability Frequency of use of strategies (weeks > 50% of time worked, days/ % time used past week) Ease of implementation Impact on work productivity Recommendation for strategy (yes/no/possibly)	Same

Table 2

Phase II - Choice of strategy, adoption, ease of use (N=19)

Strategies	N (%) choosing option	# Days used past week (ave 2 weeks)	Use past week (ave 2 weeks) *	# Weeks used > 50%	Ease of use**	Recommend			Impact on Productivity		
						Yes	Possibly	No	Positive	No change	Slower
Team based strategies											
Adjustment of work task/ process											
Rotate work tasks in the team	9 (47%)	4.4	53	5.4	42	8/9	0	1/9	5/9	1/9	3/9
Match tasks worker height/ strength	3 (16%)	3	75	6.7	26	2/3	0	1/3	3/3	0	0
Organize workflow/process to limit distance loads are moved	1 (5%)	5	50	4	45	0/1	1/1	0	***	***	***
Team lifting	11 (58%)	4.6	46	5.1	36	8/11	3/11	0	9/11	2/11	0
Adjustment/Use of equipment											
Adjust or organize equipment	2 (11%)	5	75	5.5	10	1/2	1/2	0	2/2	0	0
Use mechanical equipment	8 (42%)	3.4	53	5.1	27	6/8	2/8	0	5/8	2/8	1/8
Individual Strategies											
Lifting mechanics											
Change positioning for lifting	6 (32%)	6.5	92	6	24	5/6	0	1/6	6/6	0	0
Movement techniques for lifting	2 (11%)	5	75	8	35	1/2	1/2	0	0/2	1/2	1/2
Take small breaks	4 (21%)	4	50	4.8	25	2/4	2/4	0	3/4	0	0
Limit flexing/ flexing & twisting	3 (16%)	5	75	7.3	34	2/3	0	1/3	3/3	0	0
Adjust body position sitting/ standing	8 (42%)	5.5	75	6.9	42	7/8	1/8	0	6/8	2/8	0
Total (%)	57 (100%)					42/57 (74%)	11/57 (19%)	4/57 (7%)	42/56 (75%)	8/56 (14%)	5/56 (9%)

* 0=not at all, 100=all the time

** 0=very easy, 100=very difficult

*** Missing data