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Box Handling in the Loading and Unloading of Vans

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The handling of 2,306 boxes being loaded or unloaded from vans onto or from 4-wheeled trolleys by 31 handlers in a warehouse were characterized. Handling was videotaped and characterized through an analysis grid completed by three trained observers. The following execution parameters were observed: nature of the exertion applied by the upper limbs, plane and direction of the exertion, resulting displacement of the box, grip, use of the lower limbs and the back. Results show that execution parameters used by handlers vary considerably from those usually recommended or studied. For example, symmetric grips were rarely used (4%). The grip was modified during the handling of half the boxes. Significant knee flexion was rarely observed (3% of exertions). Each box was moved by applying an average of 3.5 different exertions. Exertions were mostly applied in a plane parallel to the shoulders; they were rarely executed in a strict sagittal plane (11%). The implication of these observations are discussed.

handling box handling techniques field study work analysis

1. INTRODUCTION

Handling techniques have been the subject of numerous experimental studies focused on the identification of the execution parameters to be recommended or prescribed. Because of the high prevalence of back problems, the two most important execution parameters considered until now have been back and knee flexion. Over time, some other parameters have been considered, such as the back or load kinetics (Dieën, Huub, & Vrielink, 1994; Leskinen, Stålhammar, Kuorinka, & Troup, 1983; Mirka & Marras, 1990), the curvature of the spine (Anderson & Chaffin, 1986; Hart, Stobbe, & Jaraiedi, 1987; Holmes, Damaser, & Lehman, 1992), the initial position of the feet, mostly parallel or apart (Anderson & Chaffin, 1986; Ekholm, Arborelius, & Nëmeth, 1982), and, more recently, the coordination (Burgess-Limerick, Abernethy, Neal, & Kippers, 1995) and the load trajectory (Plamondon, Gagnon, & Gravel, 1995).

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However, the choice of execution parameters has been limited by two dimensional models and the technology available. For example, the use of a force platform restricts foot movements. Handling techniques used in industries have also until now mainly been described in reference to back and knee flexion and, sometimes, kinematics. For example, Jones (1985) identified 5 basic different techniques: leg lift, hip-flexion lift, kinetic lift, dynamic lift, and natural lift, which is described as being an in-between leg and back lift.

The study of free lifting techniques has also attracted some attention. Free styles have been shown to be advantageous: The measured stresses are less (Anderson & Chaffin, 1986) or the maximum acceptable weight is greater (Garg, Sharma, Chaffin, & Schmidler, 1983). These free style techniques are, however, rarely described with precision. The laboratory context often imposes limits in the technique used (e.g., foot displacement) and the participants are generally unexperienced. A recent study comparing expert handlers with novices for a very simple task consisting of transferring boxes from a base to a 4-wheeled trolley showed that their handling techniques differed not only with respect to back or knee flexions, but also for the feet position, the pelvis orientation, the hand position, the way in which the boxes were positioned and moved during the transfer (Authier, Lortie, & Gagnon, 1996).

For some time, major differences have been observed from what is recommended and what is actually used in the workplace (Brown, 1973; Imbeau, Beauchamps, Normand, Courtois, & Marchand, 1990; Kuorinka, Lortie, & Gautreau, 1994). Studies also showed that training programs in "good handling techniques" have not produced the expected results (Kroemer, 1992). In particular, the trainees seem unwilling to apply all of the handling principles taught (Chaffin, Galley, Wooley, & Kuciemba, 1986; Hale & Mason, 1986; St-Vincent, Lortie, & Tellier, 1989). The main reasons advocated are the short training period and the characteristics of the work context, such as the presence of spatial restrictions. However, an experimental study conducted with experienced handlers in a context free of restrictions showed that the recommended principles were rarely used, except for a systematic attempt of bringing the boxes closer to the spine (Authier, Lortie, & Gagnon, 1996). Thus, it may be that other factors prevent the workers from being receptive to the recommended techniques.

Nevertheless, natural lifting techniques have not been systematically described (Burgess-Limerick et al., 1995). Possibly, as postulated by Troup (1979), no natural technique is identifiable. There is, however, a general agreement that natural lifting involves a posture somewhere intermediate between the extremes of a stoop and a full squat. Still, as stated by Burgess-Limerick et al., the position adopted at the start of the lift is insufficient to describe these techniques. As a fact, an analysis of the handling of 2,000 boxes conducted by Drury, Law, and Pawenski (1982) showed that handling was performed through different phases (pre-grasp, pick-up, move/carry, deposit), each with their own characteristics, that sagittal symmetric lifting and lowering tasks were the exception rather than the rule, and that most of the boxes were grasped asymmetrically and often tilted. Similar results were found in a study on the handling of loads other than boxes (Baril-Gingras & Lortie, 1995). That study also documented the nature and direction of the exertions applied and the resultant load displacements (e.g., pivoting, rotating, sliding). The study focused on goods other than boxes as they were found to be overrepresented in the accident records (Lortie, Lamonde, Collinge, & Tellier, 1996). Drury et al.'s study remains the only one to have investigated box handling more extensively, in particular the location of the grip and the tilting of the box. However, their main purpose was to document the handling contexts: median weight and sizes handled, height of pick-up and deposit, type of tasks, distance of carrying.

A better understanding of how workers handle may help to understand the factors preventing them from applying the recommended techniques. In addition, characterizing risks for techniques rarely used in reality clearly limits their preventive value. Presently, many execution parameters appear interesting. For example, the identification and characterization of the different phases in handling may be pertinent for different reasons. We may suspect that a pre-grasp phase could allow the handler to obtain information on the load and influence the coordination process. In most of the experimental studies, the load is directly lifted. Sliding or pulling action on the load before lifting it may influence the delay between the start of the lift and the attaining of significant lumbar vertebral extension. Presently, there is no clear agreement on the importance of this delay (Burgess-Limerick et al., 1995). The organization of the different phases has attracted little attention, with the focus being on the pick-up phase: Other phases such as the deposit may also be important. The latter may involve more eccentric contractions, which are considered more risky (Gagnon & Smyth, 1991); field observation of incidents shows that these occur more often at the deposit phase than at the pick-up or transfer phases. For example, more losses of balance and difficulties in controlling the load were observed at the deposit phase than in any other phases (Lortie & Pelletier, 1996). Drury et al. (1982) noted that sagittal lifting was rare, but the way in which boxes were handled was not documented. Gagnon and Smyth (1991) showed that when depositing a box on a shelf at a height above the waist, the work efforts were concentrated on the upper limbs (about 80%): Perhaps handlers developed strategies to overcome this limitation. Experimental studies also showed that an asymmetric grasp provides a horizontal and a vertical box stabilization (Drury & Deeb, 1986), whereas accidents analysis and interviews conducted with experienced handlers confirm the importance of the control in the handling process (Authier & Lortie, 1993; Lortie et al., 1996).

As suggested by some authors (Ayoub & Mital, 1989; Burgess-Limerick et al., 1995; Garg & Saxena, 1979), naturally adopted lifting techniques may be the least likely to cause injuries. However, little is known about these natural lifting techniques. The object of this study was, therefore, to characterize some execution parameters used in loading and unloading boxes from the vans of a large trucking company, in particular: the nature of the exertions, the plane and the direction of these exertions, the resulting displacement of the box, the displacement of the handler, and the use of the lower limbs and the back.

2. METHODOLOGY

2.1. Activities Studied

Trucking companies usually cater to one type of merchandise: general goods, small loads, bulky load, house furniture, and forest products. The trucking of general goods is the most important. It can be divided in two categories: the transport of complete versus broken lots. In broken lots, the trucking company transfers goods coming from different expediters. Most of the handlers in the trucking industry are employed in this sector. Presently, about 70% of goods are transported by vehicle and general goods represent 50% of total transports by the Canadian trucking industry (Société Québécoise de Développement de la Main-d'oeuvre, 1995).

The company studied is the second largest in Canada. Their warehouses and docks are the nodes of a distribution network. Warehouses are simply large rectangular surfaces surrounded by doors where vans are parked. Handling on a dock basically consists of dispatching the goods from one van into other vans according to the next destination. This may be to another dock, to another city, or directly to the client. The center of the warehouse is used for short-time stocking—the goods being left on a pallet or a trolley—and there are no shelves. Manual handling is frequent, although many goods are moved with forklifts. Manual equipment consists of 4-wheeled trolleys, drum, or 2-wheeled buggies. In large companies, handlers are specialised in loading or unloading. Only the handling of boxes, which represented more than 90% of goods moved, will be described here. The typical task of an unloader consists of identifying boxes from a lading bill, sorting and grouping them according to their destination on a 4-wheeled trolley, and driving the trolley to the appropriate loading door. The loader then brings the hand trolley in the van and transfers the boxes. Boxes can be of any size and weight, which is typical for all the trucking companies, but the average weight is about 9 kg. The study was conducted on the main dock.

2.2. Participants

Each of the 31 handlers studied (17 unloaders and 14 loaders) were videotaped for the entire duration of their shift. Their age, weight, and size were about the same (there were no significant differences) as for the whole group of handlers (43 years, 1.74 m, 72 kg). The study objectives were explained to everyone and written consent obtained.

2.3. Data

The camera was placed outside the van, on the other side of the circulation alley. Fixing a camera inside the vans was absolutely impossible as they arrive or leave fully loaded. One sequence out of three was selected. The sequence was retained only if the visibility or the position of the handler was good enough to use the analysis grid. At first, 100 boxes per participant were sampled, which represented about a quarter of the handling of boxes videotaped. However, due to the duration of the analysis and to assure the same observers completed the entire study, the number was further reduced to 50 boxes per participant. The training of the observers took three months. In total, 2,306 boxes handling were characterized.

2.4. The Analysis Grid

The structure of the observation grid is summarized in Figure 1. Each handling was broken down into four phases: pre-grasp, transfer, deposit, adjust. This is slightly different from Drury et al. (1982), who separated the transfer phase in two: a pick-up phase that refers to the moment where the participant first takes the full weight, and a move/carry phase. We kept just one transfer phase, because participants sometimes moved the box without ever completely supporting it (e.g., pivoting or moving from an edge to another, sliding the box directly on the 4-wheeled truck). Every different exertion applied by the upper limbs (e.g., a change in the nature, direction of the force applied, or in the grasp) was identified and characterized. For each, the position of the back, knees, feet, hands on the box, the displacement given to the box, the nature of the exertion, its plane (sagittal, transverse, frontal), and its direction were characterized (except situations involving a static exertion as when holding, or when exertions were applied in different directions by both arms). The displacement of the feet and switching in the grips were also observed. Therefore, a single handling could include different exertions, used in one to four of phases, with the simplest handling being a direct transfer in one continuous movement (e.g., the box is grasped and directly thrown to is final position). Any repeated exertion (e.g., a sequence of pushing) was noted but not included in the database.

Overall, 8,150 different exertions were characterized. The different dependent variables and their classes are summarized in Table 1. This grid was first developed to analyze the handling of goods other than boxes (Baril-Gingras & Lortie, 1995). The variables were chosen to fit with the videotaped material. For example, a variable on the displacement of the box was developed as handling could evidently not be simply resumed to displacements implying either lifting or lowering. Validation procedures are described in Baril-Gingras and Lortie (1990). Only variables achieving an inter- and intra-observers reproducibility greater than 90% were retained. This is why, for example, torsion and lateral flexion were not differentiated. For the back sagittal flexion, three classes ($\leqslant 20°$; $20° < a \leqslant 45°$; $> 45°$) were retained, as used by Keyserling (1986), Keyserling, Brouwer, and Silverstein (1993), and Punnet, Fine, Keyserling, Herrin, and Chaffin (1991). It must be mentioned, however, that the segregation of classes varies from one study to another. The most frequent values used to define a slight flexion are $\leqslant 15°$ or 20°. The second figure varies between 45° and 60°; 45° was chosen because pretests with measured material showed good reliability. The grid was computerized. The separation into phases was done by two observers working in pairs. Each observer entered an entire sequence. They could observe a loader or an unloader. The internal consistency of observers was pretested on a setup of different types of sequences.

The characterized independent variables were the box characteristics and the height of the pick-up and the deposit. Three classes of sizes were defined according

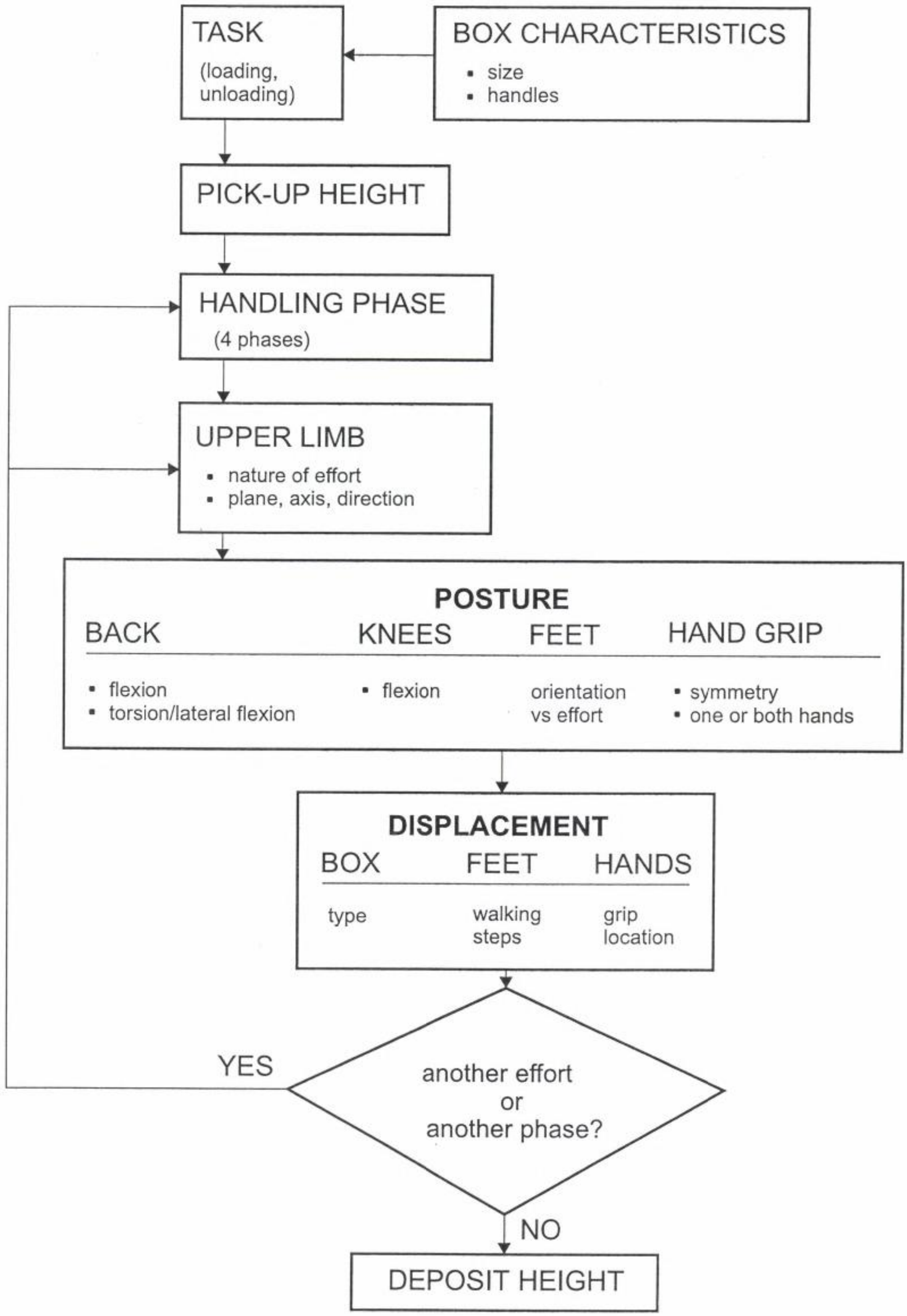

Figure 1. Structure of the observational procedure.

TABLE 1. The Variables Observed

Variable	Classes[1]	Comments
Exertion		Refer to the exertion applied by upper limbs.
Nature	Pushing, pulling, lifting, lowering, dropping, throwing, holding, supporting, both arms in opposition, exertion applied by another segment.	Arms in opposition: each arm applied a different effort (e.g., pushing with knee, lifting with thigh).
Plane	Sagittal, frontal, transverse.	Frontal: parallel to shoulders; Transverse: perpendicular to shoulders.
Direction	Downwards or upwards; towards, away from the spine, or from one side to the other.	
Back Position		
Flexion	$\leqslant 0°$, $\leqslant 20°$, $\leqslant 45°$, $> 45°$	$\leqslant 0°$: hyperextension.
T./L.F.	Torsion, lateral flexion, or both.	Cannot be reliably differentiated.
Knee Flexion	Yes (internal angle $< 120°$), no.	
Feet		
Displacement	Complete walking step?	Include at least two successive weight transfers (e.g., right-left-right).
Feet Position	Parallel or not to exertion.	Exertion applied by upper limbs.
Grip	Grip both hands, one hand; asymmetrical, symmetrical.	Example of one-hand grip: using a handle, pivoting, transport on shoulder.
Box Displacement	9 classes: turning, pivoting, raising, lowering, sliding, carrying, dropping, resisting, other.	
Box Characteristics		
Size	Small, average, large.	Defined in reference to the arms abduction ($\leqslant 15°$, $\leqslant 45°$, $> 45°$).
Liftable?	Yes, no, not sure.	Completely by one person.
Possible Grips	Handle (used?), improvised handle, pinch grip.	Handles are generally improvised from the strapping. Pinch grips: with flat boxes.

Notes. [1] For every pertinent variable, the observer could indicate "unclear;" T./L.F.–Torsion, lateral flexion, or both.

to the distance between the elbows while in abduction (see Table 1). The boxes were also categorized according to whether they could have been completely lifted off the ground by one person or not, and the possible grips. The height was evaluated in function of the participant rather than the van (height limit: 2.8 m) as the handler could climb to reach a box.

3. RESULTS

Two different denominators were used: the number of boxes (2,306) and the number of exertions (8,150). The results presented cover all of the handling without reference to the task (loading or unloading). The impact of the task is summarized at the end.

3.1. Characteristics of Boxes and Context

The boxes were mainly small (24%) or average in size (67%). The observer estimated that in 96% of the cases, the box could normally be completely lifted by a single person, for the entire handling. Only 1.5% of the boxes had handles. In 89% of the cases, the boxes were gripped in a zone between the ground and mid-thigh (43%), or mid-thigh and the shoulder (46%). Only 11% of the boxes were gripped above the shoulders. In 56% of the cases, the deposit took place in the mid-thigh/shoulder zone, and in 29% of the cases, in the ground/mid-thigh zone. The boxes were deposited above the shoulders in only 14% of the cases.

Table 2 shows the distribution of the box trajectories. In 47% of the cases, the box was transferred within the same zone. Transfers between two extreme zones—ground/mid-thigh to above the shoulders, and vice versa—represented only 9% of the transfers.

TABLE 2. Distribution of Box Trajectories: Percentage and Confidence Interval[1]

	Placement Zone			
Pick-Up Zone	Ground to Mid-Thigh	Mid-Thigh to Shoulders	Above Shoulders	Total
Ground to Mid-Thigh	15.8 [14.3–17.3][2]	21.4 [19.7–23.1]	5.9 [4.9–6.9]	43.1 [41.1–45.1]
Mid-Thigh to Shoulders	10.1 [8.9–11.3]	29.5 [27.6–31.4]	6.5 [5.5–7.5]	46.1 [43.8–48.4]
Above Shoulders	3.4 [2.7–4.1]	5.5 [4.6–6.4]	1.9 [1.4–2.4]	10.8 [9.5–12.1]
Total	29.3 [27.4–31.2]	56.4 [54.2–58.4]	14.3 [12.9–15.7]	

Notes. [1] Chi-square, $p \leqslant .001$; [2] Confidence interval at 95%.

3.2. Position of the Handler and Contact with the Box

As explained in the methods, handling could involve a sequence of different exertions. The grip was observed at three different moments: first, second exertion, and at deposit. Of the 6,208 observations, a symmetrical grip was observed in only 4% of the cases (first effort: 5%; second: 3%; placement: 4%). In the case of the first effort—the objective was generally to position the box—the box was moved with only one hand in 26% of the cases. Thirty-seven boxes had handles, of which 27 were actually used. When used, both handles were gripped symmetrically in only 5 of the 78 efforts characterized.

At the end of each exertion, the observer noted whether another exertion, a change in the grip, or both were observed. For 61% of these exertions, the grip location was modified. In fact, the same grip was used the whole time for only one of six boxes (17%) moved: The grip was changed once or more in, respectively, 40 and 43% of the cases.

The feet were positioned in the same direction as the exertion (first and second exertion) in only 4% of the cases. For 25% of the boxes, at least one complete step cycle was observed (11% of exertions): 56% occurred when the box was held, but also 22% while lifting.

A significant knee flexion (internal angle $\leqslant 120°$) was observed in only 3% of the exertions and 6% of the handling, and in, respectively, 4% and 9% of the lifting and lowering exertions.

The back was nearly straight (flexion $\leqslant 20°$) in 44% of the exertions (Table 3). However, when the back was bent, severe bending ($> 45°$) was more prevalent than moderate bending (32% vs. 19%). Torsion/lateral bending (T./L.F.) was observed in 18% of the exertions, most often together with a severe flexion. The observer noted a difficulty in characterizing a postural element for 4% of the exertions, and more specifically for the T./L.F. more than one in two.

TABLE 3. Back Position Observed While Applying Exertions[1]

Back Position	Without T./L.F. %	Without T./L.F. (number)	Combined with T./L.F. %	Combined with T./L.F. (number)	Total %
Flexion $\leqslant 20°$	39.1	(3,187)	5.1	(415)	44.2
$20° <$ Flexion $\leqslant 45°$	13.5	(1,102)	5.8	(470)	19.3
Flexion $> 45°$	24.4	(1,991)	7.3	(595)	31.7
Hyperextension	0.9	(72)	0.3	(27)	1.2
Total	77.9	(6,352)	18.5	(1,507)	96.4[2]

Notes. [1] Chi-square, $p \leqslant .001$; [2] The posture could not be classified in 3.6% of the cases ($n = 291$). In these 291 exertions, the problem was related to the observations of Flexion—37%, Hyperextension—7%, and T./L.F.—59%; T./L.F.—Torsion, lateral flexion, or both.

3.3. Exertions and Box Displacements

The focus was on two elements: upper limb exertion (nature, plane and direction) and box displacement. On average, 3.5 different exertions were applied to move each box. For 13% of the boxes, an exertion was repeated at least once. As explained in the methods, these 391 exertions were not included in the database. As it can be seen in Table 4, the two most prevalent exertions were pushing (33%) and lifting (22%). When considering the overall handling process, at some point in time, the box was either lifted, lowered, or pushed, at least for one in two, or either pulled, thrown, or held, one in four.

TABLE 4. Nature of Exertions Applied by Upper Limbs and Box Displacements[1]: Percentage and Confidence Interval

Nature of Exertion	Exertion (%) [confidence interval]	Handling (%)	Box Displacement	Exertion (%) [confidence interval]	Handling (%)
Pushing	32.7 [31.7–33.7]	70.3	raising	25.3 [24.4–26.3]	69.9
Lifting	22.0 [21.1–22.9]	64.3	sliding	16.4 [15.6–17.2]	46.3
Lowering	15.7 [14.9–16.5]	50.0	turning	12.7 [12.0–13.4]	37.1
Pulling	11.8 [11.1–12.5]	35.1	lowering	15.0 [14.2–15.8]	46.4
Holding	7.2 [6.6–7.8]	24.4	pivoting	14.6 [13.8–15.4]	39.9
Throwing	6.9 [6.3–7.5]	25.4	carrying	7.5 [6.9–8.1]	26.4
Arms in Opposition	1.7 [1.4–2.0]	5.2	dropping	5.5 [5.0–6.0]	19.4
Supporting	1.0 [0.8–1.2]	3.5	resisting	2.5 [2.2–2.8]	8.3
Other Than With Arms	1.0 [0.8–1.2]	3.3	other	0.4	0.9

Notes. [1] Chi-square, $p \leqslant 0.001$.

Table 4 shows that the box displacements varied. At some point in time, the box was either raised, in two of three cases, slid or lowered, one out of twice, and turned or pivoted, once out of three. Once in five, the box was dropped at the time of placement. Only one box out of four was carried at some point, meaning that the boxes were in constant motion three times in four.

A direct relationship between the nature of the applied efforts and the displacement of the box was observed. Overall, more than 90% of the displacements resulted from two types of exertions. Essentially, 99% of the time, a box was raised when it was picked up (86%) or thrown (14%). Boxes were slid when they were pushed (60%) or pulled (40%). Pushing rather than pulling was mainly used to pivot (79%) or turn the box (86%).

TABLE 5. Exertions (Percentage, Confidence Interval) Applied by Upper Limbs[1]

	In One Plane	Horizontal in Combination With: Upwards	Horizontal in Combination With: Downwards	Subtotal
Horizontal Plane				
Towards the Spine	21.3 [20.4–22.2][2]	15.9 [15.1–16.7]	4.3 [3.8–4.8]	41.5 [40.4–42.6]
Away From the Spine	10.6 [9.9–11.3]	12.7 [11.9–13.5]	15.6 [15.8–16.4]	38.9 [47.8–40.0]
From One Side to the Other	0.2 [0.1–0.3]	2.0 [1.7–2.3]	0.7 [0.5–0.9]	2.9 [2.5–3.3]
Transverse Plane	2.7 [2.3–3.1]	1.8 [1.5–2.1]	1.6 [1.3–1.9]	6.1 [5.6–6.6]
Sagittal Plane				
Upwards	7.3 [6.7–7.9]			
Downwards	3.3 [2.9–3.7]			10.6 [9.9–11.3]
Subtotal	45.4 [44.3–46.6]	32.4 [31.3–33.5]	22.2 [21.3–23.1]	

Notes. [1] Chi-square, $p \leqslant 0.001$; 799 exertions were not characterized (e.g., holding, pushing with the leg, both arms moving differently); [2] Confidence intervals at 95%.

For 90% of the upper limbs exertions, the plane and the direction were characterized (Table 5). The remaining 10% included static exertions (e.g., holding), exertions with both arms moving differently, or exertions provided by another segment (e.g., pushing with the knee). The exertions were carried out in one plane (mostly the horizontal one) 45% of the time. Exertions in a strict sagittal plane were infrequent (11%). In total, 83% of the observed exertions were carried out solely in a horizontal plane (32%) or in combination with a sagittal plane (51%). Exertions along an axis parallel to the shoulders were going outward as often as they were going toward the spine. Exertions from one side of the body to the other were rare (3%), as were exertions perpendicular to the shoulders (6%). Results also show that some patterns were generally avoided. For example, when the exertion was applied toward the spine, there was a four-fold difference between upwards and downward (16% vs. 4%). On the contrary, downward exertions were more often executed away from the spine than towards (16% vs. 4%).

3.4. Differences Between Loading and Unloading Tasks

Box characteristics were not identically distributed (Chi-square (2) = 36.82, $p \leqslant .001$). In loading, average-sized boxes were significatively more prevalent (L: 73.5%; U: 62.0%; t = 5.81, $p \leqslant .001$). Boxes were grasped more often in the ground/mid-thigh zone for loading, and above the shoulders for unloading, whereas the reverse was true for the placement (see Table 6). It was, therefore, not surprising to find significatively more lifting or throwing in loading (L: 33.9%; U: 25.1%; t = 8.68, $p \leqslant .001$) and more lowering in unloading (L: 11.6%; U: 18.9%; t = 8.92 $p \leqslant .001$). However, the differences between loading and unloading were generally insignificant for the other parameters studied. For example, the distribution of back postures was identical to within 2%.

TABLE 6. Distribution of the Pick-Up and Placement Heights[1] (%)

	Pick-Up		Placement	
Zone	**Loading**	**Unloading**	**Loading**	**Unloading**
Ground to Mid-Thigh	48.3	39.1	20.6	35.9
Mid-Thigh to Shoulders	44.8	47.1	54.9	57.5
Above Shoulders	6.8	13.8	24.5	6.6

Notes. [1] Chi-square, $p \leqslant .001$ for pick-up and placement.

4. DISCUSSION

This study was conducted in one warehouse. The work done in the trucking of general goods between warehouses is quite similar as to the level of technology, the equipment used, the type of loads, and the work organization. Most of the observed handlers had previously worked in other trucking warehouses and they confirmed that the work was similar to their previous work. The company itself did not consider this warehouse as different from its other warehouses. The purpose of this study, however, was not to characterize handling in the whole trucking industry, nor handling overall. In fact, handling work done in other types of warehouses (as in the food industry) or in other contexts is probably different in some respect. Whereas the average weight handled in the Drury et al. (1982) study is comparable to the one found in the present study, the handling context definitely presented some differences. For example, this dock had no shelves or similar types of space restrictions; the boxes were systematically picked up or deposited, from or onto a 4-wheeled trolley that could have been positioned in different ways. There was no conveyor (Karwowski & Brokaw, 1992). This can explain why less walking and transport were observed when compared with the Drury et al. (1982) study where boxes were carried over a median distance of 1.5 m. In both studies, however, sagittally symmetric handling and symmetric grasp were rarely observed, whereas they were frequently observed in the Karwowski and Brokaw study. The frequent use of pivoting observed is also consistent with the Drury et al. observations of box inclinations.

The results show that box handling is complex. Describing typical handling techniques appears difficult because of the multiple combinations of possible execution parameters. The variability of the techniques used was also confirmed in an experimental study where handlers moved series of boxes in a very simple context (Authier et al., 1996). General trends were, nevertheless, evidenced: asymmetric grip, frequent grip changes, exertion applied in parallel to thc shoulders, the use of back flexion. These same trends were also found in the analysis of the handling of objects other than boxes (Baril-Gingras & Lortie, 1995). Clearly, a technique cannot be restricted to either a back/knee question or to the pick-up phase.

First, as Drury et al. (1982) observed for the handling of 2,000 boxes in an industrial environment, boxes were grasped systematically with an asymmetric grip, regardless of the handling step. An asymmetric grip is considered to help box stability in space (Coury & Drury, 1982). Observation of incidents show that about one incident in four while handling involves a control problem (Lortie & Pelletier, 1996). Interviews with handlers, selected by their peers for being the best ones, showed that controlling the load is an important criterion when choosing a handling method (Authier & Lortie, 1993), and that the position of the grip is essential to do so (Authier, Lortie, & Gagnon, 1995). These experts favor asymmetric grips that also allow them to tilt or rotate the boxes in various ways. Recommending symmetric grips should, therefore, be reconsidered.

Handles are also recommended, especially when the load is heavy. The present study shows that handlers often modified their grips and rarely used both handles when they were provided. The exact location of the hands on the boxes was not observed, but Drury et al. (1982) observed that 10 positions covered 90% of the observations. Also, the type of effort and the height are known to have an impact on the optimum grip location (Deeb, Drury, & Begbie, 1985; Drury & Pizatella, 1983). In a van, both vary constantly. Therefore, for this work environment, determining an optimal handle location appears a hopeless endeavor.

The handlers were rarely observed moving the boxes only in a sagittal plane as was also noted by Drury et al. (1982). At the start of the transfer, the boxes were moved away from, or brought closer to the spine, laterally. The box was held fixed in relation to the body for only a fraction of handling. This way of working is very different from what is actually studied experimentally. Therefore, standards based on handling in a sagittal plane have limited applicability to this type of work environment. In addition, body twisting, which here could not be differentiated from lateral flexion, was not as frequently observed as in the Drury et al. study. Determining whether or not it is related to differences in the context studied or to other factors is, however, difficult. This could be explained by the handlers being able to modify the position of their feet and pelvis. It is known that moving the feet has a predominant impact on the resulting stresses (Anderson & Chaffin, 1986; Lavender, Thomas, Chang, & Andersson, 1994). Moments in torsion and lateral bending were also found to be low (about 30 Nm) in an experimental study where the participants could choose their handling method when transferring boxes from a base to a 4-wheeled truck placed perpendicularly—a typical condition in a van (Gagnon, Plamondon, Gravel, & Lortie, 1996). Presently, the horizontal work is often assumed to result in postural asymmetry, which one is amplified by asking the participants to keep their feet in a fixed position. Here, the T./L.F. were also mostly observed together with a flexion, a severe one in 40% of the time. Therefore, T./L.F. seem to be used mainly in situations in which the box size, the handling context, or both are particularly difficult. For most of exertions, apparent T./L.F. was spontaneously avoided. So, an asymmetrical work situation does not result automatically in a T./L.F. The correction factors proposed over the last few years (Waters, Putz-Anderson, Garg, & Fine, 1993), therefore, risk of being applied abusively by inexperienced observers.

The boxes were also observed to undergo many types of displacements. Raising and lowering were important, but they composed only part of the handling. Experienced handlers stated that letting the load "work for you" was important and a major reason for choosing a handling technique (Authier & Lortie, 1993). The movements of the box are probably a key element in this choice. These types of displacements could probably not be achieved with a symmetric grasp. Also, handlers often reported that not holding, restraining, or "working against" the load was important. In fact, boxes are mostly in constant motion. The percentage of boxes where the deposit was not controlled until the end—that is by throwing or letting it drop—were also found to be far from negligible. This also appears incompatible with work in the sagittal plane. It is usually recommended to avoid throwing or giving acceleration to a load. Nevertheless, throwing as done by experienced handlers deserves more attention.

Analysing the impact of independent variables in a field study is very difficult. The variables are difficult to control and few participants work in identical situations. Only an experimental setup would allow a good understanding of how the different independent variables influence the execution parameters. These independent variables were, therefore, characterized mainly to situate the handling context. In this matter, a true comparison between loading and unloading would have called for observing the loading and its subsequent unloading. The results, however, seem to show that these are not mirror images. For some reasons, handlers favor different pick-up and above all placement heights depending on the task, which results in expected differences in the distribution of exertions and box displacements. In a van, handlers can, to some extent, choose between different strategies in loading and unloading. In particular they can choose which box to move and where it will be moved. They can also climb. It was particularly noticeable that even when the vans were loaded to above-the-shoulder height, transfers from one extreme zone to the other were rather rare. Handlers managed to transfer the boxes inside the same zone almost once out of twice. Recent interviews confirmed that strategies such as unloading in a staircase pattern, are developed to achieve this goal. In the future, studying handling not only box by box, but its organization as a whole, or comparing loading and unloading situations would be interesting. However, these observed differences had surprisingly no marked impact on the other variables, such as the posture, the direction of the exertions in horizontal plane, the use of knees and the grips, at least for this level of precision.

5. CONCLUSION

Handling has been the subject of many experimental studies. Nevertheless, we are just beginning to know how handling is done in a workplace and why it is done the way it is. This study shows that handlers assigned to the loading or unloading of vans favor execution parameters that are very different from those usually studied or recommended. Assessing whether these are safer was not possible in this study; nevertheless, it is reasonable to estimate that they present some advantages. Would not a better understanding of these be welcome?

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