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Institut de recherche
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SUMMARY

The primary task of emergency medical technician-paramedics (EMT-Ps) is to provide prehospital emergency care while ensuring safe transportation of the patient to a hospital. Fundamentally, their objective is to reduce patient mortality and morbidity as much as possible by minimizing response time. Numerous studies throughout the world, including in Quebec, show that EMT-Ps have a higher rate of employment injuries and retire earlier than other workers, including those in the health system. As they get older, many EMT-Ps leave their jobs for another profession with less demanding tasks. Little attention has been paid to what actually takes place on the job and the measurements of exposure to risk factors that are currently used have often been insufficient. The objective of this project is to describe EMT-Ps' work context and to quantify their exposure to risk factors for musculoskeletal disorders.

The observation of 101 EMT-Ps working in the regions of Montreal and Quebec City over 175 work shifts made it possible to document the tasks and the many different situations that they face every day. The impact of the various work determinants was characterized and those that were adverse, that is, those that could cause an imbalance between their well-being and health and work expectations, were identified.

Confronted with ever-changing situations on the job, EMT-Ps make decisions based on the information available to them, but many aspects of the work environment cannot be predicted until their first contact with the patient. Work situations requiring an evacuation by urgent transport represented less than 10% of prehospital interventions. The difficulties faced by EMT-Ps stem from the patients' unstable health status, because it dictates what actions must be taken, such as choice of treatment protocol and priority of evacuation. This factor explains the haste exhibited by EMT-Ps, especially in urgent situations, and is partially responsible for the high workload and physical efforts of the two-person team. The care provided to patients, guided by well-defined protocols, is the task that comes with the highest risk of back injury, based on postural indexes. The tasks involved in moving patients, especially when they must be lifted and carried, are also among the most difficult. Overall, EMT-Ps who are female, have several years of seniority, or are obese adopt safer work postures than their coworkers. When carrying out urgent evacuations of patients, female EMT-Ps felt they were very pressed for time, which was expressed by a perception that they were working much harder than the men. However, with respect to physical effort, the task duration and fatigue levels were similar between the sexes. Technicians with more than 15 years of experience perceived non-urgent work situations differently. They felt that the physical effort, workload and time pressure were greater than technicians with less seniority did, although the difference was relatively small. The EMT-Ps assigned to providing care to the patient are exposed to much higher risk factors than the other members of their team. The alternation of roles within a shift after each intervention requiring an urgent patient evacuation could better distribute this exposure between teammates. Waiting periods generally follow each prehospital intervention, which provides the workers with some recovery time. Situations that demand maximum cardiorespiratory aptitude (VO_2max) are not very frequent. Therefore, the limited aerobic capacity of some EMT-Ps, observed especially among those who are obese, does not represent a major limitation in their work, although it is undesirable. Up to a point, the negative effects of a high workload during situations that require the urgent transportation of a patient appear to be offset somewhat by the EMT-Ps' the decision latitude. However, it raises the question of whether compromises are made with respect to the

quality of service, speed and their safety. The saying “every minute counts” in the prehospital environment illustrates the perceived need to rush and the associated high temporal demand, whereas “all the minutes count” in a non-urgent situation, to ensure a quality of service that will optimize the well-being of users.

This large-scale project painted a clear picture of the profession of EMT-P: the demands of the job make it an at-risk occupation with its share of difficulties. The information collected will enhance the training curricula of future EMT-Ps and will contribute to preventing health problems that affect far too many prehospital emergency care workers.

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1. INTRODUCTION

Ambulance services represent the link that provides emergency prehospital care by means of land-based medical transportation. The primary task of emergency medical technician-paramedics (EMT-P[1]) is to provide prehospital emergency care while ensuring safe transportation of the patient to a hospital. Fundamentally, their objective is to reduce patient mortality and morbidity as much as possible by minimizing response time.

The number of EMT-Ps has substantially increased in the last decade, as more than 1,250 workers joined the profession [1,2]. Between 2010 and 2012, Quebec had an average of 4,350 EMT-Ps (including 24.3% women), which corresponded to a ratio of 1 per 1,841 inhabitants [1,3]. This significant increase is explained by growth in demand for ambulance transport, which is essentially attributable to demographic and organizational factors [1]. The aging of the population and its impact on the increase in degenerative diseases explain the growth in demand for ambulance transport. From the organizational perspective, the consolidation of medical services in specialized centres has increased the number of interfacility transport cases.

This increase in the number of EMT-Ps is accompanied by a problem that tarnishes the profession's reputation: the high prevalence of musculoskeletal disorders among EMT-Ps, which partially explains the high staff turnover. EMT-Ps' work is very demanding, both physically and psychologically, and also requires a good deal of availability, since EMT-Ps may work evenings, nights and weekends [1]. The working hours can also be very long. It is important to gain a better understanding of the factors contributing to the appearance of musculoskeletal disorders in EMT-Ps in order to develop, apply and monitor preventive measures. Some recent reviews have concluded that little attention has been paid to this topic [4] and that most studies were based on small samples or convenience samples [5], which can result in certain recruitment biases [6]. The aim of this study was therefore to measure EMT-Ps' exposure to risk factors for musculoskeletal problems in a wide range of real-life work situations.

Following this introduction, the report contains five additional sections. The second section describes the issue and reviews our knowledge of the risk factors for musculoskeletal disorders affecting EMT-Ps. That section also describes the objectives of the research and the underlying hypotheses. The third section describes the methodology for the study. The following section presents the results of the various analyses describing EMT-Ps' work context and their most physically and psychologically demanding tasks and identifies the main work determinants that are responsible. A discussion section then focuses on these results, including an examination of their scope and limitations. Finally, the last section presents a conclusion to the research work, which emphasizes the applicability of the research results and the potential spinoffs.

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1 EMT-P: technician providing emergency, paramedical, ambulance-based medical care.

2. SUMMARY OF THE ISSUE, THE CURRENT STATE OF KNOWLEDGE AND THE RESEARCH OBJECTIVES

2.1 The issue

Some recent reviews have reported that EMT-Ps are subject to a number of health problems [4,5]. They have a higher rate of accidents causing injury and retire earlier than other workers in the population including those in the health care system [7]. In England and Wales, musculoskeletal disorders represent the main reason (47% to 68%) causing EMT-Ps to take early retirement [8,9]. This reality can also be observed in Quebec. A ministerial committee reported that EMT-Ps' work was physically and psychologically demanding (stress level, injuries, etc.), which explains why the turnover is so high and why so many EMT-Ps quit their jobs for less demanding ones as they get older [10]. In this regard, Service Canada points out that the proportion of workers aged 55 years and over is considerably lower than in all other professions: 7% compared to the mean of 15% observed in 2006 [1].

The prevalence of musculoskeletal disorders among EMT-Ps seems to be higher than in the general population [5]. In addition, a study of 334 Swiss EMT-Ps noted that 67% and 55% of them had reported symptoms of lower back and upper body discomfort, respectively, in the 12 months preceding the survey, which had the effect of limiting their performance of household or workplace activities (26% and 14%, respectively) [6]. A high prevalence of lower back pain (57%) and upper body pain (47%) was also observed in Swedish EMT-Ps [11]. In the U.S.A., the incidence of back pain in EMT-Ps is 25% [12].

In 2011, the degree of risk for the entire ambulance services sector in Quebec was considered to be high, according to the province's Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST). A detailed analysis of the data obtained further to a request to the CNESST by the authors indicates that, between 1997 and 2006, 4,579 cases of injuries triggering an absence from work were compensated in ambulance service workers (excluding air ambulance services). That represents a total of 290,713 days of absence from work or the mean equivalent of a 63.5-day absence per injury reported. The back and spinal column (47%) and the shoulders (8%) are the main areas affected.

Age and sex

Few studies have investigated the impact of age on the prevalence of musculoskeletal disorders in EMT-Ps. Consultation of the CNESST data from 1997 to 2006 reveals that close to 76% of the injuries listed affected workers aged 25 to 44 years old, and less than 20% of injuries affected workers aged 45 and over. The consequences of an injury, in terms of days of absence, are distinctly higher in older workers. For EMT-Ps aged 25 to 44, a workplace accident results in an average of more than 57 days' absence from work. This number rises to 87 days of absence for workers aged 45 to 54 and more than 212 days of absence for workers aged 55 and up. Since the total number of Quebec EMT-Ps in full-time equivalents by age group during those years is unknown, it was not possible to assess the prevalence by age group. Based on a retrospective survey of workplace accidents suffered by EMT-Ps in the United States, the injury rate per worker is higher in workers aged less than 30 years than in those aged 30 and over (65% vs. 39%) [13].

In 2011, 24% of EMT-Ps in Quebec were women. According to the CNESST's statistics, just over 15% of injuries associated with an absence from work were suffered by female EMT-Ps. The reported absences had a mean duration of 84 days, compared with 60 days for male EMT-Ps. More specifically, among cases associated with excessive effort during a lifting activity, there was a mean absence of 89 days for women, compared with 62 days for men.

Data from epidemiological studies in the United States show that the risk of injuries and incidence of musculoskeletal disorders in emergency medical technicians were higher than among their colleagues [7,13]. One of these studies, which retrospectively analyzed 254 work accidents resulting in injury, reported a very high accident rate among female workers: 0.86 injuries per worker per year compared with 0.5 injuries per worker per year for men. On the other hand, no significant sex-related effect was observed for the prevalence of lower back and upper body symptoms in the Swiss EMT-Ps [6].

Effect of climate

In Quebec, the number of work accidents causing injuries seems to be associated with the climate since it is higher in the first three and last three months of the year than during the six warmest months. Indeed, according to the CNESST's data, in the last decade, approximately one hundred more accidents were reported during these months; the maximum number of accidents was observed in December (n = 512). These statistics suggest that certain climate conditions exacerbate the risk of professional injuries forcing workers to stay home from work.

Findings

Other than the CNESST data, there is little information on the musculoskeletal health of Quebec EMT-Ps. Nevertheless, the CNESST's data reveal the large number of work accidents affecting them. This situation is not unique to Quebec, as it is also reported elsewhere in the world [5,8,11,14-17]. It should be remembered that the CNESST's statistics report on work accidents that were compensated; they do not take account of uncompensated accidents, temporary assignments and the various kinds of physical and psychological discomfort EMT-Ps experience.

2.2 EMT-Ps' work activity

2.2.1 Models

The interaction of the different work determinants has an impact on work activities (Figure 2-1). EMT-Ps are at the core of this interaction, which is governed by prescribed tasks [18]. Like all sensations, prescribed tasks are perceived according to each worker's convictions and motivations. This model includes the EMT-Ps' characteristics and external factors, as well as the ambulance company and its operating framework. Under the influence of these determinants, EMT-Ps make compromises between the tasks assigned to them and, to the extent possible, the minimization of negative consequences in order to preserve their physical and mental health. Each constraint or determinant contains its quota of recognized risk factors associated with the prevalence of musculoskeletal injuries suffered at work [19-23]. It should also be noted that work activities also enable workers to acquire new know-how, gain experience and increase their qualifications [19].

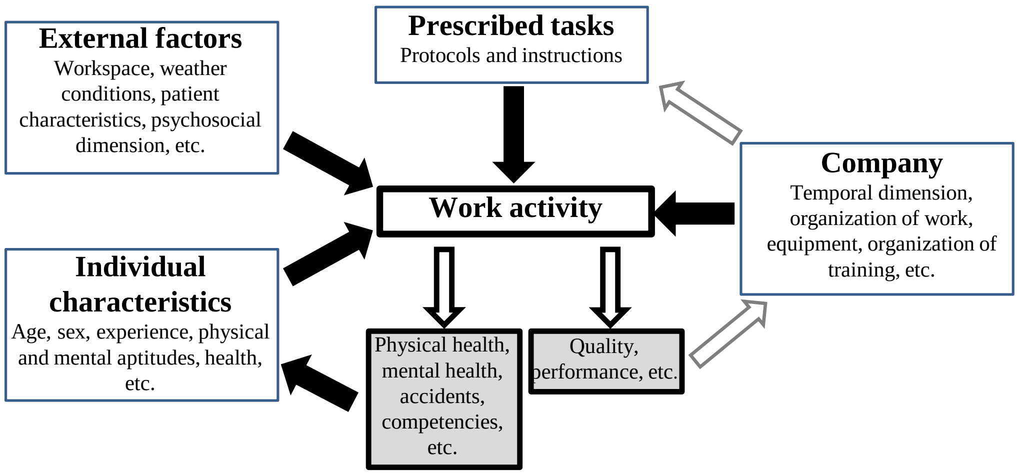

Figure 2-1 Model of dynamic interaction of work determinants adapted from Guérin *et al.* (1997).

One model of the development of musculoskeletal disorders (MSDs) is based on the notion of load, which reflects a pathogenic combination of biomechanical and psychosocial factors [24]. An injury occurs when an applied load exceeds the tolerance limit for human tissues, which itself fluctuates based on the exposure level. Thus, the appearance of an MSD is related to excessive (overstress), renewed (repetition) or continuous solicitation (static effort, i.e., maintained over time) of the worker, given the various constraints of the work situation and their respective interactions [25,26].

2.2.2 Current knowledge of EMT-Ps' work activities

Constraints of the job

In North America, the organization and coordination of prehospital services is the responsibility of regional or national health authorities or of municipalities. In Quebec, these functions are the responsibility of health and social services agencies in each region, except for Montreal and Laval (where they are entrusted to Corporation Urgences-santé, a public agency). In all other regions of Quebec, these functions are executed by private companies and cooperatives.

A health communication centre handles emergency calls coming from the 9-1-1 system, a health care institution, a police force or an individual that relate to the prehospital domain. The centre handles calls based on the *Medical Priority Dispatch System* protocol established by the International Academies of Emergency Dispatch. In 2013, the classification involved 33 types of prehospital emergency calls, allowing for the assignment of 326 combinations of codes. These codes enable EMT-Ps to be better informed before they arrive at the call location. Emergency calls can be categorized into eight priority levels that determine the severity of prehospital transport. Priority 1 represents the highest priority level and informs EMT-Ps that an immediate risk of patient mortality is possible. The assignment is immediate and urgent. The other priority codes are classified as non-urgent for routine calls that cannot be delayed (e.g., priority 3) and calls that can be delayed without harming the patient's condition. For example, priority 7 indicates that the clinical situation is stable, without known risk and with little risk of immediate deterioration. In such a situation, the assignment should ideally be transmitted in less than two hours [27].

EMT-Ps' work consists in providing prehospital emergency care for patients who need help, transporting patients by ambulance to a hospital from a private or public area, and providing interfacility services (patients may be transported from one health institution to another or taken back home after hospitalization).

EMT-Ps perform the functions of evaluating and stabilizing the patient's condition according to the protocols and the available resources, with the aim of preventing the condition from deteriorating, before the patient receives the appropriate medical care in a hospital. EMT-Ps use primary care clinical intervention protocols.[2] Their role is essential because the quality of their clinical interventions may determine whether patients survive. For ambulance transport, a prehospital intervention starts when the call centre calls and ends after triage when the patient is taken in care by the hospital (Figure 2-2A) [2,28].

In Quebec, there is only one official category of EMT-Ps, but in actuality one EMT-P in a team is assigned to patient care and the other prepares the evacuation and drives the vehicle [29]. A prehospital intervention requires the presence and expertise of both partners, who must work together [29]. These tasks are often exchanged for each prehospital intervention in a given work shift [27]. Most tasks are performed as a team.

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[2] This includes the program for administering five drugs that can alleviate breathing problems, chest pain, hypoglycemia and severe allergic reactions.

Some studies have based their analyses on the observation of real-life work activities during a shift [6,27,28,30], or more specifically, while care is provided to the patient during transportation to a hospital [31,32]. Prairie and Corbeil [28] proposed that the prehospital intervention be divided into seven families of activities, as shown in Figure 2-2B.

Several studies have emphasized the impact of constraints and determinants on working activities. Work environments are unpredictable, situations and contexts are difficult to anticipate, even the tasks to be performed and the severity of the patient's condition are often unknown until the last minute, prehospital interventions are non-redundant, and the wait time between calls is variable [6,18,30,33]. All these factors have a considerable impact on the possibility of anticipating the constraints that EMT-Ps must face at work and the resources they will need to meet them [6]. Despite the numerous constraints, EMT-Ps must constantly adapt to the physical and mental requirements associated with the profession's tasks.

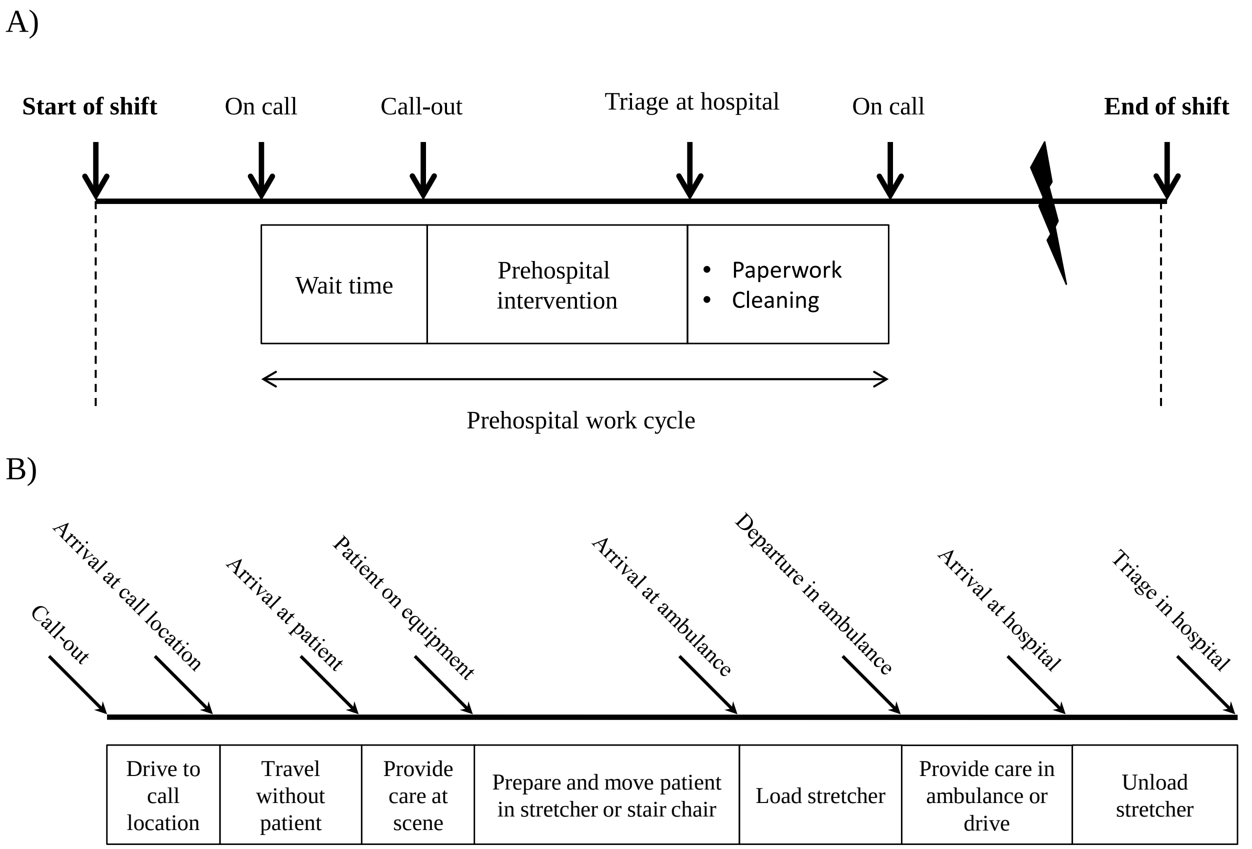

Figure 2-2 A) Overview of a work shift (adapted from [30]); B) Breakdown of a prehospital intervention into families of activities (from [27]).

The results of a pilot study[3] indicated that each team of EMT-Ps executed a mean of 2.9 and 4.0 transports, respectively, during a day shift and a night shift [28]. In addition, 82% of prehospital interventions were carried out inside a building (18% outdoors) and 42% occurred after an urgent call from a health communication centre. For this same sample of observations, the duration of a transport event (prehospital intervention) was 23.5 minutes (ranging from 8.9 to 46.8 minutes) and it required a mean of 7.2 tasks. The frequency and sequence of tasks carried out by EMT-Ps during a prehospital intervention were highly variable. The most frequent tasks were those related to moving around the site and providing care. The sequence of tasks varied based on the role played by each EMT-P on the team and some might be executed by a single person or as a team (e.g., loading the stretcher into the ambulance). The prehospital intervention might be carried out in an urgent or non-urgent context, depending on the priorities set.

Temporal aspect. The importance of the speed of the care administered to a patient is often emphasized in the prehospital domain, particularly to reduce the user mortality rate [34,35]. These studies claim that the success rate for a return of spontaneous circulation after a cardiac arrest declines by 4% to 8% for every minute that elapses between the time the patient calls emergency services and the EMT-Ps administer first aid. EMT-Ps' work habits also focus on the concepts of the *silver ten minutes* (or *platinum ten*) and *golden hour*: ten minutes to get to the

[3] Analysis of 38 prehospital interventions by EMT-Ps in Quebec City, distributed over 12 days and including 120 hours of observation during the summer of 2010.

call location, treat and stabilize the patient, then initiate transportation to the trauma centre, and 60 minutes following the accident for a trauma victim to receive definitive care at a hospital. The concept of urgency is intimately associated with prehospital care, where “every minute counts” [36].

Strains of the job

Transfers (i.e., moving, lifting and transporting) of individuals demand particular attention because of the physical effort required of EMT-Ps. According to the CNESST’s data, more than 62% of work accidents among EMT-Ps resulted from an excessive effort (while lifting, pulling, holding, etc.) or a bodily reaction (leaning, climbing, slipping, tripping, etc.). The results of several interviews, questionnaires or surveys on the health and work of EMT-Ps or firefighter paramedics have shown that the act of transferring a patient from one resting state to another represented the most arduous task when rescuing an individual in an emergency [30,37]. For example, the results of an investigation including 139 accidents in Quebec and those of a survey of 215 EMT-Ps regarding their perceptions of dangers showed that the activity perceived to be the riskiest for an accident was moving patients with equipment (37% of accidents listed) [38]. Patient transfer activities on the stretcher and into the ambulance (26%) came next. The same trends are also seen elsewhere [11,13].

EMT-Ps’ tasks can put a great strain on the musculoskeletal structures of the back and the lower and upper limbs when adopting and maintaining various working postures; they can also overtax cardiovascular capacities [15,30,37,39,40]. In a context where patients are growing heavier and obesity is increasing in Quebec [41,42],[4] it is obvious that transfer and handling tasks are becoming increasingly difficult and risky because the physical demands of the job are directly related to users’ weight.

Awkward postures. The pilot study carried out with EMT-Ps in Quebec City revealed that the kinematics of EMT-Ps’ backs while they were on the job was characterized by large maximum flexions in the sagittal plane and axial rotation (torsion), as well as high maximum speeds for lateral flexion and axial rotation [28]. These factors are known to increase biomechanical loading on the spinal column and are associated with a high risk of MSDs in the back [43]. During a significant proportion of their working time (between 16.2% and 29.3%), EMT-Ps must adopt awkward positions that harm the musculoskeletal system [30]. The main awkward positions observed in the field are backs in flexion or torsion, prolonged postures with the head in flexion or extension, and a kneeling work position [30]. Exposure to awkward postures seems to be greater in urgent situations (as identified by the health communication centre) and when the physical demand associated with tasks is greater (e.g., when lifting an obese patient) [28].

Joint efforts. As has been shown, specifically in Quebec, patient transfers and transport are physically demanding tasks for nurses that often tax their musculoskeletal system to its limits [44-46]. Biomechanical analyses conducted for the transfer of a mannequin weighing 82 kg from a bed to a stretcher showed that the moments of force on the knees and ankles of EMT-Ps assigned to care exceeded the 95th centile for maximum moments of force recommended for these joints [47]. With a lighter mannequin (48 kg), the compression values for the lumbosacral

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4 The prevalence of overweight and obesity among adults in Quebec increased from 43% in 1990 to 56% in 2004 [42]. In 2003, 14% of Quebecers were obese and 33% were overweight [43].

joint were between 3,700 and 7,600 N (mean 5,476 N) [37]. Most of the time, these assessed compression forces for the back exceeded the limit of 3,400 N recommended by National Institute of Occupational Safety and Health (NIOSH) [48]. The greatest compression forces on the back were observed when EMT-Ps transferred the mannequin from the ground to the stretcher and when they adjusted the height of the stretcher on which the mannequin was lying [30].

Respiratory endurance. An electrocardiogram recorded in working situations for eight EMT-Ps from the ambulance service in Belfast, Northern Ireland, revealed that long periods of inactivity were interspersed with periods of high physical and psychological stress that could last for several minutes [15]. The authors observed work periods lasting more than 11 minutes where heart rates exceeded the anaerobic threshold values measured in the laboratory. In addition, that same study showed a high rate of absenteeism, obesity and poor physical fitness (cardiorespiratory capacity) among ambulance personnel in Belfast [15]. Considering the low cardiovascular endurance capacities observed in workers, even low workloads could result in high or even maximum heart rates that are likely to make workers get tired fast [49]. Barnekow-Bergkvist *et al.* [39] showed that certain performance tests ($\dot{V}O_2max$ and trunk muscle endurance) can explain up to 62% of the variance observed in blood lactate accumulation (marker of muscle fatigue) caused during the movement by a two-person team of a stretcher over a route comprising stairs. A minimum level of physical fitness is therefore required to perform the most demanding tasks involved in the EMT-P's job with a minimum of fatigue to reduce the risks of injury and disability [11,39,50].

Age and sex

Several studies have shown in increase in MSDs with seniority, which suggests that there is a phenomenon of wear related to the intensity of work, and thus to time constraints, regardless of age [51,52]. According to Shephard [49], musculoskeletal injuries are more likely to occur when the worker does not have enough muscle strength to execute a handling activity. This effect appears to be greater in workers aged over 50 years [53]. Aging is often associated with a gradual, normal and inevitable decline in physical work capacities, including aerobic capacity, strength and muscle endurance [49,54]. Studies evaluating the effects of aging on working capacities face the *healthy worker effect*: workers only occupy their positions if their health permits [53,55]. The demands of the EMT-P job do not change based on the worker's age or seniority. A decline in functional physiological capacities due to advancing age can have a significant impact on older workers' performance and productivity, especially for those engaged in physically demanding tasks [56]. These tasks require physical efforts that come increasingly close to the worker's maximum physical capacities, thereby increasing the risk of musculoskeletal injuries or other health problems [20,49,56]. On the other hand, to achieve the same production objectives, older, more experienced workers may work differently than young ones; with increased experience, they develop individual and collective work strategies that allow them to continue efficiently performing high-quality tasks while protecting themselves from risks [57-59].

The results of one study indicated that the self-reported physical demands experienced by Swedish EMT-Ps were significantly associated with discomfort in the neck and shoulders during work activities only in women [11]. This association has also been observed in nurses [60,61].

The association may be due to the fact that women have lower physical capacity than men [11]. In general, women's muscle strength in the shoulders and arms is 60% lower than that of men [62]. Another explanation was suggested by Aasa *et al.* [11], who stipulate that equipment and ambulances were initially designed based on anthropometry of the male. For example, getting a stair chair into or out of an ambulance can require short people to lift it above the shoulders. This may be particularly true of women, since they are shorter on average than men. These operating conditions generally result in greater joint effort for these individuals. The mismatch between work instruments and women's morphology might also impair their ability to produce an optimal force (e.g., hand size, height of equipment).

2.2.3 Findings

To sum up, most of these studies show that EMT-Ps adopt work postures that are not favourable for their back health and often make significant muscular efforts. Some studies examined EMT-Ps' work activities, particularly while providing care in the ambulance, but very little attention has been paid to other tasks. No study has yet provided a detailed overall description of the work context, that is, the work environment, the medical or clinical reasons for the call-out, the patients' characteristics, the presence of other people, etc. According to several researchers, the lack of context for the work activity makes it difficult to apply concrete preventive measures [63,64]. Indeed, several determinants can influence certain aspects of EMT-Ps' work activities. For example, the presence of a heavy snow cover on the ground could force them to clear the road to facilitate the movement of the stretcher to the ambulance, or a clinical protocol applied to a patient who has suffered a head trauma would requires a series of operations that would be quite different from a protocol focusing on a psychosocial problem. Then again, the presence of first responders could make it easier to carry out patient movement activities by distributing the load to be lifted among several individuals (e.g., while carrying a patient immobilized on a spine board down a staircase). Evidently, the exposure to risk of injury is different in each of these cases. That is why we consider it crucial to understand the extent to which certain determinants are variable and predictable and to identify those that have a determining impact on EMT-Ps' work activities.

Analyses of the temporal aspects of EMT-Ps' work have emphasized the optimization of response time for prehospital interventions, where every minute is said to count, but have paid very little attention to the harmful effects of this demand[5] or time pressure[6] on EMT-Ps' health. In addition, time constraints are rarely the only difficulties present in the work environment; they are frequently combined with other difficult working conditions such as handling heavy loads or awkward postures [65]. This dimension of EMT-Ps' work activities must definitely be considered in the measurement of exposure to risk factors for musculoskeletal problems.

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5 Time shortage, described as the recurring recognition of not having enough time, relates to a problem with time management and is mainly the result of cognitive evaluations.

6 Haste, or the fact of being rushed, refers to an emotional experience including agitation, urgency, speed of executing tasks, vigilance regarding deadlines, and fragmentation of activities; its affective correlates are a feeling of loss of control, worry, anxiety and frustration.

The analysis of work activities must also take into consideration an appropriate selection and an adequate number of observation periods (sampling). Analysis of a small number of samples offers a limited vision of the different scenarios that can occur, including less frequent ones requiring intense physical effort that must be executed as fast as possible. This initiative should also include the observation of workers with diverse profiles to identify the impact of certain individual characteristics (seniority, sex, physical fitness and height) on work activities.

A better understanding of work activities would make it possible to improve the preventive measures now in place and, if necessary, to suggest changes with the aim of improving and optimizing certain working conditions for EMT-Ps. To date, no study based on activity analysis has provided a detailed description of these constraints and their effects on workers.

2.3 Research objectives and hypotheses

The research project's objectives were as follows:

1. Compare EMT-Ps' physical fitness to that of the general population by matching comparisons according to the worker's sex and age;
2. Document the nature of EMT-Ps' tasks and work context in the urban environment with the help of observations made in the field in winter and summer;
3. Identify the most physically demanding real-life work situations, including a detailed analysis of back postures;
4. Identify the main determinants associated with a work situation that EMT-Ps perceive to be difficult;
5. Characterize the impacts of intrinsic factors such as sex, obesity level, seniority, and musculoskeletal discomfort on EMT-Ps' motor performance and work strategies in real-world work situations;
6. Summarize analyses and determine whether the individual factors studied (sex, seniority, obesity level and physical fitness) can be considered as risk factors related to the development of musculoskeletal disorders in EMT-Ps.

The main hypotheses were:

1. Individual factors will affect EMT-Ps' cardiovascular capacities and muscular capacities, but they will be comparable to those observed in the general population;
2. Patient movement tasks will be the most physically demanding;
3. Individual factors such as sex, seniority, and obesity level will be among the main determinants explaining EMT-Ps' differential perception of effort;
4. Factors related to the task and the equipment and individual factors will impact workers' motor performance, in terms of duration, intensity and frequency of use of awkward postures during tasks associated with moving the patient.

3. METHODS

3.1 Participants

The research project took place over four years, from 2010 to 2014. Participants were recruited from three organizations in the province of Quebec: two are based in Quebec City, namely Coopérative des techniciens ambulanciers du Québec (CTAQ) and Dessercom inc., and the other, Urgences-santé, serves Montreal and Laval. The invitation to participate in this study was sent by means of mailing lists, direct solicitation at workplaces and word of mouth.

Candidate EMT-Ps could not have taken time off work due to injury in the 30 days preceding their participation in the study. They were eligible to take part in the study regardless of the type of contract they had with their organization (permanent, temporary or on call), the duration of their shifts (8 h, 10 h or 12 h) and the type of work schedule (day, evening or night). We hoped for a balanced distribution of participants in each of three groups formed based on their employment experience: individuals with less than 5 years of experience, those with 5 to 15 years of experience, and those with more than 15 years of experience.

A total of 101 EMT-Ps took part in this study: 40 from CTAQ (mean age: 36.5 ± 11.3 years; 6 women), 19 from Dessercom (mean age: 39.8 ± 11.4 years; 7 women) and 42 from Urgences-santé (mean age: 32.2 ± 9.9 years; 10 women). Complete demographic data on participants are presented in Table 4-1 in the results section.

The research project was approved by the research ethics committee at Université Laval (CERUL, Approval no. 2010-151-A-1/07-02-2011). All participants read and signed the study’s consent form.

3.2 Experimental protocol

The experimental protocol was divided into two parts: an observation portion, which required an observer to accompany EMT-Ps in real-life work situations during their shifts, and a clinical evaluation of their physical fitness done outside the workplace and outside working hours.

3.2.1 Observations

Each participant was accompanied by a member of the research team twice (two shifts), once in winter and once in summer.

The group of researchers and an ergonomist who was collaborating on the project trained three observers – two doctoral candidates and a master’s student in kinesiology – in techniques for capturing high-quality video images and interviewing the workers. The observers’ tasks consisted in first obtaining the EMT-P’s consent, agreeing with the team of EMT-Ps on the procedure for making the observations during the prehospital interventions, and attaching the portable measuring equipment (30 minutes before the start of the shift). Then their role consisted in accompanying the EMT-Ps at all times during the shift and tracking their actions and gestures by capturing video images and conducting a semistructured interview after each prehospital intervention (Figure 3-1).

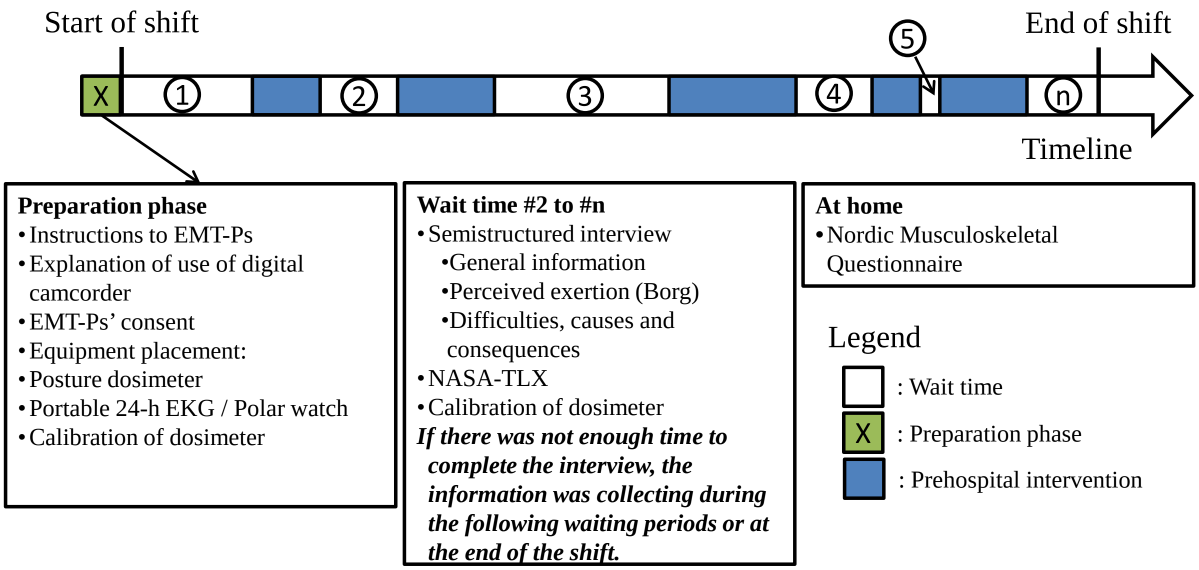


Figure 3-1 Protocol for collecting data in the field.

3.2.2 Semistructured interview and other questionnaires

The interviews with the EMT-Ps were conducted systematically during each out-of-service period (i.e., after each transport). The interview was divided into six parts: (1) degree of difficulty of the various tasks in the prehospital intervention; (2) impact of the intervention's priority level on the work activity; (3) consequences of time constraints for the work activity; (4) work done with teammate; (5) general impression of the intervention just performed; and (6) perception of the intervention based on the time of day.

The observer's questions were structured to help the EMT-Ps express the difficulties they had experienced and find out the causes and consequences associated with those difficulties. The intensity of the different families of tasks executed by the EMT-Ps was measured with the Borg Rating of Perceived Exertion (RPE) Scale [66,67]. The interviews were recorded with a digital camcorder (GZ-HD500BU, JVC Canada) or a Dictaphone (Sony IC Recorder, Canada). If the interview was not completed during the out-of-service period following the prehospital intervention it was finalized as a lower priority during the next out-of-service period or after the shift.

After each prehospital intervention, the workload was measured with the NASA Task Load Index (NASA-TLX) [68,69]. This questionnaire made it possible to assess six dimensions and calculate an overall score related to mental workload: three related to the task (mental demand, physical demand and temporal demand) and the other three related to the worker's investment in the task (performance, frustration and effort).

All the EMT-Ps also completed a questionnaire on their musculoskeletal health, which enabled us to assess the scope of the problems (i.e., soreness, pain or discomfort experienced) and identify the body areas affected [70,71].

3.2.3 Equipment

A digital camcorder (GZ-HD500BU, JVC Canada) was used to record the prehospital interventions at a rate of 30 images per second. The camcorder focused exclusively on the EMT-P who was participating in the study. The camera operator was trained to minimize his/her movements, keep the view plane orthogonal to the work plane, and maximize his/her distance in order to capture a significant portion of the EMT-P's work zone without hindering the work.

The observers captured video images in private or public places only when they had obtained consent from the patients or their proxies, the person in charge of the site, and the EMT-Ps. A consent form was given to the patients or proxies to inform them of their rights. The observers were also allowed to use their judgment regarding the nature of the case and its context to decide whether or not to film the EMT-P.

The digital recording of prehospital interventions made it possible, among other things, to analyze the activity *a posteriori* and validate the data obtained with the other measurement tools, including the posture dosimeter.

The posture dosimeter was used to measure three-dimensional trunk movements during work activities [72]. This tool is made of three components: two inertial sensors (Xsens Technologies B.V., Netherlands) on the pelvis (lower sensor) and on the thorax (upper sensor) and a flexible structure equipped with a potentiometer that connects the two orientation sensors. Each sensor contains nine sensing elements: three accelerometers, three magnetometers and three gyroscopes. The frequency of acquisition of these signals was set at 120 Hz. Data from the two sensors and the potentiometer are integrated with a complementary filter that optimizes the sensors' response. Validation and reproducibility tests, done on a calibration template with six subjects, indicated that the mean square errors were below 3° for forward and lateral flexion angles and below 6° for torsion (lengthy trials) [73].

3.2.4 Assessment of physical fitness

Each participant was invited, on a voluntary basis, to have his/her physical fitness assessed by kinesiologists. The EMT-Ps in the Quebec City region were invited to go to the physical activity sciences laboratory at Université Laval and those in the Montreal area went to the functional and psychophysiology laboratory for the evaluation of physical and psychological exercise at the research centre at Sacré-Cœur Hospital.

Participants' height, weight, waist circumference, and percentages of body fat and lean body mass were measured using standardized procedures on a bioelectrical impedance scale [74]. Then their body mass index (BMI – kg/m^2) was calculated.

The Canadian Society for Exercise Physiology's normalized weighted tests enabled us to assess the EMT-Ps' back, musculoskeletal and overall health (grip strength, push-ups and trunk flexion). In addition, the endurance of the EMT-Ps' trunk flexors [75] and their maximum isometric muscle force for lifting were measured. For the test of lifting muscle force, each participant was standing, with the trunk and legs flexed, and holding a handle at knee height (squat position). The test consisted in exerting maximum extension force against a force gauge attached to the floor [47,76]. Three trials were carried out. A two-minute rest period was allowed after each trial.

Participants also performed a maximal exercise stress test by direct measurement of gas exchange. The ramp test done on a bicycle ergometer (Excalibur Sport, Medgraphics, Saint Paul, MN) allows one to accurately determine the maximum oxygen consumption with effort ($\dot{V}O_2max$), that is, the capacity to transport and use oxygen during exertion [77]. The devices used at both test sites were the same (Ultima CPX with BreezeSuite software, Medgraphics Corp., Saint Paul, MN). The individualized increase in workload during the test was measured every second, and the maximum duration of the test was 8 to 12 minutes. $\dot{V}O_2max$ was obtained from the mean for the last 15 seconds of the test and a respiratory exchange ratio above 1.15.

3.3 Data analysis

3.3.1 EMT-Ps' Musculoskeletal health and physical fitness

The data from the questionnaire on musculoskeletal health were analyzed by grouping certain body regions together. The prevalence of musculoskeletal problems (pain, soreness or discomfort) was analyzed for the nape-neck region, the back (upper and lower), the upper limbs and the lower limbs. Problems during the last 12 months, those preventing the execution of the usual work, and those experienced within the last seven days were recorded. All of these data and the data from the assessment of physical fitness were analyzed as a function of ambulance company and of EMT-Ps' seniority, sex and BMI.

The results of the assessment of physical fitness were compared to the American College of Sports and Medicine (ACSM) standards and adjusted for the participants' age and sex.

3.3.2 Work context

The observations made in the field and the information gathered from the EMT-Ps and the organizations enabled us to create an overall picture of the prescribed task (description of the task, requirements to be met, conditions of execution) and work activities. The frequency, distribution and duration of different families of tasks, the course of activities during a shift, and sources of variation were determined after analyzing the video sequences.

Analysis charts for video captures were developed to describe the conditions in which different families of tasks were executed, emphasizing the determinants, that is, the variables that condition work strategies. The analysis in this study therefore concerned a series of determinants extracted from the observations of EMT-Ps' actual work. A first set of determinants was selected to describe the physical and social environments where the prehospital interventions occurred. The characteristics retained were the location (single-family home, apartment/condo, residence with health professionals, outdoors, or other location), temperature, weather (rain or snow), accumulation of snow or ice on the ground, whether the EMT-Ps used an elevator or staircases, and whether there were family members or other emergency workers on the scene. A second set of determinants concerned the characteristics of the patient who needed the prehospital service. Thus, data concerning the patient's age, weight, consciousness, ability to communicate, and psychosocial condition were recorded. A third set of determinants included medical information on the prehospital intervention, that is, the call priority and nature of the case established by the communication centre at the time of the call-out, the priority of transport to a receiving centre (e.g., hospital), the nature of the case and the clinical protocol administered as recorded in a prehospital intervention report by the EMT-Ps at the end of the process. A final group of determinants enabled us to describe the equipment used to evacuate the patient to the ambulance. The determinants were coded by watching the videos of the prehospital interventions with the help of observation software (Observer XT, Noldus Information Technology, Netherlands). The clinical protocols that were retained for analysis were selected based on their frequency of appearance and the opinions issued by a group of experts on the prehospital environment.

3.3.3 Analysis of strains

Biomechanical variables

Two methods were used to analyze EMT-Ps’ postures, or three-dimensional back angles. The Exposure Variation Analysis (EVA) method [78] enabled us to establish a relationship between the amplitude of back movements, the duration of postural maintenance and the total exposure time (percentage of total exposure time).

Sagittal flexions were grouped into six intensity classes: <–5° (moderate); –5° to 10° (neutral); >10° to 25° (neutral); >25° to 40° (moderate); >40° to 60° (high); >60° (very high). Lateral flexions and axial back rotations were grouped into six range of motion classes: <6° (neutral); 6° to 12° (neutral); >12 to 18° (moderate); >18° to 24° (moderate); >24° to 30° (high); >30° (very high). The duration of motion in seconds was grouped into six classes: <0.5 (short duration); 0.5 to 1 (short duration); >1 to 5 (moderate duration); >5 to 10 (moderate duration); >10 to 20 (long duration); >20 (very long duration). The centroid method was used to describe exposure measures [79]. The method records two relative distances in relation to the zero-risk situation: the mean position of the EVA data distribution on the intensity axis (EVA-intensity centroid) and on the duration axis (EVA-duration centroid). An increase in the values of the EVA-intensity centroid is caused by an increase in angular values and an increase in the EVA-duration centroid is attributable to longer-duration movements.

The second method investigates the median and extreme values of the distribution corresponding respectively to the 10th, 50th and 90th centiles of the angular values obtained by the dosimeter (Amplitude Probability Distribution Function – APDF; [80]).

Variables related to EMT-Ps' perception

An analysis of the perception of physical effort and workload was also done. Comparisons were made to determine the impact of sex, obesity, seniority, region and season. Multiple regression models were constructed with the aim of explaining the variance in variables related to EMT-Ps' perception using a combination of explanatory factors, including work context determinants and intrinsic factors.

3.3.4 Analysis of difficulties

The most difficult tasks in all the prehospital interventions were classified based on their degree of difficulty. The verbal statements obtained during interviews with EMT-Ps were transcribed and digitized. QDA Miner software (Provalis Research, Montreal, QC) was used to analyze the content of these statements. Among other things, that made it possible to group them by theme (family of tasks) and then identify the causes of difficulties (e.g., stretcher malfunction – blockage of stretcher wheels) and their consequences (e.g., "I had to lift up the stretcher to unblock the wheels"). In addition, the statements in the third part of the interview were analyzed to identify the main time constraints of the job and determine their impacts on EMT-Ps' work methods and physical exertion. The statements were also used to explain certain results obtained further to the biomechanical analyses.

3.3.5 Intrinsic factors

Motor performance is characterized by the duration and intensity of use of awkward back postures, the manifestation of certain markers of fatigue and the workload associated with urgent prehospital interventions. Work strategies are mainly determined by the duration and percentage of time allocated to different tasks and to other strategies (e.g., advance planning of the route to be taken to get to patients and execute transfer tasks; appropriate, effective communication within the team and with patients so they do not hinder the work; having the patient participate in transfer tasks; reducing lifting during patient transfers). The independent variables are sex, seniority, obesity level, and presence of musculoskeletal discomfort.

3.3.6 Statistical analyses

The statistical analyses were done with Statistica software, version 10 (Dell Software, Aliso Viejo, CA). The significance level for the comparative analyses was set at 0.05. The median and quartile values were used to describe the data's central tendency. The mean values and standard deviations were also extracted.

An important assumption in the analysis of variance (ANOVA) and t-test for differences in means is that the variances in different groups are homogeneous. This assumption was systematically verified with Levene's test. When the test was significant, nonparametric tests were applied: the Mann-Whitney U-test (comparison of two means) or the Kruskal-Wallis test (multiple bilateral comparisons). The effect size was assessed using the partial eta squared (η^2_p) calculation. η^2_p is interpreted as follows: an effect size of approximately 0.01 is low, an effect size of approximately 0.06 is moderate, and an effect size of approximately 0.14 or more is high. When the result of the ANOVA was significant, the means that contributed to the effect were determined using a variant of the Tukey test for unequal groups based on the Spjøtvoll-Stoline method (unequal N honest significant difference). Proportions were compared using Pearson’s chi-square test.

Multiple regressions were done with the stepwise method (ascending order), with an input F of 3.84 and an output F of 2.71.

4. RESULTS

4.1 Sociodemographic characteristics, medical examination and physical fitness

4.1.1 Demographic data

One hundred and one (101[7]) EMT-Ps (including 23 women) took part in this study (Table 4-1). The sample was constructed so as to include EMT-Ps with different levels of seniority; thus, it included 28 EMT-Ps with more than 15 years of experience in the profession, 35 EMT-Ps with 5 to 15 years of experience, and 38 EMT-Ps with less than 5 years of experience. The proportion of women in each sample ranged from 12% to 48%; the lowest representation was in the group of EMT-Ps with more than 15 years of experience and the highest was in the group with 5 to 15 years of experience.

Table 4-1 Demographic data extracted from the Nordic Musculoskeletal Questionnaire based on EMT-Ps' seniority group and sex.

	<5 years (n = 38)	**5–15 years** (n = 35)	**>15 years** (n = 28)	**Men** (n = 78)	**Women** (n = 23)	**Total** (n = 101)
Age (years)	26.4 (±4.5)	33.1 (±5.5)	50.3 (±5.9)	35.9 (±11.2)	33.3 (±10.6)	35.2 (±11.0)
Male/female ratio	29/9	24/11	25/3			78/23
Height (cm)	176.5 (±10.7)	174.4 (±9.1)	176.5 (±7.0)	178.4 (±7.8)	166.5 (±7.7)	175.7 (±9.2)
Weight (kg)	78.3 (±14.4)	77.0 (±15.0)	82.9 (±14.1)	83.1 (±12.0)	65.7 (±15.0)	79.1 (±14.6)
Mean BMI (kg/m^2)	25.1 (±3.4)	25.2 (±3.9)	26.6 (±4.1)	26.1 (±3.2)	23.7 (±5.0)	25.5 (±3.8)
Male/female ratio						
< 30 kg/m^2	28/7	19/10	20/2	67	19	86
≥ 30 kg/m^2	1/2	5/1	5/1	11	4	15

Fifteen percent of the EMT-Ps in the sample were considered obese according to their BMI; 52% were considered to be overweight (BMI greater than 25 kg/m^2).

4.1.2 Medical background

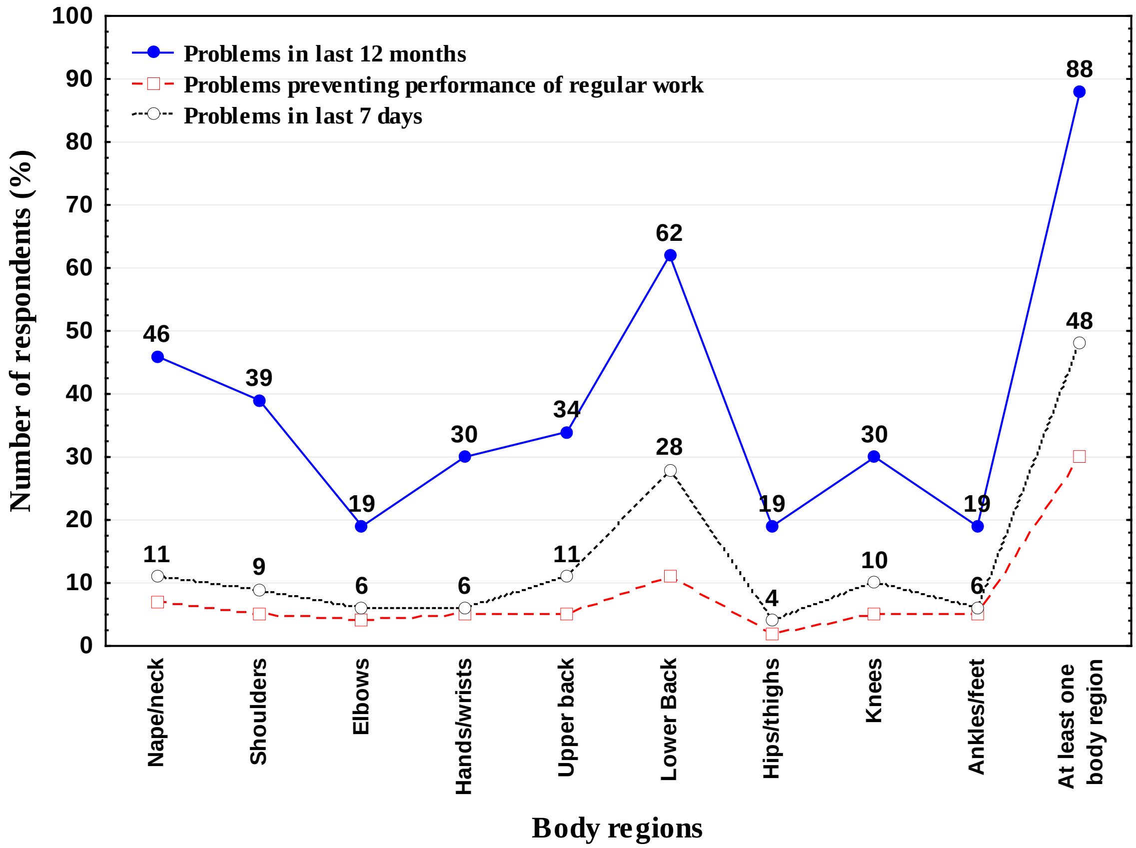
Eighty-eight percent (88%) of the EMT-Ps said they had had musculoskeletal problems (pain, soreness or discomfort) in the last 12 months (Figure 4-1). Thirty percent (30%) of them said they had had a problem that prevented them from doing their usual work.

The main body regions involved were the lower and upper back (71% of EMT-Ps). In total, 58% of the EMT-Ps said they had consulted a health care professional for their back problem. Fifteen of them had been absent from work for less than a week, seven between 8 and 30 days, and two had been on sick leave for more than 30 days.

[7] One EMT-P withdrew from the study but did complete several questionnaires.

Almost half of the EMT-Ps (48%) claimed to have experienced a problem in at least one body region during the week prior to the data collection (Figure 4-1). The main areas affected were the lower back (28%), nape/neck (11%) and upper back (11%).

Figure 4-1 Prevalence of musculoskeletal problems (pain, soreness or discomfort) by body region.



The EMT-Ps with less than 5 years of experience were the ones who reported having the fewest problems (in at least one body region) during the last seven days, and the proportion observed was lower than in other groups (34% vs. 56% for the other groups; $p < .05$; Table 4-2).

No difference between seniority groups was observed when considering problems (in at least one body region) that impaired the performance of their work.

Only one difference was detected between obese and non-obese EMT-Ps when it came to problems in at least one body region (particularly the back) that impaired the performance of their work (57% vs. 26%; $p < .05$).

Of the 24 EMT-Ps who had to take at least one day off work because of a musculoskeletal problem, 20 were not obese and 10 had 5 to 15 years of experience. The proportion of EMT-Ps in the group with 5 to 15 years of experience who had had a back problem (lower or upper) was higher than in the other groups (24% vs. 9% for the other groups; $p < .05$). This group of EMT-Ps (5–15 years of experience) is the one that had most frequently consulted a health professional regarding their back (59% vs. 32% for the other groups; $p < .01$).

Table 4-2 Prevalence of musculoskeletal problems (pain, soreness or discomfort) by body region in the sample of EMT-Ps according to their seniority and BMI.

Body region	Problem in last 7 days		Problem in last 12 months		Problem preventing performance of regular work	
	N	Relative frequency	N	Relative frequency	N	Relative frequency
Seniority						
Back						
<5 years	10	26%	25	66%	3	8%
5 to 15 years	12	35%	27	79%	8	24%
≥15 years	9	32%	19	68%	3	11%
Upper limbs						
<5 years	3	8%	20	53%	2	5%
5 to 15 years	9	26%	20	59%	5	15%
≥15 years	6	21%	17	61%	4	14%
Lower limbs						
<5 years	5	13%	5	13%	4	11%
5 to 15 years	6	18%	6	18%	3	9%
≥15 years	5	18%	5	18%	3	11%
At least one body region						
<5 years	13	34%	32	84%	10	26%
5 to 15 years	18	53%	31	91%	11	32%
≥15 years	17	61%	25	89%	9	32%
BMI						
Back						
<*30* kg/m²	29	34%	62	72%	10	12%
≥*30* kg/m²	2	14%	9	64%	4	29%
Upper limbs						
<*30* kg/m²	16	18%	51	59%	9	10%
≥*30* kg/m²	2	14%	6	43%	2	14%
Lower limbs						
<*30* kg/m²	12	14%	40	47%	7	8%
≥*30* kg/m²	4	29%	8	57%	3	21%
At least one body region						
<*30* kg/m²	40	47%	75	87%	22	26%
≥*30* kg/m²	8	57%	13	93%	8	57%

Note: figures in red indicate a statistically significant difference in relation to other groups, $p < .05$.

4.1.3 Physical fitness

Physical fitness was assessed in 54 EMT-Ps (Table 4-3). The results obtained were compared with the ACSM standards:

- Abdominal obesity (measured by waist circumference[8]) was identified in 8 out of 54 individuals (15%): one man and one woman with 5 years of experience or less, two men with 5 to 15 years of experience, and four men with more than 15 years of experience;
- Five of the eight individuals with abdominal obesity had a BMI higher than 30 kg/m^2; the other three had values of 28.7, 29.5 and 29.8 kg/m^2;
- 31% of participants had a lower-than-average $\dot{V}O_2$max value (adjusted for the participant's age and sex), which needed improvement;
- The $\dot{V}O_2$max value for all of the individuals with abdominal obesity needed improvement (minimum value: 23 ml/kg/min; maximum value: 35 ml/kg/min; mean value: 28 ml/kg/min);
- 4% of participants' scores on the push-up test needed improvement;
- 9% of participants' back flexibility needed improvement;
- One participant's lower limb strength and abdominal muscle endurance needed improvement;
- 7% of participants' back extensor endurance needed improvement;
- Overall, then, most of the participants were above the standards adjusted for age and sex.

We noted several differences between the sexes, including BMI, percentage of body fat and waist circumference (Table 4-3). The resting $\dot{V}O_2$ value and abdominal muscle endurance were lower in men, whereas grip strength and lower limb strength were higher in men.

Comparisons between the seniority groups showed differences between younger and older participants (Table 4-3). The percentage of body fat was higher in EMT-Ps with more seniority. Values for resting $\dot{V}O_2$, $\dot{V}O_2$max, arm extension strength, abdominal muscle endurance, and the endurance ratio were lower for EMT-Ps with more seniority than for those with less.

8 Waist circumference is an adiposity marker that complements BMI. Measuring the waist circumference makes it possible to determine if there is excess fat in the abdomen: when the waist circumference is more than 88 cm in women or 102 cm in men, it is considered to indicate abdominal obesity, which is associated with an increased risk of diabetes, hypertension, hypertriglyceridemia and vascular disease.

Table 4-3 Physical fitness of EMT-Ps based on seniority group and sex.

	<5 years (n = 25)	**5–15 years** (n = 15)	**>15 years** (n = 14)	**Men** (n = 41)	**Women** (n = 13)	**Total** (n = 54)
Age (years)	25.9 (±3.9)	33.7 (±4.9)	49.5 (±5.5)	34.7 (±10.6)	32.5 (±11.4)	34.2 (±10.7)
BMI (kg/m^2)	25.0 (±3.5)	25.5 (±3.0)	26.4 (±4.4)	26.3 (±3.2)	23.1 (±3.9)†	25.5 (±3.6)
% body fat	20.1 (±6.6)	22.6 (±4.1)	25.2 (±5.9)**	21.2 (±6.2)	25.0 (±5.0)‡	22.1 (±6.0)
Waist circumference (cm)	86.6 (±7.5)	88.1 (±10.3)	93.5 (±11.1)	91.8 (±8.0)	79.5 (±8.2)†	88.8 (±9.6)
Resting heart rate (beats per minute)	84 (±13)	84 (±14)	80 (±12)	84 (±13)	83 (±14)	83 (±13)
Maximum heart rate (beats per minute)	182 (±6)	176 (±14)	169 (±14)	176 (±13)	179 (±10)	177 (±12)
Resting $\dot{V}O_2$ (ml/kg/min)	7.1 (±2.1)	5.2 (±2.2)**	5.0 (±1.9)*	5.7 (±2.1)	7.2 (±2.5)†	6.0 (±2.3)
$\dot{V}O_2 max$ (ml/kg/min)	40.2 (±6.0)	36.0 (±5.7)	32.7 (±7.2)*	37.3 (±7.4)	36.5 (±5.3)	37.1 (±6.9)
Grip strength (kg)	47.7 (±11.4)	48.3 (±11.2)	44.5 (±11.5)	51.2 (±8.4)	34.0 (±9.0)†	47.0 (±11.3)
Push-ups (repetitions)	28 (±10)	24 (±9)	16 (±10)*	24 (±10)	23 (±11)	24 (±10)
Trunk flexibility (cm)	30.3 (±8.2)	27.9 (±10.3)	34.7 (±8.9)	31.0 (±10.1)	29.8 (±5.8)	30.8 (±9.2)
Abdominal muscle endurance (s)	137 (±46)	118 (±53)	88 (±54)*	111 (±51)	143 (±53)‡	119 (±53)
Lower limb strength (kg)	144.3 (±42.7)	175.8 (±57.2)	156.8 (±60.5)	173.0 (±43.4)	100.2 (±42.3)†	156.6 (±52.7)
Back extensor endurance (s)	137 (±35)	129 (±33)	139 (±35)	131 (±35)	149.2 (±28)	135 (±34)
Back maintenance time ratio	1.0 (±0.4)	0.9 (±0.5)	0.6 (±0.4)**	0.9 (±0.4)	1.0 (±0.5)	0.9 (±0.4)

The values presented are means (± standard deviations); *Different from <5 years group: $p < .05$; **Different from <5 years group: $p < .07$; †Male-female difference: $p < .05$; ‡Male-female difference: $p < .06$; min: minute. Statistically significant differences are indicated in red.

4.2 EMT-Ps' work context

In total, 628 prehospital interventions were observed during 175 EMT-P shifts (Table 4-4). The observers received the necessary consent to film 80% of the prehospital interventions. On average, the EMT-Ps received a call every 2.1 working hours (min: 1 call in 8 working hours; max: 1 call every 56 minutes) and they executed one prehospital intervention every 2.6 hours (min: 1 intervention in 8 working hours; max: 1 intervention every 88 minutes). We were able to obtain data from the prehospital intervention reports for two of the three ambulance companies that collaborated with this study, and thus were able to analyze the treatment protocols and urgency of transport for 335 of the 531 prehospital interventions that were filmed.

Table 4-4 Summary of data gathered during study.

	MTL	QC	Total
Number of shifts observed	64	111	175
Number of EMT-Ps	42	58	100
Number of calls	368	441	809
Number of cancellations	76	57	133
Refusal – transport or video recording	37	68	105
PHIs filmed	216	315	531
Number of calls per working hour	0.56	0.43	0.48
Mean frequency of calls per shift	5.8 1 every 1.8 h	4.1 1 every 2.6 h	4.7 1 every 2.4 h
Minimum frequency of calls per shift	3 1 every 3.1 h	1 1 every 6 h	1 1 every 6 h
Maximum frequency of calls per shift	11 1 every 0.9 h*	8 1 every 1.1 h	11 1 every 0.9 h
Number of PHIs per working hour	0.45	0.36	0.39
Mean frequency of PHIs per shift	4.6 1 every 2.3 h	3.5 1 every 3.0 h	3.9 1 every 2.6 h
Minimum frequency of PHIs per shift	3 1 every 4.1 h	1 1 every 8 h	1 1 every 8 h
Maximum frequency of PHIs per shift	8 1 every 1.5 h**	6 1 every 1.6 h	8 1 every 1.5 h**
Mean wait time between successive PHIs	108 min (43–239 min)	111 min (25–386 min)	111 min (25–386 min)

EMT-P: Emergency medical technician-paramedic; PHI: prehospital intervention; h: hour; min: minute; MTL: Montreal; QC: Quebec City. *Four teams of EMT-Ps received 11 calls during their shift, which lasted from 10¼ to 12 hours. **One team of EMT-Ps executed 8 prehospital interventions during their 11¾-hour shift (which included 4 cases where patients refused ambulance transportation).

4.2.1 *Physical and social environment*

Eighty-six percent (86%) of the care given to patients at the call location was provided under shelter from bad weather, more specifically in a residence where health personnel were present, a single-family home, an apartment or a condo (Table 4-5). The EMT-Ps used an elevator to get to the patient with a stretcher in 27% of prehospital interventions. In the majority of those cases, the elevator was used in a residence (65%) or an apartment/condo (31%). In three out of five interventions, they also climbed a staircase (more than five steps) to get to the patient.

Cases of providing care to a patient in an outdoor environment were not very frequent. They happened even less frequently in winter. In most prehospital interventions, including those that took place inside a building, movement with or without the patient and loading the stretcher into the ambulance took place outdoors. In winter, one out of every two prehospital interventions were executed with snow or ice on the ground; these factors increase the risk of falling down or of an incident with the stretcher or stair chair.

Three quarters of prehospital interventions were performed in the presence of relatives of the patient, witnesses or other emergency workers (i.e., nurse, firefighter, police officer, security guard, first responder, orderly). Two out of five prehospital interventions were carried out in the presence of other emergency workers, mainly when they occurred in a residence with health professionals or outdoors (Table 4-5). The other workers often helped the EMT-Ps with patient movement and lifting tasks. The role played by family members or witnesses was generally more secondary (e.g., carrying the patient’s handbag, holding a door open). Thus, as the study by Arial *et al.* [17] showed, teamwork does not end with the EMT-Ps themselves but sometimes requires collaboration with other persons present at the call location.

4.2.2 Patient characteristics

A large majority of the patients were seniors[9] (Table 4-6). On average, the patients were 59 years old (± 26 years) and weighed 70 kg (± 22 kg). The median age of patients who required care outdoors was 31 years; it was 61 years for patients encountered in an apartment or condo. For those for whom the intervention took place in a home or a residence with health professionals, the median age was 69 and 83 years, respectively. The patients generally did not have any difficulty communicating and were cooperative. Moreover, very few situations necessitated a psychosocial intervention with the patient (7%). Almost all the prehospital interventions (98%) were carried out with conscious patients. The ones involving unconscious patients required immediate or urgent transportation. This result is in accordance with clinical protocols that stipulate that an unconscious patient must be given urgent priority.

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[9] Person aged 65 years old or over.

Table 4-5 Characteristics of the physical and social work environment, expressed as a function of patient transport priority to a receiving centre as reported in the prehospital intervention report.

The data are expressed in relative frequency (%).

Determinant	Class	Relative frequency	Transport priority		
			Non-urgent	Immediate	Urgent
Work environment					
Location where care is given	Home	21.1	82.4	10.3	7.4
	Apartment	32.9	68.0	16.4	15.6
	Residence	22.6	83.5	10.1	6.3
	Outdoors	13.8	85.2	9.3	5.6
	Other	9.6	81.8	12.1	6.1
Presence of stairs	<5 steps	60.0	80.7	12.4	6.9
	≥5 steps	40.0	74.3	12.1	13.6
Use of elevator	No	73.9	78.0	11.4	10.6
	Yes	27.1	78.6	14.6	6.8
Summer (N_{Total} = 274; $N_{Outdoors}$ = 44 or 16.1%)					
Precipitation	No	92.0	78.5	13.0	8.5
	Yes	8.0	76.5	17.7	5.9
Winter (N_{Total} = 204; $N_{Outdoors}$ = 22 or 10.8%)					
Temperature	≥0°C	37.6	75.0	10.4	14.6
	<0°C	63.4	79.8	9.1	11.1
Snow or ice on ground	Absent	45.9	72.9	8.6	18.6
	Present	54.1	81.0	12.7	6.3
Precipitation	No	86.3	77.9	9.2	13.0
	Yes	13.7	72.2	22.2	5.6
Social environment					
Care provided in a house (**N_{Total} = 102)**					
Patient	Alone	31.7	84.2	15.8	0.0
Relative or witness	Present	54.5	85.4	7.3	7.3
Emergency worker	Present	13.9	62.5	12.5	25
Care provided in an apartment or condo (**N_{Total} = 158)**					
Patient	Alone	36.9	70.8	14.6	14.6
Relative or witness	Present	35.0	72.1	16.3	11.6
Emergency worker	Present	28.0	58.1	19.3	22.6
Care provided in a residence (**N_{Total} = 110)**					
Patient	Alone	10.2	83.3	16.7	0
Relative or witness	Present	20.4	68.8	31.2	0.0
Emergency worker	Present	69.4	87.7	3.5	8.9
Care provided outdoors (**N_{Total} = 68)**					
Patient	Alone	13.6	85.7	14.3	0.0
Relative or witness	Present	25.8	78.6	21.4	0.0
Emergency worker	Present	60.6	87.9	3.0	9.1

Notes: Urgent transport applies to an unstable clinical condition that requires a rapid intervention and quick departure (driving the ambulance with roof lights and siren on); immediate transport occurs in a clinical situation with the potential for instability that requires a rapid intervention and quick departure (driving the ambulance in non-urgent mode with the possibility of changing to urgent); non-urgent transport involves a non-urgent situation (the return drive is therefore in non-urgent mode).

Table 4-6 Patient characteristics as a function of the location where care is provided and of transport priority.

The data are expressed in relative frequency (%).

Determinant	**Class**	**Relative frequency**	**Transport priority**		
			Non-urgent	**Immediate**	**Urgent**
Care provided in a house (N_{Total} = 100)					
Patient's age	<65	43.0	72.7	15.2	12.1
	≥65	57.0	91.2	5.9	2.9
Weight (kg)	<60	33.4	84.0	8.0	8.0
	≥60 to <80	41.2	82.8	10.3	6.9
	≥80	25.5	80.0	13.3	6.7
Consciousness	Unconscious	0.0			
Ability to communicate	No	10.1	71.4	14.3	14.3
Psychosocial problem	Yes	7.3	80.0	0.0	20.0
Care provided in an apartment or condo (N_{Total} = 156)					
Patient's age	<65	55.1	71.2	13.6	15.2
	≥65	44.9	64.3	19.6	16.1
Weight (kg)	<60	28.5	70.6	14.7	14.7
	≥60 to <80	37.3	67.4	17.4	15.2
	≥80	34.2	69.8	16.3	14.0
Consciousness	Unconscious	3.1	0.0	0.0	**100.0**
Ability to communicate	No	9.3	70.0	0.0	30.0
Psychosocial problem	Yes	7.0	**100.0**	0.0	0.0
Care provided in a residence or home-care centre (N_{Total} = 106)					
Patient's age	<65	12.2	75.0	8.3	16.7
	≥65	87.7	86.4	9.1	4.6
Weight (kg)	<60	45.5	92.3	0.0	7.7
	≥60 to <80	41.8	90.0	6.7	3.3
	≥80	12.7	58.3	33.3	8.3
Consciousness	Unconscious	3.6	0.0	25.0	75.0
Ability to communicate	No	12.1	70.0	10.0	20.0
Psychosocial problem	Yes	0.0			
Care provided outdoors (N_{Total} = 68)					
Patient's age	<65	91.9	84.0	10.0	6.0
	≥65	8.1	**100.0**	0.0	0.0
Weight (kg)	<60	28.4	86.7	13.3	0.0
	≥60 to <80	38.8	81.8	9.1	9.1
	≥80	32.8	88.9	5.6	5.6
Consciousness	Unconscious	1.5	0.0	**100.0**	0.0
Ability to communicate	No	6.8	50	25	25
Psychosocial problem	Yes	11.9	**100.0**	0.0	0.0

4.2.3 Medical information on the prehospital intervention

Almost half of calls from the health communication centre were classified as urgent (Table 4-7). The results indicate that 68% of urgent calls required non-urgent transport to a hospital (31.5/46.1) and 13% of non-urgent calls required immediate or urgent transport (4.6+2.3/53.9). Ultimately, the EMT-Ps evacuated 79% of patients in non-urgent mode, 12% of patients in immediate mode and 10% of patients in urgent mode.

Table 4-7 Comparison of call priority from the health communication centre and priority indicated on the prehospital intervention report for patient evacuation.

	Non-urgent transport	Immediate transport	Urgent transport	Total
HCC* non-urgent	47.1%	4.6%	2.3%	53.9%
HCC* urgent	31.5%	7.1%	7.4%	46.1%
Total	78.6%	11.7%	9.7%	100.0%

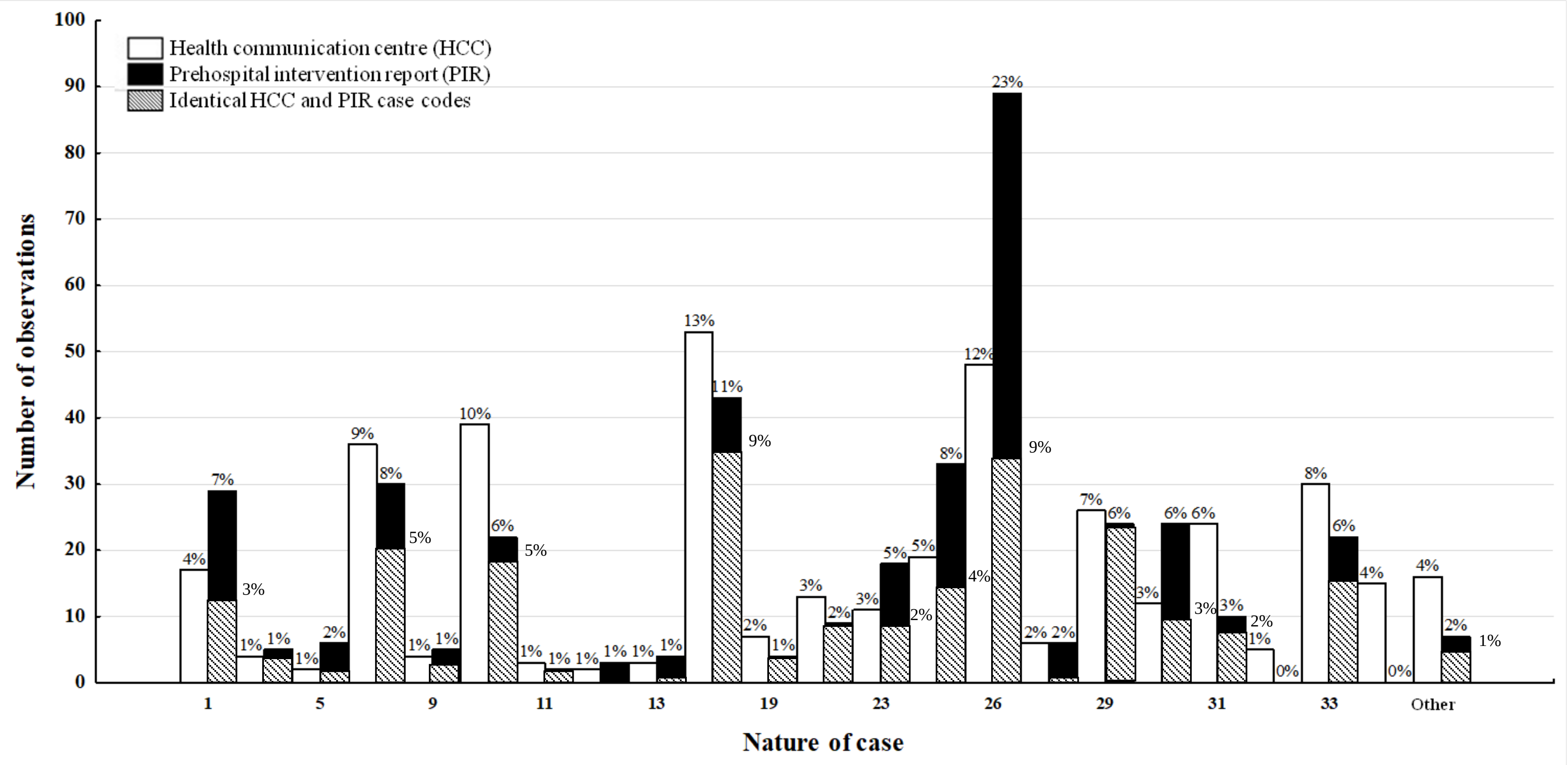
*Call from health communication centre (HCC).

Call codes provided by the health communication centre

The most frequent call codes provided by the health communication centre were cases of illness, falls or chest pain, while the most frequent codes related to the actual nature of the case, taken from the prehospital intervention reports, were cases of illness, falls or respiratory problems (Figure 4-2). The results show that 62% of the codes supplied by the health communication centre were not changed by the EMT-Ps. A number of changes were attributable to the police assistance code[10] (15 cases out of 15), since this does not appear in the classification system and consequently cannot be compiled in the same way in the prehospital intervention report. The main call centre codes that were changed in the prehospital intervention report were cases of unconsciousness (17 out of 25), interfacility transfer (15 out of 27) and chest pain (21 out of 40). For these situations, the nature of the case in the prehospital intervention report comprised illness (54 out of 89), traumatic injury (14 out of 24), abdominal pain (16 out of 29), psychiatric or behavioural problems (17 out of 32) and ingestion or overdose (9 out of 18). The main call codes that proved to be accurate at the call location concerned road accidents (24 out of 26), traumatic injury (10 out of 12), ingestion or overdose (9 out of 11), psychiatric or behavioural problems (15 out of 19), and abdominal pain (13 out of 17).

The three main codes used by the health communication centre in urgent situations were cases of chest pain, road accidents and respiratory problems (

[10] Some cases are taken charge of by police officers. In that case, the EMT-Ps' role is to transport the patient to a hospital and give him/her care and medical assistance, just like any other patient.



Definition of case codes: 1 = abdominal pain; 4 = assault, sexual assault; 5 = non-traumatic back pain; 6 = respiratory problem; 9 = cardiorespiratory arrest, death; 10 = chest pain; 11 = suffocation; 12 = convulsions; 13 = diabetic problem; 17 = fall; 19 = cardiac problem; 21 = hemorrhage, laceration; 23 = overdose, ingestion; 25 = psychiatric, behaviour; 26 = illness; 28 = cerebrovascular accident; 29 = road accident; 30 = traumatic injury; 31 = unconsciousness, fainting; 32 = unknown problem; 33 = interfacility; Other = allergy, poisoning (code 2), animal bite, attack (code 3), burn, explosion (code 7), inhalation, hazardous materials (code 8), eye problem (code 16), headache (code 18), pregnancy, labour (code 24), edged weapon, firearm (code 27), and codes 36 and 40.

Figure 4-2 Histogram comparing the nature of cases provided by the health communication centre and those recorded in the prehospital intervention report.

Table 4-8 Most frequent call codes transmitted by the health communication centre in urgent and non-urgent situations.

HCC* call priority	Most frequent calls	Nature of HCC* case	Relative frequency (%)
Urgent	1st	Chest pain	9.6
	2nd	Road accident	6.2
	3rd	Respiratory problem	6.2
	Other	20 different ones	25.4
Non-urgent	1st	Fall	11.0
	2nd	Illness	9.6
	3rd	Respiratory problem	4.4
	Other	27 different ones	27.6

*Call-out from health communication centre (HCC).

Table 4-9 Most frequent treatment protocols in urgent and non-urgent situations depending on the urgency of transport of the patient to a hospital (N = 390).

Transport type – PIR	Most frequent evacuation	Frequency	Nature of case – PIR	Treatment protocol
Urgent	1st	6	Respiratory problem (Code 6)	MED 8
	2nd	4	Chest pain (Code 10)	MED 10
	2nd	4	Cerebrovascular accident (Code 28)	APP (n = 2) MED 14 (n = 1) MED 15 (n = 1)
	2nd	4	Unconsciousness, fainting (Code 31)	MED 2
	Other	19	14 different ones	
Immediate	1st	10	Illness (Code 26)	APP (n = 5) MED 1 (n = 2)
	1st	10	Chest pain (Code 10)	MED 10
	3rd	7	Respiratory problem (Code 6)	MED 8 (n = 4)
	Other	19	9 different ones	
Non-urgent	1st	78	Illness (Code 26)	APP (n = 48) MED 1 (n = 10)
	2nd	33	Fall (Code 17)	APP (n = 8) TRAU 0 (n = 8) TRAU 1 (n = 6)
	3rd	30	Psychiatric, behavioural problem (Code 25)	PSY 1 (n = 14) APP (n = 5)
	Other	166	24 different ones	

HCC: health communication centre; PIR: prehospital intervention report; Treatment protocols: APP = Assessment of clinical condition; MED 1 = Weakness; MED 2 = Impaired consciousness; MED 6 = Acute confusion; MED 8 = Shortness of breath; MED 10 = Chest pain; MED 14 = Paralysis; MED 15 = Loss of consciousness or syncope; PSY 1 = Behavioural problem; TRAU 1 = Adult trauma; TRAU 0 = Indications for spinal immobilization.

Urgency of transport to hospital

According to the prehospital intervention reports, although the frequency is low, cases of chest pain, respiratory problems, cerebrovascular accident and unconsciousness or fainting were the most frequent during a prehospital intervention that required urgent transport (Table 4-9). In non-urgent situations, cases of falls, illness, and psychiatric or behavioural problems were the most frequent.

Type of clinical protocol

Assessment of clinical condition (APP) was the protocol applied most frequently by EMT-Ps. It is used to assess the situation (primary assessment – ABCDE) and check vital signs. The second most frequently applied protocol is the one related to indications for spinal immobilization (TRAU 0) (Table 4-10).

Table 4-10 Most frequently observed determinants and their frequency according to clinical protocol (N = 335).

Clinical protocol	Absolute frequency	Relative frequency (%)	Determinant of the situation Median (25th and 75th centiles)		Most frequent location (%)
			Patient age (years)	Patient weight (kg)	
Assessment of clinical condition (APP)	128	38.2	65 (36–80)	65 (57–80)	Apartment/ Condo (30%)
Indications for spinal immobilization (TRAU 0)	29	8.7	40 (19–70)	64 (58–77)	Outdoors (48%)
Chest pain (MED 10)	23	6.9	69 (50–81)	72 (59–86)	Apartment/ Condo (60%)
Abdominal pain (MED 9)	23	6.9	61 (33–79)	72 (66–91)	House (36%)
Shortness of breath (MED 8)	21	6.9	70 (54–80)	68 (52–82)	Apartment/ Condo (40%)
Adult trauma (TRAU 1)	16	4.8	65 (26–82)	70 (56–83)	Residence (43%)
Behavioural problem (PSY 1)	14	4.2	37 (27–52)	80 (73–91)	Apartment/ Condo (55%)
Intoxication and drug addiction (MED 12)	14	4.2	50 (31–53)	73 (55–86)	Apartment/ Condo (45%)
Weakness (MED 1)	12	3.6	62 (51–82)	69 (61–89)	House (50%)
Other protocols	55	16.4	64 (30–85)	68 (48–82)	Apartment/ Condo (33%)
All protocols	335	100.0	60 (34–80)	68 (57–82)	Apartment/ Condo (33%)

The protocol for behavioural (psychiatric) problems (PSY 1) was mostly applied with an adult population with a median age of 37 years. However, the adult trauma (TRAU 1) and weakness (MED 1) protocols were generally applied with seniors (medians higher than 62 years). The heaviest cases were those associated with behavioural problems while the lightest were patients who had suffered a trauma that necessitated spinal immobilization. In general, the protocol for indications for spinal immobilization was most frequently observed in the case of care provided outdoors (48%).

4.2.4 Variations in sequence of tasks and description of equipment used

To execute a prehospital intervention, the team of EMT-Ps must carry out different families of activities. The sequence for performing tasks was very variable, although the starting and ending activities were fairly stable from one intervention to another (Figure 4-3).
Prehospital interventions almost always started with tasks related to travel to the call location, without the patient being present. The EMT-Ps got to the call location, bringing with them the materials or equipment needed to evacuate the patient. Then the activity of patient care started. A complete lack of tasks related to patient care activities at the call location was very rare (2%). That mainly happened when a patient was waiting for the ambulance, for example standing on the sidewalk, and entered the ambulance independently.

The EMT-Ps must necessarily bring the semi-automatic monitor/defibrillator with them. They must also decide what other materials and equipment they will bring (diamond 3, Figure 4-3). More than three quarters of prehospital interventions required the use of treatment equipment (e.g., oxygen tank, first aid kit, etc.). The EMT-Ps used different methods of carrying the equipment to the patient (diamond 4, Figure 4-3). It was carried on the stretcher in 56% of cases, both on the stretcher and by the EMT-Ps (on a shoulder strap or in their hands) in 35% of situations, or only by the EMT-Ps in 9% of cases. In addition, certain care provision periods were interrupted by movements to the ambulance to get additional equipment (diamond 7,Figure 4-3). Most of the time, this task was performed by the EMT-P assigned to driving (whose role is also to assist with care and prepare the evacuation equipment), but on some occasions both EMT-Ps had to return to the ambulance to get additional material or equipment and bring it to the location where the patient was.
Transportation of the patient to the ambulance was mainly done with the stretcher. On a few rare occasions, the EMT-Ps brought the powered stretcher close to the patient even though there was a straight staircase. Certain staircases could be accessed by adjusting the height of the stretcher and static maintenance by the EMT-Ps, while on other occasions, the stretcher had to be lifted to take it upstairs and the stretcher with the patient on it had to be lifted to go back downstairs.

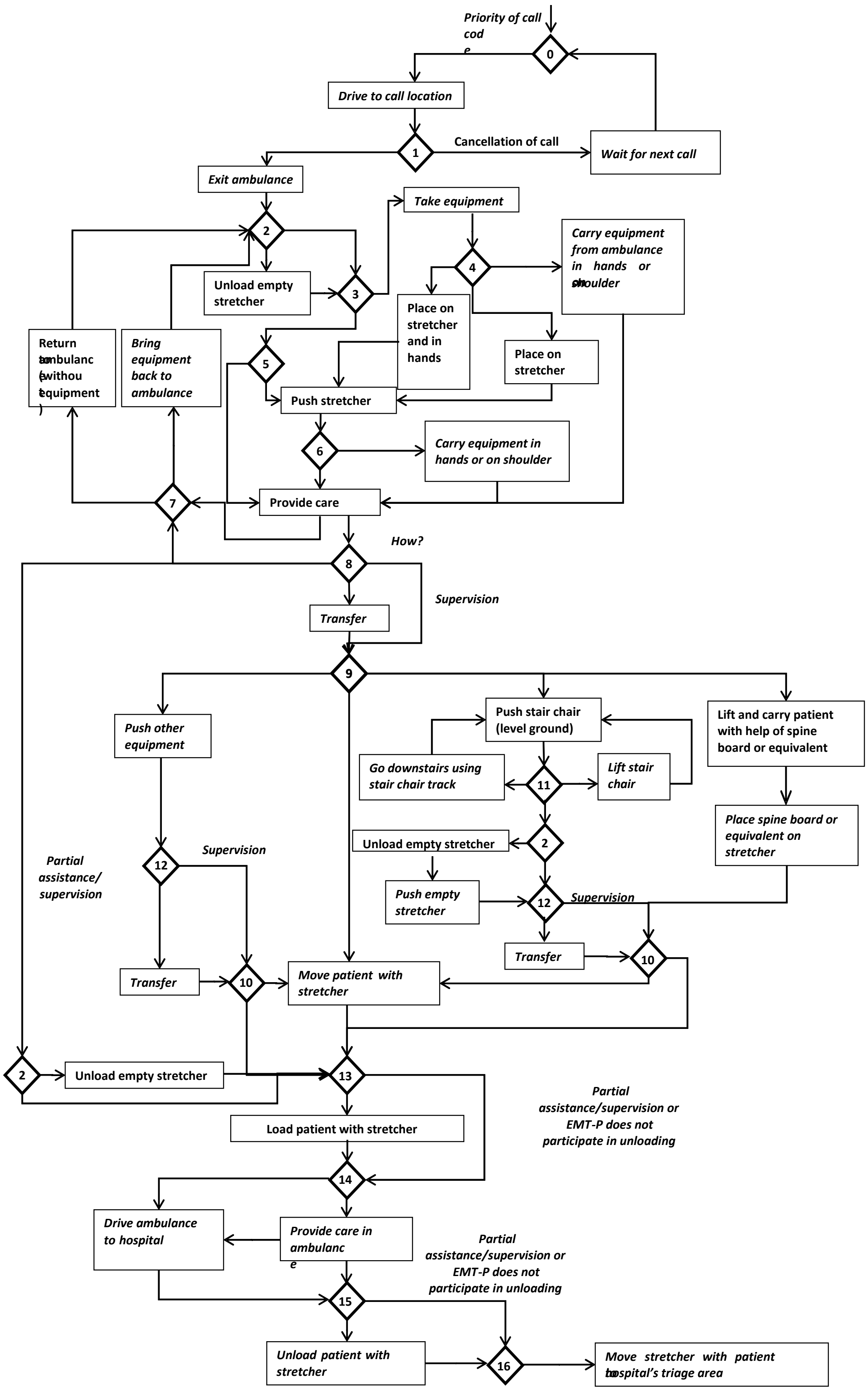


Figure 4-3 Flowchart of decisions (numbered diamonds) and EMT-Ps' actions requiring a physical effort (rectangles) during a prehospital intervention.

Notes: 0. Receive a call-out from the health communication centre; 1. Possible change of assignment (cancellation of call); 2. Unload or do not unload the stretcher from the ambulance; 3. Take or do not take equipment (first aid kit, monitor, oxygen tank, or equipment for patient evacuation); 4. Carry the equipment on the stretcher, on the shoulders or in the hands, or both; 5. Move or do not move the stretcher to the place where the patient is located; 6. Based on the patient's physical environment, bring or do not bring the stretcher to the patient; 7. During preparation of the evacuation (generally EMT-P 2), carry or do not carry the equipment back to the ambulance; 8. How to move the patient to the ambulance?; 9. Move the patient to the ambulance with a piece of transportation equipment; 10. Move or do not move the patient to the ambulance with the stretcher; 11. Move the patient in the stairs with the stair chair or lift to get over an obstacle; 12. How to move the patient on the stretcher?; 13. Load or do not load the patient and the stretcher into the ambulance; 14. Help or do not help EMT-P 1 to provide care in the ambulance; 15. Unload or do not unload the patient on the stretcher from the ambulance; 16. Move the patient on the stretcher to the hospital triage area.

The stair chair was also used several times (17%; N = 89), but almost exclusively in an environment with staircases. On two occasions, a stair chair was used to move the patient because the elevator was too narrow to fit the stretcher into. On another occasion, the stair chair (Ferno, *Combo Stretcher/Chair*) was used as a spine board to hand-carry the patient in a spiral staircase, and another time the EMT-Ps used a stair chair on an escalator in a metro station. The stair chair was mainly used when the patient was conscious and able to maintain postural tone, particularly when seated. In other words, no patient who was lying on the ground and unable to get up was moved with a stair chair. Other equipment was used in those circumstances, such as the spine board (or long support board) or vacuum mattress.

On just three occasions (4%), the EMT-Ps moved a patient in total assistance mode (complete control of the patient's body), to transfer a patient seated on a surface above the ground to the stair chair. In all other cases, the patients sat on the stair chair independently (under supervision) or with the help (partial assistance mode) of the EMT-Ps or other emergency workers to mitigate the patient's disabilities.

Movement both downstairs (88% of cases) and upstairs (12% of cases) was done in teams of two individuals: one standing behind the patient and being supported by the extendable handles (hoop-shaped) at the top of the stair chair's back (or by the retractable handles at the top of the seat back while climbing a staircase) and the other facing the patient and being supported by the telescopic handles under the seat and at the patient's feet. The frequency of use of the stair chair was higher for EMT-Ps working in Montreal (Montreal: 25% of interventions; Quebec City: 11%, $p < .001$). For prehospital interventions in Quebec City, 85% of EMT-Ps assigned to patient care (out of 34 cases) were positioned facing the patient. Only one model of stair chair was used, the Stryker with a track. For interventions in Montreal, contrary to the observations in Quebec, the positioning of EMT-Ps around the stair chair was not as systematic, with only 54% of EMT-Ps assigned to patient care (out of 52 cases) positioned facing the patient. In 12% of cases (6 out of 52), the EMT-Ps used a compact stair chair model (Ferno), sometimes with the help of a harness to make it easier to lift in staircases (2 out of 6 cases). On all other occasions, the Stryker model with a track was used.

All patient movements in a stair chair in staircases were followed by a transfer of the patient to the stretcher (diamond 12, Figure 4-3). In the great majority of cases, this operation took place outdoors and close to the ambulance. The level of assistance provided for the patient varied depending on his/her health status and age: 54% of movements required total assistance by the EMT-Ps and 46% of them were executed by the patient under the supervision or with the partial

assistance of the EMT-Ps. The most commonly applied treatment protocols when moving a patient in a stair chair were the ones for assessment of the clinical condition (24%), chest pain (18%), shortness of breath (14%) and abdominal pain (10%).
The use of a spine board to evacuate a patient was observed 24 times (5% of the 531 prehospital interventions). On 16 occasions (67% of movements with the spine board), the EMT-Ps had to negotiate at least one landing while carrying the patient. In two of these cases, they were going upstairs. The spine board is generally used in treatment protocols for trauma or indications for spinal immobilization or adult trauma (TRAU 0: N = 5; TRAU 1: N = 2) or for an unconscious individual, for example during medical cardiorespiratory arrest of an adult (RÉA 1: N = 3). The patients were lying on the ground (N = 16), sitting on a chair or couch (N = 2), sitting on the seat of a motor vehicle (N = 3, observed only in Quebec City), or lying on a bed (N = 3). The patient on the spine board was moved without assistance by a two-person team of EMT-Ps six times. On six occasions, the two EMT-Ps received help from the patient's relatives or other emergency workers to hold doors open or carry their equipment while they were moving the patient. However, 46% of the time (11 occasions), the patient was moved by a team of at least three people and they were not always EMT-Ps. For these 11 transfers, there was a minimum of four people and a maximum of eight people assigned either to carry the patient or to help the people who were carrying the patient. This help was generally provided by another team of EMT-Ps or a supervisor (observed 8 times), police officers (observed 7 times) or firefighters (observed 6 times, only in Montreal). On only one occasion, the patient was lifted and carried by a single EMT-P using a spine board adapted to the patient's size (the patient was a small child). For almost all movements (23 out of 24), the EMT-Ps or other workers placed the spine board and the patient on the stretcher before moving the stretcher to the ambulance. When the patient was lying on the stretcher, the spine board was not always removed, particularly in cases of obvious death, intoxication and drug addiction. In most cases (15 out of 24), the stretcher was left outside and could not be brought closer to the patient's location. On a single occasion, the two-person team of EMT-Ps carried the patient directly into the ambulance without using the stretcher, which had remained inside the vehicle (this was another case of a patient who was a small child). On another occasion, the two EMT-Ps brought the stretcher right to the patient, climbing a straight staircase. They then used the spine board to transfer the patient from the floor to the stretcher, and during the return, lifted both the stretcher and the patient while going down the same staircase.

The final tasks performed by EMT-Ps were generally executed in the following sequence: loading the patient on the stretcher into the ambulance, driving to the hospital (and providing care in the ambulance), unloading the patient at the hospital with the help of the stretcher, and moving the patient to the hospital's triage area (diamonds 13 to 16, Figure 4-3). In 16.7% of cases, the patient got to the ambulance independently (i.e., walking without the help of transportation equipment). Thus, the loading and unloading of the patient on a piece of transportation equipment did not occur. Patients who moved independently were mostly covered by the assessment of clinical condition protocol (N = 15), but there were also cases of intoxication and drug addiction (N = 4) and behavioural problems (N = 3). In the latter cases, the treatment protocols suggest, under certain circumstances, that patients should be made to walk to prevent any form of psychological decompensation.

4.3 Exposure to awkward back positions

4.3.1 Analysis of families of activities

The tasks related to care provided to the patient, either at the call location or in the ambulance, are the ones during which the EMT-Ps' exposure to awkward postures (in amplitude and duration) is the greatest among all the tasks they must perform during a prehospital intervention (Table 4-11, Figure 4-4. For EMT-Ps assigned to care, the mean back posture on the sagittal plane was 28° and 41°, respectively, for care provided at the call location and in the ambulance. In addition, such tasks executed for a patient who remains immobile most of the time force the EMT-Ps to adopt static postures while applying the different clinical protocols. This is particularly true in the case of care provided in the ambulance compartment, where the patient is lying on the stretcher and the EMT-P is confined to the bench next to the stretcher. The mean duration of maintenance of sagittal flexion of the back was more than 10 seconds, while the duration for the other planes of motion was greater than 5 seconds. The assistance provided by the other EMT-P is also not without risk. Although generally busy preparing the evacuation equipment, that EMT-P was often involved in applying the treatment protocol at the call location and adopted static working postures while remaining close to the patient. The mean amplitude for sagittal flexions and the duration of back posture maintenance are among the highest compared to other tasks (Figure 4-4A).

The adoption of awkward postures was also observed when patients were moved in a stair chair. In general, EMT-Ps positioned facing the patient adopted sagittal trunk flexions that were significantly greater than their colleague, on average more than 13° greater (31° vs. 18°) and more than 23° greater for maximum amplitude (52° vs. 29°). The EMT-Ps facing the patient adopted greater trunk flexions for a larger proportion of their work time than those positioned at the head of the stair chair (3.4 vs. 2.7, n = 37 and n = 38; $p < .001$, $\eta^2_p = .19$). These postural differences were observed when going both up- and downstairs, and for both male and female EMT-Ps.

Stair chair movement also triggered several asymmetrical movements with large amplitude (12° in lateral flexion and 14° in torsion; Table 4-11). Although the handles of the stair chair oblige the user to adopt a symmetrical back posture, asymmetry can arise in the case of a change of direction while going up- or downstairs, while alternating the footrests during movement, when an EMT-P was watching where to put his/her feet, when an EMT-P had to hold a door open for the stair chair to go through, when grabbing hold of a railing to keep his/her balance, etc.

The Stryker stair chair with a track is equipped with a mechanism enabling users to slide it down staircases, minimizing lifting actions during movement. This mechanism is only effective for going downstairs. The EMT-Ps can make use of the effect of gravity on the stair chair to start the downward movement. Thus, the EMT-Ps' muscle components work eccentrically while the stair chair is sliding on the stairs during the descent. Although this kind of mechanism is available, many movement operations (31%) involved lifting the stair chair and the patient at least once (i.e., lifting the entire weight), either on the whole staircase or only on a few unstable or irregular steps. Lifting of the stair chair was frequently observed while moving over a raised door threshold. For patient movements that necessitated going upstairs, the track mechanism was never used; instead, the EMT-Ps opted to lift the stair chair and the patient. Regarding awkward postures, no statistically significant difference was observed between movements with or without lifting of the stair chair.

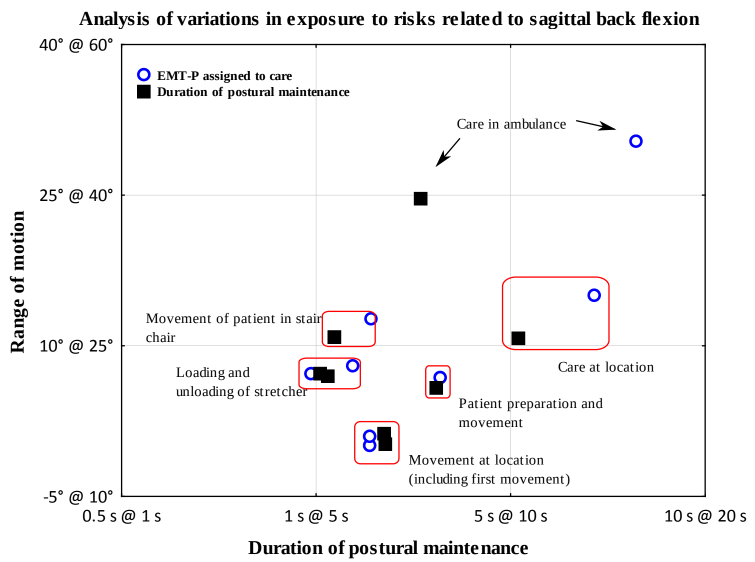
In the case of the EMT-P facing the patient, the maximum sagittal flexions and mean lateral flexions were significantly greater during movements of the patient with the stair chair in a single-family house than in an apartment or condo (90th centile for sagittal flexion: 64° vs. 49°; mean for lateral flexion: –5° vs. 0°; ps < .05). EMT-Ps positioned behind the patient engaged in fewer asymmetrical back postures when moving the stair chair in a single-family home than in an apartment or condo (mean for torsion: –2° vs. –5°; p < .05).

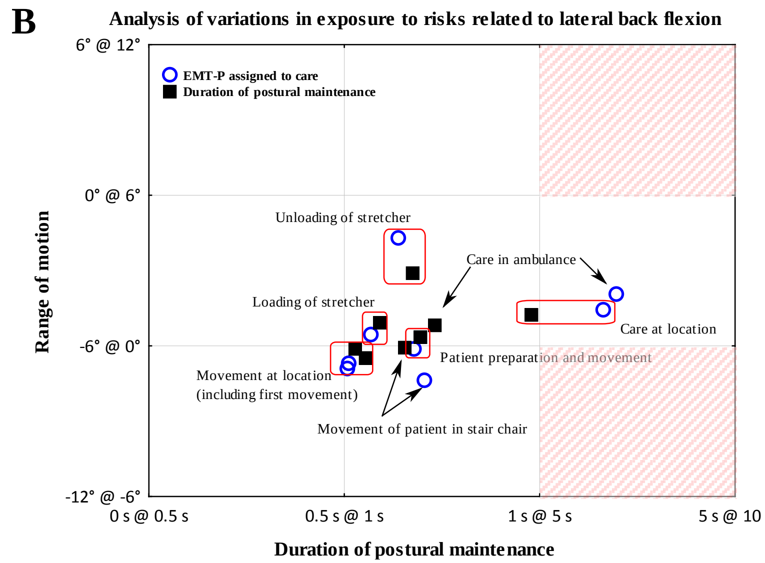
For the other families of tasks, few differences were observed based on the role played by the EMT-Ps. Exposure to postural risks is quite low compared to care-related tasks; the mean back angles are relatively close to neutral postures and have mean maintenance durations of less than 5 seconds for back angles in the sagittal plane and less than 1 second for asymmetrical back movements (Figure 4-4). The tasks of loading and unloading the stretcher were generally done as a team (loading: 90.5% of cases; unloading: 91.4%). No difference in back posture was observed during loading or unloading by a single worker or by a team.

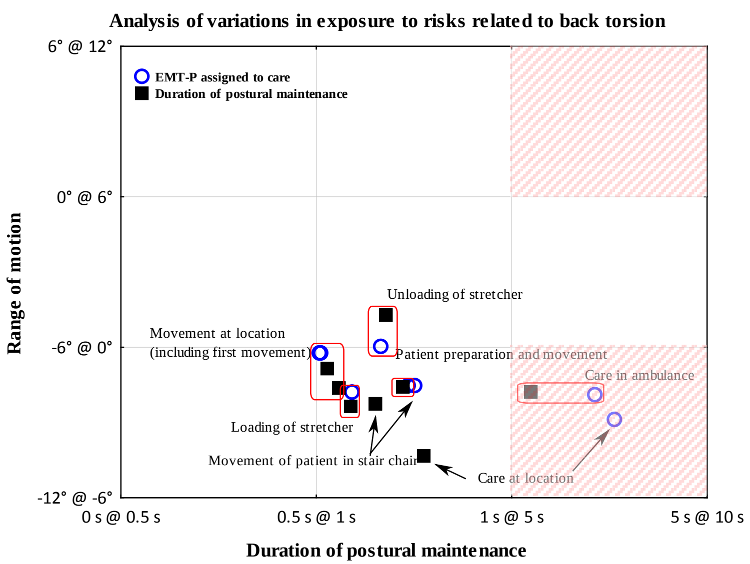
Table 4-11 Median and quartile for different variables (10th, 50th and 90th centiles, and mean) related to trunk angles based on families of tasks and the role played by EMT-Ps.

	1st movement (EMT-P 1)	1st movement (EMT-P 2)	Movements at location (EMT-P 2)	Care at location (EMT-P 1)	Care at location (EMT-P 2)	Preparation and movement toward ambulance (EMT-P 1)	Preparation and movement toward ambulance (EMT-P 2)	Movement in stair chair (EMT-P 1)	Movement in stair chair (EMT-P 2)	Loading on stretcher	Care in ambulance (EMT-P 1)	Unloading of stretcher
Sagittal flexion												
10th centile	1,8 (-2,1 - 5,6)	0,8 (-2,8 - 4,4)	0,5 (-2,3 - 3,9)	4,6 (0,6 - 11,0)	2,8 (-1,7 - 6,7)	2,8 (-1,7 - 7,4)	1,6 (-1,6 - 5,6)	6,4 (0,4 - 10,5)	6,5 (0,6 - 11,9)	3,6 (-0,5 - 9,0)	27,9 (19,7 - 34,3)	4,4 (0,8 - 9,7)
Median	9,0 (5,5 - 13,1)	8,6 (5,0 - 12,5)	9,2 (5,8 - 12,6)	17,7 (8,1- 36,4)	12,7 (7,2 - 22,5)	11,7 (7,4 - 20,3)	11,4 (6,7 - 17,0)	18,3 (9,0 - 27,9)	16,2 (11,7 - 24,1)	13,4 (8,1 - 21,2)	40,3 (33,8 - 48,9)	12,6 (7,7 - 18,9)
90th centile	17,5 (12,8 - 24,0)	18,2 (13,7 - 25,4)	21,8 (16,2 - 30,9)	46,1 (27,7 - 62,0)	46,0 (29,5 - 58,1)	29,3 (19,1 -46,7)	31,1 (20,1 - 43,1)	49,6 (28,9 - 60,3)	35,8 (25,9 - 46,3)	26,8 (19,5 - 37,1)	53,9 (44,7 - 60,4)	29,1 (19,2 - 40,6)
Mean	11,5 (7,5 - 16,3)	12,6 (8,9 - 16,5)	16,3 (11,9 - 21,5)	27,9 (18,3 - 37,7)	24,7 (18,5 - 31,6)	19,9 (13,4 - 27,9)	20,3 (14,7 - 26,1)	30,2 (17,5 - 35,4)	23,8 (17,7 - 30,7)	17,0 (11,8 - 24,1)	41,3 (34,9 - 48,1)	18,3 (10,8 - 24,5)
Lateral flexion												
10th centile	-9,7 (-14,6 - -5,7)	8,8 (-14,2 - -6,1)	-10,0 (-14,1 - -6,9)	-10,5 (-14,1 - -7,1)	-9,6 (-13,7 - -7,2)	-11,0 (-14,3 - -7,2)	-10,8 (-15,2 - -7,4)	-11,7 (-17,3 - -9,0)	-11,0 (-15,5 - -5,0)	-9,1 (-13,4 - -5,1)	-10,4 (-13,8 - -6,5)	-6,8 (-11,5 - -2,7)
Median	-1,3 (-5,1 - 1,9)	-0,9 (-4,3 - 1,6)	-1,0 (-3,4 - 1,6)	-1,4 (-4,5 - 1,9)	-1,1 (-3,9 - 1,2)	-0,8 (-4,1 - 1,6)	-0,8 (-4,2 - 1,7)	-1,5 (-7,4 - 1,4)	-2,3 (-6,0 - 3,1)	-0,8 (-4,9 - 3,6)	-0,9 (-4,2 - 2,7)	0,9 (-2,6 - 5,3)
90th centile	6,2 (3,2 - 10,8)	6,4 (3,8 - 10,2)	7,5 (5,0 - 11,1)	7,9 (4,1 - 12,0)	7,7 (4,6 - 11,4)	8,1 (4,6 - 11,4)	8,3 (5,4 - 12,5)	6,0 (-0,3 - 9,7)	5,7 (0,9 - 13,6)	7,2 (3,1 - 12,3)	8,9 (5,1 - 13,3)	8,4 (3,7 - 15,0)
Mean	-0,8 (-4,1 - 2,1)	-0,4 (-3,0 - 2,2)	0,1 (-2,3 - 2,4)	-0,3 (-3,2 - 2,6)	0,3 (-2,4 - 2,5)	-0,4 (-2,6 - 2,0)	-0,4 (-2,8 - 2,6)	-2,3 (-7,7 - 0,8)	-1,5 (-6,6 - 4,1)	-0,6 (-4,4 - 3,0)	0,8 (-1,9 - 4,2)	0,5 (-2,6 - 4,5)
Torsion												
10th centile	-8,6 (-13,8 - -4,3)	-9,7 (-13,9 - -6,3)	-11,1 (-14,7 - -8,0)	-12,2 (-18,0 - -6,5)	-12,0 (-17,2 - -7,5)	-11,5 (-15,4 - -7,2)	-11,4 (-16,5 - -8,1)	-12,6 (-17,9 - -6,9)	-12,6 (-16,4 - -6,6)	-11,2 (-16,0 - -7,6)	-13,2 (-18,9 - -8,2)	-10,1 (-14,6 - -6,2)
Median	-0,4 (-4,6 - 3,0)	-1,5 (-5,1 - 1,3)	-1,8 (-4,6 - 0,4)	-4,0 (-8,6 - -0,2)	-3,1 (-6,8 - -0,03)	-2,6 (-6,0 - 0,0)	-2,9 (-5,7 - -0,1)	-3,8 (-8,0 - -1,3)	-3,5 (-6,7 - -0,2)	-3,4 (-6,8 - -0,7)	-5,3 (-9,8 - -1,0)	-2,7 (-5,9 - 0,6)
90th centile	6,7 (2,8 - 11,1)	6,0 (3,1 - 9,6)	6,6 (3,9 - 9,0)	3,3 (0,0 - 6,4)	3,9 (1,4 - 6,4)	4,9 (2,5 - 8,5)	4,8 (2,0 - 7,9)	3,0 (-0,5 - 7,1)	3,3 (0,9 - 6,8)	4,0 (0,7 - 7,5)	2,7 (-1,8 - 6,1)	5,3 (1,5 - 8,5)
Mean	0,2 (-4,7 - 3,5)	-0,9 (-4,4 - 1,9)	-0,9 (-3,8 - 1,2)	-2,9 (-7,5 - 0,5)	-2,9 (-6,4 - 0,5)	-1,7 (-4,8 - 1,6)	-2,2 (-5,3 - 0,5)	-4,7 (-7,6 - -0,8)	-4,1 (-6,7 - 0,1)	-3,3 (-6,7 - -0,2)	-3,4 (-7,3 - 0,9)	-1,9 (-5,4 - 1,2)

Notes: EMT-P 1 = EMT-P assigned to care; EMT-P 2 = EMT-P assigned to driving. Movement at the location comprises movements without the patient and includes the 1st movement; cells in red indicate values exceeding 40° for sagittal flexion and 18° for lateral flexion and torsion; cells in orange indicate values exceeding 25° for sagittal flexion (AND less than 40°) and 12° for lateral flexion and torsion (AND less than 18°).







Notes: The y-axis contains the mean centroid values for all EMT-Ps of range of motion classes (EVA-intensity centroid). The x-axis contains the centroid values for postural maintenance duration classes (EVA-duration centroid). The role played by the EMT-Ps is indicated by symbols (empty circle: EMT-P assigned to care; black square: EMT-Ps assigned to driving). The horizontal or vertical gap between symbols represents a difference in risk exposure. The areas with pink hatching were arbitrarily chosen to illustrate the most at-risk areas (necessitating postures that are no longer neutral and prolonged maintenance durations). Finally, the red rectangles were drawn to make it easier to identify similar tasks; the longer the rectangle, the greater the difference between the roles played by the EMT-Ps.

Figure 4-4 Analysis of exposure to risks related to sagittal back flexion (A), lateral back flexion (B) and back torsion (C) based on families of tasks and roles played by EMT-Ps.

4.3.2 Analysis of clinical protocols applied at the care location

As a general rule, exposure to awkward positions for EMT-Ps assigned to patient care was significant for all the treatment protocols observed in this study: sagittal back flexion had a mean value of 28° and maintenance duration of 11 seconds; lateral back flexion and back torsion were relatively neutral and maintenance durations were approximately 5 seconds (Table 4-12).

Clinical protocols associated with an adult trauma or isolated trauma of the extremities stood out from the other protocols because they were characterized by the adoption of trunk flexion postures at an angle of more than 35° (Figure 4-5A). The EMT-Ps assigned to care in an adult trauma case adopted back flexions greater than 55° for 10% of the duration of care at the call location.

The application of the treatment protocol for cases of intoxication and drug addiction also necessitated the adoption of awkward postures with a sagittal flexion of more than 35° and mean maintenance durations of 14 seconds. The value of the 90th centile for sagittal back flexion for EMT-Ps assigned to care (10% of care time > 60°) was the greatest for all 14 protocols observed.

Two cases of acute confusion taken on by EMT-Ps assigned to care appeared in our sample. The EMT-Ps adopted back postures characterized by a relatively neutral position in the sagittal plane, strong asymmetry in the other planes of motion, and mean postural maintenance durations (in all three planes) that were the longest for all 14 protocols observed.

An EMT-P administering an adult medical cardiorespiratory arrest protocol (RÉA 1) was only observed once; he adopted back postures characterized by very short maintenance durations (<1 second) in a more markedly asymmetrical position (back in lateral flexion and torsion) than for the other protocols (Figure 4-5 C and E). For the EMT-P assigned to driving and assistance, the exposure was clearly different from his colleague’s: more pronounced sagittal back flexion with a mean maintenance duration of 12 seconds and torsion motions held for a mean 14 seconds.

For the other protocols, the back postures adopted by the EMT-Ps who provided assistance with care (EMT-P 2) were slightly more neutral on the sagittal plane (25° vs. 28°), and the mean duration of postural maintenance was shorter, at 1 to 2 seconds for each plane of motion ($ps < .001$).

Table 4-12 Median (quartile) of different variables (10th, 50th and 90th centiles, and mean) describing trunk angles based on the clinical protocols applied by the EMT-P assigned to care.

	Assessment of clinical condition (APP)	Weakness (MED 1)	Shortness of breath (MED 8)	Abdominal pain (MED 9)	Chest pain (MED 10)	Intoxication and drug addiction (MED 12)	Behavioural problem (PSY 1)	Indications for spine immobilization (TRAU 0)	Adult trauma (TRAU 1)	Adult medical cardiorespiratory arrest (RÉA 1)	Other	All protocols
Sagittal flexion												
10th centile	4,1 (-0,2 - 9,6)	-0,3 (-1,0 - 3,6)	1,2 (0,2 - 6,5)	-0,5 (-7,7 - 1,8)	4,1 (2,6 - 6,0)	5,5 (4,2 - 8,0)	4,2 (-0,5 - 6,7)	0,8 (-4,0 - 18,6)	11,5 (9,6 - 14,9)	20	6,0 (1,0 - 11,6)	4,1 (0,0 - 10,5)
Median	11,3 (5,9 - 28,2)	12,1 (10,7 - 13,2)	12,7 (4,6 - 41,6)	7,5 (3,5 - 10,4)	20,5 (8,9 - 23,6)	47,2 (11,0 - 50,7)	22,1 (10,0 - 27,9)	24,7 (3,7 - 41,2)	45,7 (38,8 - 52,2)	26,7	18,0 (11,6 - 38,3)	17,3 (6,6 - 37,4)
90th centile	32,8 (16,4 - 52,1)	45,2 (38,5 - 52,4)	51,9 (30,4 - 60,0)	42,2 (36,7 - 54,2)	48,5 (30,6 - 63,5)	61,2 (19,0 - 70,4)	41,2 (28,2 - 49,8)	49,1 (33,0 - 87,4)	54,8 (53,7 - 64,2)	34,9	54,4 (35,2 - 69,9)	45,5 (25,6 - 61,0)
Mean	23,0 (13,7 - 34,1)	25,1 (22,4 - 28,9)	27,7 (16,0 - 36,6)	22,1 (19,4 - 27,9)	27,2 (15,1 - 38,3)	38,9 (20,0 - 41,5)	23,1 (16,4 - 29,5)	33,9 (16,0 - 50,6)	39,1 (36,4 - 42,5)	28,6	33,1 (24,3 - 41,0)	27,9 (16,8 - 38,3)
Lateral flexion												
10th centile	-10,5 (-12,9 - -6,0)	-9,1 (-10,2 - -8,0)	-12,8 (-15,5 - -5,1)	-14,3 (-20,0 - -9,4)	-11,4 (-14,4 - -7,6)	-14,9 (-17,6 - -8,0)	-5,5 (-8,2 - 7,6)	-10,5 (-12,3 - -4,2)	-9,8 (-10,4 - -7,9)	-21,4	-13,7 (-20,2 - -10,0)	-10,5 (-13,8 - -7,3)
Median	-2,1 (-4,2 - 1,8)	-3,0 (-3,7 - -1,9)	-1,3 (-3,3 - 1,8)	-4,5 (-6,8 - -2,3)	0,1 (-4,6 - 3,0)	-5,1 (-6,5 - -0,6)	1,4 (-0,4 - 16,1)	-0,8 (-4,3 - 3,6)	0,4 (-0,5 - 1,9)	-12,1	-2,2 (-7,9 - 1,1)	-1,6 (-4,4 - 1,8)
90th centile	6,3 (4,0 - 10,1)	7,0 (6,3 - 8,7)	10,3 (6,6 - 11,1)	4,8 (1,7 - 10,6)	8,0 (3,8 - 12,7)	4,5 (4,2 - 7,9)	10,6 (4,4 - 19,5)	8,5 (1,4 - 13,8)	9,6 (6,0 - 15,1)	-0,5	8,2 (3,9 - 12,5)	7,7 (3,9 - 11,1)
Mean	-0,3 (-3,2 - 1,7)	1,1 (-0,3 - 2,3)	-0,9 (-3,0 - 2,9)	-1,7 (-3,6 - -1,1)	-0,2 (-3,6 - 4,1)	-2,2 (-5,7 - -0,4)	2,0 (-1,8 - 13,4)	-1,0 (-3,3 - 4,9)	1,4 (-0,6 - 4,3)	-9,2	-1,0 (-3,7 - 1,1)	-0,4 (-3,2 - 2,3)
Torsion												
10th centile	-10,8 (-16,3 - -7,1)	-15,1 (-15,5 - -14,4)	-9,3 (-12,8 - -5,1)	-11,1 (-21,0 - -4,6)	-15,9 (-22,8 - -12,2)	-18,1 (-19,5 - -5,2)	-13,7 (-18,4 - -5,3)	-16,4 (-21,1 - -5,9)	-19,3 (-21,3 - -10,1)	-16,6	-11,7 (-21,3 - -8,0)	-12,2 (-17,9 - -7,0)
Median	-4,2 (-8,6 - -0,7)	-4,1 (-8,9 - 1,0)	0,1 (-5,0 - 1,4)	-0,1 (-5,1 - 3,0)	-8,1 (-10,8 - -4,2)	-1,6 (-14,4 - -1,3)	-4,1 (-7,7 - -1,1)	-5,9 (-9,8 - 0,2)	-6,1 (-12,2 - -0,8)	-8,8	-4,1 (-8,8 - -1,5)	-4,2 (-8,7 - -0,5)
90th centile	2,2 (-0,7 - 6,1)	7,1 (2,8 - 9,6)	5,0 (4,0 - 6,1)	5,8 (3,7 - 6,5)	-1,2 (-2,1 - -0,2)	2,4 (-1,0 - 8,0)	0,6 (0,1 - 4,0)	1,6 (0,9 - 3,9)	3,1 (0,9 - 6,9)	-0,8	3,4 (1,9 - 5,9)	2,7 (-0,1 - 6,1)
Mean	-3,1 (-6,0 - -0,8)	0,2 (-7,4 - 2,0)	-0,8 (-2,1 - 2,4)	0,2 (-5,8 - 0,8)	-7,5 (-11,1 - -4,1)	-0,9 (-8,2 - 2,1)	-6,0 (-8,4 - -0,5)	-6,3 (-7,2 - 1,2)	-3,7 (-10,2 - 0,0)	-3,1	-2,4 (-6,6 - -0,1)	-3,1 (-7,2 - 0,2)

Notes: cells in red indicate values exceeding 40° for sagittal flexion and 18° for lateral flexion and torsion; cells in orange indicate values exceeding 25° for sagittal flexion (AND less than 40°) and 12° for lateral flexion and torsion (AND less than 18°). Only one case of RÉA 1 observed.

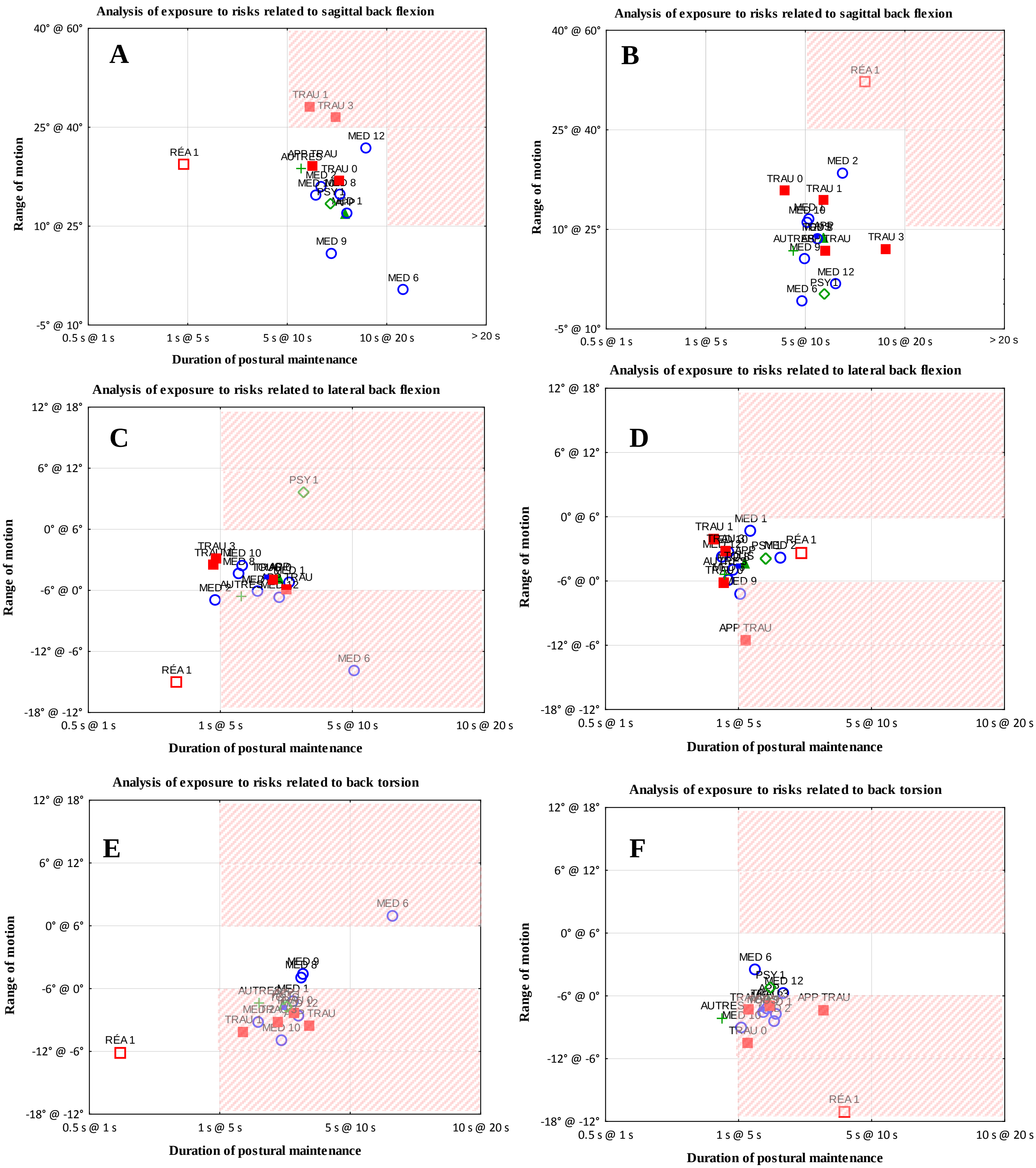


Figure 4-5 Variations in exposure to risks related to sagittal back flexion (A & B), lateral back flexion (C & D) and back torsion (E & F) based on 14 clinical protocols.

The left-hand graphs concern EMT-Ps assigned to care and the right-hand graphs concern EMT-Ps assigned to driving who participated in administering care. The six “MED” protocols are indicated by empty blue circles, the four trauma protocols by red squares, the one protocol related to assessment of the clinical condition by a green triangle, the behavioural problems protocol (PSY 1) by an empty green diamond, the adult medical cardiorespiratory arrest protocol (RÉA 1) by an empty red square, and the mean value for the other protocols by a green cross. The areas with pink hatching were arbitrarily chosen to illustrate the most at-risk areas.

4.3.3 Analysis according to sex

Several differences between male and female EMT-Ps were noted. At the time of the initial movement toward the call location, women who filled the role of EMT-Ps assigned to driving had greater back extension values (♀–2° vs. ♂1°, $n_♀ = 44$, $n_♂ = 195$; $p < .001$, $\eta^2_p = .05$), but on average, they adopted more neutral postures in the sagittal plane than men (♀10° vs. ♂13°; $p < .05$, $\eta^2_p = .03$). They also adopted greater maximum torsions than men (90th centile: ♀9° vs. ♂6°; $p < .001$, $\eta^2_p = .06$). No difference was detected regarding measures of exposure for the three planes of motion and when all movements without the patient were compiled.

When the EMT-P assigned to care or the EMT-P assigned to driving applied an assessment of clinical condition protocol, no difference was observed between the sexes. Differences between the sexes were observed for the application of the protocol for adult trauma (TRAU 1) by the EMT-P assigned to care: the centroid for sagittal back flexion movements was higher in female EMT-Ps than in males (♀4.7 vs. ♂4.0 $n_♀ = 3$, $n_♂ = 5$; $p < .05$, $\eta^2_p = .54$), which means that, on average, women adopted greater trunk flexions for more of their working time than men. It was not possible to analyze the other protocols due to the small number of observations.

Regarding patient movements in a stair chair, when the team of EMT-Ps was mixed, the male EMT-P generally took the head position, specifically on 65% of occasions (13 out of 20 times when going downstairs). When the male EMT-Ps were positioned facing the patient, they adopted greater back flexions for a longer proportion of the task time than the women (EVA-intensity centroid: ♂3.6 vs. ♀3.0; $n_♂ = 27$, $n_♀ = 10$; $p = .06$, $\eta^2_p = .10$). Among EMT-Ps in the head position to move a stair chair, male EMT-Ps adopted much greater sagittal back flexions than women (median: ♂16° vs. ♀5°; 90th centile: ♂31° vs. ♀18°; mean: ♂21° vs. ♀9°; EVA-intensity centroid: ♂2.9 vs. ♀2.1; $n_♂ = 31$, $n_♀ = 7$; ps < .05, $\eta^2_p = .13$ to .33). The EMT-Ps’ height explained 33% of the variation in the EVA-intensity centroid for sagittal flexion ($p < .001$).

At the time of loading the stretcher into the ambulance, male EMT-Ps adopted greater sagittal back flexions than women (median: ♂16° vs. ♀12°; 90th centile: ♂30° vs. ♀25°; mean: ♂19° vs. ♀15°; $n_♂ = 268$, $n_♀ = 68$; ps < .01, $\eta^2_p = .03$ to .04). They also had more extreme lateral flexions (90th centile: ♂8° vs. ♀6°; $p < .05$, $\eta^2_p = .01$) and torsions (90th centile: ♂12° vs. ♀10°; $p = .05$, $\eta^2_p = .01$). Moreover, men adopted more acute back flexions and torsions for a greater proportion of the loading time than women (EVA-intensity centroid for sagittal flexion: ♂2.9 vs. ♀2.6; $p < .05$, $\eta^2_p = .01$; EVA-intensity centroid for torsion: ♂5.6 vs. ♀6.0; $p < .001$, $\eta^2_p = .02$).

The same results were observed during care provided in the ambulance. On average, compared to women, men flexed their back 6° more ($n_♂ = 157$, $n_♀ = 37$; mean: ♂43° vs. ♀37°; median: ♂42° vs. ♀38°; ps < .01, $\eta^2_p = .02$ to .04) and adopted greater back flexions for a larger proportion of care time in the ambulance (EVA-intensity centroid for sagittal flexion: ♂4.4 vs. ♀4.1; $p < .01$, $\eta^2_p = .03$). The EMT-Ps' height explained 4% of the variation in the EVA-intensity centroid for sagittal flexion ($p < .01$). No difference between sexes was observed for the tasks of patient preparation and moving the patient to the ambulance or for unloading the stretcher from the ambulance.

4.3.4 Analysis according to seniority

During the first movement toward the call location, the EMT-Ps assigned to care with the most seniority (>15 years) adopted back flexions with lesser range of motions for a greater proportion of the time than those with less seniority (<5 years) (EVA-intensity centroid for sagittal flexion: 2.2 vs. 2.4 vs. 2.6; $n_5 = 88$, $n_{5–15} = 66$, $n_{15} = 51$; $p < .01$, $\eta^2_p = .06$). The EVA-duration centroid for lateral flexion was lower in EMT-Ps with the most seniority (1.8 vs. 2.0 vs. 2.2; $p < .05$, $\eta^2_p = .04$). No difference was observed between seniority groups among the EMT-Ps assigned to driving.

No difference between EMT-P seniority groups was observed regarding back postures at the time the assessment of clinical condition protocol was applied. For the chest pain and adult trauma protocols, the EVA-duration centroid for lateral flexion for EMT-Ps with most seniority was greater than that for the less experienced ones (MED 10: 3.7 vs. 3.3; $n_5 = 4$, $n_{15} = 3$; $p < .05$, $\eta^2_p = .76$; TRAU 1: 3.3 vs. 2.7; $n_5 = 4$, $n_{15} = 2$; $p < .05$, $\eta^2_p = .82$), which means that longer postural maintenance durations occupied a greater proportion of their working time (i.e., more work in static postures). The EMT-Ps with more than 15 years of experience adopted mean and extreme back sagittal flexions with lower values than the EMT-Ps with less seniority when administering the clinical protocol for shortness of breath ($n_5 = 3$, $n_{15} = 4$; 90th centile: 34° vs. 60°; mean: 18° vs. 31°; ps < .05, $\eta^2_p = .62$ to .67). The EVA-intensity centroid for sagittal flexion also tended to be lower for more experienced EMT-Ps (2.6 vs. 3.8; $p = .05$, $\eta^2_p = .55$). Given the small number of observations per seniority group, we were not able to do comparisons for the other clinical protocols.

When preparing the patient, moving toward the ambulance, and loading the stretcher into the ambulance, the only difference among EMT-P seniority groups, regardless of their role, concerned the maximum amplitude for back flexions (10th centile), which was lower for EMT-Ps with more than 15 years of experience (preparation and movement phase: –13° vs. –12° vs. –9°; $n_5 = 172$, $n_{5–15} = 142$, $n_{15} = 108$; $p < .001$, $\eta^2_p = .06$; loading phase: –13° vs. –12° vs. –9°; $n_5 = 143$, $n_{5–15} = 111$, $n_{15} = 81$; $p < .001$, $\eta^2_p = .05$).

Substantial differences between groups were observed regarding back postures while the EMT-Ps administered care in the ambulance. The EMT-Ps with the most seniority adopted safer postures in terms of sagittal flexion and back torsion than those with less than 5 years of experience, while the group with 5 to 15 years of experience was halfway between the other two groups ($n_5 = 81$, $n_{5–15} = 61$, $n_{15} = 53$; sagittal flexion = median: 44° vs. 40° vs. 37°, $p < .01$, $\eta^2_p = .06$; 90th centile: 57° vs. 52° vs. 47°, $p < .001$, $\eta^2_p = .10$; mean: 44° vs. 42° vs. 37°, $p < .001$, $\eta^2_p = .07$; torsion = 10th centile: –15° vs. –14° vs. –10°, $p < .001$, $\eta^2_p = .08$; median: –7° vs. –7° vs. –2°, $p < .001$, $\eta^2_p = .09$; mean: –4° vs. –4° vs. 0°, $p < .01$, $\eta^2_p = .06$). This effect had an impact on measures of postural exposure: the EMT-Ps with most seniority adopted more neutral back postures for a larger proportion of the time spent on care in the ambulance than the EMT-Ps with less than 5 years of seniority (sagittal flexion = EVA-intensity centroid: 4.5 vs. 4.3 vs. 4.1, $p < .01$, $\eta^2_p = .05$; torsion = EVA-intensity centroid: 5.3 vs. 5.4 vs. 6.0, $p < .01$, $\eta^2_p = .07$). The same finding applied to torsion back postures in EMT-Ps assigned to driving the vehicle who performed a few tasks in the ambulance compartment before driving the vehicle to a hospital. The EMT-Ps with most seniority adopted safer (torsion) back postures than their colleagues ($n_5 = 46$, $n_{5–15} = 37$, $n_{15} = 21$; 10th centile: –16° vs. –15° vs. –9°, $p < .05$, $\eta^2_p = .09$; median: –8° vs. –7° vs. –1°, $p < .01$, $\eta^2_p = .10$; mean: –6° vs. –7° vs. –1°, $p < .01$, $\eta^2_p = .09$; EVA-intensity centroid: 5.0 vs. 5.1 vs. 6.1, $p < .01$, $\eta^2_p = .09$). No major difference between groups was observed when they moved the stair chair or unloaded the stretcher from the ambulance.

4.3.5 Analysis according to obesity

Obese EMT-Ps assigned to driving adopted less awkward extreme sagittal flexion postures and adopted them less often than other EMT-Ps during the first movement toward the call location ($n_{SP} = 208$, $n_{OB} = 32$; 90th centile: 21° vs. 14°, $p < .01$, $\eta^2_p = .04$; mean: 13° vs. 6°, $p < .001$, $\eta^2_p = .06$; EVA-intensity centroid: 2.4 vs. 2.0, $p < .01$, $\eta^2_p = .04$). Similar results were observed for the first movements of EMT-Ps assigned to care ($n_{SP} = 184$, $n_{OB} = 29$; mean: 12° vs. 8°, $p < .05$, $\eta^2_p = .02$; EVA-intensity centroid: 2.4 vs. 2.2, $p < .05$, $\eta^2_p = .02$).

Exposure to awkward back postures during the execution of the assessment of clinical condition protocol was different among obese and non-obese EMT-Ps, particularly in the asymmetrical planes of motion. The mean and extreme values were greater in obese EMT-Ps for lateral back flexion movements ($n_{PS} = 52$, $n_{OB} = 5$; 10th centile: –10° vs. –14°, $p < .05$, $\eta^2_p = .07$; mean: 0° vs. –5°, $p < .05$, $\eta^2_p = .08$), but more neutral for torsion movements (10th centile: –12° vs. –5°, $p < .05$, $\eta^2_p = .09$; mean: –4° vs. 1°, $p < .05$, $\eta^2_p = .07$). No other analyses could be done for the other protocols. The same differences were noted during patient preparation and movement to the ambulance for EMT-Ps assigned to driving ($ps < .05$). In addition, on the sagittal plane, obese EMT-Ps adopted more neutral postures than non-obese ones ($n_{PS} = 369$, $n_{OB} = 55$; 90th centile: 33° vs. 28°, $p < .05$, $\eta^2_p = .01$; mean: 21° vs. 16°, $p < .05$, $\eta^2_p = .01$).

No difference was observed for movements in the stair chair and care provided in the ambulance. As for loading the patient on the stretcher into the ambulance, the time spent in awkward sagittal back flexion postures was shorter among obese EMT-Ps than in the non-obese group ($n_{PS} = 301$, $n_{OB} = 42$; EVA-intensity centroid: 2.8 vs. 2.4, $p < .001$, $\eta^2_p = .03$). In addition, obese EMT-Ps spent less time in static asymmetrical positions than non-obese EMT-Ps (lateral flexion = EVA-duration centroid: 2.2 vs. 1.9, $p < .001$, $\eta^2_p = .04$; torsion = EVA-duration centroid: 2.2 vs. 1.9, $p < .001$, $\eta^2_p = .03$). The same differences between obese and non-obese EMT-Ps were observed for unloading the stretcher from the ambulance ($ps < .05$).

4.3.6 Analysis according to perceived discomfort

Another series of analyses was conducted to compare EMT-Ps who had felt discomfort in the back or upper limbs during the last seven days (and during the year preceding their participation in the study) and those had not felt any discomfort while being exposed to awkward and static postures. The only differences were observed during the patient care tasks and depending on the role played by the EMT-Ps while doing so. When the EMT-Ps were assigned to care at the call location, the value of the 90th centile for sagittal back flexion was significantly lower for EMT-Ps who felt discomfort in the upper limbs (n_{OK} = 151, n_{UL7D} = 33; 37° vs. 45°, $p < .05$, η^2_p = .02). However, the durations of exposure and the posture maintenance times were similar. No difference was observed during this task between the individuals who felt back discomfort and those who did not. Among EMT-Ps assigned to driving who assisted with care at the call location, the ones who felt back discomfort adopted more awkward sagittal flexion postures than the ones who did not, and they did so more often (n_{OK} = 131, n_{BACK7D} = 67; 50th centile: 14° vs. 19°, $p < .05$, η^2_p = .03; EVA-intensity centroid: 2.9 vs. 3.2, ps < .05, η^2_p = .03). No difference was observed between EMT-Ps with and without upper limb discomfort.

In the ambulance, EMT-Ps assigned to care who had experienced back discomfort adopted static working postures (in all three planes of back motion) for shorter durations than the EMT-Ps who had no discomfort (n_{OK} = 126, n_{BACK7D} = 50; delta EVA-duration centroid ranging from 0.2 to 0.3; ps < .05, η^2_p ranging from 0.03 to 0.05). In addition, the EMT-Ps who felt discomfort in the upper limbs adapted less awkward sagittal flexion postures, and did so less frequently, than EMT-Ps who were free of discomfort (n_{OK} = 145, n_{UL7D} = 28; 50th centile: 35° vs. 41°, $p < .05$, η^2_p = .03; 90th centile: 46° vs. 53°, $p < .01$, η^2_p = .04; EVA-intensity centroid: 4.0 vs. 4.3, p = .06, η^2_p = .02). A summary of the main results for measures of exposure to awkward and static back postures appears in Table 4-13.

Table 4-13 Summary of main results of measures of exposure to awkward and static postures according to sex, seniority, obesity and feelings of musculoskeletal discomfort.

Task	Role	FEMALE EMT-P (compared to male EMT-P)		EMT-P WITH 15 YEARS OR MORE (compared to EMT-P with less experience)		OBESE EMT-P (compared to EMT-P with healthy weight or overweight)		EMT-P WITH DISCOMFORT UPPER LIMB OR BACK (compared to EMT-P who felt no discomfort in last 7 days)	
		Positive aspect	Point to watch	Positive aspect	Point to watch	Positive aspect	Point to watch	Positive aspect	Point to watch
1st movement	1			**AP flexion ↘** SP lateral ↘		AP flexion ↘			
1st movement	2	AP flexion ↘	AP torsion ↗			**AP flexion ↘**			
Care: APP	1					**AP torsion ↘**	**AP lateral ↗**	AP flexion ↘	
Care: TRAU 1	1		***AP flexion ↗***		***SP lateral ↗***				
Care: MED 8	1			***AP flexion ↘***					
Care: MED 10	1				***SP lateral ↗***				
Preparation and movement	1&2			**AP torsion ↘**		AP flexion ↘ AP torsion ↘	AP lateral ↗		
Movement in stair chair	F	**AP flexion ↘**							
Movement in stair chair	B	***AP flexion ↘***							
Loading stretcher	1&2	AP flexion ↘ AP torsion ↘ AP lateral ↘		AP torsion ↘		AP flexion ↘ SP lateral ↘ SP torsion↘			
Care in ambulance	1	AP flexion ↘		**AP flexion ↘** **AP torsion ↘**				SP flexion ↘ SP lateral ↘ SP torsion↘	
Unloading stretcher	1&2					AP flexion ↘ SP lateral ↘ SP torsion ↘			

Notes: ↗ means and increase ↘ means a decrease in exposure to awkward postures; role 1: EMT-P assigned to care; role 2: EMT-P assigned to driving. Small significant effect (lightface, black), moderate effect (boldface, black), strong effect (boldface, italics, red). F: EMT-P positioned facing the patient; B: EMT-P positioned behind the patient. AP: awkward postures; SP: static postures; flexion: sagittal flexion; lateral: lateral flexion.

4.4 Temporal aspects of prehospital intervention

4.4.1 Mean duration of prehospital interventions

When the call priority from the health communication centre was classified as urgent, the mean driving time to the call location was 8.5 (± 5.3) minutes, or 3 minutes faster than for a non-urgent call ($n_{N-U} = 273$, $n_U = 246$; $p < .001$, $\eta^2_p = .07$).

The execution of work activities at the call location (i.e., those preceding the driving of the ambulance to a hospital) lasted a mean 15.9 (± 7.9) minutes and no difference was observed between the different patient evacuation priorities ($p = .44$). The mean duration for urgent patient transportation to a hospital was 11.1 (± 4.8) minutes, or 5.0 minutes faster than the mean for immediate transportation and 6.4 minutes faster than the mean for non-urgent transportation ($n_{N-U} = 307$, $n_I = 46$, $n_U = 38$; $p < .001$, $\eta^2_p = .04$).

In total, prehospital interventions in urgent situations were 7.4 minutes faster than interventions that required immediate transportation, and 9.0 minutes faster than those in non-urgent situations ($p < .001$, $\eta^2_p = .04$).

4.4.2 Duration of activities at the call location

The assessment of clinical condition (APP) protocol was the most frequently observed (Table 4-14). The mean duration of activities associated with the APP protocol at the call location (15.3 ± 7.2 minutes) was no different from that in other situations. The duration of activities at the call location for a treatment protocol related to intoxication or drug addiction (MED 12) or behavioural problems (PSY 1) was shorter than the duration of activities for protocols related to weakness (MED 1), shortness of breath (MED 8) and chest pain (MED 10) (Table 4-14, ps < .05).

The various patient evacuation priorities did not appear to influence the duration of the treatment protocols (i.e., those with a sufficient number of observations, namely assessment of clinical condition, shortness of breath and chest pain; $p = .21$).

First movement of EMT-Ps

The first movement at the call location generally took 0.5 minutes longer for the EMT-Ps assigned to driving than for those assigned to care (2.0 vs. 1.5 minutes; $p < .01$, $\eta^2_p = .02$). Although most of the time the two EMT-Ps walked to the patient together, certain situations forced the EMT-Ps assigned to care to go directly and speedily to the patient, particularly during urgent calls from the call centre (urgent: 1.3 minutes; non-urgent: 1.8 minutes; $p = .06$; Table 4-14). This difference based on the call centre’s priority was not observed for EMT-Ps assigned to driving ($p = .49$).

Initial movements that took place outdoors generally took less time (<1 minute) than those that occurred inside a building (ps < .01). Conversely, certain determinants from the physical and social environment increased the duration of the initial movement. For example, movements that required the use of an elevator lasted a mean 4.0 minutes, or almost 3.2 minutes longer than those associated with situations where EMT-Ps did not use a staircase or an elevator to get to the call location ($p < .001$). Elevators are found in a high proportion of institutions and seniors' residences (79% of cases observed), which explains why the duration of the first movement was longer in this type of environment than in others ($ps < .001$). The use of staircases prolonged the mean duration of the first movement by 0.4 minutes, compared to movements without a staircase or elevator ($ps < .01$). The presence of emergency workers (first respondents, nurses, firefighters or police) at the call location had the effect of extending the duration of the first movement by just over 1 minute, regardless of the role played by the EMT-Ps ($ps < .001$). The duration of the initial movement of EMT-Ps assigned to care was slightly longer when there were family members or witnesses at the call location (+0.3 minutes; $p < .001$). No difference was observed between sexes, seniority groups and BMI groups ($ps > .12$). It appears that EMT-Ps assigned to driving in regular teams took 0.5 minutes less to complete the initial movement ($p < .05$).

Other movements by EMT-Ps assigned to driving

The duration of movements made by Montreal EMT-Ps was longer than that of their colleagues in Quebec City (5.8 vs. 4.8 minutes; $p < .05$, $\eta^2_p = .02$). Movements that required the use of an elevator or staircase lasted a total of more than 1 minute longer than those for which neither had to be used. On average, there was one additional movement toward the ambulance when an elevator or staircase was used than in situations where neither was used ($ps < .001$). There were also more movements (approximately one more) when the call location was a single-family house than in other locations ($ps < .05$), but the duration of movements remained similar to the others ($p = .10$). There was no impact of temperature lower than 0°C or of precipitation during movements ($ps < .24$). In winter, the total duration of movements tended to be 0.9 minutes longer when there was snow or ice on the ground ($p = .09$). No difference was observed regarding worker-related determinants ($ps > .52$).

Care provided to patient

The mean duration of care provided by EMT-Ps assigned to care was 8.4 minutes. The application of the assessment of clinical condition (APP) protocol took a mean 7.9 minutes. This duration is significantly shorter than the duration of the clinical assessment – trauma protocol ($n_{APPTRAU} = 5$; APP TRAU: 13.7 minutes; $p < .05$, $\eta^2_p = .05$) or the protocol applied further to a cardiorespiratory arrest in an adult ($n_{RÉA1} = 2$; RÉA 1: 17.1 minutes; $p < .05$, $\eta^2_p = .07$). An unstable patient health status (judged by the evacuation priority) did not impact the duration of care, which remained essentially equivalent to the mean duration observed during non-urgent patient evacuations ($p = .18$). The application of treatment protocols by the EMT-P assigned to care for a patient aged 65 years or older lasted 3.1 minutes longer than with a younger patient (10.3 vs. 7.2 minutes; $p < .001$, $\eta^2_p = .07$). When care was provided out of doors, the duration of care was significantly shorter than for care provided inside a building (outdoors: 4.3 minutes; single-family house: 11.6 minutes; condo: 9.9 minutes; institution: 9.7 minutes; $p < .001$, $\eta^2_p = .21$). The presence of relatives or witnesses seemed to prolong the duration of care by 2.2 minutes, when it was provided by the EMT-P assigned to care ($p < .05$, $\eta^2_p = .03$). When the temperature outdoors was below 0°C, as compared to a temperature above freezing, the care provided inside a building lasted 2.0 minutes longer (9.1 vs. 11.1 minutes; $p < .05$, $\eta^2_p = .03$). No impact of sex, obesity level or seniority was observed ($ps > .40$).

The time spent on care at the call location by EMT-Ps assigned to driving varied depending on the protocol. For patients with chest pain (MED 10), the EMT-Ps assigned to driving assisted their partners for 12.1 minutes, which is longer than for situations requiring the application of the assessment of clinical condition (APP: 6.8 minutes) and behavioural problems (PSY 1: 3.1 minutes) protocols (ps < .01, $\eta^2_p = .20$). Although it was only observed once, the protocol administered after a cardiorespiratory arrest in an adult (RÉA 1) required manoeuvres for 26.1 minutes. Application of the APP protocol took 2.8 minutes longer when the patient was aged 65 years or over than for younger patients (8.2 vs. 5.4 minutes; $p < .05$, $\eta^2_p = .10$). Application of the protocol for indications for spinal immobilization (TRAU 0) took at least 10 minutes more when the patient was over 65 years old ($p < .01$, $\eta^2_p = .43$).

Preparation and movement of patient to ambulance

In most cases, patients were moved to the ambulance on a stretcher or a stair chair. In 16.3% of cases, the patient walked to the ambulance under his/her own power, and the duration of these movements was 1.4 minutes, or 2.3 minutes faster than when the patient was transferred to the ambulance on a stretcher ($p < .001$, $\eta^2_p = .11$). The most common protocols applied when a patient walked independently were those for assessment of clinical condition (n = 25; 26.6% of APP protocols), behavioural problems (n = 8; 57.1% of PSY 1 protocols) and intoxication and drug addiction (n = 6; 46.2% of MED 12 protocols).

When the patient was located outdoors, the operation to move the patient to the ambulance, with a duration of 1.9 minutes, was faster than in other locations ($p < .001$, $\eta^2_p = .18$). Movement of a patient from a single-family home, with a duration of 3.0 minutes, was also faster than from a multi-unit building ($p < .001$, $\eta^2_p = .10$). Use of an elevator prolonged the patient movement operation by 2.6 minutes when the call location was indoors ($p < .001$, $\eta^2_p = .25$). The presence of a relative, witness or other emergency worker increased the duration of the activity by 0.9 to 1.1 minutes ($p < .001$, $\eta^2_p = .03$). Patient movements that started indoors on a cold day (<0°C), required an additional 1.0 minute compared to those carried out on warmer days ($p < .01$, $\eta^2_p = .03$). No impact of the presence of snow or ice on the ground or precipitation was observed.

The duration of patient movement was similar for the different treatment protocols, except the ones for cardiorespiratory arrest in an adult ($n_{RÉA1} = 3$; RÉA 1: 1.1 minutes; p = .06) or isolated trauma of the extremities ($n_{TRAU3} = 7$; TRAU 3: 1.8 minutes; $p < .05$, $\eta^2_p = .04$). Movement in these cases was faster than for the assessment of clinical condition protocol (APP: 3.8 minutes). An unstable patient health status did not affect the duration of movement to the ambulance (urgent transport: 4.1 minutes; non-urgent transport: 3.7 minutes; p = .55). Movement of a patient aged more than 65 years took 1.5 minutes longer than for younger individuals ($p < .001$, $\eta^2_p = .09$).

Patient movements executed by EMT-Ps in Quebec City were faster than those performed by their Montreal counterparts (3.4 vs. 4.0 minutes; $p < .01$, $\eta^2_p = .01$). No other difference was observed between other groups of individuals.

Movement of patient in a stair chair in a staircase

The mean duration of this activity was 1.2 (± 0.8) minutes and the maximum duration observed was 4.2 minutes. Movement of a patient in a stair chair was slightly faster from a single-family house than from an apartment or condo building (1.0 vs. 1.4 minutes; $p < .05$, $\eta^2_p = .05$). No difference was observed regarding patient- and worker-related determinants.

Loading of stretcher and patient

The loading of the stretcher and patient into the ambulance lasted a mean 0.4 (± 0.2) minutes (maximum duration = 1.2 minutes). The duration of loading increased by 7 seconds when the ambulance was parked on a slope ($p < .05$; $\eta^2_p = .04$). The presence of relatives, witnesses or other emergency workers and loading done from an institution or seniors' residence were factors that slightly increased the duration of the task, by at most 6 seconds (ps < 0.01, η^2_p = .02–.06). Other trends observed (obesity and working alone) reduced the duration of the movement by at most 3 seconds. Loading went no faster when the patient's health status was considered to be unstable ($p = .58$).

Unloading of stretcher and patient from ambulance

The mean duration for unloading the stretcher and patient from the ambulance was 0.4 (± 0.2) minutes (maximum duration = 2.8 minutes). Movement of the stretcher and the patient from the ambulance by a single EMT-P or by EMT-Ps in Quebec City was slightly faster, 0.1 minutes, than in Montreal (ps < .06, η^2_p = .01–.09). Unloading of the heaviest patients lasted almost 4 seconds longer than for lighter patients ($p < .05$, $\eta^2_p = .02$). Among the trends observed, regular teams took a bit more time than irregular ones (+6 seconds; $p = 0.08$) and EMT-Ps with 5 to 15 years of seniority were 2 seconds faster than the other groups ($p = .08$). Patients were not unloaded faster when their health status was considered to be unstable ($p = .37$).

A summary of the impact of the main determinants on the duration of activities appears in Table 4-15.

Table 4-14 Frequency and duration (median and quartiles) of prehospital intervention.

Clinical protocol	Relative frequency *,**	Duration (minutes)				
		Driving ambulance to call location	Duration of care at call location (EMT-P assigned to care)	Activity at call location**	Driving ambulance to hospital	Prehospital intervention from call-out to unloading of patient at hospital
Assessment of clinical condition (APP)	38.6	8.8 (6.2–13.1)	6.8 (3.1–10.8)	14.8 (10.5–19.6)	14.6 (10.3–20.1)	41.4 (34.5–49.8)
Weakness (MED 1)	3.6	11.0 (7.1–17.4)	12.3 (8.8–15.5)	19.9 (15.3–22.0)	17.1 (11.0–22.6)	46.0 (36.3–62.9)
Impaired consciousness (MED 2)	2.1	6.6 (6.6–13.6)	6.3 (5.7–10.3)	14.6 (11.9–22.4)	9.3 (5.7–13.2)	30.3 (29.3–44.9)
Acute confusion (MED 6)	2.4	6.4 (4.7–8.9)	10.3 (1.5–19.1)	17.8 (10.6–29.5)	12.4 (9.2–15.8)	39.3 (31.7–49.5)
Shortness of breath (MED 8)	6.3	7.7 (5.5–8.9)	8.6 (7.1–9.7)	19.9 (17.3–23.0)	13.4 (9.7–17.1)	42.1 (37.0–48.0)
Abdominal pain (MED 9)	6.9	10.9 (7.6–14.7)	9.5 (6.5–12.0)	14.6 (10.6–21.6)	16.6 (12.0 –23.4)	42.1 (36.1–56.0)
Chest pain (MED 10)	6.6	8.5 (5.5–11.4)	7.5 (1.3–13.0)	21.2 (19.0–22.6)	14.6 (12.0–20.7)	46.9 (40.1–52.0)
Intoxication and drug addiction (MED 12)	4.2	5.0 (3.7–7.5)	4.7 (2.0–6.8)	9.0 (6.4–12.6)	9.9 (6.4–12.9)	27.3 (17.2–29.9)
Clinical assessment – trauma (APP TRAU)	1.8	12.0 (7.1–25.0)	15.4 (15.4–17.2)	23.1 (20.9–28.0)	15.5 (12.7–27.9)	52.8 (47.8–76.8)
Indications for spinal immobilization (TRAU 0)	8.7	10.8 (6.3–9.5)	7.5 (4.6–12.9)	16.5 (9.4–14.3)	18.4 (14.9–24.5)	54.5 (38.6–58.5)
Adult trauma (TRAU 1)	4.8	8.3 (6.3–9.5)	6.8 (4.9–10.5)	13.9 (9.8–18.1)	11.1 (9.3–14.8)	38.7 (29.3–45.2)
Isolated trauma of extremities (TRAU 3)	2.4	9.6 (7.6–17.6)	6.5 (5.4–7.6)	12.8 (9.4–14.3)	22.9 (18.9–26.4)	47.0 (39.3–53.0)
Behavioural problem (PSY 1)	4.2	9.2 (7.7–13.8)	1.5 (1.3–4.4)	9.2 (2.9–15.8)	17.6 (9.9–27.5)	37.0 (32.9–49.9)
Adult medical cardiorespiratory arrest (RÉA 1)	0.6	4.7 (4.0–4.7)	15.1	25.3 (16.3–34.3)	6.2 (4.4–7.9)	37.0 (25.1–48.9)
Other	6.6	9.8 (5.2–14.1)	7.0 (4.9–13.4)	14.7 (10.1–19.9)	16.3 (11.9–24.7)	42.4 (33.5–53.6)
All protocols	100.0	6.1 (8.8–12.9)	7.4 (3.7–12.0)	15.8 (10.4–20.9)	14.9 (10.5–20.7)	42.1 (34.1–52.2)
All interventions	519	8.9 (6.2–12.9)	6.7 (4.0–10.5)	15.3 (10.4–20.5)	15.1 (10.3–20.9)	41.7 (34.1–51.8)

* The analysis relates to 332 of the 531 prehospital interventions filmed; ** Includes activities from arrival at the call location – that is, as soon as the ambulance door opens – to the end of loading the stretcher and the patient into the ambulance. Cells in red indicate the longest durations for all treatment protocols and cells in yellow the shortest.

Table 4-15 Descriptive statistics for durations (in minutes) of families of activities and impact of the main determinants related to the worker, the patient and the physical and social environment of the prehospital intervention.

Activity	Median duration (quartile)	Impact of determinants		
		Worker	Patient	Physical and social environment
First movement of the EMT-P assigned to care at the call location*	0.9 (0.4 – 2.0)		**Age > 65 years ↗** **Urgent call ↘**	**Elevator ↗** **Staircase ↗** **Family and friends ↗** **Other emergency workers ↗** **Outdoors ↘** **Residence ↗**
First movement of the EMT-P assigned to driving at the call location*	1.4 (0.8 – 2.9)	**Regular team ↘**	**Age > 65 years ↗**	**Elevator ↗** **Staircase ↗** **Other emergency workers ↗** **Outdoors ↘** **Residence ↗**
Total duration of movement at the call location* by the EMT-P assigned to driving	4.5 (3.3 – 6.4)	**Montreal ↗**		**Elevator ↗** **Staircase ↗**
Care provided at the call location by the EMT-P assigned to care	7.6 (4.2 – 11.8)		**Age > 65 years ↗** **APP TRAU protocol ↗** **RÉA 1 protocol ↗**	**Elevator ↗** **Staircase ↗** **Family and friends ↗** **Outdoors ↘** **Snow on ground ↗** **Temperature < 0°C ↗**
Care provided at the call location by the EMT-P assigned to driving	6.6 (4.3 – 10.0)	**Montreal ↗**	**MED 10 protocol ↗** **RÉA 1 protocol ↗** **Age > 65 years (APP) ↗** **Age > 65 years (TRAU 0) ↗**	**Elevator ↗** **Staircase ↗** **Outdoors ↘**
Preparation and movement of the patient to the ambulance	3.2 (1.6 – 5.0)	**Montreal ↗**	**Age > 65 years ↗** *RÉA 1 protocol ↘* **TRAU 3 protocol ↘**	**Elevator ↗** **Family and friends ↗** **Other emergency workers ↗** **Outdoors ↘** **Single-family home ↘** **Temperature < 0°C ↗**
Moving the patient in a stair chair in a staircase	0.8 (0.5 – 1.6)			**Apartment/Condo ↗**
Loading the stretcher and patient into the ambulance	0.4 (0.3 – 0.5)	*Done alone ↘* *Obesity ↘*		**Vehicle on slope ↗** **Family and friends ↗** **Other emergency workers ↗** **Residence ↗**
Care provided in the ambulance by the EMT-P assigned to care	16.6 (11.8 – 22.0)		**Urgent transport ↘**	
Unloading the stretcher and patient from the ambulance	0.3 (0.3 – 0.4)	**Montreal ↗** *Done alone ↘* *Seniority (5–15) ↘* *Regular team ↗*	**Body mass ↗**	

Notes: * indicates that the task was executed without the patient; ↗ indicates an increase in time (slower) compared to the opposite condition; ↘ indicates a decrease in time (faster) compared to the opposite condition; determinants in bold indicate that data are statistically significant ($p < .05$), while those in italics indicate a trend ($p < .10$).

4.4.3 Time constraints

Temporal demand

Temporal demand represents the time that EMT-Ps considered they had to carry out their work during the prehospital intervention. It is a perception-based index where high demand meant that the time allocated to help the patient was very short (scale from 0 to 10; 10 represents the highest demand). The temporal demand for urgent transportation (i.e., when a patient presented signs of instability) was significantly higher than that observed during prehospital interventions requiring immediate and non-urgent transportation (urgent: 3.8; immediate: 2.4; non-urgent: 1.5; ps $< .05$, $\eta^2_p = .17$). In urgent situations, female EMT-Ps considered the temporal demand to be higher than males (6.5 vs. 3.5; $p < .05$, $\eta^2_p = .16$). The same finding applied to immediate transportation situations (4.0 vs. 2.1; $p < .01$, $\eta^2_p = .19$), whereas no difference between sexes was detected for non-urgent situations. An increase in temporal demand was noted in EMT-Ps with more than 15 years of experience compared to younger ones, but only in non-urgent situations (1.9 vs. 1.5; $p = .05$, $\eta^2_p = .02$). No effect of obesity on temporal demand was noted.

The equipment used by EMT-Ps to move the patient was also associated with an increase in temporal demand (none: 1.3; stretcher: 2.0; stair chair: 2.2; spine board: 3.6; ps $< .01$, $\eta^2_p = .06$).

The perception of temporal demand was higher when EMT-Ps were assigned to care than when they were assigned to driving (3.3 vs. 2.6; $p < .001$, $\eta^2_p = .01$). EMT-Ps who felt musculoskeletal discomfort in the back or upper limbs found the temporal demand to be higher than those who felt no discomfort (2.2 vs. 1.7; ps $< .05$, $\eta^2_p = .01–.02$).

Regression model: $r^2 = .22$ The temporal demand with which an EMT-P must deal is associated with the urgency of transport ($\beta = .35$), back discomfort ($\beta = .20$), type of equipment ($\beta = .18$) and whether he/she works in Quebec City or Montreal ($\beta = –.11$).

Time pressure

Time pressure represents the pressure that EMT-Ps felt (emotional experience) in relation to the time they had to execute the prehospital intervention. Time pressure is related to workers' subjective experience. The key idea is that it is a sensation that may or may not match the reality of the time constraints of work, whether prescribed or actual [81]. High time pressure was associated with a fast, agitated pace (scale from 0 to 10).

The urgency of transportation had a considerable impact on the time pressure felt by EMT-Ps. The ones who had evacuated a patient in urgent conditions rated this pressure at 4.7, higher than the ratings of 2.5 and 1.5 for immediate and non-urgent transport (ps $< .001$, $\eta^2_p = .26$). The use of equipment to evacuate the patient also contributed to increased time pressure (none: 1.2; stretcher: 2.2; stair chair: 2.5; spine board: 3.5; ps $< .01$, $\eta^2_p = .06$). The type of protocol applied with the patient also seemed to influence time pressure. The mean time pressure experienced during protocols applied in the few cases of adult medical cardiorespiratory arrest (RÉA 1) was rated at 8.5. This value was significantly higher than those observed for the assessment of clinical condition (APP: 1.4) protocol, and the mean for all protocols of 1.9 (e.g., PSY 1: 1.5; MED 1: 1.6; MED 6: 1.5), but not significantly different from the protocols for impaired consciousness (MED 2: 4.3), shortness of breath (MED 8: 3.0) and indications for spinal immobilization (TRAU 1: 3.1).

The EMT-Ps assigned to patient care felt greater time pressure than those assigned to driving (2.4 vs. 1.9; $p < .05$, $\eta^2_p = .02$). EMT-Ps who had felt musculoskeletal discomfort in the back in the last year experienced greater time pressure than their colleagues (2.4 vs. 1.7; $p < .05$, $\eta^2_p = .03$).

The EMT-Ps with the most seniority also felt more time pressure than their colleagues but only in non-urgent situations (>15 years: 2.1; 5 to 15 years: 1.3; <5 years: 1.3; ps < .05, $\eta^2_p = .06$). No difference was observed among the groups formed on the basis of EMT-Ps' obesity levels. The time pressure felt by female EMT-Ps in urgent situations was higher than that felt by their male coworkers (7.5 vs. 4.4; $p < .05$, $\eta^2_p = .12$). The same trend was observed for immediate transport situations (3.8 vs. 2.2; $p < .05$, $\eta^2_p = .12$).

Regression model: $r^2 = .29$
The time pressure experienced by an EMT-P is a function of the urgency of transport ($\beta = .45$), seniority ($\beta = .16$), back discomfort ($\beta = .12$) and type of equipment ($\beta = .12$).

4.4.4 Verbal expressions of time constraints

In rather less than half of the interviews (45%), the EMT-Ps reported a lack of urgency or of factors that could impact the temporal aspects of the intervention. The care provided to the patient and his/her evacuation occurred without urgency and the EMT-Ps felt able to control the pace, that is, without feeling pressure. This lack of time constraints seemed to make it easier for the EMT-Ps to execute their tasks and work as a team.

Several things affected the degree of time pressure experienced by EMT-Ps during an intervention and the time they considered adequate to execute their work in an optimal manner (Figure 4-6), two factors that are significantly correlated ($r = .74$; $p < .05$). The EMT-Ps interviewed reported that the urgency attributed to the evacuation priority was the predominant factor modulating the estimated time to perform the necessary ambulatory work during a prehospital intervention, especially when it was considered to be urgent. This factor was mentioned in 41.6% of the interviews carried out after prehospital interventions (Table 4-16). Evacuation priority is determined based on the patient's health status. According to the interviews, consciousness, how much bodily fluid has been lost (e.g., heavy bleeding, abnormal urination) and the clinical condition of vital signs are the main elements in the clinical assessment of the patient's health.

In addition, it should be emphasized that EMT-Ps have to respect numerous treatment protocols established to ensure a complete assessment of the patient's medical condition and provide appropriate care, regardless of the evacuation priority of the situation that arises. Thus, according to several respondents, although they are necessary, these protocols often add to the time pressure felt by paramedics in an urgent situation, since they are inevitably associated with an increase in intervention time and governed by prescribed maximum intervention times (e.g., *silver ten minutes*, *golden hour*). The use of working techniques other than the standardized ones that accompany each clinical protocol is often related to patient movement in order to save time. This was mentioned in 15% of the interviews conducted after prehospital interventions. These techniques included using whatever is at hand to avoid returning to an ambulance; planning in advance the minimum equipment to bring to the call location; carrying equipment themselves rather than putting it on the ground to make room before moving the stretcher through a door, etc. According to several EMT-Ps, another factor that modulates the time need to help the patient and contributes to the time pressure of an intervention is the time spent moving around the call location or transferring the team and the patient to a hospital. The paramedics questioned mentioned that the main causes associated with long transport times were a long distance to be covered to get to the intervention location or to a hospital and traffic jams.

Several other time constraints were mentioned by the EMT-Ps, but with lower frequency; they included the presence of a pet or a dangerous environment that required additional action to secure the site, a patient lying on the ground when the EMT-Ps arrived, an unsanitary location, a patient with dubious hygiene, the presence of first responders on the site, a child patient surrounded by his/her parents or family, and cases where the EMT-Ps knew the patient.

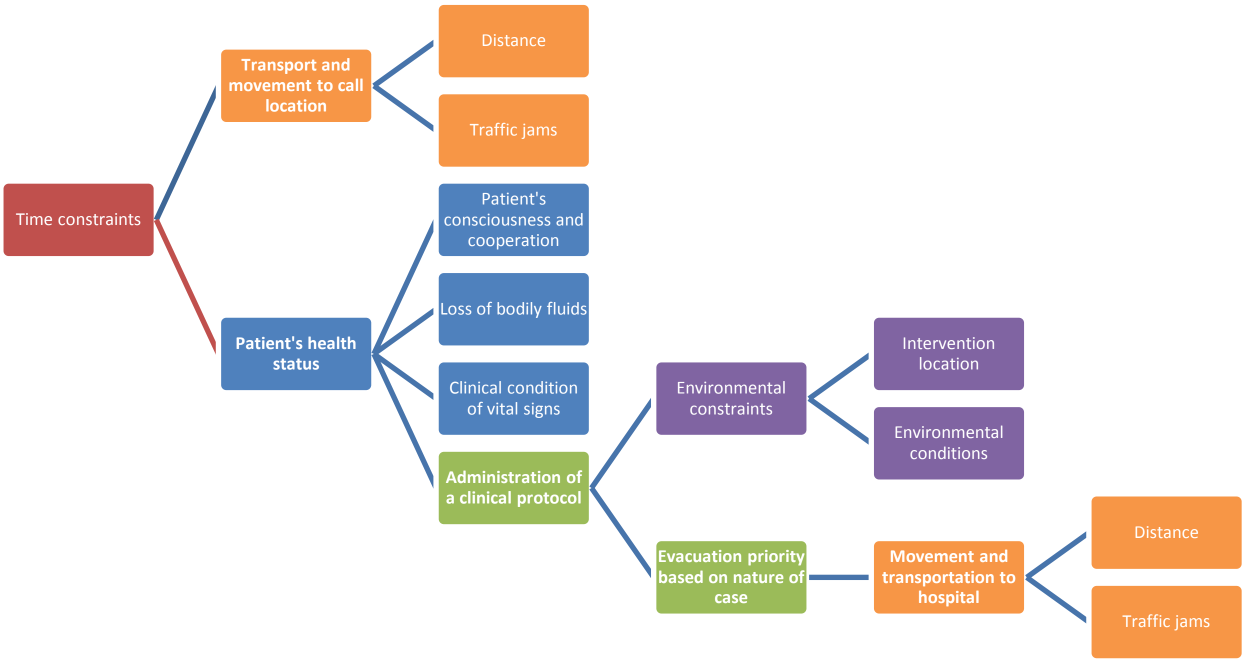


Figure 4-6 Time constraints affecting a prehospital intervention as identified by EMT-Ps, in semistructured interviews after their prehospital interventions.

Table 4-16 Time constraints mentioned by EMT-Ps during their interviews after the prehospital interventions.

Time constraint	Extracts from interviews with EMT-Ps	Frequency
Non-urgent situation (the necessary care is given without urgency and is controlled by the EMT-Ps, without pressure)	*"When it's not urgent, we have more time to apply our techniques. There's no point in doing an urgent evacuation when it's not necessary. I have the time to treat my patients better and that also prevents them from getting anxious […] You can take the time to pick everything up. As you saw, we attached all the kits to the stretcher and then we left. The more time you have to analyze things, the better you position yourself and the less you strain."* *"Not hurrying, but we had to go faster than the other guy* [patient]. *There was a chance he'd lose consciousness. It would've been more complicated up there if he'd lost consciousness."*	231 (44.9%)
Patient's health status (physical or mental condition, clinical condition)	*"If you have an unstable patient, you have to strain to go faster, so it's more physically demanding because you have to work faster. But working faster doesn't mean doing things wrong – there is a limit. You mustn't work so fast you hurt yourself or forget things."* *"I would say it was difficult* […] *My work methods changed because then my colleague went down alone to get the stretcher. If it had been a priority 7, I might have left the lady alone and gone down to get the stretcher with my colleague."* *"To save ourselves as many back-and-forth trips as possible, I try to go out with as much equipment as possible, which necessarily requires a bit more physical effort* […]*."* *"Just vigilance. That means I wasn't rushing but I just had to be vigilant, watch for the signs and symptoms that could tell us 'Oops', it may be more serious than we thought."* *"Essentially, yes […] because at other times, we can arrive, talk, find out exactly what's going on, take our time. But that time, as soon as we got there, I immediately asked my partner to prepare the drug […]. We don't have time to place the monitor, don't have time to start doing things right. […] we do it, and then we manage things afterward* […]*."* *"The time demand had an impact on our working methods* […] *yes, we take the stretcher but we don't want to take too long because we know she had a syncope, we know she's known for her history and the medications she takes, we know she has a pacemaker* […]*, we don't know what the problem is and we definitely don't want it to come back."* "[…] *it was a question of life and death, seconds counted at that point, but we wanted to get to the hospital fast, since he might have had a head trauma.* […] *he was actually conscious and he could answer our questions, time demand, yes, we had to hurry, but we couldn't skip steps to get done* […]*."* *"Even if it hadn't been high priority, I would have made the same movements or the same efforts* […] *I didn't run because we're not supposed to run either* […] *I would've done the same things, even if it had been priority 3 or 4. Maybe with more dialogue and less concentration."*	214 (41.6%)
Use of work techniques (steps in the treatment protocol, techniques used by the EMT-Ps to move the patient; may require time to reflect and properly analyze the situation)	*"We would have done the same thing, even if we had had to be fast; it would've been pressure, saturation, though the blood sugar would have been taken in the ambulance, but it would have happened all the same* […] *No, it had no impact on our physical effort."* *"I had no pressure. Code 17 alphas are probably what we do most – what we just did. Fall, no pain, we're going to the hospital. We don't feel any stress.* […] *a code 17, over 65 years old, we're going to use a mattress, doesn't matter when, what, why* […] *That's the protocol. So it had no impact on our physical*	76 (14.8%)

Time constraint	Extracts from interviews with EMT-Ps	Frequency
	efforts. You have to apply the protocol." *"In any case, we had to do a 12D, which takes as long as it takes. So that's why we remained there for close to 10 minutes* […] *We had to take the time to do things right."* *"We often try to use what we have at hand, specifically to avoid having to go back to the truck, even if it's not urgent, because we walk less and in the end we save time just the same."* *"It's not as if there'd been a pneumothorax because of a blow in his ribs, a perforated lung, and we'd had to intubate him and he was unconscious. In that case we'd have asked for help from the people there to move him faster, bring him to the stretcher, help hold the stretcher so we had our hands free to go faster, whereas then,* […] *we didn't have to hurry."*	
Prescribed optimum duration and duration of care (Optimum duration that is taught; this becomes a constraint when EMT-Ps try to minimize the time needed to provide care or transport the patient by ambulance; EMT-Ps have a certain amount of time to execute their tasks effectively)	"[…] *our protocols dictate that there's more urgency, because in a high-speed impact, we have a protocol called the 'silver ten minutes'; we have 10 minutes at the location, no more, we have to respect that time. We have to be at the hospital within an hour once the patient is immobilized."* *"Afterward, we do the analysis, we were at the location for 10 minutes. But on-site I can't tell whether we've been there 10, 15 or 3 minutes. […] We manage the signs and symptoms. We take the time we need."* *"Yeah, less than 10 minutes at the location. We have to respect that, so it's another source of stress when we know he's unstable like that. And overall, through the whole intervention, we have to respect the 'golden hour' [i.e., one hour maximum]. […] But obviously, if he's vomiting, that changes everything."* *"It was a short turnaround, I had to do it in a short period of time. I couldn't take more time […] I would rate it 7/10 […] it was a priority case, you have to act fast but methodically. So it's still the same way of doing things, except you go faster."*	70 (13.6%)
Intervention location (environmental factors that affect the EMT-Ps' work activities)	*"A patient who stinks; I won't neglect my work methods or take more risks because it stinks there. It's a drag* […] *but I won't upgrade the priority for that. A public place will impact what I can do on-site or what I'll do in the ambulance. For example, if someone needs an EKG in a public place, I'll wait and do it in the ambulance."* *"[…] we had time, he was stable, but we were getting wet. For everyone's sake, we had to hurry anyway, plus we were blocking the road and the intersection – it's a big intersection. So we had to move it."* *"[…] In other situations, I would say yes [temporal demand], we're blocking the highway, we're blocking traffic, so go – we load the patient and we get out of there. The police want to free things up, remove the car. Sometimes, yes, we have limited time and the police like it when we get out as fast as possible."* *"We were close to the patient, it went well, except that there was no lighting. We had to know if it was the right drug, because if you can't see the colours, it can go badly."* *"So I'll say 7* [7/10 for temporal demand]. *It's high because we were really far away when it came in, then it came in as a priority 3 and normally we have 15 minutes to get there. Umm… I drove a bit faster because it involved a colleague* […].*"*	38 (7.4%)
Equipment used (concerns both the equipment used to move patients and the equipment to assess patients' health)	*"Say the patient's unstable, instead of taking the stair chair, we'll take the board because he can't sit down.* […] *the more pressure you have, the less stable the patient is, often you need equipment to take care of the patient* […] *it's rare for one of them to walk to the ambulance."* *"In fact, we could have taken the scoop* […] *to get him out of the room. But to get him down the stairs, the only tool we have to immobilize a person and prevent them from moving, apart from the vacuum mattress*	30 (5.8%)

Time constraint	Extracts from interviews with EMT-Ps	Frequency
	we have for road accidents, is the spine board with straps. Then for a death, we won't use a mattress that could get fluid or blood or who knows what on it; that equipment is used for people who've had accidents."	
Presence of other people (all the people who get involved in an intervention who are not EMT-Ps or first responders)	"[…] *normally, the police should have moved the kids away, but the kids kept coming back, it was pretty annoying. And they kept asking questions around us and they weren't in a normal state, they were upset, they were all jumpy, plus they were all stoned, so that always increases our stress because we're constantly wondering: OK, where are they?* […]" *"I would say 4/10.* […] *At one point, I found that it seemed to be taking a long time because there were lots of people who wanted to get involved and help the lady. However, it meant that my colleague was caught up in all that, and I wanted my colleague to help me get the woman sitting up because I thought that she'd been lying in that position on the ground long enough."*	14 (2.7%)
Patient transport (refers to the techniques or logistics used to evacuate the patient to the hospital)	*"It took more time because of the weather and the traffic on the road. But the time inside the house, there isn't a specific time you can say you'll take, we have to take the time to do our stuff. Inside the house, no problem, but the problem we had was the route to get to the hospital, which was more problematic."*	11 (2.1%)
Weather conditions (include all kinds of weather conditions: cold, rain, heat wave, snow)	*"I noticed you were running."* EMT-P's answer: "[…] *when it was time to get the patient into the ambulance so she wouldn't get wet* […], *it was for the patient's comfort. Just to avoid getting her wet, but if it had been a dangerous environment for us, I wouldn't have done it."* *"0/10… It really wasn't rush. If it had been raining out, we would've had to go faster."* *"I'd say 4/10 because of the cold. We hurried to wrap him up, then get him inside, then remove the stretcher. Because if it had been nice and sunny we would've done that outdoors. If it had been hot, say in July, nice and warm, we would've lowered the stretcher there, we would've stood up, we would've removed it, we would've had room to work, then after that, he could've sat up."*	9 (1.7%)
Patient's attitude (applies to situations where the patient shows or makes the EMT-Ps aware of his/her displeasure or inflicts time pressure on the EMT-Ps during the intervention)	*"The only temporal demand I felt was when we arrived at the location and the lady commented on the fact that we took our time* […] *That won't have an impact on how I do things, it'll have an impact on my feeling about the patient* […] *I'll feel pressure from them, but I'll still do things at my speed, the way I want to do them, take the time to do them, but that's the only demand I feel. Pressure somewhere, it's not from my boss, it's not from the dispatcher, it's not from the call priority, it's related to the patient when I feel pressure to work faster."* *"I'd say that sometimes you don't want them to go the bathroom and you insist that they don't go. Hold on, wait, we work fast… I think the time pressure came more from the fact that she had RSP* [retrosternal pain] *and she wanted to go to the bathroom, then there was a kind of constraint. It's more related to the patient. It was annoying for us."*	8 (1.6%)
Time during shift (may impact the intervention by speeding up (end) or slowing down (beginning) the work pace)	*"The time demand is more from the end of the shift than from the intervention. You want to finish up but you still have to take the time to do things right as well."*	6 (1.2%)

Table 4-17 Descriptive statistics for scores related to EMT-Ps' perception of workload based on the type of patient transportation to a hospital.

Urgency of transport	Score (recalculated out of 10) Mean (Q25, Q50, Q75)							Borg Scale Mean (Q25, Q50, Q75)
	Time pressure	**Mental require-ments**	**Physical require-ments**	**Performance dissatisfaction**	**Frustration**	**Effort**	**Workload (total score)**	
Non-urgent	1.5 (0, 1, 2)	2.2 (1, 2, 3)	2.3 (1, 2, 3)	2.9 (1, 2, 4)	1.6 (0, 1, 2)	2.5 (1, 2, 3)	2.6 (1.5, 2.5, 3.5)	2.1 (1, 2, 3)
Immediate	**2.5*** (1, 3, 3)	2.8 (2, 3, 4)	2.8 (2, 3, 4)	3.0 (1, 2.5, 4)	1.7 (0, 1, 2)	3.2 (2, 3, 5)	**3.1*** (2.1, 3.3, 4.0)	2.6 (2, 2, 4)
Urgent	**4.7**†‡ (2, 5, 7)	**3.8**†‡ (2, 3, 5)	**3.7**† (2, 3, 5)	1.9 (1, 2, 3)	1.8 (0, 1, 3)	**4.6**†‡ (3, 5, 6)	**3.9**† (2.5, 3.6, 5.6)	**3.5**†‡ (2, 3, 4)

* = p < .05 between immediate and non-urgent; † = p < .05 between urgent and non-urgent; ‡ = p < .05 between urgent and immediate; M = mean; Q = quartile.

4.5 Physical and mental effort

4.5.1 Workload

The perceived workload on a scale of 0 to 10 (with 10 being the highest workload), as assessed by total score on the NASA-TLX [68], was higher during urgent transport situations than in immediate or non-urgent transport cases (ps < .05, $\eta^2_p = .07$; Table 4-17). The factors influencing the EMT-Ps' perceptions of workload during prehospital interventions included time pressure, mental demands, physical demands and effort, while satisfaction with their performance and frustration with their work did not seem to be affected by the patient's evacuation priority. In urgent patient transportation situations, the workload perceived by female EMT-Ps was greater than that of male EMT-Ps (5.9 vs. 3.7; $p < .05$, $\eta^2_p = .11$). EMT-Ps assigned to patient care who had felt musculoskeletal discomfort in the back during the last year considered the workload to be higher than those had not felt any discomfort (3.4 vs. 2.7; $p < .01$, $\eta^2_p = .04$). No effect was observed regarding EMT-Ps' seniority ($p = .40$) or obesity level ($p = .15$).
Regardless of the role played by EMT-Ps, perceived workloads during protocols applied in the few cases of adult medical cardiorespiratory arrest (RÉA 1) and indications for spinal immobilization (TRAU 1) were rated at 7.8 and 3.9. These values were greater than the rating of 2.5 obtained for assessment of clinical condition (APP) protocols (ps < .01, $\eta^2_p = .13$). Perceived workload during the clinical assessment – trauma (APP TRAU) protocol also tended to be higher (4.0 vs. 2.5; $p = .07$). The perceived workload of EMT-Ps assigned to care during the protocol for impaired consciousness (MED 2) was twice as high as that for the APP protocol ($p < .05$). In general, EMT-Ps assigned to patient care perceived a greater workload than EMT-Ps assigned to driving the ambulance (3.3 vs. 2.6; $p < .001$, $\eta^2_p = .04$). The perceived workload for prehospital interventions with patients aged 65 years or over was no different than that related to other interventions ($p = .17$). The perceived workload was greater for interventions involving the heaviest patients (>80 kg) compared to other patients (3.3 vs. 2.8; $p < .001$, $\eta^2_p = .03$).

The equipment used by EMT-Ps to move patients was also associated with an increase in workload (none: 2.3; stretcher: 2.9; stair chair: 3.2; spine board: 4.6; ps < .05, $\eta^2_p = .08$). EMT-Ps who took the stairs during a prehospital intervention perceived a greater workload than those who had to use an elevator (3.2 vs. 2.7; $p < .05$, $\eta^2_p = .02$).

Regression model: $r^2 = .22$
EMT-Ps' workload is a function of their equipment ($\beta = .24$), their role ($\beta = -.19$), the urgency of transportation ($\beta = .18$), back discomfort ($\beta = .15$), the patient's weight ($\beta = .14$), and their seniority ($\beta = .10$).

4.5.2 Perception of physical exertion (Borg Scale)

In total, 21% of prehospital interventions were perceived as physically “somewhat hard” or “harder,” and this was observed both in Quebec City and in Montreal. In only 9% of prehospital interventions was the physical exertion judged to be at least “hard.” EMT-Ps who had evacuated a patient in urgent mode rated the perceived effort as 3.5 (scale from 0 to 10; 3.5 represents a perceived effort between “moderate” and “somewhat hard”; Table 4-17), which was higher than the ratings of 2.6 and 2.1 obtained for transportation in immediate and non-urgent modes (between easy and moderate; $ps < .01$, $\eta^2_p = .08$). Approximately 45% of these interventions were associated with a perceived effort of at least “somewhat hard” (compared to 28% for immediate transport and 16% for non-urgent transport; $p < .001$). The use of equipment to evacuate the patient also helped to increase the perceived physical exertion (none: 1.2; stretcher: 2.4; stair chair: 3.0; spine board: 4.0; $ps < .01$, $\eta^2_p = .20$). The use of a staircase compared to the use of an elevator or of neither an elevator nor a staircase was associated with a slight increase in perceived physical exertion (+0.4 out of 10; $p < .01$, $\eta^2_p = .02$). The perceived physical effort in the case of protocols applied for the few cases of adult victims of a medical cardiorespiratory arrest (RÉA 1) was rated 5.5 (hard) and in the case of indications for spinal immobilization (TRAU 1) it was rated 3.3 (between moderate and somewhat hard). These ratings were higher than those observed for assessment of clinical condition (APP: 2.2; $ps < .05$, $\eta^2_p = .07$). Older patients and patients with a higher BMI were associated with a greater perceived physical effort (<65 years: 2.3; >65 years: 2.5; $p < .05$, $\eta^2_p = .01$; <60 kg: 1.9; between 60 and 80 kg: 2.4; >60 kg: 2.9; $ps < .05$, $\eta^2_p = .07$).

The perception of physical exertion did not differ based on sex, regardless of the patient evacuation priority ($p = .95$). For EMT-Ps with more than 15 years of seniority, the perceived physical effort was higher than for the group with 5 to 15 years (2.5 vs. 1.9; $p < .01$, $\eta^2_p = .04$) and slightly higher than for those with less than 5 years of seniority (2.5 vs. 2.1; $p = .11$) but only for non-urgent transport cases. The physical exertion of obese EMT-Ps seemed to be lower than for their colleagues, but only in non-urgent situations (1.8 vs. 2.2; $p = .09$). The physical effort felt by EMT-Ps assigned to patient care in immediate or urgent transportation mode was greater than that perceived by EMT-Ps assigned to driving (3.5 vs. 2.6; $p < .05$, $\eta^2_p = .08$). Individuals who had experienced back discomfort during the last year had a greater perceived physical exertion during immediate or urgent evacuations than EMT-Ps without back discomfort (3.3 vs. 2.4; $p < .01$, $\eta^2_p = .09$).

Regression model: $r^2 = .30$ EMT-Ps’ perception of physical exertion is a function of the equipment used to move the patient ($\beta = .38$), the patient’s weight ($\beta = .22$), the urgency of transport ($\beta = .15$), their seniority ($\beta = .14$) and back discomfort ($\beta = .22$).

When they compared the least physically demanding and the most physically demanding prehospital interventions they had ever experienced in their careers, EMT-Ps indicated that prehospital interventions that required non-urgent transportation were among the easiest (1.8 out of 10; 95% confidence interval: 1.7–2.0). Those that required immediate transportation were rated 2.3 out of 10 (95% confidence interval: 1.9–2.7). Prehospital interventions that required urgent transportation were rated between easy and moderate (2.7 out of 10; 95% confidence interval: 2.2–3.1).

When we compared the perceived physical effort during prehospital interventions to the most difficult situation the participants had ever experienced, no difference was detected between sexes and seniority groups. Obese EMT-Ps stated that they had experienced more physically difficult situations in the past compared to what they experienced during the study than non-obese EMT-Ps (obese: 1.6; non-obese: 2.0; $p < .05$, $\eta^2_p = .01$).

4.5.3 Dynamic work

Assessment of energy expenditure

Calculations were done to assess the energy expenditures needed to execute a hypothetical extreme prehospital intervention lasting 60.3 minutes and requiring very substantial physical exertion. Details of these calculations are shown in Appendix 1. The energy expenditure to execute the work was assessed at 5.0 kilocalories per minute, or 40.1% of the maximum capacity ($\dot{V}O_2max$) of the worker in the poorest physical condition. The maximum continuous working time was assessed at 30.4 minutes and the minimum rest time between interventions was assessed at 15.8 minutes.

Perception of fatigue

General fatigue (scale from 0 to 10, with 10 being the highest level of fatigue) was similar between sexes and between obese and non-obese EMT-Ps (ps > .18). Bearing in mind the shift (morning, day, evening or night) and considering that EMT-Ps with the most seniority have the best chances of obtaining a shift starting in the morning or during the day, while those with least seniority are more likely to get an evening or night shift, no difference was observed between seniority groups. However, individuals who executed a prehospital intervention at night rated their fatigue at 4.4 out of 10, compared to 3.0, 2.2 and 1.7 for those who worked the evening, day and morning shifts, respectively (ps < .001, $\eta^2_p = .19$). EMT-Ps who reported back discomfort during the last year experienced more fatigue after the intervention than those who said they had not had any back discomfort (2.8 vs. 2.0; $p < .001$, $\eta^2_p = .03$).

Fatigue was higher for EMT-Ps assigned to care than for their colleagues assigned to driving (3.3 vs. 2.0; $p < .001$, $\eta^2_p = .09$). The urgency of transport and the clinical protocol did not seem to affect EMT-Ps' fatigue. Workers in the Montreal area also reported feeling more tired after their prehospital interventions than EMT-Ps in the Quebec City area (3.1 vs. 2.3; $p < .01$, $\eta^2_p = .04$). The fatigue experienced after prehospital interventions that required the use of a spine board was higher than that experienced when moving a patient on a stretcher (3.6 vs. 2.5; $p < .05$, $\eta^2_p = .02$).

Regression model: $r^2 = .22$
Perceived fatigue after a prehospital intervention is a function of shift (β = .34), back discomfort (β = .17), the EMT-P's role (β = –.18) and the use of equipment (β = .10).

4.5.4 Difficulties experienced during work

After each prehospital intervention, the EMT-Ps were asked about the difficulty of the tasks they had just performed. The tasks most likely to be associated with difficulties were ranked (Table 4-18). At the top of the list, we find moving the patient in a stair chair, regardless of the urgency of the transportation, and the administration of care at the call location in work situations requiring immediate or urgent transportation. A high proportion of these work situations were associated with a difficulty level considered to be at least "somewhat difficult" (Table 4-18).

Table 4-18 Summary of difficulties according to tasks, EMT-Ps' roles and the urgency of transportation (in descending order of difficulty). Difficulties were rated on a scale from 0 to 10, where 10 represented the most difficult situation ever experienced.

Task	Role	Urgency of transport	Mean (± SD)	Proportion of "somewhat difficult" or more (≥4/10)
Moving patient in a stair chair: going upstairs	1 & 2	Urgent – Immediate	5.0 (±1.7)	67% (2/3)
Moving patient on a spine board or equivalent	1 & 2	Non-urgent	4.4 (±2.2)	67% (6/8)
Moving patient in a stair chair: going upstairs	1 & 2	Non-urgent	4.2 (±0.8)	80% (4/5)
Administration of care at the call location	2	Urgent	3.8 (±1.9)	47% (7/15)
Moving patient in a stair chair: going downstairs	1 & 2	Urgent – Immediate	3.2 (±1.1)	50% (8/18)
Administration of care at the call location	1	Urgent – Immediate	3.2 (±1.6)	28% (13/46)
Transfer of patient to transportation equipment	1 & 2	Urgent	3.0 (±1.9)	37% (13/35)
Moving patient in a stair chair	1 & 2	Non-urgent	2.9 (±1.5)	30% (12/40)
Administration of care in the ambulance	1	Urgent – Immediate	2.7 (±1.5)	33% (11/38)
Moving patient in a stair chair: going downstairs	1 & 2	Non-urgent	2.6 (±1.6)	23% (7/31)
Administration of care at the call location	1	Non-urgent	2.3 (±1.6)	14% (19/138)
Transfer of patient to transportation equipment	1 & 2	Immediate	2.2 (±1.7)	8% (3/37)
Moving about the call location (without the patient)	2	Urgent	2.1 (±1.3)	13% (2/16)

Note: role 1: EMT-P assigned to care; role 2: EMT-P assigned to driving; ratings of 2 or less out of 10 are considered to be "easy."

The proportion of EMT-Ps who had experienced situations described as "somewhat difficult" or worse was not significantly different based on sex or seniority. The proportion of obese EMT-Ps who had experienced "somewhat difficult" or worse working situations while moving the patient with transportation equipment (other than the stair chair) was significantly lower than the proportion of non-obese EMT-Ps (obese: 1.4%; non-obese: 11.8%; $p < .01$). Obese EMT-Ps may have made use of their body mass (e.g., as a counterweight) to guide and move the stretcher and the patient.

The proportion of EMT-Ps with a history of back discomfort who had experienced "somewhat difficult" or worse situations while transferring a patient on transportation equipment was greater than that of their healthy colleagues (back discomfort: 24.2%; no discomfort: 15.2%; $p < .05$). Regarding loading the stretcher into the ambulance, a higher proportion of EMT-Ps with upper limb discomfort than those without had difficulties (upper limb discomfort: 14.5%; no discomfort: 5.8%; p < .05). The proportion of EMT-Ps who had experienced difficulties while moving the patient in a stair chair was significantly higher for EMT-Ps working in Quebec City than for individuals in Montreal (Quebec: 50.0%; Montreal: 20.8%; p < .01). A first important difference between EMT-Ps in Quebec and Montreal concerns equipment: in Quebec, the EMT-Ps used a stretcher chair with a track (Stair Pro®, Stryker); in Montreal, EMT-Ps also had the option of using a foldable stair chair without a track (Ferno). A second difference is related to the frequency of having to lift the stair chair, which was much greater in Quebec than Montreal (Quebec: 85%; Montreal: 18%). Finally, a third explanation could be related to the assignment of roles while moving the stair chair. For EMT-Ps working in Montreal, this decision seemed to be based on their preferences or the circumstances at the time rather than on their respective roles during the intervention, as seemed to be the case for EMT-Ps in Quebec.

Difficulties while moving the patient in a stair chair

An analysis of the interviews was done to highlight the causes and consequences of the difficulties perceived by EMT-Ps, when moving a patient in a stair chair (Table 4-19). The most frequently reported difficulty concerned the type of staircase. The step rise and tread depth, uniformity of their dimensions and stability, the surface, the type of quarter turn staircase (at the top, middle or bottom) or spiral staircase, the step width, and the bars and their spacing in the railing can all present obstacles for manoeuvring a stair chair, especially models with a track, which are larger. Several Montreal EMT-Ps emphasized how useful the Ferno stair chair is, especially due to its manoeuvrability in quarter turn and spiral staircases.

"The Ferno stair chair works very well, the one without a track. Honestly, it has proven its value. And I'd say that, for newer people who have worked with it less, it's more awkward. But I've worked with it for three years full-time. That stair chair doesn't hold many secrets from us. […] *I've never hurt myself with that one. But with the other kind, I once had a sprain* [ankle] *on badly adapted steps."*

Female EMT-P, 5 to 15 years' experience

EMT-Ps who moved a patient with a Ferno stair chair could also use a harness, but there are differing opinions about its use [82]. Some workers will not use one to "save time" or because they consider that the patient's body mass does not represent a constraint. They prefer to use equipment that is less well adapted to the work environment and compensate by adopting awkward work positions and making additional efforts. Other EMT-Ps use a harness to better distribute the load to be carried or free their hands to ensure that their body is balanced while moving the patient.

"I don't work with it [harness] *much, in staircases that are straight or have corners because I don't like it.* […] *when you want to put it down, you have to lengthen them, and afterward, when you want to lift it, you have to shorten them. At that time, the way the steps were made, I think I would've had to do it about seven times. So it would've been long, it would've wasted time. If the patient had been heavier, I might have gotten them out at that point to have less of a load on my shoulders. Otherwise, when it's outdoors or with spiral staircases, when it's really dangerous or outdoors, and I have less support, I'll go and get them so I can put my hands on the railings and have good support."*

Male EMT-P, less than 5 years' experience

The EMT-P assigned to care is generally positioned facing the patient to maintain visual contact and detect any changes in his/her medical condition. When going downstairs, the EMT-P assigned to care is therefore stationed at the patient's feet and is moving backward. However, this rule may be modified based on the teammates' preferences and the difference in the EMT-Ps' heights. The same advantages for both possible height-based scenarios (the taller person is positioned at the patient's head or feet) were defended by EMT-Ps in the interviews (Table 4-19).

Confined space in the working environment, the patient's body mass and the use of equipment to assist with care represent other frequently mentioned sources of difficulties (Table 4-19). The main consequences reported by EMT-Ps are additional actions that they have to consider to push, pull, hold or adopt awkward working postures, without even mentioning losing their balance, which can sometimes make them fear for the patient's safety.

"I had to lift it higher and I had to strain a bit more because I had to lift higher, and that scared the patient because there was a wheel that got stuck or something. […] *it made a little bump and she jumped; pretty much all of them do that when they're in the air, in winding staircases. That's why we warn them clearly. We say: keep your hands close to you, don't touch anything, don't get caught in anything."*

Male EMT-P, less than 5 years' experience

Table 4-19 Difficulties expressed regarding movements with the stair chair (total of 29 cases with a difficulty level of 4 or more out of 10).

Cause	Consequence	Extracts from interviews with EMT-Ps	Frequency
Type of staircase	Pushing/pulling/holding action Patient imbalance Loss of balance Using a harness Lifting action Getting stuck	*"The staircases were tiny, all crooked and like a maze, so that's why it was difficult."* *"As I said, I should've taken the Ferno, since it was a spiral staircase.* […] *We were supported on a single track but it slipped. The patient was unbalanced on the stretcher. It wasn't ideal."* *"The fact that they looked high and narrow to me and you had places that were quite tight, but up above we could move pretty well.* […] *that's what was scariest: the steepness, fears and the sort of petit-point where I didn't feel stable. With steep stairs, what can be dangerous or problematic is that it can start coming down pretty fast or it doesn't grip and it doesn't do any good. So both of us, we were forced to lift it* […]*"* *"The steps weren't super-stable and since there was a kind of curve, and then another curve, afterward, and I was going down on the narrow side of the step, rather than the wide one. And the wheels, basically, even though we had gotten rid of all the slack, tightened the stair chair's straps as much as possible, the wheels were kind of touching, so we had to go gently, and luckily the gentleman didn't move, because if he had gotten the least bit panicky, he could've hit something. Because with the harnesses, it's more our bodies that are supporting him* […]*"* *"The stairs were winding so we couldn't use the tracks* […] *I was below, so I had to keep the stretcher higher, because otherwise, the wheels got caught in the steps from above and it got a bit unbalanced; then at one point, the patient freaked out, she put her hand on the wall because she thought she was falling* […]*."* *"The difficulty was that below the stairs there was a turn. So it wasn't easy. […] My teammate was pressed against the wall and at one point I had a handle that was caught in the door. So I couldn't move forward."*	16 (55.2%)
Equipment used	Pushing/pulling/holding action Holding action Loss of balance Asymmetrical lifting/pulling/pushing action	*"Often with the stair chair, you tilt it forward, it gets on the stairs properly and then it moves by itself. But that time, we had to strain a lot, more than usually. It didn't engage properly on the stairs. I don't know if it was because I wasn't tilting enough, and also the patient was pretty heavy."* *"The tracks on the back of our stair chair were a bit loose, which meant that he was at the bottom holding the load.* […] *Sometimes they don't slide, but those ones were sliding a bit too much."* *"In theory, we should've left him connected to the monitor, so I should've gone down with the monitor on my back.* […] *It's not a backpack, you hold it on one side. He needs to be monitored, he needs to get oxygen, but you saw, with the oxygen, we have to hold it however we can. There's no miracle solution. If we put it horizontally, we don't fit through the doors. If we put it vertically, then when we lean over, well, the tank sticks up into the air a bit, so*	12 (41.4%)

Cause	Consequence	Extracts from interviews with EMT-Ps	Frequency
		sometimes we get caught on it. […] I think there's no worse way of getting injured. It's on a shoulder strap, it slides, it falls, it weighs close to 35 pounds, you have it on one side, you have the patient on the other. Sometimes, you have to hold a door open, you have the monitor about to fall, you have to do it with your foot."	
Patient's body mass	Pushing/holding action Loss of balance Straining in reaction to patient movements	"[…] *350 pounds, that's a bit tough because you have to hold it plus the stair chair* […]." *"When you have a fat person, sometimes their weight shifts on the stair chair."* *"When their weight shifts, it's even worse; you have a kind of imbalance on one side or the other."*	11 (37.9%)
Physical environment	Going downstairs backward with the patient in reverse position Asymmetrical lifting/pulling/pushing action Synchronized pushing/pulling action Loss of balance Additional instructions to calm patient	*"Normally, we turn around, but that time because the outside door closed by itself, and we didn't get any cooperation from the lady, who could have held it* […]. *I continued going down backward, but usually we turn around, but there wasn't a long enough cement walkway outdoors to turn around safely without having problems like straining in a crooked position or dropping the patient."* *"The causes were that there were lots of very tight corners, so it was pretty difficult to turn around. The patient herself wasn't very heavy, but we were getting stuck in the corners. So then we had to put her down sometimes, change the stretcher's angle a bit so we could get out of the corners. I think we had to turn around three times."* *"We got caught on a frame and I think we were stuck for a bit. It was hard to agree that we had to pull. I think there was a communication problem."* *"When there's just a little notch at the bottom of the doorframe, all we have to do is press down a little bit on the back handles and the wheels lift up* […] *But that time* […] *the patient got a bit scared because we had to, like, lift to move the first two inches* […] *afterward, I, like, let it down so I could rest my wheels on the ground, but I realized that it was lower* […]."	7 (24.1%)

Cause	Consequence	Extracts from interviews with EMT-Ps	Frequency
Positioning of EMT-Ps	Pushing/pulling/holding action Awkward back postures	*"Yes, when you're going upstairs and you're at the top it's harder because you're the one who's straining backward and lifting your legs, and they're going forward.* […] *when you go downstairs, it's much easier for the person at the top than the person at the bottom since the person at the bottom holds the weight a bit, they're the one who engages the wheels in it."* *"At the feet, you're leaning more, then you strain much more than at the head. The weight is heavier at the feet, you're always leaning down, while at the head, you're at the same level. But that's it, when you're at the feet, you're working low down, and working low is when you strain your back much more."*	6 (20.6%)
EMT-Ps' height/size	No consensus	*"It seems that girls really like to be at the feet. I don't know, it's a question of habit. Or it's because I'm short, I always stationed myself at the feet."* *"Why I chose the position at the feet: the fact that I'm shorter. Since, basically, you're closer to the patient, and at the top, you have to clear the wheels as well, so it's easier for my teammate to be at the top than at the bottom."* "[…] *taller means you have to bend down more and then lift. No, generally, when there's a short person and a tall person, you put the short one at the top and the tall one at the bottom; it's easier that way."*	5 (17.2%)
Snow/ice on ground	Loss of balance Lifting/pulling action moving backward Lifting/pulling action Awkward back postures	*"The steps hadn't been properly cleared of snow and ice, so that was a bit dangerous. Otherwise, it was the part related to the sidewalk and the start of the yard, where there was some icy snow. It was more difficult with the ice and that stair chair, because it has four wheels, but they're small wheels, so if you're going forward, if the wheels catch in the ice, it can just take off forward. So you have to go backward, but backward on ice is dangerous, after all."* *"There was a bit of ice. It meant I had to bend down to lift the front of the wheels."*	3 (10.3%)
Patient's health status	Straining in reaction to patient movements Straining more while moving the load away from the body	"[…] *at one point he grabbed onto the railing, so that made our descent a bit complicated.* […] *in view of his confusion, because I could see that his speech wasn't too organized, he didn't understand clear instructions like 'keep your hands close to you'."* "[…] *most of the time, we put their arms under the straps, but we didn't do that, so that's why she was able to grab his arms, and that's dangerous because it can unbalance us."* "[tilting the stair chair to go upstairs] […] *I found myself with his face not far from my face, in fact very close, and since there was blood and dirt and all that, I had to move my arms away, and then I had to compensate with force and not with the right movements* […]."	3 (10.3%)

Cause	Consequence	Extracts from interviews with EMT-Ps	Frequency
Patient's positioning on stair chair	Counterbalancing with an asymmetrical action	"[…] *at one point, she leaned toward me a bit. I had to move more to the side to support her weight on the side because she was kind of unbalanced."*	2 (6.9%)
Direction of movement in staircase	Lifting/pulling action moving backward Loss of balance	"[…] *to climb the stairs, we had no choice, it's the only way: lifting with our arms. It works well to go downstairs* (the stair chair track) *and when the stairs are straight* […]," *"Yes, and it's tough on the calves, after that, the other person can't move forward too much because they can push you over backward. At the same time, you always have to lift your legs up from a step every time."*	2 (6.9%)
Type of surface on staircase or ground	Pushing/holding action Lifting action Patient imbalance Additional instructions to calm patient	*"It's never ideal with the tracks on a carpet on the stairs.* […] *We never know what to expect. Often the tracks don't roll and they slide."* *"The stair chair won't work on gravel. The wheels are too small, so that's why we lifted it up."*	2 (6.9%)
Presence of relatives or other people	Limited room to manoeuvre	*"More than once, we had to tell the family to keep back* […] *They want to be close to their relative, but it gets in our way.*	1 (3.4%)

Other difficulties

When administering care at the call location, the main difficulties reported concerned the patient's health status: consciousness, autonomy, pain level, and jointly with the patient's health, the type of clinical protocol administered by the EMT-Ps and the urgency of the transportation required. Other patient-related constraints, such as body weight, advanced age and ability to communicate clearly, underlay various difficulties experienced at work. The patient's physical environment also represents a significant cause of difficulties. When the patient is lying or sitting on the ground, care is administered while adopting awkward, static work postures. Working in a confined space may require additional actions to get the patient out and create a work space, but that is not always possible (e.g., patient in a bathtub; small, cramped apartment). For prehospital interventions done out of doors, weather conditions can also affect the EMT-Ps' perception of difficulties. The patient's bodily hygiene and the (lack of) cleanliness of the location can also make the work more difficult. Nauseating odours usually trigger a normal avoidance reaction, which can give rise to the adoption of awkward work positions and asymmetrical efforts while pushing, pulling or holding a load at arm's length.

We encourage readers to consult the dissertations by Jérôme Prairie and Dominique Larouche to find out more about the difficulties experienced by EMT-Ps during other work activities.

5. DISCUSSION

5.1 Variability of the prehospital intervention context

Each time they face new work situations, EMT-Ps make decisions based in the information available to them (Figure 4-3). From this perspective, as soon as a team is assigned to a call by the health communication centre, according to the standards of the medical priority dispatch system, they receive the first set of information concerning the nature of the clinical case, the level of urgency and the context (e.g., 29 D-02F priority 1: 29 = Road/transportation accident; D = Urgent level; 02 = High-speed impact; F = Rollover). The data regarding the call location are also crucial for the team of EMT-Ps. A geolocation system installed in the ambulance provides the exact location and optimized route. If one of the two EMT-Ps is already familiar with the location and its various access routes, that will help them save time in getting to the call location, for example, by knowing the best route to take with the ambulance, knowing where there are potential detours to avoid traffic jams and parking the vehicle in the right spot close to the call location to facilitate access to the patient and ensure that he/she can be quickly evacuated to the appropriate hospital.[11]

Once the ambulance has arrived at the location, the EMT-Ps must generally go on foot to the exact spot where the patient is. They will always bring the monitor/ defibrillator with them, and must also decide what other equipment and materials they will carry. Once again, an EMT-P's past experience can be beneficial when returning to a location with which he/she is familiar. To promote efficient movement (i.e., optimum duration), the decision must also take into consideration various aspects of the call location, such as the presence or absence of a security door (if there is one, it is important to know the procedure for gaining access, such as the buzzer code or how to get help), the availability of an elevator sufficiently large for the stretcher to fit into, the existence of a staircase, etc. The presence of people, such as caregivers or others from the vicinity, who can indicate where to go also promotes faster movement around the call location.

With experience, EMT-Ps manage to anticipate certain elements of the working context, which helps them to act appropriately in different situations and work as fast as possible. For example, when they leave the ambulance, they will take the stretcher with them if a call comes from a residence with medical personnel since most such buildings have elevators. They therefore presume that they will be able to get the stretcher to the patient without needing additional evacuation equipment.

Several aspects of the work context remain unpredictable until the first contact with the patient. For example, if the information provided by the call centre contradicts the patient's actual health status, the EMT-Ps will react by applying the appropriate protocols. This can lead to many kinds of reactions: a return trip to the ambulance to get missing equipment, a request for help from a second team of EMT-Ps, a cessation of the prehospital intervention if the patient refuses to be moved, etc.

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[11] The EMT-Ps will not necessarily go to the closest receiving centre. They generally adapt to the nature of the case. If the patient regularly visits a particular hospital, they will go to that one. When some hospitals are overloaded, they will go to another receiving centre that has room.

The results of this study indicate that, in three out of five cases, the clinical code provided by the health communication centre at the time of the call-out remains unchanged after the EMT-Ps have evaluated the situation. This indicates that some of the information transmitted upstream can help EMT-Ps anticipate the patient's medical condition, especially in the case of back pain (non-traumatic), cardiorespiratory arrest (or death), suffocation, heart problem or road accident. Conversely, according to our sample, the cases most subject to change were those related to chest pain, respiratory problems, unconsciousness and interfacility transfers. In these cases, the EMT-Ps' first contact with the patient was essential to dictate their next actions.

Another unpredictable aspect emerges as soon as contact is made with the patient, namely the helping relationship. This relationship is generally beneficial and it changes throughout the intervention in parallel with the treatment protocol. The helping relationship allows EMT-Ps to reassure patients and prevent certain situations from getting worse. As shown above, situations that required immediate or urgent transportation appeared in less than 22% of the prehospital interventions. In many situations, the intervention resembles a helping relationship more than a care-providing relationship. The EMT-Ps then become front-line social case workers and they had to have excellent interpersonal skills.

The sequence of families of activities in the work cycle during a prehospital intervention becomes variable after the initial contact with the patient. Although the EMT-Ps apply clinical protocols with standardized, rigorous procedures, their number, the patient's physical and mental health, and the physical and social environment where the patient is located represent numerous sources of variation that make each work cycle all but unique. More specifically, when applying the same clinical protocol on different occasions, the operations (and their sequencing) executed by the EMT-Ps will differ according to the patient's state of health, ability to communicate, cooperativeness, and mobility, along with the clutter around the patient, the accessibility of the location, and the degree of help (or hindrance) provided by relatives or caregivers. The location where the patient is may mitigate uncertainty (though without eliminating it completely). For example, it is rare for EMT-Ps to work with a young adult patient in a residence with health professionals, and it is much more probable that they will find an elderly patient with a well-defined physical or mental health problem and be able to count on the presence of health professionals on-site. Situations requiring a clinical protocol related to a behavioural problem generally involve adults who are either outdoors (in the street) or in an apartment. Thus, the clinical protocol and the location of the prehospital intervention represent two focal points (determinants) to be taken into consideration when describing EMT-Ps' work activities.

There are also situations where EMT-Ps perform a reduced selection of (or no) actions to assess the patient's clinical condition at the call centre. For example, in the case of a patient with chest pain in a public place, the EMT-Ps will hurry to load him/her into the ambulance to do an EKG, since placing electrodes over a large expanse of the patient's chest requires a high level of privacy. In this specific case, care provided on-site will be minimized so it can be partially done in the ambulance.

In addition, EMT-Ps execute prehospital interventions in a two-person team, where each one has a different role. The composition of the team, its experience, each team member's specific training and their common reference points (protocols) are other determinants that can affect the sequence of families of activities in the prehospital intervention. EMT-Ps also have to interact and work with other professionals (e.g., firefighters, police officers) during a prehospital intervention, especially in the case of urgent calls.

Rest periods represent another unpredictable element. They are inserted into the work cycle between prehospital interventions. They also depend on the number of ambulances available to respond to urgent calls.

This study enabled us to quantify the variations inherent in the work of EMT-Ps and document the foreseeable and unforeseeable aspects of the profession of the basis of a sample of 175 work shifts for EMT-Ps in the Montreal and Quebec City regions. However, it is important to mention that the reality of prehospital work may differ in certain respects for EMT-Ps who work in rural regions or elsewhere in the world (e.g., frequency of prehospital interventions, type and frequency of clinical protocols, work environments, types of patients, rotating schedules, etc.). It is difficult to say whether the number of units of analysis (individuals, shifts observed, tasks performed, etc.) was sufficient to accurately quantify the variations in the EMT-Ps' working context in an urban setting. Considering our research question and the means available to us (human, financial and time resources), we consider that we applied a statistically sound approach in terms of representativeness. The variations we report here clearly illustrate the gap that can sometimes exist between the work prescribed (and taught) and the actual work (the way the work is concretely carried out). This kind of exercise is necessary to improve our understanding of EMT-Ps' work activities and, ultimately, find preventive solutions for the health problems that many workers in prehospital care experience.

5.2 Physical demands of the job

5.2.1 Physical fitness

For most of the EMT-Ps, their physical fitness was better than the standards adjusted for age and sex. Slightly less than one third of the EMT-Ps had below-average cardiorespiratory capacity. No significant association was observed between their physical fitness and the various measures of exposure to risk factors or the difficulties experienced at work. Considering that this field study allowed us to analyze extremely varied work contexts and that the frequency of work situations requiring a substantial physical effort in relation to the workers' maximum capacity (exertion) was relatively low ("hard": <10%), this lack of association was predictable. By individually analyzing the six interventions that were perceived as "very hard" (~1%), we saw that they concerned only male EMT-Ps with 2 to 31 years of experience (mean ± standard deviation: 13 ± 12 years), with a BMI of 23 to 35 kg/m^2 (28 ± 4 kg/m^2), a height ranging from 167 to 185 cm (178 ± 6 cm) and a maximum cardiorespiratory capacity ($\dot{V}O_2max$) ranging from 23 to 48 ml/kg/min (37 ± 11 ml/kg/min). In other words, physically difficult situations were not experienced only by women, young workers, short workers, and workers who were obese or in poor physical condition; on the contrary, they affected a diverse range of workers with varied physical and physiological characteristics.

Several researchers have claimed that a minimum level of physical fitness is required to carry out the most demanding tasks with minimum fatigue to reduce the risks of injury and disability [11,39,50]. In each prehospital intervention, the EMT-Ps lifted, pushed or pulled loads (objects or humans). The frequency and duration of these movements were not very high but the intensity was at some points. None of the participating EMT-Ps injured themselves during their shifts. However, it should be recalled that, on the musculoskeletal tests, almost all the EMT-Ps obtained results equal to or greater than the mean for the general population (which was not the case for the physiological measures). This may be explained by the fact that many of the EMT-Ps had been given a physical fitness test when they were hired, or while they were undergoing their training, and candidates who did not meet the physical criteria were eliminated from the profession. It should, however, be noted that preselecting candidates, based on their physical fitness among other things, does not protect them from musculoskeletal disorders. This can be seen indirectly by noting the high rate of injuries reported year after year. Thus, EMT-Ps' physical fitness does not constitute the only determinant promoting their success at physically arduous tasks.

In recent years, the acquisition of equipment used to move patients (powered stretchers and stair chairs with tracks) has considerably reduced the frequency of load lifting during a prehospital intervention. The powered stretcher offers a clear advantage when it can be moved close to a patient who requires evacuation in total assistance mode. The work to adjust the stretcher height is done by the electric motor, which eliminates many of the constraints related to load lifting. During the loading and unloading phases, an powered stretcher can be lifted by two people, unlike a manual stretcher, which must be lifted by a single person. This is another advantage even though powered stretchers are heavier. The addition of tracks to a stair chair is positive when it is used in certain environments (e.g., while going down a staircase that has regular stairs that are sufficiently wide, etc.). Nevertheless, lifting of stair chairs was often observed while going downstairs, and inevitably while going upstairs. The advantages exist insofar as the equipment works properly and is not broken. During our observations, all three ambulance companies that collaborated with the project had this equipment, which is not necessarily the case for all companies in other regions of Quebec or elsewhere in Canada.

Although an accumulation of physical effort was possible during a work shift, it was not common. The frequency of prehospital interventions ranged from one intervention every 2.2 hours (in Montreal) to one intervention every 2.8 hours (in Quebec). That cycle leaves long recovery periods between prehospital interventions. In such circumstances, the energy expenditure can increase, particularly due to an increase in mental activity (e.g., increase in vigilance/concentration, planning of future steps), and an acceleration of the pace of work, but it would be surprising for this to call on individuals' maximum voluntary capacity. Use of the spine board was significantly associated with greater fatigue than use of a stretcher. However, the fatigue level of 3.5 out of 10 was still quite low. Since the level of physical engagement, as assessed by the perceived exertion scale and the calculations of energy expenditure, is relatively moderate during a prehospital intervention, and the recovery periods seem to be long enough and frequent enough, the dynamic nature of the work does not seem to be a real problem in the profession. Measures of heart rate were collected, which will make it possible to more accurately assess the energy expenditure and validate the results presented here, but they have not yet been processed.

The lack of any obvious effect of poor physical fitness on the increase in exposure to risk factors for MSDs is not in any sense a plea in favour of trivializing workers' physical condition. EMT-Ps' physical fitness modulates their ability to perform physically demanding work. The better it is, the lower the perceived effort. In addition, it is important to reiterate and emphasize the benefits of physical activity in general, both for quality of life and as a major determinant of health and wellness. It is strongly recommended that EMT-Ps adopt and maintain an active lifestyle, integrating a sufficient amount of moderately intense physical recreational activities so they can profit from the well-known benefits of regular physical activity [83-85].

Notwithstanding their physical fitness, EMT-Ps are required to intervene at a specific time, in an environment that is generally unfamiliar, and to make efforts that can be intense and prolonged. This scenario does not seem to be ideal, given that a long period of inactivity may precede intense physical activity. Contrary to popular belief, taking a warm-up period including stretching exercises does not seem to reduce the risk of musculoskeletal trauma or injury in such situations [86,87]. The mechanisms for developing an MSD that are most likely to occur, given the various constraints in the work situation and their interactions in EMT-Ps' work, are related to short-term excessive (overstress) or continuous (static effort maintained over time) effort by the worker.

Margin of manoeuvre

According to some researchers, the margin of manoeuvre is based on constraints but also on each worker's external and internal resources [88]. It is developed throughout the lifetime and the career path. In our study, several work situations necessitated intense physical exertion. For example, moving a patient with a spine board or a stair chair while going down a quarter turn or spiral staircase, or climbing one or two flights of stairs, constitute work situations that demand intense physical effort. EMT-Ps could always count on their teammate's help and thus carry out the work as a team. Teamwork makes it possible to allocate or divide the load to be lifted or moved, which has a direct impact on the effort perceived by an EMT-P. Similarly, the presence of other emergency workers (first responders, firefighters or police officers), particularly during urgent calls, sometimes made it possible to increase the number of people who helped move the patient. Although it has less effect, witnesses or family members could help the EMT-Ps if they executed tasks related to patient movement (e.g., pushing the stretcher under a patient who is being held by the EMT-Ps). On the other hand, as mentioned in the interviews with EMT-Ps, witnesses or relatives could sometimes make it harder to execute certain tasks. Technical support is also available to EMT-Ps, who can ask for backup from another team in specific specialized cases (e.g., moving an obese patient). In cases where more than two workers are participating in a task, special attention must be paid to teamwork (distribution of tasks, movement techniques and synchronization method) to ensure that this determinant helps rather than hinders the activity. Finally, EMT-Ps have a number of work tools available for patient movement. The appropriate selection of equipment can be an advantage that reduces the physical demands related to moving a patient.

During urgent evacuations, time constraints can incite EMT-Ps to hurry; this is described in more detail in the following section. Haste rarely leads EMT-Ps to rush to the point of running, forgetting to execute some steps of the clinical protocol, or losing control of the pace of work. Time constraints, which vary depending on the nature of the case and often contribute to the time pressure felt by EMT-Ps, affect the deployment of strategies to estimate the duration of activities, anticipate the future and make decisions to save time and effort.

A heavy workload combined with low decision latitude restricts the formulation of actions and thus undermines workers' health [89]. In this regard, Coutarel [25] proposes that MSDs are "the reflection of a lack of employee flexibility in the job" (p. 23). In the great majority of work situations, the EMT-Ps seem to have a lot of flexibility. Hegg-Deloye *et al.* [90] noted that the psychosocial strengths characterizing the work of EMT-Ps in Quebec are their decision latitude and recognition. This finding was also reported in a Swedish study, but the researchers did not observe any significant association between high decision latitude and a decrease in health problems in male or female paramedics [91]. Nevertheless, it would be a good idea to further investigate activities where external constraints (e.g., urgency) mean that the solutions available in EMT-Ps' toolbox are more limited. An increase in job flexibility is a crucial aspect of MSD prevention. This objective fits in with the desire to strengthen workers' "power to act" so they can be informed players in building their own health and developing their activities [92,93].

5.2.2 Temporal aspects

Every minute counts

The temporal aspects of the profession related to prehospital care present a dual reality. The temporal organization of non-urgent interventions is characterized by a flexible work flow where all minutes count, that is to say, every minute is used to ensure quality service that optimizes users' well-being. Conversely, every minute is counted in urgent situations. The time constraints characterizing urgency impose a more rigid temporal organization of activities and workers feel strong pressure that can become problematic in the medium and long term, especially for female workers.

A significant decrease in the duration of a prehospital intervention was observed for transportation in urgent mode, that is, when the patient's health was considered to be unstable. This observation has also been reported in other scientific studies and government reports [10,28,36]. Interventions made in urgent evacuation priority took less time, mainly because of a reduction in the duration of ambulance driving activities, although several regulation strategies regarding summation and anticipation during the intervention were applied at the call location. The activities carried out by EMT-Ps are executed in a dynamic environment in real time and cannot be stopped. EMT-Ps must complete the various steps while rigorously respecting the need to execute procedures that will increase the intervention time and also respecting the maximum prescribed times (e.g., *silver ten minutes* and *golden hour*). They also have to remain focused and react to the patient's signs and symptoms, which guide their actions at all times.

In non-urgent situations, the various operations comprising each treatment protocol dictate the pace of the prehospital intervention. Several EMT-Ps mentioned that, in such situations, they had all the time they needed to carry out their duties, they were relaxed, they took time to "dialogue" with the patient and they did not experience any temporal demands. In urgent situations, the durations of tasks were similar to those observed in non-urgent situations. The analysis of these data does reveal the true reasons for this, but there are several possible explanations. It may be that, in urgent situations, EMT-Ps have to perform additional operations. For example, when they provide care at the call location, EMT-Ps may execute certain operations faster but they may have more of them to perform. Ultimately, the duration of care at the call location appears to be equivalent, regardless of the urgency of the evacuation. Furthermore, none of the EMT-Ps rushed to the point of running while moving a patient. The systematic application of the different steps in their protocols (evacuation or treatment) seems to play the role of a metronome ensuring both the good performance of the work (regardless of the work context) and its execution in a safe period of time for themselves and for the patient. Working quickly may also demand more dynamic, operational cognitive activity: eliminating superfluous operations and concentrating on the steps in the treatment protocol, planning the optimum route to get to the location or evacuate the patient, or creating a work "bubble" that protects them from possible factors that could interrupt their rhythm or distract their attention. Finally, statistically speaking, the extreme variability of working locations would ideally necessitate a sample of observations sufficiently large to appropriately test the null hypothesis (absence of difference).

Nevertheless, it is important to keep things in perspective. If it were possible to save a few seconds by performing tasks faster at the call location, that would still represent a proportionally much smaller saving than the time saved while driving the ambulance in urgent mode.

Emphasizing the optimization (i.e., reduction) of response time related to tasks performed at the call location could endanger the already precarious balance between quality of the care provided for the patient (including his/her comfort) and risks to the worker's physical and mental health. Work tasks done in urgent mode are characterized by an impressive number of risk factors (awkward and static postures, excessive straining, workload) that were both observed by us and mentioned by the EMT-Ps.

Impact of time constraints on the choice of work methods

Very few respondents reported that temporal demand had an impact on their work methods, since most of them mentioned that they had to respect all of the assessment and clinical intervention protocols that were established, and that they had learned, for a particular kind of case or problem. These protocols were put in place to guide work methods and provide the most complete and appropriate care for the patient's condition. However, in light of the significant variability in prehospital interventions, some EMT-Ps remembered that more than one protocol sometimes applies to a given situation. These EMT-Ps therefore emphasized the importance of the decision latitude they enjoyed in their work. Indeed, this kind of flexibility is essential to allow EMT-Ps to establish the priority for application of assessment and intervention protocols in order to administer appropriate prehospital care in urgent situations. In this sense, several factors can influence the choice of the sequence of treatment protocols administered by the team of EMT-Ps. For one thing, EMT-Ps often emphasized that an unstable patient health status is one of the main factors affecting the application of intervention protocols. In fact, when the patient presented unstable vital signs, the optimum intervention turnaround time was considerably reduced, obliging the EMT-Ps to hurry with the intervention to ensure that the patient arrived at a hospital as fast as possible. The main signs of unstable patient health mentioned by the EMT-Ps we interviewed included deteriorating consciousness, cyanosis or pallor, a significant change in pulse and hypotension.

In addition, the EMT-Ps mentioned the impact of the environment on the work methods they applied during an urgent intervention. Indeed, they noted that public places, unfavourable weather conditions (e.g., rain, snow, heat wave), and unsanitary locations were the main environmental characteristics impacting the speed of an intervention in order to maximize the patient's wellbeing. For example, some EMT-Ps preferred to change the sequence of tasks in order to execute some steps of the protocol inside the ambulance, where they could not be seen by the public and could assure the patient of privacy. Arial *et al.* [17] also noted that Swiss EMT-Ps' tasks were often interrupted, which distracted their attention, increased their workload and slowed them down. Some strategies were mentioned such as the prolonged use of medical instruments to induce calm and silence around them, thereby giving them some respite to think and refocus on the task [17]. Divided attention can also increase risks to the health and safety of both the EMT-Ps and the patient.

To sum up, the EMT-Ps we interviewed mentioned that, in most interventions, instability of the patient's health and problematic environmental characteristics influenced the speed of execution of their tasks and the sequence in which they applied the intervention protocols, rather than their work methods as such.

Impact of time constraints on physical effort exerted

In light of the analysis of the contents of the interviews, few of the EMT-Ps indicated that time constraints affected their physical exertion during an intervention. In fact, they insisted on the importance that they attributed to appropriate execution of the handling and movement techniques, regardless of the urgency of the situation, to avoid risks of injury. Nevertheless, the EMT-Ps reported that the patient's consciousness and level of autonomy could have an impact on the extent of the physical efforts they had to make during a prehospital intervention. According to their interviews, the greatest physical effort was exerted in a situation where the patient's consciousness and autonomy were low, since in that case the patient could not really work with them and the load to be lifted and moved could be heavier. However, some EMT-Ps admitted that, in situations where the evacuation priority was high, the substantial temporal demand (cognitive analysis of the time required for the intervention) could influence the techniques they used, for example by increasing the speed with which they performed them, and the physical effort necessary to accomplish them. At first sight, it may seem contradictory not to connect working faster and straining more. It is true that the EMT-Ps performed the same tasks, but increasing the speed requires an additional physical demand, greater energy expenditure and a very different cognitive load (since the EMT-P has less time to anticipate and process information in order to make decisions). Working faster could also mean that an EMT-P executes more tasks in the same time, but that was not explicitly reported. The risk of MSDs may be higher in situations with high temporal demands, since "working faster" requires increased solicitation of the body's muscle components. This increased muscle solicitation can be observed both for the effector muscle, which executes the action faster, and for the postural muscles, which stabilize the body and execute actions that require speed and precision [94]. On the other hand, their perception of physical effort could be affected by cultural factors related to the job (ideas, traditions, behaviours). Their engagement and excitation clearly show their strong interest in urgent situations. Considering the relatively low frequency of such work situations, it is possible that the nature of the work the EMT-Ps want alters their conception of normal work conditions or what is acceptable, which may cause them to underestimate the physical effort required during their work.

In all cases, the results of this study indicate that the existence of time constraints influences the physical demands on EMT-Ps, just as it affects the mental side of work and the perceived workload.

5.2.3 Other determinants that play a role

Figure 4-6 summarizes all the determinants related to a time constraint, which characterize the most physically demanding real-life work situations. Environmental physical constraints are among them. If the patient is on the ground (lying or sitting) when the EMT-Ps arrive, it is generally the result of a fall or other accident that results in a fragile health condition. Of course, the patient's position in the work context represents the central point in the prehospital intervention. The helping relationship and the administration of care to the patient are centred around this position. If the patient is positioned close to the ground, the EMT-Ps will undeniably be exposed to awkward and static postures more than for other tasks performed at the call location. Cramped physical environments can make it difficult, or even impossible, to bring the stretcher (or other equipment) close to the patient, or can impair the EMT-Ps' working postures and restrict their breadth of movement while they are providing care and transferring the patient to the transportation equipment. The lack of an elevator and the presence of a staircase (higher than the vertical wheelbase of the stretcher) will force the EMT-Ps to use other transportation equipment, such as a stair chair or, in some cases, a spine board. These two pieces of equipment are significantly associated with an increase in perceived physical effort, mental load, fatigue, pressure and temporal demand. Additional difficulties were noted as a function of the type of staircase (quarter turn or spiral staircase), snow cover or ice on the steps, and the direction of movement (i.e., upstairs or downstairs). Particular attention should also be paid to the type of stair chair, since models with tracks appear to be less suitable for staircases with limited space, those with non-uniform or unconventional stairs, and especially quarter turn and spiral staircases. The alternative solution, observed only with the EMT-Ps working for Urgences-santé (Montreal) is to use a stair chair without a track. In addition, some EMT-Ps prefer to use a harness to carry the stair chair and thus support the patient's entire body mass while negotiating the stairs.

Perceived physical exertion was more marked for the protocols for adult medical cardiorespiratory arrest (RÉA 1) and indications for spinal immobilization (TRAU 1), which are situations where the EMT-Ps used the spine board to transport the patient to the ambulance. In addition, the EMT-Ps adopted awkward and static postures (sagittal flexion and asymmetrical back positions), which are especially problematic. The care phase takes up most of the prehospital intervention time at the call location; it lasted a mean 8.4 minutes and as much as a mean 20 minutes for the RÉA 1 protocol. EMT-Ps' exposure to risk of MSDs is therefore doubled, in both scope and duration. The role played by EMT-Ps also has an impact on their perceptions of physical exertion, demands, time pressure, workload, fatigue and the adoption of awkward and static back postures. Overall, EMT-Ps assigned to care are more exposed to significantly greater risk factors than their teammates. The alternation of roles during a shift represents, at the very least, a necessity – even an obligation – so that the workload can be fairly distributed between teammates. Based on these results, it appears clear that the administration of care to the patient at the call location by the EMT-P assigned to care should be the subject of a more in-depth analysis to identify the problematic determinants and suggest preventive measures to reduce EMT-Ps' exposure to these risk factors.

5.3 Intrinsic factors

The patient's characteristics and needs and the environment in which the patient is located are powerful determinants of EMT-Ps' work activities. The combination of these determinants makes each prehospital intervention singular and unique, regardless of the sex, obesity level, or seniority of the EMT-Ps or the discomfort they feel. Although every EMT-P has his/her own characteristics and motivations, certain trends regarding work methods or postural attitudes emerged when we compared groups. The differences were identified especially during actions that result from decisions related to the administration of the clinical protocol and how the patient is evacuated (from the selection of equipment to move the patient to the route taken when returning to the ambulance).

5.3.1 Sex

In the context of an urgent patient evacuation, female EMT-Ps felt strong time pressure, which was expressed by a much greater perceived workload than their male colleagues felt. However, the level of physical exertion, duration of tasks and fatigue level were similar for EMT-Ps of both sexes. Hegg-Deloye *et al.* [90][12] observed that EMT-Ps in Quebec have very high workloads *and* decision latitude and that this applied to a high proportion of workers, both men and women, and both novices and veterans. Considering all the prehospital interventions, including the non-urgent ones, we also saw a lack of differences. Some hypotheses can be formulated to explain the difference between men's and women's perception of the workload in urgent situations. Ability to manage stress could partially explain the difference [95]. As well, women may be more exposed to the job's psychosocial constraints than men [96]. Women who play multiple roles, such as wife and mother, and who have heavy family responsibilities as well as a job are more at risk of feeling a high psychological demand and experiencing low decision latitude [97]. Our current data are insufficient to draw any clear conclusions, but this is a question that should be specifically investigated in future.

In general, women adopted safer work postures than men. Only two work situations presented the opposite picture. During trauma care at the call location, female EMT-Ps engaged in more extreme trunk flexions for a larger proportion of the working time than men. It was not a matter of time or of difficulties experienced, since no male-female difference was detected in this study. The type of helping relation, level of attention and empathy, and communication with the patient could explain the postures adopted by EMT-Ps to get closer to the patient. During the initial movement to the call location (EMT-P assigned to driving), the amplitude of female EMT-Ps' back torsions was greater than that of men. That was probably due to their carrying equipment slung over one shoulder or in one hand, which triggers a more pronounced back asymmetry in order to counterbalance the weight of the equipment.

Although indirectly related to sex, an effect of the worker's height was also observed in certain work situations. When loading the patient and the stretcher into the ambulance, male EMT-Ps adopted more marked back flexion postures; on the other hand, once the stretcher was lifted off the ground, women held it with their hands closer to their shoulder height than men.

No consensus among male and female paramedics was observed regarding positioning around the stair chair when moving a patient in a staircase. However, postural analyses showed that EMT-Ps who were facing the patient adopted more extreme sagittal back flexion postures than those who were positioned behind the patient, when going both downstairs and upstairs. Regardless of their position, men flexed their back more than women. These results suggest that it would be advantageous to position the shorter EMT-P in the team at the patient's feet, or at least to consider a system of alternation, in order to minimize and share among teammates the exposure to awkward positions while using the stair chair in staircases.

5.3.2 Seniority

EMT-Ps with over 15 years of seniority experienced as many difficulties as the ones with less seniority. Overall, the level of post-intervention fatigue and the duration of tasks were similar between seniority groups. In urgent situations, all groups experienced the same perceptions. Non-urgent work situations (~79% of prehospital interventions) were experienced differently by EMT-Ps with 15 of experience or more. Their perception of physical effort, workload, pressure

[12] Self-report data taken from a questionnaire on psychosocial constraints.

and temporal demand was greater than for EMT-Ps with less seniority, although at relatively low levels. The basic level of physical exertion at work was therefore significantly higher in common, easy operations. Aging is often associated with a normal decline in physical work capacities [49,54]. As workers age, tasks that demand physical efforts gradually approach their maximum physical abilities, thereby increasing the perceived physical effort [56]. On the other hand, to achieve the same production objectives, older workers may develop individual and group working strategies that enable them to continue to efficiently perform high-quality work while protecting themselves from risks [57-59]. Our analysis of postural data indicates that the EMT-Ps with the most seniority adopted safer work postures than those with less seniority. Another explanation focuses on the "healthy worker effect" whereby workers whose health has deteriorated (whether or not due to strenuous work) tend to quit the job earlier, while workers who were initially in better health or more resistant are better able to tolerate long working hours. In this context, particular attention should be paid to workers who adopt awkward or static positions.

5.3.3 Obesity

The postural constraints that surplus body weight impose undeniably result in an overload of the musculoskeletal structures of the back. In addition, the morphology of obese workers limits the possibility of bringing a load to be moved in close to the body before lifting it. These biomechanical aspects expose obese workers to greater risks of developing an MSD than healthy-weight workers when handling loads [98,99]. In our study, obese EMT-Ps adopted safer working postures than non-obese ones. The adoption of more neutral working postures than non-obese EMT-Ps allows obese EMT-Ps to offset the effect of these biomechanical constraints and thus reduce their exposure to risk.

Moreover, obese EMT-Ps reported fewer difficulties than non-obese ones in at least one task: moving the stretcher and the patient to the ambulance. The causes of difficulties reported by EMT-Ps included the use of access ramps (barrier-free route),[13] which must include a transition slope according to Quebec's construction standards; limited space, especially in the turns of certain access ramps; and surface type (gravel, grass, etc.). The counterweight technique is very useful in moving the stretcher. Heavier operators who adopt this technique therefore have an advantage that can make it easier to move the stretcher with a load.

On the other hand, this finding may be due to a sampling bias. The number of observations of obese EMT-Ps was much lower than for non-obese ones. As well, in comparing the intensity of the prehospital interventions with those they had previously experienced, the obese EMT-Ps reported experiencing easier work situations than the non-obese ones.

The lower aerobic capacity of obese individuals may be one of the factors responsible for fatigue when they are subjected to strenuous work conditions [100]. In this study, obese EMT-Ps did not experience different fatigue levels from non-obese ones after their prehospital interventions. Considering that a waiting (recovery) period generally follows each prehospital intervention and

[13] https://www.rbq.gouv.qc.ca/fileadmin/medias/pdf/Publications/francais/ConceptionSansObstacles.pdf. Accessed December 15, 2015.

that the dynamic nature of EMT-Ps' work applies infrequently, obese EMT-Ps are not unduly disadvantaged by their lower cardiorespiratory endurance.

5.3.4 Discomfort

Discomfort generally triggers protective reactions to avoid aggravating the condition. The main differences between paramedics who felt discomfort (in the back or upper limbs) and those who did not were observed during the provision of care: adoption of less awkward postures and shorter duration of postural maintenance, as well as a shorter duration of care activities at the call location by approximately 2 minutes. The existence of discomfort systematically affected the perceived workload, temporal demand, physical effort and fatigue level, for both male and female EMT-Ps, regardless of their seniority. This result is in accordance with other studies. Hansson *et al.* [101] found that participants with neck and shoulder discomfort reported greater exposure to problematic back postures and movements than those with no discomfort for the same mechanical exposure level. Aasa *et al.* [11] showed a significant association between perception of physical demands and discomfort in the neck and shoulders during work activities in female EMT-Ps. Thus, participants who feel musculoskeletal discomfort in a key body part while performing work seem to overestimate their exposure to risk factors.

We also noticed that workers who had felt discomfort were more likely to indicate that they had experienced difficult situations, especially while moving a patient on transportation equipment (in the case of those who reported back discomfort) and while loading the stretcher and patient into the ambulance (for those who reported upper limb discomfort). These results must be interpreted with caution, since even though the associations were significant, no causal relations have been proven.

5.4 Limitations

The different groups were compared on the basis of samples that were essentially different (with regard to the number of observation units and the content). This field study had the purpose of analyzing EMT-Ps' exposure to risk factors. Although this analysis is based on over five hundred prehospital interventions, the work context (and exposure to risk factors) was different for each intervention. We hypothesized that the number of observation units would enable us to gather normally distributed data, which would allow for this kind of comparison. Two-way and three-way cross-tabulations of variables were often limited by an overly small number of observations. It is possible that significant differences could be the result of multiple confounding variables other than the ones used to build these comparison groups. For this reason, a considerable effort was made to identify the confounders, that is, variables that could have the greatest impact on the measures of exposure: the EMT-P's role, the urgency of transport, and the clinical protocols.

Only one EMT-P in each team was the subject of an in-depth study (posture dosimeter, video recording). Thus, the work team dimension was not exploited to its full potential.

The method chosen for recruiting participants may have caused an experimental bias. Indeed, the study was based on voluntary participation, so it is possible that the candidates were almost exclusively individuals who had confidence in their working skills [15]. In addition, although the EMT-Ps executed their normal work tasks, it is possible that some of them paid particular attention to their work techniques knowing that they were being observed. If one of these possibilities actually applied, then the results of this study may have underestimated the measures of exposure to risk factors for MSDs.

For purposes of this study, the EMT-Ps carried equipment on their back (posture dosimeter). Even though it weighed less than 3 kg, wearing the equipment may have affected their work and their actions.

The physiological data on heart rate were not analyzed in detail. The study of the content of the interviews has not been completed for all families of activities and certain analyses have not been integrated into this research report. Finally, considering the technical constraints related to the use of a video camera in an ecological context, the biomechanical analysis of the most physically demanding work situations concerned only the activity of loading the stretcher and the patient into the ambulance. Readers are asked to consult the list of publications produced by this project to find out more, particularly about the activities of loading the stretcher and patient into the ambulance and moving the patient in total assistance mode.

6. CONCLUSION

It is undoubtedly the case that it is the constraints affecting a job that are risky and not the job as such [102]. The relationship between constraints and professions is an obvious one, but it is not necessarily automatic: EMT-Ps' working conditions vary according to the context of their tasks. This study quantified the variation in the determinants and constraints inherent in EMT-Ps' work and documented the predictable and unpredictable aspects of the job. An unstable patient condition is the cornerstone of difficulties with the job, since it dictates how further actions will proceed, namely the choice of clinical protocol and the priority for patient evacuation. This determinant explains why EMT-Ps sometimes rush and is partially responsible for a high workload and high physical efforts by a team of EMT-Ps. The care that follows, the pace of which is dictated by well-defined protocols, represents task where the exposure to the risk of back injury, based on postural indexes, is highest. In addition, such time constraints can be problematic in the medium and long term, because they make workers, especially women, feel pressured.

The alternation of roles within a shift after each intervention requiring an urgent patient evacuation could better distribute this exposure between teammates. Tasks related to moving the patient, especially in total assistance mode (e.g., movements executed in staircases), also underlie these difficulties. Overall, female EMT-Ps, obese EMT-Ps and EMT-Ps with several years of seniority adopted safer working postures than their colleagues. To some extent, this high workload is offset by paramedics' decision latitude, although it does raise the issue of compromise between service quality, haste and personal security.

Although every minute counts, when EMT-Ps rush at the call location, they often save only a few seconds, and sometimes endanger their own physical and mental health to provide speedy, professional service and maximize the patient's comfort. Driving the ambulance, though, represents a critical activity where essential minutes really can be saved. Thus, it is important to modulate this business culture: in urgent situations, every minute actually does count, but in non-urgent ones all the minutes count.

This large-scale project made it possible to create a clear picture of EMT-Ps' profession, its risks and its difficulties. The information collected in this report will enhance the content of future EMT-Ps' training and contribute to the application of preventive solutions for the health problems that still afflict too many workers in the prehospital urgent health care environment.

6.1 Applicability of results

The analyses carried out in this study are based on a sample of 175 shifts involving EMT-Ps who work in the Montreal and Quebec City regions. These analyses are based on direct measures of their exposure to risk factors and on observation of their work activities in the course of their duties. Thus, this research report provides a detailed description of the working conditions experienced by Quebec EMT-Ps. This reality may differ in some respects from the conditions experienced by EMT-Ps who work in rural regions (e.g., frequency of prehospital interventions, use of manual stretchers, type and frequency of clinical protocols, work environments, types of patients, rotating schedules, etc.) or elsewhere in the world.

6.2 Possible spinoffs

- Creation of a database governed by the rules of Université Laval’s ethics committee, which allow us to keep these data for the next 25 years. The purpose of this database is to make the data available for potential related projects. Such projects must foster an understanding of the physical, mental and social demands of EMT-Ps’ profession and of their work activities as a complex whole in order to suggest changes intended to optimize EMT-Ps’ health and the quality of the services they give patients;
- Improvement of the content of training given to students in prehospital urgent care programs;
- Enhancement of EMT-Ps’ training programs by developing decision support tools, further investigating the concepts of tolerance and compromise, contextualizing know-how, etc.;
- Advancement of knowledge further to future studies, which should specifically examine the risks associated with the administration of certain clinical protocols and the evacuation of patients in total assistance mode, including with a stair chair or spine board.

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APPENDIX 1

Dynamic Work: Work-Rest Alternation

Terminology:

- maximum continuous work time: maximum acceptable uninterrupted work time, depending on the intensity of the work.
- rest time: duration of the recovery period following the work activity that is necessary based on the intensity and duration of the work.
- Maximal aerobic capacity: maximal aerobic capacity related to maximal oxygen consumption ($\dot{V}O_2$max, in kg/ml/min or kcal/min).
- work cycle: duration of the prehospital intervention from the call-out until the patient is unloaded at the hospital.

Purpose: Assess the maximum energy expenditure based on a hypothetical extreme scenario, evaluate the maximum continuous work time and rest time to minimize the impacts of fatigue after a prehospital intervention.

Working hypotheses:

- The *extreme* work cycle for EMT-Ps is made up of light work activities related to the driving of an ambulance, occupying 62%[14] of the cycle time, moderate work occupying 25% of the work cycle time, and heavy and very heavy work activities accounting for 10% and 3% of the work cycle time, respectively.
- The acceptable energy expenditure limit is 4 kcal/min,[15,16] above which a rest period is necessary to minimize the appearance of physiological fatigue symptoms, which may subsequently cause workplace accidents and injuries.

Initial data:

- A 30-year-old man; body mass of 110 kg; height of 178 cm.
- Minimum value of maximal aerobic capacity measured in the laboratory of 23.4 kg/ml/min or 12.4 kcal/min.
- Duration of prehospital intervention: 60.3 minutes (value of 90th centile);
- Energy expenditure based on whole-body effort level:[17]
    - Light work: 2.5 kcal/min
    - Moderate work: 3.8 kcal/min
    - Heavy work: 6 kcal/min
    - Very heavy work: 10 kcal/min

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14 Represents the median value for ambulance driving time in the 531 prehospital interventions studied.

15 Lehmann G (1958). Physiological measurements as a basis of work organization in industry. *Ergonomics* 1, 328–344.

16 Astrand, PO, Rodahl, KA. *Textbook of work physiology—Physiological basis of exercise*, 3rd ed. McGraw-Hill, New York, 1986, pp. 295–505.

17 Taken from figure 1.21 (p. 73) of *Kodak's ergonomic design for people at work*, 2nd ed., by SN Chengalur, SH Rodgers and TE Bernard, Hoboken, NJ: John Wiley & Sons, 2004.

Method:

- Use of the Eastman Kodak Company's work classification method to assess total maximum energy expenditure for the work cycle.
- Use of a table[18] to estimate basal metabolism in kilocalories per minute as a function of the worker's body mass, height and age.
- Use of the Kamon equation[19] to assess the maximum acceptable continuous work time leading to exhaustion and of criteria[20] allowing the determination of a safe work time.
- Use of two models[21-22] to assess the theoretical duration of rest time that should follow the continuous work period when the previous criteria are not met.

Calculations:

<u>BASAL METABOLISM</u>

The interpolation of values in the table (height in cm 180; body mass in kg 110) enables us to approximate the value of the participant's basal metabolism at 2,277 kcal/24 h or 1.6 kcal/min.

<u>TOTAL ENERGY EXPENDITURE TO PERFORM THE WORK</u>

$$\boldsymbol{E = \sum_{k=1}^{n} e_k P_k + M_B} \qquad (1)$$

E: energy expenditure to perform the work; k: {light, moderate, heavy, very heavy}; n = 4 levels of effort called on during the work; e_k: energy expenditure for effort level k; P_k: percentage of cycle time requiring effort level k; M_B: basal metabolism.

E = 5.0 kcal/min

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18 Spitzer H, Hettinger T. Tables donnant la dépense énergétique en calories pour le travail physique. Paris: *Cahiers du B.T.E.* 1966.

19 Kamon E (1979). Scheduling cycles of work for hot ambient conditions. *Ergonomics,* 22, 427–440.

20 (1) if $f\dot{V}O_2max \geq 0.50$, use one third of the time prescribed by equation 2; (2) if $0.40 \leq f\dot{V}O_2max < 0.50$, use half the time prescribed by equation 2; (3) if $0.33 \leq f\dot{V}O_2max < 0.40$, use the time prescribed by equation 2.

21 Tiwari PS, Gite LP (2006). Evaluation of work-rest schedules during operation of a rotary power tiller. *International Journal of Industrial Ergonomics* 36(3):203–210.

22 Lehmann G (1958). Physiological measurements as a basis of work organization in industry. *Ergonomics* 1(4), 328–344.

<u>CALCULATION OF MAXIMUM CONTINUOUS WORK TIME</u>

$$\boldsymbol{T_w = \frac{40}{f\dot{V}O_2max} - 39} \qquad (2)$$

T_w: maximum continuous work time; $f\dot{V}O_2max$: fraction of $\dot{V}O_2max$ (maximal aerobic capacity) to perform the work ($f\dot{V}O_2max = \dot{V}O_2work / \dot{V}O_2max$).

$f\dot{V}O_2max = 0.40$

$T_w = 60.8$ minutes

The use of the safety criterion would reduce the continuous work time by a factor of 2, to 30.4 minutes. This is less time than the duration of the simulated prehospital intervention. A calculation of rest time (recovery period) specific to this work situation must therefore be done.

<u>CALCULATION OF REST TIME</u>

Model 1

$$\boldsymbol{T_{r1} = T\frac{(E-a)}{(E-b)}} \qquad (3)$$

T_{r1}: rest time assessed by model 1; T: actual work time; E: energy expenditure to perform the work; a: energy expenditure based on acceptable $\dot{V}O_2$ (equivalent to 33% of $\dot{V}O_2max$); b: energy expenditure based on resting $\dot{V}O_2$ (basal metabolism).

T = 60.3 min
a = 4.1 kcal/min
b = 1.6 kcal/min

T_{r1} = 15.8 min

Model 2

$$T_{r2} = \boldsymbol{T}\left(\frac{\boldsymbol{E}}{\boldsymbol{a}} - \boldsymbol{1}\right) \qquad (4)$$

T_{r2}: rest time assessed by model 2; T: actual work time; E: energy expenditure to perform the work, a: acceptable energy expenditure (equal to 4 kilocalories per minute).

T_{r2} = 13.1 min

Interpretation:

The value of the maximum continuous work time is slightly higher than the simulated work time. However, when the safety factor was applied, the situation was reversed. In that condition, a rest/recovery period was necessary. The calculated rest time ranged from 13 to 16 minutes depending on the model. These results mean that each prehospital intervention should be followed by a rest period lasting at least 13 minutes in order to minimize the effects of fatigue related to the physical aspects of the prehospital intervention.

Limitations:

- Thermal conditions can influence energy expenditure, but this factor was not taken into consideration in solving the problem.
- When the work requires a series of long rest periods and short work periods, the resumption of work after the break creates an additional energy expenditure (Simonson effect).
- The models used can lead to significant errors. It would be preferable to directly measure oxygen consumption during the work or use an approximation based on working heart rate.