

Engaging Workers in WRMSD Prevention: Two Interdisciplinary Case Studies in an Activity Clinic

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Abstract

BACKGROUND

This paper reports on two case studies conducted by the Activity Clinic team to support the prevention of Work-Related Musculoskeletal Disorders (WRMSDs) in the workplace. Research so far qualifies WRMSDs as multifactorial and organizational pathologies. It has also demonstrated that in situ clinical analysis of the work activity improves the understanding of WRMSDs and their long-term prevention.

OBJECTIVE

In the two cases reported here (one in the car industry and the other among gravediggers in a large French city), the interventionist framework combined ergonomic observations, biomechanical monitoring, and a developmental methodology called Cross Self-Confrontation (CSC). The goal was to help workers and managers reflect on their work constraints, the impact of those constraints on health, and the possibility of transforming the work.

METHOD

Volunteers among the workers were prompted to engage in collective re-thinking of their work based on video-recordings and monitoring of their physical activity. In the CSC dialogues, biomechanical or ergonomic quantitative representations of the work activity were transformed by the researchers and the workers into argumentation and analysis tools for understanding and prevention of WRMSDs. CSC interviews were recorded and

analyzed to track the dynamics of collective elaboration – both conceptual and practical – on WRMSDs prevention.

RESULTS

CSC discussions helped workers and managers transform their views on health, activity, and work constraints, and experiment with alternatives for health protection. The dialogical framework and quantitative representations were instrumental in the process of collective re-conceptualization of conflicts in the work activity and of resources for its transformation.

CONCLUSION

This research demonstrates how the integration of biomechanical and ergonomic mediations in the CSC framework promotes WRMSDs prevention in the workplace. This integration supports discussions within work teams and across organizational levels on work dimensions, which may lead to alternatives supporting health.

Keywords

Power to act; Cross Self-Confrontations; Intervention; Dialogue; Developmental
Methodology

1. BACKGROUND

1.1. WRMSDs: A growing occupational pathology

Work-related musculoskeletal disorders (WRMSDs) have been an increasing concern for occupational health practitioners and for researchers involved in prevention of occupational diseases in the last decades [1]. The term WRMSDs refers to around 15 occupational illnesses that affect the osteoarticular system, muscles, and connective tissues, resulting in tendinous, vascular, nervous, and muscular problems, affecting either the upper or the lower members, as well as the back and neck [2, p.202]. WRMSDs have become the largest category of professional illnesses in France. In 2010, according to the French General Health Plan, 78.7% of all compensation for occupational illnesses in France was related to WRMSD cases [3]. Furthermore, the number of new WRMSD cases requiring compensation increased by 35.7% between 2006 and 2010, which equates to an increase of 10,000 cases in 2010 [3]. Considering the large number of cases involved, this is a source of great concern for both professionals engaged in WRMSD prevention and researchers.

In Canada, the EQCOTESST survey reports that "one Québec worker in five is estimated to report a non-traumatic musculoskeletal disorder (MSD) perceived as being work-related, i.e. significant musculoskeletal pain that interferes with activities is experienced often or all the time and is attributed, partly or entirely, to one's main job (16% of men and 25% of women)" [4].

WRMSDs are not new, since they have been reported since the nineteenth century [1]. However, their current increase has been explained by the following two factors. First, the

increasing recognition of their importance in workplace health regulation worldwide enables better epidemiological evaluation. Nevertheless, in some countries, such as Switzerland, the number of WRMSD cases is under-estimated because of a low level of self-reporting and lack of legal recognition of these occupational diseases [5].

Second, transformations in the organization of work have major impact on working conditions (increased work pace, increased division of labor, limited maneuver margins, etc.) and on the possibility for cooperation among workers (regarding goal setting, collective handling of variations in production methods, management of incidents, and organization of time and breaks), and therefore causes the work to have increasingly detrimental effects on health [6, 7, 8, 9].

1.2. WRMSDs as a symptom of organizational dysfunction

WRMSDs result from an imbalance between the functional possibilities of the workers and the biomechanical demands of the work (caused by heavy loads or repetitive strain, which occur in a work context, under time pressure, and with limited opportunities to rest and recover) [10]. The combination of psychosocial factors and individual risk factors with the biomechanical demand increases the risk of WRMSDs [11]. Organizational and psychosocial work demands exacerbate the deleterious effect of physical work demands: "The prevalence of work-related WRMSDs and of absence from work for this reason is strongly associated with exposure to physical work demands (...). There is also a much higher prevalence of WRMSDs among workers exposed to various organizational and psychosocial work demands (e.g. job strain, iso-strain, effort-reward imbalance, emotionally demanding work, tense situations in relations with the general public, psychological and sexual harassment) than are those who are not exposed. In addition, the

prevalence of WRMSDs rises to approximately 40% in workers exposed to the combination of at least four physical work demands and an organizational work demand. It is also strongly associated with psychological distress and depressive symptoms in both men and women." [4, p.13].

This interplay of physical, organizational, and psychosocial demands explains why WRMSDs have been considered not only as occupational diseases linked to gesture repetition but also as "symptoms of organizational pathology" [7]. Daniellou highlights that "WRMSDs are not (only) a medical problem, they are a strategic issue for the organisation, requiring upper management's involvement and commitment. WRMSDs prevention requires new forms of dialogue between all stake holders (decision makers, designers, personnel representatives, health staff, workers, including middle management) and relevant forms of participation" [8, p.27].

1.3. A prevention strategy based on clinical work analysis

Risk prevention classically requires the identification and reduction of risks. In situations inducing WRMSDs, this model is difficult to apply, as the source of risks is in the work itself: "Trying to apply the classical prevention model (identifying dangers and limiting risks) is insufficient when one deals with health problems that are relative to the nature of work, as it is not possible to distance the workers from their work." [12, p.48]. An alternative view on WRMSDs prevention is required. It was initiated in the late 1990s, with claims that "workers' health is constructed by personal influence on work situations thanks to the development of a professional identity forged within a professional group" [13]. The models of prevention of this second position then attempt to restore the workers' maneuver

margins, to “develop the resources and technical means to confront all that is not envisaged by work prescriptions.” [2, p.208]. Within this alternative view on prevention, the Activity Clinic approach relies on a broad definition of health, inspired by the work of Canguilhem [14], as one’s power to act upon one’s environment and upon oneself [15].

This alternative view on prevention is based on a detailed clinical analysis of the work activity, which highlights work constraints and helps prioritize the required transformations of the work conditions. This work analysis aims to better understand the conditions for action of the subjects and their maneuver margins for efficient and sustainable prevention [16]. Research so far has demonstrated that the most significant results in improving occupational health were obtained by "mobilising the employees collectively by giving them a new understanding of the constraints involved in their work and their effects on their health." [17, p.174]. The perspective of engaging workers in WRMSDs prevention has also been supported by Participatory Ergonomics, defined as "practical ergonomics with participation of the actors in problem-solving" [18, p.6]. Participatory Ergonomics highlights the role of the team guiding the intervention process, made up of "employees and their representatives, managers, ergonomists, health and safety personnel, and research experts" [18, p.7]. Ergonomics research insists on understanding the context of activity of the subjects in the field, as the positive impact of a preventive intervention on health will depend largely upon the long-term engagement of the local subjects [19]. Caroly & al. state that "the possibility of integrating health and safety in a company's projects can be developed thanks to a work collective made up of multiple-logic [multidisciplinary] stakeholders (production engineer, ergonomist, professional risk specialist, foreman, company nurse...)" [19, p.598]. They also demonstrate the importance of engaging workers

with different perspectives at all levels in the company: operators, managers, occupational health practitioners, Health & Safety experts [20].

In summary, this alternative view of prevention is based on three elements:

- A definition of health, which stresses that prevention depends heavily on extending the power to act [15] or maneuver margins [9] of the subjects;
- A focus on a clinical analysis of the work activity in all its individual, collective, and organizational dimensions;
- The creation of a team of people (research collective) participating in the intervention process, and their engagement in the analysis, diagnosis, and transformation of the work process.

From this perspective, WRMSDs result "from a triangular conflict between an atrophy of the "power to act" in work situations, the impossibility "to be able to think" about the human activity performed, and to "be able to discuss" the issues involved in the survival of the company [Daniellou, 1998, quoted in 2, p.208].

Our research contributes to this rich perspective on WRMSDs prevention. We follow the French ergonomic tradition in stressing the participation of operators and the importance of work teams in the prevention of work-related illness, as well as in transforming the organization of the work. However, we attempt to complement this approach through a methodology that engages the workers in a precise and detailed analysis of their work activity – which is contrasted with that of their colleagues – to propose changes to pathogenic work environments. The quality of the work of co-analysis performed by the workers becomes a means for them to first be seen as authorities on their work, and then, during the steering committee sessions, to influence the managers responsible for designing

the work process. The work teams therefore, starting with the associated research team, become a means to transform the organization and improve the health of all concerned.

2. METHOD

2.1 A developmental methodology to engage workers in activity analysis and transformation

In these cases, the research and intervention process was based on developmental methodologies [15, 21, 22, 23, 24]. Within the perspective of the Activity Clinic, the Cross Self-Confrontation methodology engages workers in detailed, dialogical, transformational co-analysis of their work activity [25, 26, 27]. Activity here exceeds the observable actions of the subjects: It also includes invisible psychological dimensions. Following Vygotsky, who wrote that “at each moment, a human being is full of unrealized possibilities” [28, p.76], work activity is seen as a compromise: between what is required of the workers and what they think they should do in the situation, between the meaning and the effectiveness of the action, and between what has to be done and what else could be done [21]. Human action is the result of subjective arbitration between several possible actions. These tensions, these compromises, these unrealized possibilities led Clot [21] to keep the effective dimension of the unrealized activity within the activity, and thus to consider what is actually realized, as well as what could have been, could be, or will be realized in the worker's subjective activity. Therefore, Clot distinguishes on one hand the *realized activity*, which is what the worker does and which is observable by its result, and, on the other hand, the *real of activity* which refers to the unrealized possibilities described by Vygotsky: to

what workers don't do, what they aim to do without succeeding, what they abandon doing, what they think they would do under different conditions, or even what they do to avoid doing what is expected of them. The *real of activity* is full of unresolved conflicts, which are entry points for development dynamics [15]. Only indirect methodologies may offer access to these structuring dimensions.

This indirect methodology relies largely on a group of workers, volunteers involved in the research, called an "associated research group" [29]. The collaborative and collective dimension is critical throughout the intervention process. At the very beginning of the research, workers interact with researchers at the workplace, while researchers observe the activity. With their questions and way of observing, the researchers attempt to place the workers in the position to observe their own activity. At a later stage, some workers engage themselves formally in the research, and come to discuss their activity in a structured way. They collectively choose relevant work sequences to analyze, which will be filmed in the workplace. The analysis is conducted through repeatedly confronting the workers with these video films, which they comment on during simple and cross self-confrontation interviews [30]. The comparison of individual ways of performing tasks, with special focus on their variations, opens the door to new questions and reflections.

In this collaborative developmental methodology, workers therefore collect the data, analyze the data, define the research questions, discuss the research process, evaluate its results, support change, implement the changes, and evaluate them over a longer term. All these contributions are made possible by close discussion between researchers and workers about objective data on activities in the field. In the two cases reported in this paper, objective data from the video films were complemented by ergonomic and biomechanical

data gathered at the workplace. These quantitative representations of the activity, using figures and graphs, supported the discussions between workers, and later on, between workers and managers, as will be demonstrated in the Results section. The output of the intervention process is an edited selection of video clips showing both the work activity and excerpts from Cross Self Confrontation interviews, in which workers debate about ways to perform the work and conflicts endemic to their occupation. These videos point out the generic conflicts – whether resolved or unresolved – in the course of the activity, collective resources to face them, and the occupational skills used. They are then discussed in a broader forum, with other colleagues, managers, and with the steering committee.

2.2. Functional steps in the Cross Self-Confrontation methodology

Engaging workers at different organizational levels in a deep discussion of conflicts, resources, and potential developments within the activity, requires a structured methodology, which we divide into three steps. The researchers frame the research within the organization, by forming a steering committee, an associated research group of volunteers, and by discussing the demand from the managers and the workers. The researchers then conduct a co-analysis of the work activity by consulting with the associated research group to select, the work sequences to further analyze in detail, video recording these sequences, and discussing them with volunteers in simple and cross self-confrontation interviews. Lastly, the researchers and volunteers jointly select the video clips of the work and the interviews, especially those that feature debates about important aspects of the work, and those that reveal underlying generic conflicts. These videos are

commented on and arranged in a final documentary form (film-based report), which is presented to a wider audience consisting of other colleagues, managers, as well as the steering committee. In doing so, the researchers aim to articulate the controversies on the work activity and disseminate them within the organization. The table below describes this process more precisely:

Table 1: Functional steps in CSC methodology

| |
|--|
| Framing the research within the organization |
| - Initiate encounters and observations at the workplace |
| - Form and lead a steering committee for the research within the organization |
| - Form a group of volunteer workers to co-analyze their activity; this group is closely associated to the intervention process, and called the “associated research group” |
| - Elaborate the request for intervention and identify demands within the organization |
| - Organize the research: people, equipment, sequence, and calendar |
| |
| Initiating and framing the discussion: data collection and co-analysis |
| - Select the activity sequences to be recorded and analyzed with the associated research group |
| - Record videos of the work activities |
| - Choose video material for simple self-confrontation interviews |
| - Conduct simple self-confrontations (the worker comments on the film of his or her activity while watching it with the researcher) |
| - Choose video material for cross self-confrontation interviews |

| |
|--|
| - Conduct cross self-confrontations (two workers cross-comment on the film of the activity of their peer, with the researcher); look for controversies about the work. |
| - Select video material for the group discussions (from films of the activity, of the simple self-confrontation, and the cross self confrontation) |
| - Conduct group discussions in the “associated research group” |
| |
| Producing documentary material and extending the discussion: films, presentations, and reports |
| - Select video material for the steering committee and for the larger work environment |
| - Present and discuss the results of the intervention process; engage other colleagues, managers, health practitioners, and the steering committee in the discussion; disseminate the controversy to different levels of the organization. |
| - Analyze the whole data set, processes, and effects of the research |
| - Produce documentary material: final report, video... |

However, this methodology is not a linear process, but a circular one: outputs of one phase of the intervention are used to engage other colleagues, managers, experts, and the steering committee in the discussion, in order to “disseminate the controversy to different levels of the organization”, as stated above (see also [31] for a deeper presentation of this circular process).

2.3. Participants, data collection, and analysis

In the two cases presented in this paper, the intervention began with a request on WRMSDs. The table below summarizes the details of the intervention process:

Table 2: Composition of groups and duration of the research

| | Case 1 Car Industry | Case 2 City Gravediggers |
|--|---|--|
| Composition of the research team | Three researchers: one full time (Ph.D. student, performing the ergonomic analysis then the cross self-confrontation co-analysis), two part-time (one in ergonomics, one in work psychology). | Six researchers, one full time (PhD student in work psychology), five part-time: two in ergonomics, two in biomechanics, one in work psychology. |
| Composition of the steering committee | The steering committee consisted of the project and purchasing manager (the sponsor); the assistant for quality, security, and environment and CHSCT secretary (Committee for Hygiene, Safety, and Working Conditions); an HR manager; a Production manager, and the researchers. | The steering committee was led by the director of the city cemetery department (the sponsor) and included around 15 people plus guests invited by the director at certain points. The committee included the researchers, an occupational physician, an occupational nurse, the manager of the occupational medicine department, the two conservators of the cemeteries where the research took place, the chief gravediggers of these two sites, an occupational risk prevention engineer, and a risk prevention specialist assigned to counsel the gravediggers. |
| Composition of the associated research group (volunteers engaged in co-analysis of their work activity) | 10 workers out of 25, i.e. 40% of the team. | 12 workers out of 30, i.e. 40% of the workforce. |
| Duration of the intervention process | From September 2008 to December 2010. | From end of 2006 to beginning of 2010. A follow-up intervention is currently underway. |
| Duration of the data collection in Simple and Cross Self-Confrontation interviews | From December 2009 to October 2010. | 2007 |

During and after the intervention process, the researchers analyzed the collected data. They selected and transcribed sequences that show the development of individual and collective re-thinking about organizational constraints, historical and generic conflicts, and resources for the activity, as well as their link to the WRMSDs issues. The data consist mostly of dialogues. Therefore, an analysis of these dialogues is performed, based on interlocutory logic, which enables to capture the development of the debate, argumentation, and controversy in the course of the dialogue. More precisely, we analyze the interlocutory activities by tracing their development through the dialogue [26, 32, 33].

3. RESULTS

3.1. Case study 1: Multidisciplinary research on WRMSD in the car industry

The first case study was conducted in collaboration with ergonomics researchers. The intervention took place in two-step: In the first, detailed measures of the work activity were performed as parts of an expert diagnosis on WRMSDs. In the second, analysis of the activity was developed using Cross Self-Confrontation. Workers were encouraged to analyze their own activity in structured dialogues based on objective tracking of work in video sequences. At the outset, these two steps were viewed as complementary research, but in fact, they proved to be interdependent [12], as shown below.

3.1.1. Context and objectives of case study 1

At this site, the research was initiated by the Organization and Methods Department, which wanted to understand the effects of some new assembly lines on occupational risks for workers. This required a study of the work of operators in modular manufacturing units. These units assemble components on car bumpers. They deliver their production in “synchronized workflow” to the car manufacturer, using tightly coupled, “just-in-time” production methods. Some workers were declared unfit because of lumbar pain, and the company decided to investigate the long-term effects of these production methods on employee health. Managers wished to increase their knowledge about the work of the operators, the occupational risks, and the prevention of WRMSDs.

The initial ergonomics diagnosis located the main work constraints and suggested recommendations to improve the work conditions. This preliminary study employed biomechanical monitoring to validate hypotheses about links between work conditions and health status. Several methods were used in this first phase:

- Observation and counting steps,
- Questionnaire about pain and work conditions,
- Physiological measures, including cardiometers during one workday, pull & push measures on carts, joint-angle calibration, and use of a pedometer to determine the distance walked per day.

The results of this first study pointed out a high level of external constraints linked to the work organization. Their impact on both the individuals, such as demanding physical and cognitive effort and a strong tendency towards hiding pains, and on the group (socially poor work climate) was highlighted.

A meeting was organized to present these results. Many questions arose. Managers discovered that "*it was necessary to change the work organization and their health conception*", but wondered "*how to do that in the forthcoming projects*". The operators requested more details from the researchers about "*how to adopt better ways of working*" in order to preserve their health. To respond to these process-oriented demands, an Activity Clinic approach was adopted, using the methodology of Cross Self-Confrontation in the intervention. Operators (10 out of 25) agreed to participate in co-analysis of their work. The goal was to investigate the potential resources in the work situation together with the group of operators: a co-analysis aimed to transform workers into observers and critics of their own activity, in order to change the way the work is organized.

The analysis produced many debates among co-workers. The operators documented and compared different ways of performing tasks, resulting in new options to take care of their health. The results from quantitative monitoring of work activity were surprising to the participants, which triggered efforts to find alternative and different ways of working.

3.1.2. 14 kilometers per day: ergonomic data transformed into analysis and tools for debate among operators

To illustrate and discuss this approach, we focus on a discussion that took place within the associated research group. We present a part of this discussion to show how operators used a prior ergonomic diagnosis to start a debate about their work. In this meeting, operators pointed out different pacing of work to produce a stock at the end of the line. A senior operator reminded her colleagues of one biomechanical measure from the previous ergonomic analysis. This observation arose spontaneously, without any incentive from the researchers.

The dialogue below takes place in between three operators (O1, O2, and O3). The operators have to assemble bumpers and load them into a large, metal-framed cart to produce a stock for transport by truck. In order to avoid a shortfall of stock to transport, they work rapidly between truck loading times to produce as many bumpers as possible. In this dialogue, they start to discuss their work pace, based on the ergonomic measures from the pedometers, which leads to a controversy between O1 and O3 on the correct working pace.

Transcript from a sequence of Cross Self Confrontation: “14 kilometers”

R is the researcher, O1, O2, O3 are the operators. The number before is the speech turn number.

1. *O1- We didn't stop, you— well, you should have watched us working, you would have said, “What the hell is this?” Ask her— she [an ergonomist] even put on ... she put that thing for the cardio on us.... (laughs) But no joking, we had ... we had to wear the cardio thing, then the....*
2. *R- The ... pedometers— yes, yes.*
3. *O1- That day, it measured— there's ... there's— it's X [another line worker].*
4. *O2- Hmm.*
5. *R- 14 kms, she calc ... calculated 14 kilometers.*
6. *O3- That's what we do, huh.*
7. *O1- No, but ask her, it was terrible! There, you didn't have any time for a breather....*
8. *O3- Unbelievable.*

9. O1- *But there's a time, I swear, there's a time when you say— it's true when you see somebody who comes, who works like that, calmly, you... you say, oh shit, get a move on, because you... you don't get it; you say, hang on, we have to get into it, to work hard— we always had to, we always had to work like that, you know what I mean? We were always ... in a state of emergency, always having to produce ... to produce bumpers. Today, we are at least lucky enough to be able to work pretty calmly. The guys— they can be at ease in their minds. I don't understand why today we should go backwards and make them hurry.*

10. O3- *But....*

11. O1- *The result, it's, it ... it ... it ... the result— it would be 100 times better if they work calmly; who's going to assemble a bumper quietly instead of— oh shit, I don't have any time— then the carts, then that thing— oh shit, I got my foot stuck in the cart because I wanted to move faster, because, shit, we have to keep on going, we have to ..., you see?*

12. O3- *But I'm not sure it's necessary to rush like a maniac to fill your truck, that's why ... it's a good idea to try to calculate how many carts we can fill ... in between two truck loads. That could be ... that would be a very good idea.*

A detailed analysis of speech turns here is outside the scope of this paper, but we would like to emphasize the following points:

- O1 uses biomechanical metrics as an argument to question the work pace. At the beginning of this extract (Speech turn 5), O1 reminds the group that the researcher had “calculated 14 km” in the first phase of the research. She adds (Speech turn 7) "you didn't

have any time for a breather”. O1 links her present pace to her job history and to the critical need to produce sufficient stock while in a “state of emergency” (Speech turn 9). Thus in this discussion between the operators, a biomechanical result becomes a psychological instrument in a Vygotskian sense [34] to (re)consider their pace of work.

- An implicit occupational debate on the appropriate work pace begins when O3, also an experienced operator, adds: “I’m not sure it’s necessary to rush like a maniac to fill your truck”. This is followed by a questioning of the need to complete a stock at the end of the production line (to fill three or four carts in advance) to be considered efficient. Operators discuss the link between their intensive work pace and the real efficiency of their habit of creating an intermediary stock. The controversy about the work pace, initiated by the observation that they walk 14 kilometers per day, as measured by the research team, lead to a discussion of the concrete function of the stocks in their activity, and therefore, on the organization of the work .

The number of kilometers walked per day, objectified through the ergonomic diagnosis, here plays a dialogical function. This impressive result of “14 kilometers” produces an interior and external dialogue on the work pace and the question regarding the stock. This debate is an important experience for the associated research group: They experience how dialogue on details of the activity reveals alternatives for increased meaning and efficiency in everyday work.

The objective measure "14 kilometers per day" also triggered further discussion among managers and health practitioners: The managers started to discuss solutions to change these work conditions. They were also impressed by the knowledge demonstrated by the workers in their Cross Self-Confrontation discussions. The staff manager concluded:

“finally, we see concretely that you have the solutions. I consider that this work analysis is very interesting for the setup of appropriate processes because processes change constantly”. The steering committee acknowledged the relevance of the operators’ collective reflection for efforts to improve the work process.

3.1.3 Implications of Case Study 1

In this dialogical framework, the ergonomic diagnosis had effects on the work activity that were not originally sought. The Activity Clinic's methodological framework has here been enriched by the preceding ergonomics methods, which contributed to sustainable prevention in two ways: On one hand, the quantitative ergonomic results the workers, and exteriorized elements of their subjective work experience, which could then be referred to during debate in the co-analysis group; on the other, they created a discussion space for changing the work organization, the work pace, and the definition of prevention in this company. Multidisciplinary intervention in two steps (objective analysis of the work activity, then structured, dialogical co-analysis among the workers) becomes a tool for the transformation of work organizations and the prevention of major occupational risks.

3.2. Case study 2: Biomechanical metrology and Cross Self-Confrontations for WRMSDs prevention among gravediggers

The second case study comes from multidisciplinary research on WRMSDs conducted with gravediggers [35]. The study combined elements of ergonomics, biomechanics, and

psychology [36,37]. Its purpose was to lead these workers to contribute actively to WRMSD prevention by eliciting dialogue and controversies concerning their way of working. This research was part of a larger French national research project led by a multidisciplinary team of specialists in ergonomics, psychology, biomechanics, and sociology. The project contributed to a more precise definition of the components of sustainable WRMSD prevention programs in public and private companies, through a comparison of different prevention policies in various contexts [16]. One of the components highlighted by this national research is the necessity to empower workers to act in their workplaces. The researchers in this multidisciplinary framework attempted to support the workers' efforts to improve the way they perform their tasks.

3.2.1. Context and objectives of case study 2

This intervention was initially launched by a department of occupational health in a large French city that wanted to expand its program for sustainable prevention of WRMSDs. An occupational health physician noticed shoulder and lumbar complaints among gravediggers. By using a clinical, standardized examination, the physician diagnosed 53% of these workers as suffering from lumbar problems and 13% from tendonitis of the upper limbs. The department of occupational health asked our team to intervene with the gravediggers as well as with their managers.

Gravediggers usually perform four types of activities: unearthing tombstones, digging, exhumation, and inhumation. Our multidisciplinary framework focused on the digging activity. Most of the time, the gravediggers excavate graves using tools such as a shovel, pick, spade, and fork. Manual excavation is required in the oldest historical cemeteries because topographical constraints restrict the use of machinery. In such cases, the

gravediggers employ different gestures to dig manually. In the first step of the intervention, the gravediggers and the occupational physician expressed the wish to gain greater understanding of one particular gesture: throwing soil backward.

For the gravedigger, throwing soil backward consists of shoveling earth from the tomb and throwing it over his shoulder. This gesture is considered one of the most pain-ridden motions in that occupation. Both the gravediggers and their occupational physician wanted to highlight its inherent complexity. The over-the-shoulder throw became the unit of analysis within the multidisciplinary framework.

3.2.2. Methodology: Integrating biomechanical data into Cross Self-Confrontation among gravediggers

The research protocol was conducted as follows: Eight volunteers, all gravediggers, took part in a biomechanical study. The activity of eight muscles – both left-and-right anterior, medial, and posterior deltoids and lumbar muscles – was recorded by surface electromyography under real working conditions (manual digging of 1.5 – 2.0 meter-deep graves). These muscles were selected based on pains reported by gravediggers, clinical examination by the occupational physician, as well as the preliminary results provided by our field observations. Each gravedigger executed 60 over-the-shoulder throwing movements, which were filmed synchronously with biomechanical data acquisition. The muscular activity of each shoulder was assessed for each throwing movement by combining the activity of the three subdivisions of each deltoid muscle. Two series, corresponding to the most and least stressful over-the-shoulder throws, were defined for each gravedigger

based on the intensities of shoulder and lumbar muscle activity: the less stressful throws defined the "green range" of the movements executed and the most stressful throws defined "the red range".

The biomechanical analyses were then integrated into the Self- and Cross-Confrontation steps of our methodological framework. The gravediggers were confronted with videos that showed several over-the-shoulder throwing gestures:

- The Self-Confrontation aimed at developing internal dialogues for each gravedigger, who was shown a video of the two series of over-the-shoulder throws requiring the most and the least muscle activity. Then researchers encouraged the participant to compare his own movement with his colleagues' movements. As a result, this framework allowed each of them to compare their own gestures in a virtual dialogue with others, thus opening them up to new possibilities in performance of their work.
- The Cross-Confrontation with two gravediggers aimed at developing controversies about their work. The researchers pinpointed the gravediggers' differing viewpoints with the intent to evoke other, yet-to-be realized approaches. As a result, the gravediggers rehearsed different ways to reinvent their own throwing gestures, and more globally, to further the development of their occupation.

3.2.3. Peer dialogue: comparisons of work gestures



Gravediggers D. and G. demonstrating the over-the-shoulder throw to their colleague in the Cross Self-Confrontation interview

Transcript of a sequence of the Cross Self-Confrontation Interview:

“The green range”

R. is the researcher, D. and G. are two gravediggers who volunteered for this analysis in Cross Self-Confrontation.

1. *R: Do you find that he's straining there, from what you see him doing? ...*
2. *D: We should do another video and I would be in the green range even for both sides of my body now.*
3. *R: That makes your workmate smile.*
4. *G: Even though you say that, it's still the same, huh... You wouldn't be in the green range, anyway.*
5. *R: What's your workmate doing that's keeping him out of the green range, based on what you see him doing?*
6. *G: He would be twisted up ... well, even, even if he changed the position of his legs...well... I don't know, he twists himself anyway [pause] because you hold yourself like this when you throw the dirt like that? [pause] Are his legs in the correct position there?*

7. *R: Move over to the side, there.*
8. *G: Go on! [D stands up] Toss the dirt on that side!*
9. *D: I hold the shovel like this.*
10. *G: OK.*
11. *D: Yep, I lever it upward and then let it drop.*
12. *G: Yes, but look at your shoulder [pause] it's actually doing this.*
13. *D: No, my arm it's ... it stays like that.*
14. *G: Yes, but you're doing—*
15. *D: It's not—*
16. *G: It's like that, anyway.*
17. *D: My arm is not in the air, huh.*
18. *G: But even though it's not in the air, you are doing that anyway! When you're doing that, look at my shoulder, it doesn't move! I do it like this and my arm slides easily [pause]. Try to do it on the other side, like me, like this.*
19. *D: But no, like that, I'm doing it like you, I'm doing it just as easily.*
20. *G: Ah, well, there it is; well, I think that way you force yourself less than on the other side, but maybe I'm wrong. [Silence]*

A detailed analysis of this dialogue is outside the scope of this paper, but we would like to emphasize the following points:

- Both of the gravediggers transform the "green range" (representing the painless over-the-shoulder throw) – which symbolizes a quantitative biomechanical

evaluation – into a psychological instrument in order to convince their co-worker (and sometimes the researcher) of their viewpoints in the argumentation process.

- In the discursive movement, both of them attempt other ways to perform their own over-the-shoulder throw. The dialogical framework is also an experimentation framework. The need for simulation is triggered by the prompting of the “green range”, which evokes both surprise and expectancy in the workers.

This multidisciplinary framework allows the gravediggers to rediscover some of their occupational dilemmas, which are linked to the awareness of one’s own way of moving; to enrich their knowledge of their work based on inter-individual disparities; to evoke collective dialogue within their thinking by transforming the evaluated gesture into a dialogical object; and to reactivate the psychological function of the collaborative group (the power of comparisons) within the individual gesture.

This framework also allows a transformation of:

- The managers' points of view concerning the way to prevent WRMSDs. In association with the gravediggers, they reconsider the design of occupational training regarding ways to use the body to perform tasks;
- The relationship between some of the gravediggers and the occupational physician: In clinical interviews, the gravediggers now speak not only about their pains but also about the constraints they face while using these gestures in their concrete activity [38].

3.2.4. Implications of case study 2

Biomechanical metrology was not only used to quantify the body movement performed in this study: Presentation of the results also enabled the gravediggers to expand their knowledge of the over-the-shoulder throw and, thereby, to discuss it in greater depth.

Concerning the Cross Self-Confrontations, each of the gravediggers involved within the framework was confronted not only by his own video but also by those of his co-workers. Comparison between peers was encouraged through the viewing of their video sequences. This early introduction may have encouraged not only the dialogues, but also the gesture controversies we witnessed during the Cross Self-Confrontation stage. New occupational controversies could be developed. The multidisciplinary framework enabled the group of gravediggers to become a fresh source of proposals for developing the methods of performing proper body movement and protecting health.

4. Discussion

These two case studies describe rather different approaches of multidisciplinary research. In the first intervention, an initial ergonomic analysis of the activity of the workers was conducted. A subsequent analysis from an Activity Clinic perspective enabled the participation of the workers in the developmental analysis of their activity. The researchers encouraged task-related debates among the workers. This change in the research position, from expertise on the topic to support for dialogical analysis, had an influence on the workers' analysis activity. Surprisingly for us, findings from the ergonomics diagnosis were raised within the dialogical framework and spontaneously used by the workers to support their arguments. This first intervention raises the question of the role of a classical ergonomics diagnosis within an Activity Clinic framework. Here, it proved useful, both to respond to a demand from the managers and from the operators, and as a resource for the analysis and argumentation among the workers, as it exteriorizes the work activity in an

impressive, quantitative way (“14 kilometres”). This intervention is also distinguished by the fact that the same researcher embodies the multidisciplinary framework: In this case, the continuous presence of the researcher certainly influenced the workers to employ shared references from the ergonomics phase within the dialogical analysis phase. For them, the analysis was not divided into two parts, as the same researchers continued to investigate the same problems. Although the intervention was clearly structured in two distinct phases, it was experienced as a continuous process by the workers involved.

In the second intervention, the researchers employed a developmental approach from the outset. They explicitly collaborated with ergonomists on the field observations and with biomechanics colleagues to perform quantitative monitoring of the activity of specific muscles in specific work situations. Then they organized the Cross Self-Confrontation interviews on the basis of the work sequences, which had been recorded. Therefore, the Cross Self-Confrontation was based not on long sequences of work activity but on many short (1-2 minutes) sequences of work activity associated with red and green diagrams of muscular effort. This red/green symbolism had powerful effects. It generated specific argumentation by the workers, who tried to “go to the green” again, simulating and discussing the correct gestures within the dialogical framework. The workers themselves turned scientific representations into effective argumentative and analysis tools to support occupational dialogue and controversies and co-analysis of the work activity. The migration of findings from another discipline into the dialogical framework was spontaneous and originated by the workers in our first case study, but planned and organized by the researchers in the second. Both cases point to the power of objective monitoring to

stimulate reflection about the activity, with data collected using established methods in the first phase of the research.

Some representations of the work activity, which were constructed by researchers, proved to be helpful for the workers who participated in the Activity Clinic analysis: whether the “14 kilometers” measure or the “green range”, the participants were impressed, expressed surprise, and conveyed their desire to surpass their current understanding. These quantitative diagrams or metrics served as a means to approach the everyday activity and engage the workers in the research. They were recalled by the workers in the argumentative process, to demonstrate their points or discredit the point of view of their peers. Their factual character makes them an appropriate discussion tool, as they can be used by different workers in multifaceted ways to contest unilateral points of view:

- In the first case study presented, the "14 kilometers" measure is striking to both the workers and their managers. Whereas one of the operators recalls this measure as an impressive accomplishment, one of her colleagues turns it into a proof of excessive effort – as is also the case in the analysis by the managers, who conclude that "it is too much".

- In the second case study presented, the green range is understood as a visual metaphor for proper, efficient, and non-damaging ways of working. It is set as an achievable goal by the first gravedigger, who states that he would do better now, if another video of his work were produced. The second gravedigger expresses his skepticism, also using the "green range" argument: "You wouldn't be in the green range, anyway". The green range enables them to speak in a tangible way about the intangible nature of the gestures used to perform work, and their long-term effects on health. In disagreement about what is correct, they contrast

their different gestures in the Cross Self-Confrontation interview, which becomes a receptive simulation space.

Here, science provides different artifacts that are of practical use to the workers: quantitative representations of their actual work, which objectify some of its characteristics and translate them into striking, visual forms and compact formulas; a dialogical framework to compare, contrast, confront, comment on, and discuss their way of working in terms of both individual and collective efficiency, as well as its effects on health; and opportunities to expand the analysis through the hierarchy within the organisation.

5. Conclusions

This paper addresses several questions: How can quantitative data become a tool for reflection by workers that helps them transform their work activity? How does this change in the status of scientific representations affect the research project's collaborators, including the workers, their managers, health practitioners, and the researchers themselves? What is the effect of these new scientific representations on the content and form of the dialogues and controversies arising in Cross Self-Confrontations?

This paper provides some answers to these questions. It shows how quantitative data produced in an interdisciplinary framework were appropriated by the participants in our developmental methodologies in ways that were surprising to the researchers, and especially as argumentative tools to support positions in controversies. The dialogical framework engenders arguments, which the workers experienced in the first steps of the research (as in our first case study): Impressive data that objectify the work activity (such as the ergonomic measure "14 kilometers per day") become tools for argumentation and

reflection among the workers. It may also be that visual representations of quantitative testing (such as the red/green convention to represent the amount of muscular effort) trigger discussions and orient them in specific directions (as in our second example). So doing, the results of these quantitative tests find a new application through the different interpretations of those involved in the field. Workers are not only confronted by scientific analyses that they could validate or deny, but are using the quantitative results and representations made available to them, and the dialogical framework itself, as tools to rethink their work activity, and sometimes to rehearse their working gestures or renew the way they perform their work. In addition, the workers' dialogues, which serve as data to help the work psychologists in these methodologies interpret the situation, may also become data for colleagues from other disciplines, to help them interpret their own data. These contrasted case studies not only highlight the heterogeneity, difficulties, and surprises inherent in the practice of interdisciplinary research, but also show that these surprises and difficulties may give rise to unexpected knowledge and transformation.

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