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Physical workload and psychosocial working conditions in Swedish pig transport drivers

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ABSTRACT

Working conditions of 20 Swedish pig transport drivers (PTD) were assessed by a questionnaire, a workshop, and recorded postures and movements during on-farm loading, driving, unloading at abattoir and vehicle cleaning. High arm positions and high frequencies of shoulder problems indicated an excessive physical load on shoulders. Extreme crouching postures inside vehicles and high frequencies of lower back problems indicated high load on the back of PTDs. Inadequate design of on-farm loading areas was associated with knee discomfort. Observed variation in workload between PTDs could be explained by differences in physical working environment and pig handling practices. PTDs reported high job satisfaction and commitment although conflicts with farmers and official veterinarians, as well as regulatory conflicts were emphasized. We conclude that issues of inadequate farm and abattoir facilities, stakeholder conflicts and insufficient training in animal handling need to be addressed to ensure sustainable PTD working conditions.

1. Introduction

Since the beginning of the 20th century, pig production continues to undergo massive intensification and specialisation in most industrialised countries, leading to larger and fewer farms and abattoirs with increased distances between them (Sørensen et al., 2006). In Sweden today, approximately 2.5 million finishing pigs are transported to slaughter annually by some 100 pig transport drivers (PTD) (pers. comm., A. Falk., Swedish Association of Road Transport Companies, June 18, 2020), from about 900 farms to 20 abattoirs of which a few slaughter the majority of all pigs (Statistics Sweden, 2020; Swedish Board of Agriculture, 2020).

PTDs play a key role in the pork production chain and in many countries including Sweden they are legally responsible for the welfare of the animals during loading, driving and unloading (EU Regulation No. 1/2005). Abattoirs contract commercial animal hauliers, either sole proprietors or with up to dozens of employed PTDs, to collect and transport pigs from farmers. Such a subcontractor situation, combined with rivalry between hauliers, is associated with insufficient safety management (Valluru et al., 2017) and violations of best work practices. Transport routes are planned by either the haulier manager or the abattoir, depending on contract details, and are determined by the trade relationship between abattoir and farmer, not necessarily related to transport distance.

Transportation employees are frequently reported in work-related accidents, including fatalities (Wiatrowski and Janocha, 2014; Chandler et al., 2017), with the majority of injuries occurring outside the truck while handling goods (Chandler et al., 2017). A high centre of gravity and unsecured loads in moving vehicles are generally known to decrease vehicle stability. Modern transport vehicles used by Swedish PTDs have 2–4 loading levels with hydraulic hoist systems and the combined capacity of a truck-trailer is 200–300 pigs. In farming, including pig production, handling of animals is the major cause of physical injury in handlers (Langley and Morrow, 2010). Handling of large animals, for example finishing pigs which weigh approximately 120 kg at slaughter transport, increase the risk of accidents. Moreover, varying and sometimes frequent use of handling tools has been observed in PTDs during unloading of pigs (Bornhede, 2014) indicating a potentially high physical workload. Although little is known about other tasks, loading of pigs at the farms may be even more demanding due to

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occasional suboptimal conditions. A broad assessment of PTDs physical workload is therefore needed to reveal potential risks of work-related musculoskeletal disorders.

Monotonous repetitive work, awkward postures, heavy lifting and lack of recovery are aspects important within the construct of physical workload (da Costa and Vieira, 2010). Long-term exposure to high physical load can cause musculoskeletal disorders such as rotator cuff syndrome in shoulders and back pain illness (Dalbøge et al., 2014; Rwamamara et al., 2010). Because physical exposure is difficult to assess through observations or self-reports, technical recordings are necessary to evaluate ergonomic risks (Balogh et al., 2019). Methods for assessing both task and job exposure, applicable for intervention studies, have previously been evaluated (Hansson et al., 2010). Triaxial accelerometers have been found suitable for objective assessment of angular velocities and positions (flexion/extension) of the head, neck, back and upper arms during work (Hansson et al., 2001), and are used to establish exposure-response relationships for work-related disorders. For example in the meat-cutting industry, a high physical workload indicated by rapid movement in the upper arms and wrists and high prevalence of hand and elbow disorders (carpal tunnel syndrome), have been found (Arvidsson et al., 2012). Relationships between head, arm and wrist velocities and reported disorders such as tension neck syndrome and carpal tunnel syndrome have been described (Balogh et al., 2019) and threshold limit values of postures and velocities for head, upper arm and wrists have recently been suggested (Arvidsson et al., 2021 in press).

PTDs usually work alone, sometimes during night-hours, circumstances that reduce recovery possibilities and are regarded as psychosocial risk factors (Costa, 1996; European Agency for Safety and Health at Work, 2011). Generally, psychosocial risk factors also involve high work demands, low perceived control and role conflicts. PTDs work is governed by legislations covering a range of topics from occupational safety and animal welfare to traffic rules. For example, legislations cover responsibilities such as safeguarding pig welfare, limiting transportation to 8 h (including loading and unloading) and limiting driving to 4.5 h before taking a break. Violations often involve fees to the haulier company. Along with the agreed delivery time to abattoirs, this potentially results in safety policy and practice (deliver on time) conflicts (Murphy et al., 2018).

Ensuring the wellbeing of professionals in the animal production sector is important in itself and, moreover, in the holistic 'one welfare' perspective due to links between human wellbeing and animal welfare (Pinillos, 2016). The main focus of previous research related to animal transportation have been on effects of animal stress on meat quality (Goumon and Faucitano, 2017; Gesing, 2010; Fitzgerald et al., 2009; Werner et al., 2007), and loading and unloading have been described as highly stressful situations for pigs with risk of decreased welfare (McGlone et al., 2014; Bench et al., 2008). If PTDs working environment is poor, it will likely adversely affect the welfare of the pigs (Anneberg and Sandoe, 2019). To date, PTDs physical and psychosocial working environment have received little scientific attention, possibly due to demanding conditions for data collection.

This study was part of a large multidisciplinary project, aiming to find solutions for improved human wellbeing and animal welfare during slaughter transport of finishing pigs. The objective was to study Swedish PTDs' working environment, and more specifically to a) estimate their physical workload, b) describe their psychosocial working environment and c) identify factors that may influence the physical and psychosocial working environment.

2. Material and methods

2.1. Ethical approval

This study was approved by the Regional Ethical Review Board of Gothenburg (ref. 070–18) for human subjects, and by the Animal Ethics Committee of Gothenburg (Dnr 5.8.18–12650/2018) for animal research. Participation was voluntary and haulier managers, PTDs, farmers and abattoirs gave their informed consent before data collection.

2.2. Study design and subjects

A mixed-method exploratory approach, involving quantitative and qualitative methods, was adopted. To support the choice of methods, a meeting was arranged in February 2018 where two retired PTDs, two abattoir managers and two farmers commented on the questionnaire content and shared their knowledge about PTDs work.

Haulier companies were randomly selected by asking Swedish large-scale abattoirs to participate and to provide contact details of contracted hauliers. Haulier managers suggested PTDs among their staff, who were then asked to participate. Permission from farmers to collect data during loading was obtained before each visit. Four abattoirs and four hauliers participated. One abattoir, one haulier and several farmers declined participation. A total of 18 participants (2 females and 16 males, aged 20–54 years) from four hauliers operating in the south, southwest and middle-north of Sweden were included in technical recordings of physical workload and answered a questionnaire. Additionally four PTDs not included in physical recordings answered the questionnaire after distribution from haulier managers. Participants had at least 6 months experience of pig transportation. Altogether, the 22 participants constituted approximately 15–20% of the PTDs operating in Sweden today.

PTDs participating in physical workload recordings estimated the average time per week for loading and unloading pigs between 2 and 20 h (median 10 h), and the average time for driving pigs between 5 and more than 30 h (median 27 h). Transport vehicles usually had three levels. (Table 1).

Table 1
Descriptive background information from a questionnaire for Swedish pig transport drivers (n = 22), 2018–2019.

Variable	TDs included in workload measurements		TDs included in survey only	
	n	Value	*n*	Value
Age (years)	18	31[a] (20–54)[b]	4	30[a] (27–32)[b]
Males/females	18	16/2[c]	4	4/0[c]
Total number of pig transport drivers employed by haulier	16	10[a] (3–18)[b]	4	11[a] (3–14)[b]
Experience of working with pigs before present employment, yes/no	16	9/7[c]	4	0/4[c]
Time working with pig transport (years)	16	4[d] (0.5->10)[b]	4	5[d] (2->10)[b]
Number of abattoirs receiving transports (1/2/3/>3)	16	7/5/2/2[c]	4	3/1/0/0[c]
Number of decks on vehicle (1/2/3/4)	16	0/3/11/2[c]	3	0/0/3/0[c]
Number of pigs usually unloaded at abattoir (<100/100–200/>200)	15	1/8/6[c]	4	0/0/4[c]
Average time per week loading or unloading pigs (hours)	14	10[d] (2–20)[b]	4	15[d] (10–15)[b]
Average time per week driving pig transport vehicle (hours)	14	27[d] (5->30)[b]	4	25[d] (20->30)[b]

[a] Mean.
[b] Range.
[c] Number of respondents.
[d] Median.

2.3. Work tasks

Standard pig transportation routines involved driving to farm-site, one to three loadings of pigs at one or several farm-sites, driving to abattoirs, unloading pigs and cleaning vehicles. Before, between, during and after these tasks, PTDs also had to for example position vehicles, arrange gates inside vehicle, change clothes and wait. Five work tasks were distinguished:

Loading: started when the first pig entered the loading area and finished when the ramp was hoisted after the last pig was loaded. Handling tools, a sorting board and/or a rattle paddle, were used to herd pigs. Variations in loading area design influenced the physical work space and ramp slope, and farm management influenced the number of pigs to be handled at a time. Loading included walking, waiting, using tools, pushing and crouching (in the bottom level of the vehicle at the end of loading).

Driving: started when the vehicle started moving, either before or after the completion of the first loading and stopped when the vehicle stopped, either at the farm-site or at the abattoir. Working postures were not observed while driving.

Unloading: started when the first pig was unloaded and finished when the last pig exited the vehicle. Handling tools, a rattle paddle and/or a sorting board, were used to herd pigs. Unloading conditions were more consistent than at loading, with little or no ramp slope and consistent flow of pigs. Unloading included walking, using tools, pushing and crouching (in the bottom level of the vehicle at the beginning of unloading).

Cleaning: started with removal of manure in vehicles and finished when PTDs changed into clean work-wear. Cleaning included shoveling or washing out manure, applying detergents and washing with high water-flow hose while walking, crouching and standing stationary.

Preparing/other: occurred before, between and after the tasks described above. Preparing included waiting time, change of clothes, and preparing vehicles and surroundings for loading, unloading or cleaning.

2.4. Data collection

Physical workload recordings and questionnaire responses were collected from October 2018 to January 2019. A workshop was conducted in June 2019, approximately 6 months after the last technical recording. Data collection was performed cognizant of avoiding prolonging or disturbing PTDs work.

2.4.1. Physical workload

PTDs (n = 18) included in the technical recordings were, except while driving to the abattoir, observed during one 'loading at farm to cleaning vehicle after unloading at abattoir'- sequence (described as 'whole day').

Postures and velocities of head, upper back and upper arms were recorded with two types of triaxial accelerometers. For the first 7 PTDs, accelerometers (Logger Teknologi HB, Åkarp, Sweden) connected to a separate data logger (Logger Teknologi HB, Åkarp, Sweden) with a sampling frequency of 20 Hz, were used (described by Hansson et al., 2001; Hansson et al., 2003). For the remaining 11 PTDs, accelerometers with an integrated data logger (USB Accelerometer Model X16-mini, Gulf Coast Data Concepts, LLC, Waveland, MS, USA) with a sampling frequency of 25 Hz, were used (Dahlqvist et al., 2016). Reference postures for head, back and arms were set as described by Dahlqvist et al. (2016).

Biaxial flexible electro-goniometers (Model SG75; Biometrics Ltd., Cwmfelinfach, Gwent, UK) connected to a Mobi-8 logger (TMS International, Oldenzaal, The Netherlands) with a sampling frequency of 128 Hz were used to record postures and velocities of both wrists (Simonsen et al., 2018). Reference postures were set as described by Simonsen et al. (2018).

Workload was thus expressed as eight different measures, varying continuously over time: head angle forward-backward (flexion), back angle forward-backward, upper arm elevation angle (in any direction) on both sides and wrist angle forward-backward on both sides.

2.4.2. Questionnaire

After these observations, PTDs received a questionnaire containing 82 questions; 23 questions covered the topics of work experience and operating procedures and 59 covered the topics of working environment and psychosocial and physical health disorders. Questions about operating procedures included vehicle design and time spent on different tasks. Working environment questions involved work demands, work control, role expectations and musculoskeletal complaints, corresponding to the QPS Nordic Questionnaire (Q 1–33; 48–59) (Kuorinka et al., 1987). Questions on perceived skills, work commitment, work satisfaction and mental symptoms were based on the Copenhagen Psychosocial Questionnaire (COPSOQ; Q 34–47) (Kristensen et al., 2005). Likert scales with five levels were used in all working environment questions except for mental symptoms which had six levels. Scales varied from "very rarely or never", "do not agree at all", "very bad", "no part of the time" and "no, never" to the opposite. In total 20 PTDs

Table 2
Group means (standard deviation) of the physical workload of head, back and upper arms in 17 Swedish pig transport drivers during work (a loading at farm to cleaning vehicle at abattoir-sequence), 2018–2019.

	Distribution (percentile)	Whole day	Loading	Driving	Un-loading	Cleaning	Preparing/other
Duration minutes [min/max]	Na	369 [177/566]	56 [18/120]	147 [41/244]	22 [10/38]	82 [33/166]	62 [37/111]
Head flexion							
Posture (°)*	50th	7 (6.3)	23 (8.2)	−2 (4.9)	22 (6.4)	26 (7.6)	17 (8.6)
	90th	43 (9.4)	44 (9.1)	9 (6.2)	47 (9.5)	50 (9.8)	51 (8.8)
Velocity (°/s)	50th	15 (2.7)	21 (8.9)	11 (2.3)	25 (4.1)	22 (7.4)	19 (4.9)
Back, forward							
Posture (°)*	50th	7 (5.2)	14 (7.7)	−2 (8.2)	14 (5.8)	15 (5.5)	10 (6.5)
	90th	30 (8.8)	35 (11.7)	11 (6.3)	52 (15.5)	37 (9.8)	35 (8.9)
Velocity (°/s)	50th	12 (2.4)	17 (9.6)	8 (1.9)	22 (4.5)	20 (6.8)	15 (3.8)
Upper arm, right							
Elevation (°)	50th	41 (4.4)	31 (4.8)	47 (7.7)	32 (5.4)	35 (4.1)	35 (4.6)
	90th	66 (6.7)	57 (9.9)	65 (9.5)	60 (10.4)	73 (13.4)	71 (9.1)
Velocity (°/s)	50th	30 (8.6)	49 (26.8)	16 (3.7)	63 (11.4)	67 (23.8)	44 (11.4)
Upper arm, left							
Elevation (°)	50th	44 (7.8)	30 (6.5)	60 (9.9)	32 (5.8)	32 (5.9)	35 (7.2)
	90th	74 (10.7)	56 (7.6)	76 (12.3)	61 (7.7)	66 (9.8)	68 (8.4)
Velocity (°/s)	50th	28 (8.8)	50 (24.5)	16 (2.8)	56 (13.8)	56 (22.5)	42 (11.2)

NA= Not applicable
Positive values indicate flexion (forward), negative values indicate extension (backwards).

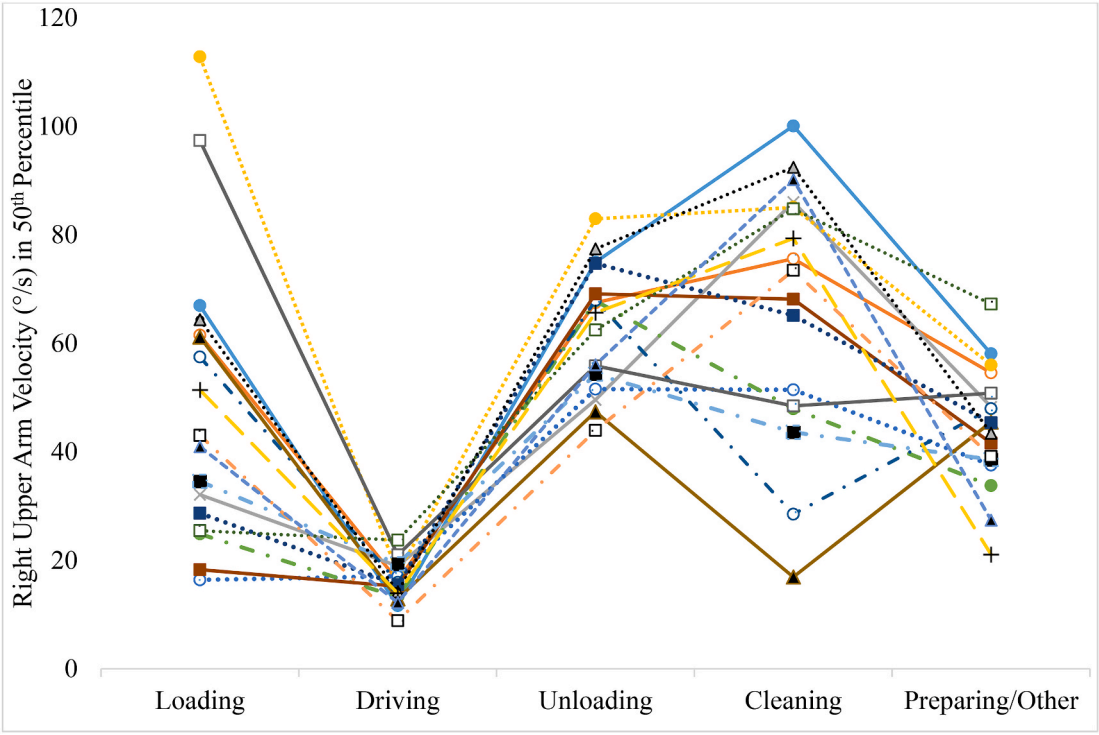

Fig. 1. Generalized angular velocity for right upper arm (°/s, 50th percentile) in 17 transport drivers during different work tasks, 2018–2019.

Table 3
Group means (standard deviation) of the physical workload of wrists in 15 Swedish pig transport drivers during work (a loading at farm to cleaning vehicle at abattoir-sequence), 2018–2019.

	Distribution (percentile)	Whole day (n = 15)	Loading (n = 15)	Driving (n = 13)	Un-loading (n = 13)	Cleaning (n = 12)	Preparing/other (n = 15)
Wrist flexion, right							
Posture (°)[a]	50th	−17 (10.3)	−14 (9.9)	−18 (16.1)	−16 (7.6)	−22 (10.5)	−11 (9.3)
Movements							
Velocity (°/s)	50th	11 (5.5)	12 (7.5)	5 (2.2)	18 (4.2)	20 (5.2)	17 (4.1)
Rest <1°/s (% of time)	Na	4 (2.9)	8 (6.6)	5 (5.1)	2 (2.1)	1 (0.9)	3 (3.0)
Wrist flexion, left							
Posture (°)[a]	50th	−17 (10.9)	−17 (10.4)	−20 (18.0)	−16 (12.7)	−17 (8.2)	−12 (10.0)
Movements							
Velocity (°/s)	50th	8 (2.7)	9 (5.4)	6 (2.2)	13 (4.6)	12 (5.6)	13 (3.5)
Rest <1°/s (% of time)	Na	4 (2.1)	8 (5.1)	2 (1.6)	2 (2.1)	3 (4.8)	5 (2.3)

Na= Not applicable.
[a] Positive values indicate palmar flexion, negative values indicate dorsal flexion.

responded with 16 of these participating in the technical recordings.

2.4.3. Facilitated workshop

The 18 PTDs observed and their haulier managers were invited to a workshop to discuss working environment and physical workload of PTDs. Out of 22 invited, 12 participated (11 PTDs whereof 1 manager). One researcher (SW) facilitated the workshop. Questionnaire and workload results were presented first. The participants were then divided into three mixed groups based on affiliation and work experience, and asked to discuss flaws, challenges and difficulties in their work, reflect on causes and suggest corrective action. A plenary discussion followed. Notes were taken continuously during the discussions and participants were given the opportunity to add information anonymously in writing.

2.5. Statistical analysis

2.5.1. Technical recordings

The data from the recordings were processed according to Hansson et al. (2003) and Dahlqvist et al. (2016). The data from one PTD were excluded due to technical problems. The ten workload measures were summarized by work task and for the whole day by calculating the 10th, 50th and 90th percentiles of the angular distribution for head and back inclination and upper arm elevation, the 50th percentile of the angular velocity distribution of the head, back and wrists, the generalized angular velocity distribution for upper arms, and the percentage of time with wrist flexion angular velocity <1°/s for each PTD.

2.5.2. Questionnaire

Descriptive statistics were obtained for background information and musculoskeletal complaints. For data on working environment and musculoskeletal complaints, indices were constructed for each scale

Table 4
Statistics of six different dimensions describing perceived psychosocial working environment according to a questionnaire to 20 Swedish pig transport drivers, 2018–2019.

Dimension	Description of scale (number of questions)	Mean ± sd
Work demands[a]	Quantitative demands (4)	0.43 ± 0.18
	Decision demands (3)	0.70 ± 0.14
	Learning demands (2)	0.38 ± 0.16
	Safety & economic risks (2)	0.60 ± 0.33
Role expectations[a]	Role conflicts (3)	0.25 ± 0.21
	Pressure from farmer/veterinarian (2)	0.48 ± 0.29
Work control[b]	Positive challenges (3)	0.82 ± 0.11
	Control of decision (2)	0.58 ± 0.18
	Control of pacing (2)	0.61 ± 0.23
Mastery of work[b]	Perception of mastery (3)	0.85 ± 0.11
	Perception of physical and psychosocial ability[c] (2)	0.83 ± 0.10
Work commitment and satisfaction[b]	(4)	0.60 ± 0.19
Psychosocial workload[a]	Psychosocial symptoms[d] (8)	0.17 ± 0.09

[a] High score indicates high demands, risks, role conflicts and psychosocial workload.
[b] High score indicates high perceived control, mastery and engagement.
[c] One missing value (19 responses).
[d] Psychosocial symptoms in the last 4 weeks.

within dimensions. The original five-, and six-level ordinal scores were rescaled to a range of 0–1. Indices were calculated on individual levels as means of the corresponding scores for the questions included in the scale. The group-level means from each scale are presented with standard deviations (SD). Seven questions were excluded from the analysis because they did not contribute with useful information.

2.5.3. Workshop

Workshop notes were compiled and key concepts identified by sorting into 1. Main area, 2. Main issue, 3. Psychosocial cause and effects, 4. Physical cause and effects and 5. Suggested corrective actions.

3. Results

3.1. Physical workload

For practical reasons, some of the PTDs repeated pig loading at one or several farms. In total, 27 loadings and 18 unloadings were observed, whereof ten PTDs loaded one time, seven loaded two times and one loaded three times. The number of pigs per loading varied from 49 to 258 (mean 120) and in total 3229 pigs were transported. Whole day recordings varied in length from 177 to 566 min (mean ± SD, 369 ± 119 min), starting between 4:00 and 13:00 h. The mean (min-max) time for loading, driving, unloading, cleaning and preparing was 56 (18–120), 147 (41–244), 22 (10–38), 82 (33–166) and 62 (37–111) minutes respectively. For moving pigs, PTDs used sorting boards and/or rattle paddles of a Swedish design (LG Produkter AB, Sölvesborg, Sweden). At loading, 13 PTDs used both a paddle and a board and five used the board alone. At unloading, 12 used only a paddle, three used only a driving board and three used both. One PTD used ear protection and all wore steel-capped boots during loading and unloading, but no other use of protective equipment was observed.

Results for inclinometry recordings are presented in Table 2. Due to technical difficulties, data from one PTD were lost. The group means (means of PTDs median values) for whole day measurements of head and back forward flexion (50th percentile) were both 7°, and velocities were 15°/s and 12°/s respectively. Group means of whole day measurements in right upper arm elevation was 41° and the velocity 30°/s (50th percentile), in the 90th percentile right upper arm elevation was 66°. At *loading*, *unloading* and *cleaning* the highest arm velocities (49, 63 and 67°/s), head velocity (21, 25 and 22°/s) and flexion (23, 22 and 26°), and back velocity (17, 22 and 20°/s) and flexion (14, 14 and 15°) (50th percentile) were recorded. *Preparing/other* involved less active movement and values for velocities and postures were lowest during *driving*, except for arm elevation. Arm elevation exceeded 30° in all tasks (50th percentile). Back flexion was 52° in the 90th percentile during *unloading*. High between PTD variations were recorded in median arm velocities during *loading* (16–112°/s) and *cleaning* (17–100°/s) (Fig. 1).

Results for goniometry recordings of wrists are presented in Table 3. Due to technical difficulties, data were lost for the whole day in three PTDs and partly lost for another three PTDs. The group means for whole day recordings of right wrist posture and velocity (50th percentile) were 17° (dorsal flexion) and 11°/s. Velocities were highest during *cleaning* (20°/s) and lowest during *driving* (5°/s).

3.2. Questionnaire

Participants reported high personal engagement, high work quality satisfaction and good ability to cope with psychosocial and physical demands (Table 4). However, high work demands (decision demands and safety and economic risks), and to some extent pressure from stakeholders and lack of control of decision were also reported. A few psychosocial symptoms were reported (Table 4). High prevalence of discomfort or pain in lower back was reported by most PTDs, in neck/shoulders by approximately one third of the PTDs, and in knees by half of them, in the last 12 months as well as the last 7 days (Table 5).

3.3. Facilitated workshop

Several issues were perceived by the PTDs to negatively impact their working environment. Psychosocial and physical workload issues related mainly to conditions on farm, at abattoirs, and to regulations and abattoir requirements or conditions for delivery. The PTDs stated that they generally did not report work-related injuries, so as to not to complicate the work of their superior. Nevertheless, the PTDs expressed belief in their own ability to handle physical and psychosocial demands. They were committed to the job and perceived it as highly meaningful. One PTD summarized his view by "You are satisfied because you enjoy the job. Otherwise, you would no longer be here. Then you would be on sick leave".

Seven main issues were identified (Table 6). Lower back, neck/shoulder and knee complaints were at times reported due to unsatisfactory design of loading/unloading and cleaning areas at farms and

Table 5
Perceived work-related physical complaints (pain or discomfort) during the preceding 12 months or 7 days according to a questionnaire to 20 Swedish pig transport drivers, 2018–2019; number (%) of respondents.

Complaint	Last 12 months					Last 7 days, at any rate
	Very seldom or never	Rather seldom	Occasionally	Rather often	Very often or always	
Lower back	3 (15)	6 (30)	9 (45)	2 (10)	0 (0)	12 (60)
Neck or shoulders	3 (15)	11 (55)	3 (15)	1 (5)	2 (10)	6 (30)
Elbows or hands	11 (55)	3 (15)	6 (30)	0 (0)	0 (0)	3 (15)
Knees	5 (25)	5 (25)	4 (20)	4 (20)	2 (10)	10 (50)

Table 6
Issues related to working environment and workload on farm, at abattoir, in vehicle and structurally, identified in a facilitated workshop with 12 Swedish pig transport drivers, 2019.

Area	Main issue	Discussed psychosocial cause – effect	Discussed physical cause – effect
Farm	Design of loading area	Insufficient space or lack of separate indoor loading space; lack of weather protection and lighting – difficulty to inspect pigs and sort away pigs not fit for transport; flexible operational procedures required; high workload	Insufficient space or lack of a separate indoor loading space; lack of weather protection and lighting – physically demanding to load pigs; high pressure on knees
	Communication with farmers	Unrealistic expectations from farmers; insufficient preparations; lack of communication from farm staff, especially regarding injured or diseased pigs – pressure to transport pigs not fit for transport; fear of conflict with farmer; insufficient time to count and assess pigs; need to sort pigs during loading, resulting in impaired work flow and efficiency	Pigs are fed shortly before loading – pigs less willing to move; increased overall workload
Abattoir	Communication with official veterinarians	Inconsistent veterinary judgements; lack of clarity from abattoir veterinarians regarding unfit pigs – unclear criteria for fitness of pigs; feeling of being monitored and sometimes filmed; fear of getting reported	–
	Equipment for cleaning vehicles	Varying availability of appropriate cleaning facilities – need to remove manure manually instead of flushing with water hose, resulting in high overall workload; queue to cleaning area, resulting in long waiting time before cleaning can start and limited time for cleaning	
Vehicle	Vehicle design	–	decrease working height on bottom floors of three- to four-tier vehicles – necessary to crouch inside vehicle, especially during unloading, resulting in increased load on back
Structural	Time constraints	Complex regulations; penalties at late arrival to abattoir and at violation of rules on driving and rest times – necessary to sometimes clean vehicle during breaks; rush during loading of pigs	–
	Lack of competence	High demands on expertise and job commitment; high workload; not possible to get less demanding work in the same employment – hard to find skilled drivers with an eye for animals; estimated high number of non-reported work-related injuries and sick-leave	

abattoirs. PTDs believed inappropriate design of the loading area at farms had a strong impact on workload in general and knee discomfort in particular, due to the knees being pressed against the driving board when pigs were pushed forward. A poor loading area design was described as insufficient light, insufficient space and lack of protection from wind and direct sunlight, making it difficult to load pigs and to detect health issues that would deem pigs unfit for transport.

One PTD described how farmers occasionally tried to hide diseased pigs in the middle of an animal group, and before the current disease control regulations that prohibit farmers returning pigs to their housing facilities, it was easier to reject loading pigs unfit for transport. PTDs also emphasized the need to adapt to farmer routines at loading, and a lack of communication from farm workers, for instance regarding the number of pigs brought out of the building at one time. There was also a concern about inconsistent assessment of fitness of pigs between official veterinarians at abattoirs, and lack of feed-back from veterinarians to PTDs on those pigs consider to be unfit, increasing PTDs' fear of being secretly monitored and reported to animal-welfare authorities. One PTD described how some competing hauliers regularly transported pigs unfit for transport in order to gain good reputation among farmers. Difficulties to comply with all legislation governing time limitations, especially provisions on driving times and driving breaks for drivers *versus* transport times for animals, were emphasized. In case of unforeseen events that prolonged loading or driving time, compliance with one regulation was said to violate another one.

To solve or alleviate the perceived problems, the PTDs suggested a number of actions, such as well-designed on-farm loading areas, adequate lighting in loading areas, suitable flow of pigs (not too fast, nor too slow), improved farmer commitment to deliver only pigs fit for transport, improved communication with veterinarians about what should be regarded as an unfit pig, more uniform assessment of pigs between veterinarians, and adequate facilities for cleaning vehicles at abattoirs.

4. Discussion

This study reveals large differences in physical workload between both PTDs and the different tasks required. Although PTDs reported high job satisfaction and commitment, as well as contentment with their own performance, there were indications of high work demands, conflicts with different stakeholders, and difficulties in meeting different regulations governing time limitations.

The varied and in some respects high physical workload recorded, especially during loading, unloading and cleaning vehicles, is consistent with what PTDs reported in the workshop. Varied work is associated with a lower risk of musculoskeletal disorders in the neck and upper limbs compared to more repetitive work (Nordander et al., 2009), however large variations in workload have been found in several varied and/or mobile types of work (Hansson et al., 2010). In this study, none of the PTDs was observed to take work breaks, indicating a possible lack of essential rest, although breaks may have occurred during driving to abattoirs. Efforts to reduce PTDs' workload and improve their wellbeing will most likely increase their ability to ensure good welfare of the animals that they handle (Anneberg and Sandoe, 2019).

There are not many technical aids for loading/unloading pigs, which means that work flow is highly dependent on the pigs' willingness to enter/exit the truck, which is in turn influenced by the design of the loading area, weather, lighting, farm-staff working routines, unloading-bay design, pigs' handling experience and pig genetics (Goumon and Faucitano, 2017). In this study, PTDs reported that inadequate designs of the loading area contributed significantly to increased physical workload when handling pigs, especially leading to knee pain. A detailed plan for the loading area is not required in the Swedish official process of approval of new or rebuilt animal buildings (Hultgren 2009), which may lead to unnecessary inferior designs. Research has shown that pig welfare is affected by handling and that management procedures vary among farmers as a result of underlying beliefs about pigs (Hemsworth et al., 1989). Difficulties to load slaughter pigs, due to previous rough handling or inferior loading area design, is clearly an animal welfare issue. Future research should elucidate how different loading area designs affect loading efficiency, PTD workload and pig welfare.

Three-level transport vehicles, in which the floors can be lifted up and down by hydraulic hoist systems, are standard in Swedish commercial pig transport. To access the inner parts of the vehicle when the two top floors are occupied, i.e. towards the end of loading and in the beginning of unloading, the working space is limited to a height of approximately 100 cm. The observed 90th percentile back forward

flexion of 52° during unloading of pigs reflects extreme crouching postures, and is likely a contributing factor to reported lower back problems. Even though unloading is the least time-consuming task, it should be considered a risk factor. In addition to having to stoop, there is a risk of being pushed or run over by pigs in the confined space. Four-level vehicles also exist, which have an even lower minimum working space. Threshold limits have not previously been suggested for back postures or velocities, but studies on professional garbage collectors, who also reported lower-back discomfort, have shown high back loads during pushing, pulling or lifting garbage containers (Barkstedt et al., 2016). In some respects, these tasks are similar to PTDs work, such as spreading litter material, moving gates, pushing pigs, and scraping litter.

Group means of whole day velocities of upper arms and wrists did not exceed recently reported threshold limits of 60°/s and 20°/s, respectively (Arvidsson et al., 2021 in press), most likely due to low arm velocities during driving when PTDs arms are rested on the steering wheel. The variation between PTDs in arm velocity during loading and cleaning probably reflects differences in the physical environment (for example, design of loading area and cleaning facility), which agrees with the PTDs concern for sometimes inadequate loading and cleaning facility designs leading to increased work effort. The variation could also indicate individual variations in working methods (for example, pig handling behaviour and work pace), and a possible need for training in animal handling of some of the PTDs.

Head flexion, upper arm elevation and wrist velocity have been previously associated with neck problems in various occupational groups (Nordander et al., 2016). In the present study, high upper arm elevations (right arm, whole day exposure, 90th percentile) exceeded threshold limits previously suggested for the prevention of musculoskeletal disorders (Arvidsson et al., 2021 in press). However for a large part of the time, during driving of the vehicle, arms were supposedly supported by the steering wheel, and therefore arm elevation during this task is unlikely to contribute to musculoskeletal disorders in neck and shoulders. This complicates the assessment of the whole day's exposure to elevated arms, as recently discussed by Palm et al. (2018). During cleaning of vehicles, the most time-consuming of the more physically active tasks, head forward flexion and right wrist velocity were found to be highest. Together, these findings possibly explain PTDs reported discomfort in neck/shoulders, and signal the importance of access to adequate cleaning facilities. The sub-contractor situation further complicates this, and abattoir management, who is responsible for the facilities, may lack motivation to provide proper facilities for PTDs (Valluru et al., 2017).

Despite physically demanding working conditions, PTDs reported that they perceived the work as meaningful and engaging, indicating a high work satisfaction. Moreover, the reported high perceived work capacity, i.e. the belief of being able to handle physically and psychosocially demanding situations, is possibly a prerequisite for this type of work. Reported demands for attentiveness and endurance, as well as fear of severe consequences in the event of mistakes, are matters known to increase stress (Leijten et al., 2015) and could, in combination with the moderately low perceived control over workload, increase the risk of discomfort in neck, shoulders and back, as reported by the Swedish Council on Health Technology Assessment (SBU, 2012, 2014). PTDs stated that work-related injuries were generally not reported, which may reflect a norm that one should endure difficulties without complaining, and therefore, related official statistics may underestimate the incidence of work-related injuries.

The expressed concern about difficulties in finding and rejecting pigs with health disorders during loading and the lack of clarity from abattoir veterinarians regarding unfit pigs suggest a problem for PTDs communicating with stakeholders, and may have contributed to the perceived lack of control over workload. The importance for truck drivers to collaborate and communicate well with stakeholders was described by Wioland (2013) who emphasized the need for professional skills, such as ability to readjust and communicate while still following regulations. In this study, PTDs suggested that improved commitment of farmers to present only healthy pigs would likely improve the working environment. To reduce PTDs fear of unknowingly being reported for transporting unfit pigs, communication between veterinarians and PTDs needs to be improved.

Existing regulations meant to safeguard human wellbeing (EU Regulation No. 561/2006 on driving times, breaks and rest periods for drivers) and animal welfare (EU Regulation No. January 2005 on animal transport) are not always compatible. In animal welfare legislation, transportation starts when the first animal is loaded and ends when the last one is unloaded, while PTDs' regulated driving time starts when the vehicle first moves, i.e. usually before the loading starts and finishes when the PTDs stops the vehicle after completing the day's driving. Thus a lengthy loading process will reduce the time on road, which, along with keeping the planned time for delivery to abattoirs, is likely to increase time pressure, stress and the risk of making mistakes with possible negative consequences for both the PTD and the pigs. Moreover, PTDs reported to sometimes register time for cleaning of vehicles as driving breaks. This can be described as a conflict between safety policy and practice (Murphy et al., 2018), possibly caused by an increasingly competitive livestock transport industry.

The limited number of participants in the workshop and questionnaire (n = 12–20) necessitates cautious interpretation of the results, although the sample was estimated to constitute approximately 15% of PTDs working in Sweden at this time. It cannot be ruled out that the PTDs who agreed to participate had a comparatively positive attitude towards their work, which may have created selection bias. However few approached PTDs declined participation and the study subjects represented a reasonable spread in age and work experience. All but two PTDs were male, presumably reflecting the distribution between sexes in this occupational group.

The participating PTDs transported pigs in the middle-north, southwest and south of Sweden. PTDs working in areas with relatively many farms in close proximity to abattoirs (typically for southern Sweden) would be expected to have shorter hauls with increased number 'loading-to cleaning-sequences' per work shift. Subsequently, workload and safety risks for those PTDs increase due to increased proportion of work outside the truck (Chandler et al., 2017; Reiman et al., 2018), compared to PTDs working in areas with less farms and abattoirs (typically for northern areas) where hauls are longer.

Information about PTD musculoskeletal complaints was acquired through a questionnaire. Clinical examinations may have given a more objective view, but were not considered feasible in this context. After completion of observations in the same day but outside the study, a few of the PTDs repeated the loading-to-cleaning sequence with another slaughter delivery; hence the whole day recordings probably underestimated the total workload of a working day. Some goniometer data were lost, which may be explained by the fragility of sensors.

In conclusion, the present study indicates that Swedish pig transport drivers' working conditions vary considerably both between tasks during the working day and between drivers performing these tasks. There is a risk of high loads on shoulders during loading and unloading pigs and cleaning of vehicles, and on back and knees during loading and unloading. Poor loading area design, specifically a lack of sufficient lighting, space and protection from wind and direct sunlight, causes difficulties in moving pigs forward and therefore increases the risk of knee discomfort. The psychosocial work environment is impaired by complex regulations, time pressure and lack of communication with farmers and official veterinarians regarding health status of pigs. These matters need to be addressed to ensure sustainable working conditions for drivers. Regardless of perceived difficulties, work satisfaction in Swedish pig transport drivers is high.

Author statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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