Modified wean-to-finish mat as an alternative handling tool for moving grow-finish pig cadavers: A pilot study

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Summary

Through the National Pork Board, the US pork industry provides recommendations for humane handling tools and acceptable non-ambulatory pig handling methods. While these recommendations are useful, there is a lack of published evidence regarding the efficacy of humane handling tools commercially available for moving non-ambulatory pigs. Wean-to-finish mats are commonly used on-farm to provide comfortable resting areas for newly weaned pigs and to minimize feed waste around feeders. The objective of this project was to test a commercial wean-to-finish mat as a humane handling tool for non-ambulatory grow-finish pigs. On-farm testing was accomplished using pig cadavers (n = 3; 135, 118, and 68 kg) to evaluate mat effectiveness based on employee effort and preference. Our results do not support wean-to-finish mats as effective handling tools for moving non-ambulatory grow-finish pigs.

Keywords: swine, caretakers, grow-finish pig, handling tools, non-ambulatory pigs

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Resumen - Tapete modificado de destete a finalización como herramienta alternativa de manejo para mover cadáveres de cerdos de crecimiento-finalización: un estudio piloto

A través de la National Pork Board (NPB por sus siglas en inglés), la industria porcina de Estados Unidos ofrece recomendaciones para herramientas de manejo humanitario y métodos aceptables de manejo para cerdos no-ambulatorios. Si bien estas recomendaciones son útiles, hay una falta de evidencia publicada sobre la eficacia de las herramientas de manejo humanitario disponibles comercialmente para mover cerdos no-ambulatorios. Los tapetes de destete-finalización se usan comúnmente en la granja para proporcionar áreas de descanso cómodas para cerdos recién destetados y para minimizar el desperdicio de alimento alrededor de los comederos. El objetivo de este estudio fue probar un tapete comercial de destete-finalización como una herramienta de manejo humanitario para cerdos no-ambulatorios en el crecimiento. Las pruebas en la granja se realizaron con cadáveres de cerdos (n = 3; 135, 118, 68 kg) para evaluar la efectividad del tapete en función del esfuerzo y la preferencia de los empleados. Nuestros resultados no apoyan a los tapetes de destete-finalización como una herramienta de manejo efectiva para mover cerdos no-ambulatorios en crecimiento a finalización.

Résumé - Tapis pour porcs en pouponnière-finition comme moyen alternatif pour déplacer les cadavres de porcs en croissance-finition: Étude pilote

Via le Conseil National du Porc, l'industrie porcine des États-Unis fournie des recommandations sur des outils de manipulation humanitaires et des méthodes de manipulation acceptables pour les porcs non-ambulatoires. Bien que ces recommandations soient utiles, il y a un manque de preuves publiées concernant l'efficacité des outils de manipulation humanitaires commerciale-ment disponibles pour déplacer les porcs non-ambulatoires. Les tapis pour porcs en pouponnière-finition sont fréquemment utilisés pour fournir des zones de repos confortables pour les porcs récemment sevrés et pour minimiser le gaspillage d'aliments autour des trémies. L'objectif de ce projet était de tester un matelas commercial pour les porcs en pouponnière-finition comme outil de manipulation humanitaire pour des porcs non-ambulatoires en croissance-finition. Des tests à la ferme ont été réalisés en utilisant des cadavres de porcs (n = 3; 135, 118, 68 kg) afin d'évaluer l'efficacité de tapis basée sur les efforts des employés et les préférences. Nos résultats permettent de conclure que les tapis pour porcs en pouponnière-finition ne sont pas des outils de manipulation efficaces pour déplacer des porcs non-ambulatoires en croissance-finition.

The National Pork Board provides recommendations for humane handling of non-ambulatory swine through the Pork Quality Assurance Plus and Transport Quality Assurance programs.[1,2] Building on these educational programs, the Common Swine Industry Audit (CSIA) is an audit tool designed to meet company and customer needs by validation of on-farm practices impacting animal welfare and food safety and includes requirements for humane swine handling.[3] As a critical element of the CSIA, willful acts of abuse and neglect are strictly prohibited and can result in automatic audit failure.

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Willful acts of abuse and neglect is partially defined as "[d]ragging of conscious animals by any part of their body except in the rare case where a non-ambulatory animal must be moved from a life-threatening situation. Non-ambulatory pigs may be moved by using a drag mat."[3] Despite this requirement, there is a lack of published evidence to guide producers on commercially available options and efficacy of humane handling tools available for use with non-ambulatory pigs, including design of drag mats.

Non-ambulatory pigs can occur on-farm due to injury, illness, or fatigue during daily operations or loading and unloading from transport trailers. Hence, employees may be required to move non-ambulatory pigs into or out of pens, alleys, and load-out areas. Wean-to-finish mats are commonly used on-farm to provide comfortable resting areas for newly weaned pigs, to minimize waste around feeders, and for lame pigs.[4-9] The objective of this project was to test a commercial wean-to-finish mat as a humane handling tool for non-ambulatory grow-finish pigs.

Materials and methods

All research was approved by Iowa State University Institutional Review Board for Human Subject Research (Approval No. 18-003). On-farm testing was accomplished using pig cadavers rather than live animals, therefore, Institutional Animal Care and Use Committee approval was not needed.

Wean-to-finish mat and modifications

Four wean-to-finish mats were purchased from Hog Slat (SKU: 544187F, Humboldt, Iowa). Each mat weighed 23.1 kg, measured 1.8 m long × 1.2 m wide × 1.3 cm deep, and were made of Nyracord rubber (Figure 1A). Modifications were performed to reduce mat width, improve stability, and to affix handles. These modifications took approximately 45 minutes to complete for each mat. Modifications consisted of cutting a mat down its length to produce 2 separate drag mats. To add stability to each wean-to-finish mat, two PVC trim boards (55.9 cm long × 8.9 cm wide × 2.5 cm deep) were centered and attached 12.7 cm from the top of the mat on the top and bottom surfaces. The PVC trim boards were affixed using 2 carriage bolts (1.3×7.6 cm^2), 2 flat washers (1.3 cm), and 2 hex nuts (1.3 cm; 13 thread size) and 4 exterior wood screws (8×5.1 cm^2) were drilled into the PVC trim boards. To affix handles, 2 holes were drilled into the PVC trim boards and a 2.7 m polypropylene rope was inserted and knotted on the top surface. The final modified wean-to-finish mat dimensions were 1.8 m long × 60.9 cm wide (Figures 1B and 1C). Each mat cost $44 plus modification costs of $31 for a total cost of $75 per mat.

Animals and facilities

The study was conducted on a commercial grow-finish site in central Iowa (Table 1). Three commercial crossbred pigs identified as euthanasia candidates were selected from the hospital pen by the company veterinarian. Two pigs had a belly rupture as a result of abdominal contents passing through the midline defect of the umbilicus and the third pig had a chronic illness due to poor body condition, injury, or bacteria/virus disease. The 3 compromised pigs were euthanized according to company protocols, which were consistent with industry guidelines.[10] Prior to euthanasia, pigs were able to individually walk to a weigh scale (Raytec WayPig 300; AGRIsales Inc, Ceresco, Nebraska) where body weights were collected and rounded up to the nearest whole number. The cadavers weighed 68 kg, 118 kg, and 135 kg.

Employee enrollment

Six English-speaking employees (five male and one female) were enrolled in the study by the company veterinarian. Employees ranged in age from 23 to 60 years, in height from 106.2 to 195.6 cm, in weight from 63.5 to 133.8 kg, and in experience from 1 to 30 years. The employees comprised members of the production well-being team, the engineering team, and the farm manager. On the day of the study, each employee was asked to complete a demographics questionnaire prior to completing the cadaver movements using the mat.

Cadaver movement

Two empty pens were designated as the home pen (start) and hospital pen (end). Both pens were fully slatted (12.7 cm slat width × 2.5 cm slot width) and the alley was partially slatted with a solid concrete center (115.8 m × 30.3 cm). The distance between the entrance of the home pen and entrance of the hospital pen was 57.9 m. Each cadaver was positioned inside the home pen, 2.8 m from the alleyway gate and 2.3 m from the right pen divider, and oriented with the head towards the alleyway. At the start of each cadaver movement, the employee was asked to roll the cadaver onto the mat and move it from the home pen to the hospital pen. For all employees, the cadaver movements were performed using the heaviest to the lightest cadavers. Time to complete cadaver movement was measured at three time points: 1) Duration to roll cadaver from home pen floor onto the mat. 2) Duration to move mat and cadaver from the home pen into the alleyway, defined as the mat being entirely inside the alley and oriented towards the hospital pen. 3) Duration to move mat and cadaver along the alleyway and into the hospital pen, defined as the mat being entirely inside the hospital pen.

Peak exertion force

An FGV-HXY High Capacity Digital Force Gauge (Nidec-SHIMPO America Corporation, Itasca, Illinois) was attached to the mat handle to record peak force applied by the employee while moving the cadaver. Each employee held his or her arms with the force gauge positioned at waist height and pulled for 5 continuous seconds. Peak force was collected during the cadaver movement in 2 locations: in the alleyway immediately outside the home pen and inside the hospital pen.

Employee physiologic measures

One researcher collected each employee's physiologic measures at 2 different time points: baseline resting levels in the home pen and post exertion levels collected immediately after moving each cadaver. A pulse oximeter (Pulse Oximeter 50DL; Clinical Guard, Atlanta, Georgia) was placed onto the employee's index finger to collect heart rate and oxygen saturation. Consistent with other studies,[11,12] a minimum 5-minute resting period was provided between movement of each cadaver to allow physiologic measures to return to baseline levels.

Employee evaluation and mat durability

During each resting period, employees were asked to evaluate the mat using the survey described in Table 2. The mat was moved 3 times per employee resulting in the mat tool evaluation being completed 18 times. Comments were also solicited for each question to collect qualitative data.

Durability of the mat was evaluated by one of the researchers for presence of holes, rips, and creases at the conclusion of each cadaver movement. If observed, these were counted, measured, and photographed.

Statistical analysis

The mat tool survey responses were evaluated by calculating the mean and standard

Figure 1: A) The wean-to-finish mat was modified in order to safely move a grow-finish pig cadaver from the home pen to the hospital pen. The original wean-to-finish mat dimensions were 1.8 m long × 1.2 m wide × 1.3 cm deep. B) Top side of the modified mat. The mat was modified by adding two 55.9 cm pieces of PVC trim board (one located on the top and one on the bottom), 2 carriage bolts, 2 flat washers, 2 hex nuts, and 4 exterior screws to provide a durable re-enforcement. A 2.7 m polypropylene rope was attached to create a handle using the 2 empty holes located to the inside of the carriage bolts. The final mat dimensions were 1.8 m long × 0.6 m wide × 1.3 deep. C) Bottom side of the mat had the second PVC trim board and 2 hollow holes where the 2.7 m polypropylene rope was attached.

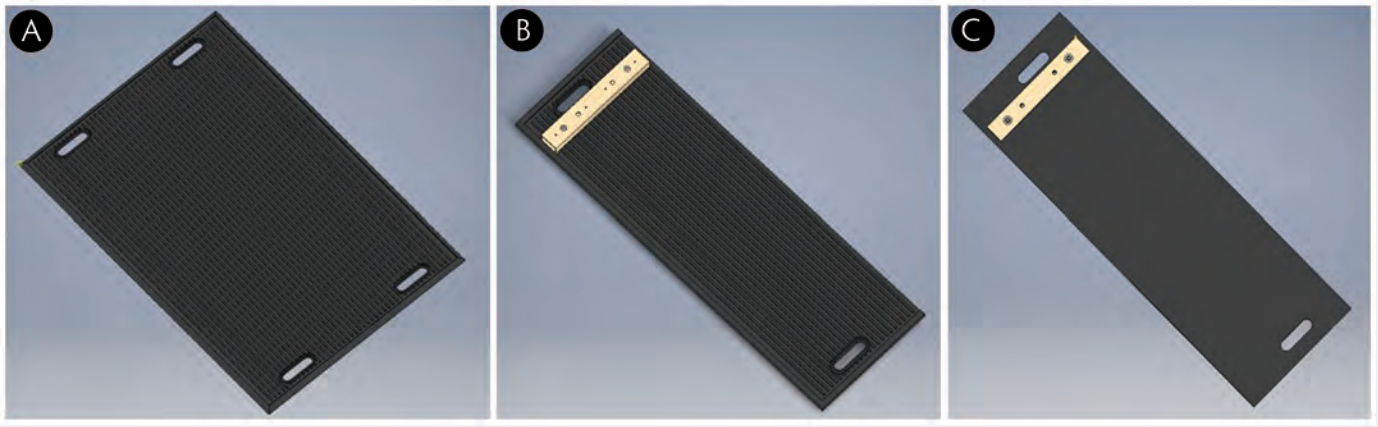

Table 1: Building and production specifications of the central Iowa commercial grow-finish site where the mat was evaluated as a handling tool to move grow-finish pig cadavers

Measure	Details
Site capacity, No. pigs	5,350
Projected market weight, kg	127
No. of barns	1
Rooms per barn	1
Space allowance, m^2	0.67
No. pigs/pen	30
Barn width, m	12.5
Barn length, m	115.8
Pens/barn	64
Pen width, m	3.1
Pen depth, m	5.8
Pen flooring	Fully slatted concrete
Slat width, cm	12.7
Slot width, cm	2.5
Alley width, cm	53.3
Gate width, cm	82.6
Gate length, m	2.7
Distance of cadaver movement, m	57.9

deviation of 6 employees. Mat durability was evaluated by counting and measuring holes, rips, and creases after movement from the home pen to the hospital pen. Two new variables were created for employee heart rate and oxygen saturation:

Change in heart rate (bpm) = hospital pen heart rate – baseline resting heart rate

Change in oxygen saturation (%) = hospital pen post exertion oxygen saturation – baseline resting oxygen saturation

The distribution of the peak exertion force, cadaver movement duration, change in heart rate, and change in oxygen saturation were evaluated using the PROC UNIVARIATE procedure (SAS v 9.2, SAS Inst, Inc, Cary, North Carolina). Data met the assumption of normality and were analyzed using a mixed model method (PROC MIXED) for parametric data. Employee was the experimental unit. The statistical design was a complete randomized design with the statistical model including the fixed effect of employee (n = 6) and cadaver (n = 3). A $P \leq .05$ was considered significant and PDIFF option was used to separate means when fixed effects were significant sources of variation.

Results and discussion

Duration of cadaver movement

Time to move the cadaver onto the mat did not differ between employees ($P = .87$) or

Table 2: Employee mat tool survey*

Questions†					
1. Rate mat for:					
a) Rolling cadaver from home pen floor onto mat	5	4	3	2	1
2. Positioning ease of cadaver onto mat:‡					
a) Home pen	5	4	3	2	1
b) Alley	5	4	3	2	1
3. Rate mat for:					
a) Moving mat in home pen towards pen gate	5	4	3	2	1
b) Moving mat out of home pen and into alley	5	4	3	2	1
c) Moving mat down the alley to hospital pen	5	4	3	2	1
4. Rate mat for:					
a) Mat size to move cadaver§	5	4	3	2	1
b) Mat weight to move cadaver¶	5	4	3	2	1
5. Do you think the mat could easily be used to move a non-ambulatory market-weight pig		Yes		No	
6. Would you recommend this mat to other producers to move a non-ambulatory market-weight pig		Yes		No	

* During each resting period, employees were asked to evaluate the mat using the mat tool survey. Each employee (n = 6) filled out 3 surveys, one per cadaver (n = 3), for a total of 18 surveys completed.
† Survey responses were scored on a 5-point scale (5 = very easy, 4 = easy, 3 = neutral, 2 = difficult, and 1 = very difficult) for questions 1 through 4. Questions 5 and 6 were scored as Yes or No.
‡ Positioning defined as cadaver head positioned toward handle and legs/body centered on the mat.
§ Mat size defined as whether the length and width affected movement ease.
¶ Mat weight defined as whether the weight affected movement ease.

cadavers ($P = .30$). Mean duration (SE) to move cadavers onto the mat was 5.7 (4.6) seconds (range, 2-13 seconds; 135 kg), 7.5 (3.6) seconds (range, 3-13 seconds; 118 kg) and 3.7 (1.9) seconds (range, 2-7 seconds; 68 kg).

No employee was able to complete the entire movement such that none of the cadavers were moved into the hospital pen using the mat. The mean duration for failed attempts was 9.0 seconds.

Only 1 employee was able to move all cadavers into the alleyway with a mean (SE) duration of 37.3 (12.7) seconds; 2 employees were able to move the heavier and lighter cadaver into the alleyway (mean [SE] duration; 68 kg: 11 [5.7] seconds; 135 kg: 39.5 [34.6] seconds).

Peak exertion force

Since employees were unable to move cadavers into the hospital pen, peak exertion force was measured only once at the furthest location reached for each cadaver movement. Employees did not differ for force used ($P = .40$). Mean (SE) peak exertion force was 592.0 (41.2) N and ranged from 357.8 to 835.7 N. Less peak force was used for the lightest cadaver (mean [SE]; 68 kg: 393.7 [38.8] N; 118 kg: 647.3 [46.5] N; 135 kg: 735.1 [48.8] N; $P < .001$).

Employee physiologic measures

Employees did not differ in baseline resting heart rate ($P = .23$) or baseline oxygen saturation ($P = .25$). Similarly, change in heart rate ($P = .23$) and oxygen saturation ($P = .09$) did not differ between employees moving cadavers. Mean (SE; range) duration for change in heart rate was 49.0 (13.1; 35-71 bpm, 38.8 (12.7; 19-53) bpm, and 39.5 (8.8; 29-52) bpm for 135, 118, and 68 kg cadavers, respectively. Mean (SE; range) change in oxygen saturation was 0.8% (1.3%; 0%-3%), -0.5% (1.0%; -2% to 1%), and -0.2% (0.75%; -1% to 1%) for 135, 118, and 68 kg cadavers, respectively.

Mat tool durability

There were no rips, holes, or creases after being used in 18 cadaver movements.

Employee evaluation

Surveys were obtained from all 6 employees for all 3 cadaver movements (Tables 3 and 4). Feedback from employees on the potential of the mat as a handling tool was mixed. Employees agreed that moving the mat in the home pen was very difficult, and the 3 employees who were able to move the mat out of the pen into the alley scored it as very difficult, even with the lightest cadaver. Employees commented that the mat was stiff and lacked movement ease. These comments support the researchers' casual observations of employee frustration during cadaver movement.

Rolling cadavers onto the mat was ranked as neutral or easy in 9 of 18 surveys (50.0%). In the home pen, positioning cadavers onto the mat was ranked as easy (72.2%). In the alley, repositioning cadavers onto the mat was ranked as neutral (31.3%) or difficult (31.3%).

Three employees ranked the mat size as difficult and commented that the mat was awkward to carry throughout the barn and was a little too wide to fit in the alley (2 employees). All employees ranked the mat weight as difficult or very difficult and commented that the mat itself was too heavy to move, a problem that increased with the addition of a cadaver (3 employees).

All employees felt strongly that the mat would not easily move a non-ambulatory market-weight pig and would not recommend this mat to other employees for moving a non-ambulatory market-weight pig.

Table 3: Employee (n = 6) responses to the mat tool survey

Questions*	Score frequency, No. (%)				
	5	4	3	2	1
1. Rate mat for:					
a) Rolling cadaver from home pen floor onto mat	4 (22.2)	9 (50)	2 (11.1)	0 (0)	3 (16.7)
2. Positioning ease of cadaver onto mat:					
a) Home pen	2 (11.1)	13 (72.2)	2 (11.1)	0 (0)	1 (5.6)
b) Alley	2 (12.5)	4 (25.0)	5 (31.3)	0 (0)	5 (31.3)
3. Rate mat for:					
a) Moving mat in home pen towards pen gate†	0 (0)	0 (0)	0 (0)	3 (33.3)	6 (66.7)
b) Moving mat out of home pen and into alley‡	0 (0)	0 (0)	0 (0)	4 (44.4)	5 (55.6)
c) Moving mat down the alley to hospital pen§	NA	NA	NA	NA	NA
4. Rate mat for:					
a) Mat size to move cadaver	1 (5.6)	5 (27.8)	5 (27.8)	1 (5.6)	6 (33.3)
b) Mat weight to move cadaver	1 (5.6)	2 (11.1)	1 (5.6)	7 (38.9)	7 (38.9)

* Questions 1 through 4 of the mat tool survey were scored using a 5-point scale: 5 = very easy, 4 = easy, 3 = neutral, 2 = difficult, and 1 = very difficult.
† Results are from five employees who were able to move at least one of the three cadavers in the home pen towards the alley.
‡ Defined as mat being entirely inside the alley and oriented towards the hospital pen. Results are from five employees who were able to move at least one of the three cadavers out of the pen into the alley.
§ No results are available for moving the mat down alley into the hospital pen, as no employees were able to complete this cadaver movement.
NA = not applicable.

Conclusions

Field expertise associated with moving non-ambulatory pigs has resulted in several guidance documents. The American Meat Institute[13] recommends using slide boards, sleds, and cripple carts to move non-ambulatory pigs within meat processing plants. Similarly, the Transport Quality Assurance program[2] recommends stretchers, sleds, hand carts, and specialized skid loaders for moving non-ambulatory pigs. When non-ambulatory pigs occur on farms, the Pork Quality Assurance Plus program[1] recommends using plastic sleds or drag mats. Despite these recommendations, science-based publications validating different handling tools recommended for moving non-ambulatory pigs is lacking.

A pitfall to this wean-to-finish mat was the starting weight at 23.1 kg. A lighter mat (eg, a polyethylene wean-to-finish mat weighing 7.7 kg) could be an option to test when moving grow-finish pig cadavers and hence other options should be investigated. Different modifications to this wean-to-finish mat could improve ease of movement (eg, adding a slick surface underneath the mat) and adding buckle restraint straps could help to keep pigs secure. Without inclusion of restraint straps, the pig's head and legs could catch in penning when moving from the home pen to the hospital pen.

The mat was durable within the context of being used 18 times with pig cadavers since there were no rips, holes, or creases. This mat needs to be tested in a wider context to determine the durability over extended use.

It is important to test potential on-farm handling tools for ease of use, employee safety,[14] and pig welfare.[15,16] To ensure pig and employee safety, it is important for facilities to have wide enough alleys and pen openings, appropriate and durable handling equipment, and correctly trained employees.[17] The purpose of this study was to determine if this mat could be a suitable handling tool for live non-ambulatory pigs on-farm. If feasible, this mat could have multiple uses (provide comfortable resting areas for newly weaned pigs, to minimize waste around feeders, and for lame pigs)[4-9] and would be cost effective since it was relatively economical to modify (approximately $100). Unfortunately, based on our findings the current mat is not recommended as a suitable handling tool to move cadavers or non-ambulatory pigs on-farm.

Implications

- This mat was not suitable for manually moving non-ambulatory grow-finish pigs.
- Further mat modifications could improve ease of movement and positioning to keep the pig secured.

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Conflict of interest

None reported.

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Table 4: Employee responses to the mat tool survey by cadaver weight

	Cadaver weight, kg		
	135	118	68
Questions*	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
1. Rate mat for:			
a) Rolling cadaver from home pen floor onto mat	3.2 (1.7)	4.2 (0.8)	3.5 (1.4)
2. Positioning ease of cadaver onto mat:			
a) Home pen	4.0 (0.6)	3.8 (0.4)	3.7 (1.4)
b) Alley	3.4 (1.5)	3.0 (1.2)	2.3 (1.6)
3. Rate mat for:			
a) Moving mat in home pen towards pen gate	1.0 (0)§	1.0¶	1.6 (0.5)**
b) Moving mat out of home pen and into alley†	1.0 (0)§	1.0¶	1.8 (0.4)**
c) Moving mat down the alley to hospital pen‡	NA	NA	NA
4. Rate mat for:			
a) Mat size to move cadaver	2.7 (1.4)	3.3 (1.4)	2.0 (1.3)
b) Mat weight to move cadaver	1.8 (1.2)	2.8 (1.5)	1.5 (0.5)

* Questions 1 through 4 of the mat tool survey were scored using a 5-point scale: 5 = very easy, 4 = easy, 3 = neutral, 2 = difficult, and 1 = very difficult.
† Defined as mat being entirely inside the alley and oriented towards the hospital pen.
‡ Defined as mat being entirely inside the hospital pen. No results are available for moving the mat down alley into the hospital pen, as no employees were able to complete this cadaver movement.
§ Results shown are from the 3 employees who were able to complete the 135 kg cadaver movement.
¶ Results shown are from 1 employee that was able to complete the 118 kg cadaver movement, therefore an SD could not be calculated.
** Results shown are from 5 employees who were able to complete the 68 kg cadaver movements.
NA = not applicable.

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