MONITORING ACCELERATION (G-FORCE) DURING ANIMAL TRANSPORTS

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Background

Transport to the abattoir may stress animals (Bradshaw et al. 1996) and affect meat quality (Lehenska et al. 2002). One potential stressor is the motion of the truck. Vibration leads to increased heart rate (Perremans et al. 1998), increased plasma levels of cortisol (Perremans et al. 1995; Perremans et al. 2001), beta-endorphin (Perremans et al. 1995), and adrenocorticotropic hormone (Perremans et al. 2001). Vibration is also believed to be the reason why pigs develop motion sickness with vomiting (Randall and Bradshaw, 1998), whereas acceleration can cause animals to loose balance and receive injuries. The physical and physiological reactions of the animals during transport have a strong impact on the energy consumption within individual muscles, which in turn has strong implications for the quality of the final meat product (Rosenvold & Andersen, 2003).

Objectives

It is the objective to develop a monitoring system of G-force / vibration on animal transports fully integrating data on vehicle speed, road type, and balance of the animals on the truck. The system should be able to save data for evaluation and documentation. Also the system should be prepared for future modifications allowing the system to provide on-line alarms to the driver when certain pre-set G-force values are exceeded.

Materials and methods

Based on LabView software from National Instruments Corporation a programme (‘G-force Viewer’) was developed. ‘G-force Viewer’ integrates the information into a screen display that simultaneously shows data for G-force (‘G-logger’), vehicle speed (GPS), animal balance (video camera), road type (video camera) and altitude (‘G-logger’).

A tri-axis G-force logger (‘G-logger’) was developed. The ‘G-logger’ constantly measures G-forces in all three axis and calculates the resultant G-force. It also measures barometric pressure that can be converted into altitude. The unit can store data up to 200 times per second.

Two units of the ‘G-logger’ were tested on a real pig transport on a fully air suspended three-axel truck (photo). The ‘G-loggers’ were set to log 100 times per second (100Hz). Each logger was placed on the rubber-coated floor and a 15 mm thick polyethylene foam was placed on top of the logger before a metal protective casing was firmly pressed down over it. The casing was fastened by four screws through the rubber layer and into the underlying aluminium floor. In this way it was believed that the ‘G-logger’ would fairly realistically record the vibrations / G-forces that the pigs are subjected to through their contact with the rubber floor. One ‘G-logger’ was mounted in the rear pen. This logger was placed 94 cm from the rear end; 151 cm aft of the rearmost axel and 274 cm aft of the central pivotal point of vertical movements. The central pivotal point was estimated to be half way from the fore axle to the centre point between the two rear axles (see photo). Another ‘G-logger’ was mounted in the pen located directly over the central pivotal point.

A video camera (Sony DCR-TRV10E) equipped with a wide-angle lens was mounted over the pigs in the rear pen in which the floor area per 100kg pig was 0.42 m^2. Another camera was mounted in the driver’s cabin filming out the windscreen. A Global Positioning System receiver (Garmin eTrex Summit GPS) was used to record vehicle speed and location.

The test drive was intentionally made on secondary roads to get a picture of the worst scenario for transport conditions in Denmark. With very few exceptions the roads were paved.

Results and discussion

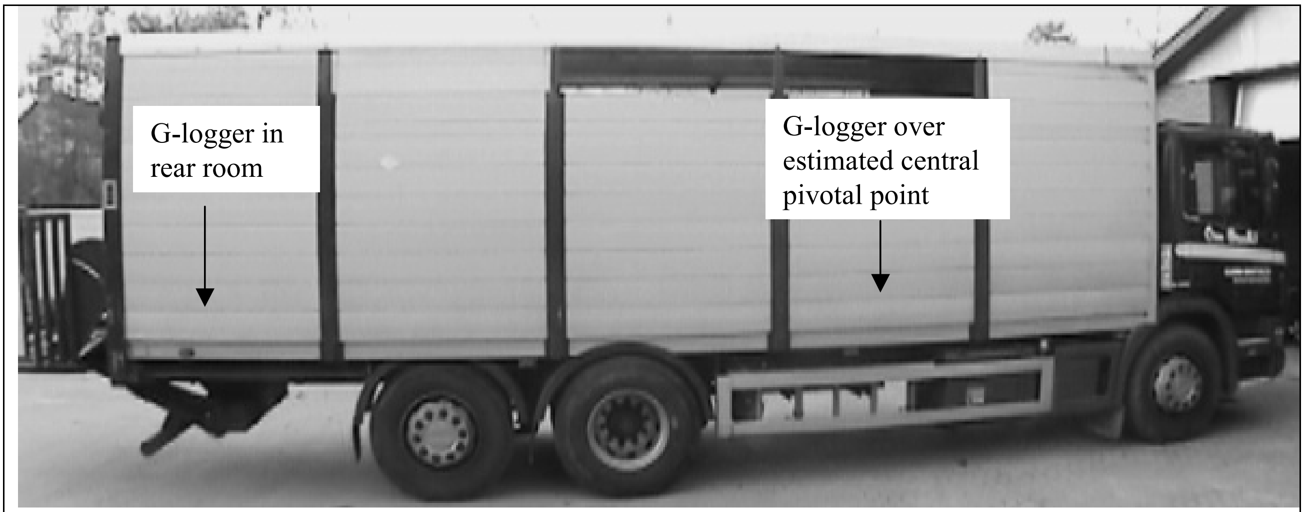

Photo. Truck used for the test of 'G-loggers'. Scania P94 6x2, OptiCruise automatic gear. Fully air suspended. The truck was loaded with approximately 5 tons of pigs.

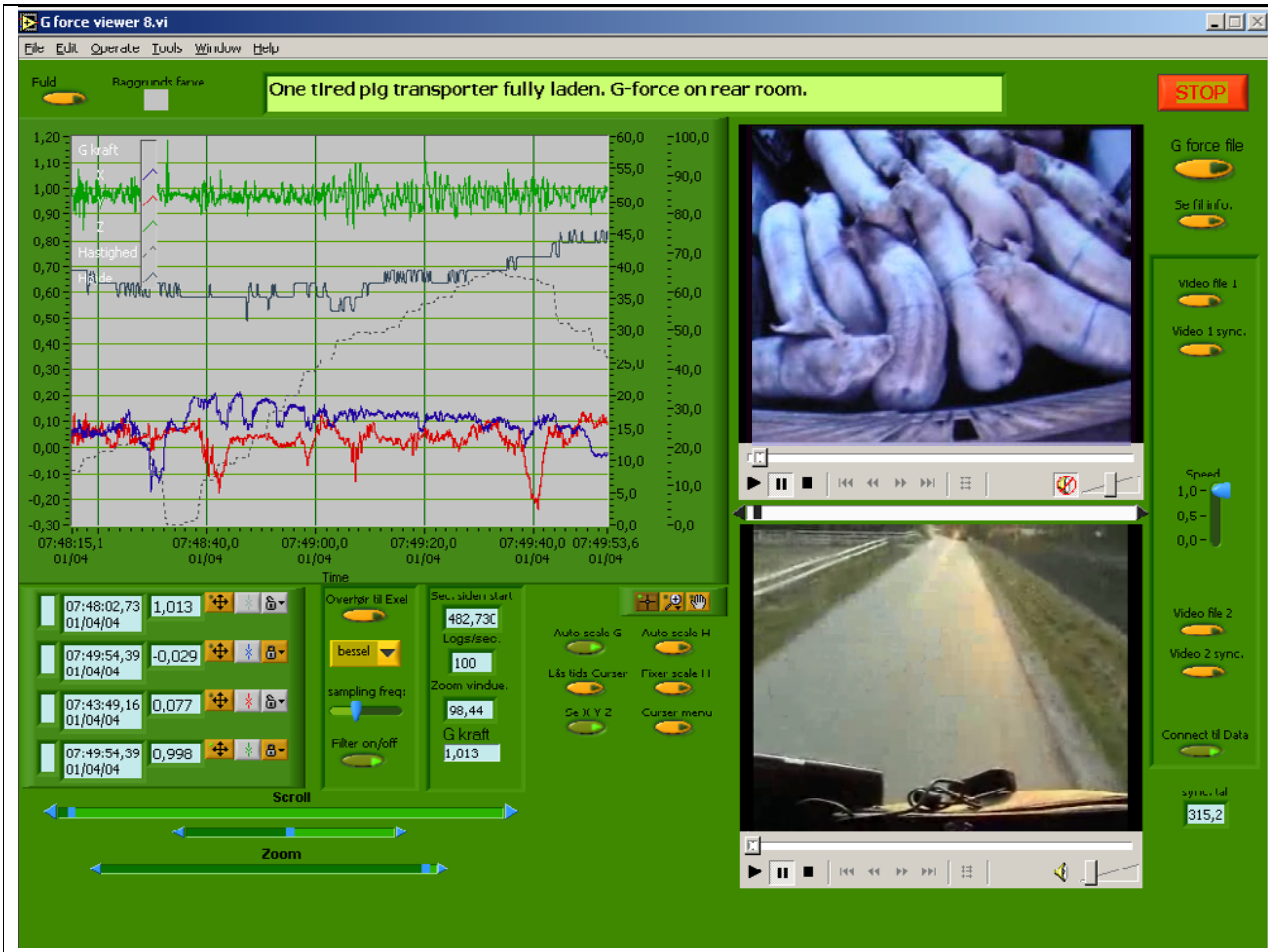

Figure 1. Screen display with two videos and graph showing curves for G-force in the x-, y-, and z-plane, vehicle speed, and altitude. The graph for the resultant force has been omitted for clarity. Data from rear pen. 1st order Bessel low pass filtered.

<u>G-force measurements.</u> Figure one is a screen display from the 'G-force Viewer' showing 1 minute:38 seconds of the test drive. Figure two shows another screen display from the same part of the test drive. Most imbalances of pigs seem to be caused by roundabouts as these caused repetitive shifts in direction of G-forces in two planes i.e. 0.4G laterally due to turns, and 0.3G for-aft due to acceleration and de-acceleration. When travelling at 70 km/h and maximum brake was applied - triggering the ABS anti-blockage system - the

G-force in the fore-aft direction (**X**) was 0.6g. With a loading density of 100 kg per $0.42m^2$ this braking forced pigs forward in the pen and the ones not leaning against anything lost their balance - this happened again when the brake was released or when the truck came to a complete halt. Other loading densities would obviously have given different results. G-force in the vertical plane had negligible effects on balance.

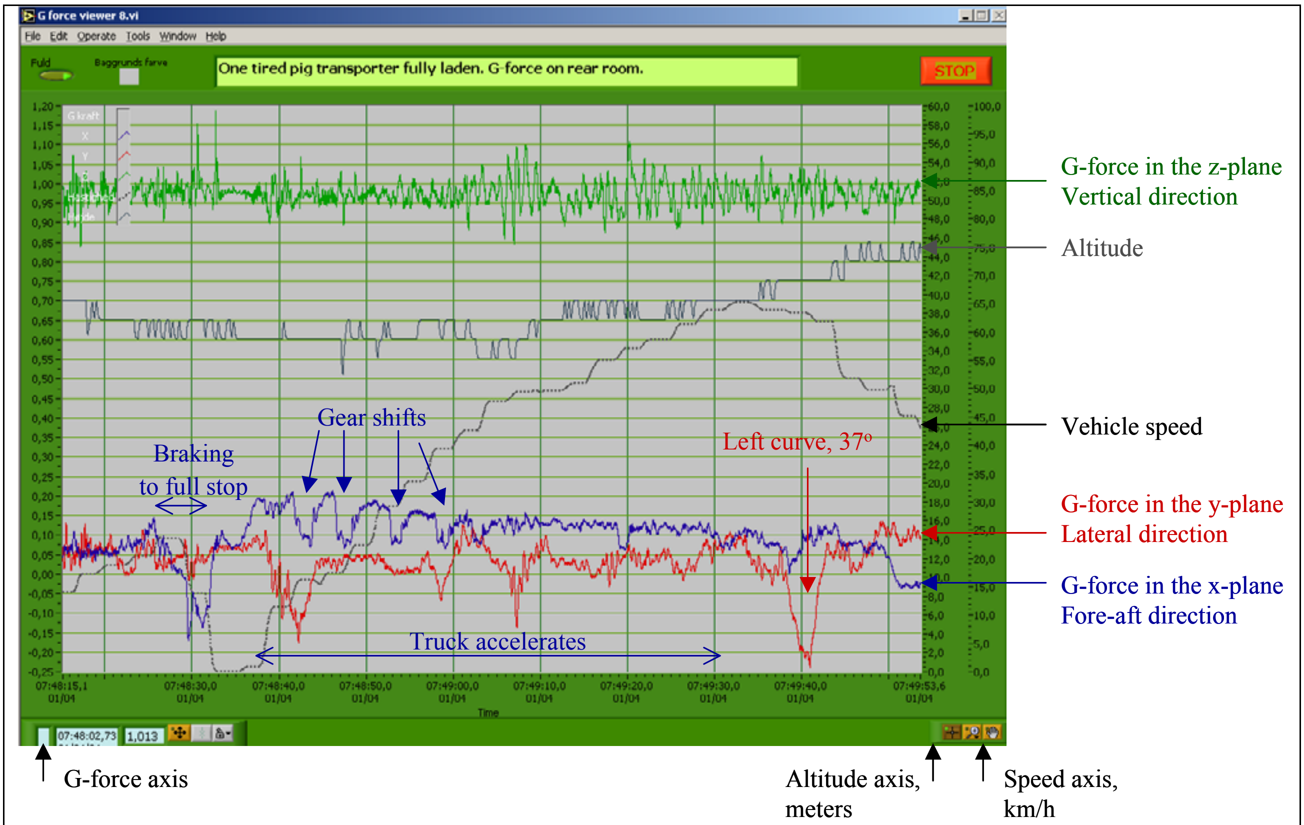

Figure 2. Screen display with only graphs. Data from rear pen. 1st order Bessel low pass filtered. The graph for the resultant force has been omitted for clarity.

<u>Vibration measurements.</u> The raw unfiltered G-force data (figure 3) reveals that in the vertical plane G-forces of ultra short duration (<3/100 second) of up to 3G occasionally occurred. However, this also happened occasionally when the fully laden truck was stationary leading to the conclusion that it was caused by the movements of the pigs. Probably when a pig stepped on the 'G-logger'. Ultra short peaks will probably have only minor effects on the pigs.

At a vehicle speed of 60 km/h the prevailing vibration frequency was 25-33 Hz with an amplitude of 0.05G in the lateral direction (**Y**); 25-33 Hz with an amplitude of 0.1G in the fore-aft direction (**X**); and 20-25 Hz with an amplitude of 0.2-0.4G in the vertical direction (**Z**). With reference to human vibration studies (Griffin, 1990; BSI, 1987), Randall et al (1995) speculated that pigs would feel less discomfort at these frequencies than at lower frequencies. With piglets Perremans et al (2001) found that - with regard to short durations (less than one hour) of vertical vibration - higher frequencies (18Hz) are less stressful than lower frequencies (2-8Hz). Since the prevailing vibration recorded in the current test was predominately of sinusoidal nature, the vertical amplitude of 0.2-0.4G can be estimated to correspond to 1.4-2.8 m/s^2 RMS (Griffin, 1990 p 468) and thus well below the maximum RMS value of 3 m/s^2 recommended by Perremans et al (1998). The effect on pigs from lateral vibration is unknown. With exception of the fore-aft direction (X) the vibration during driving conditions on the fully laden truck resembled the vibrations recorded on the stationary empty truck with the engine running. Thus the vibrations are caused by the engine. In the X-direction very little vibration occurred on the stationary empty truck with the engine running.

Conclusions

The 'G-logger' and the 'G-force viewer' provide easy to use tools for measurements of G-force and vibration on pig transporters. With minor modifications it can be used as an on-line alarm system educating the driver.

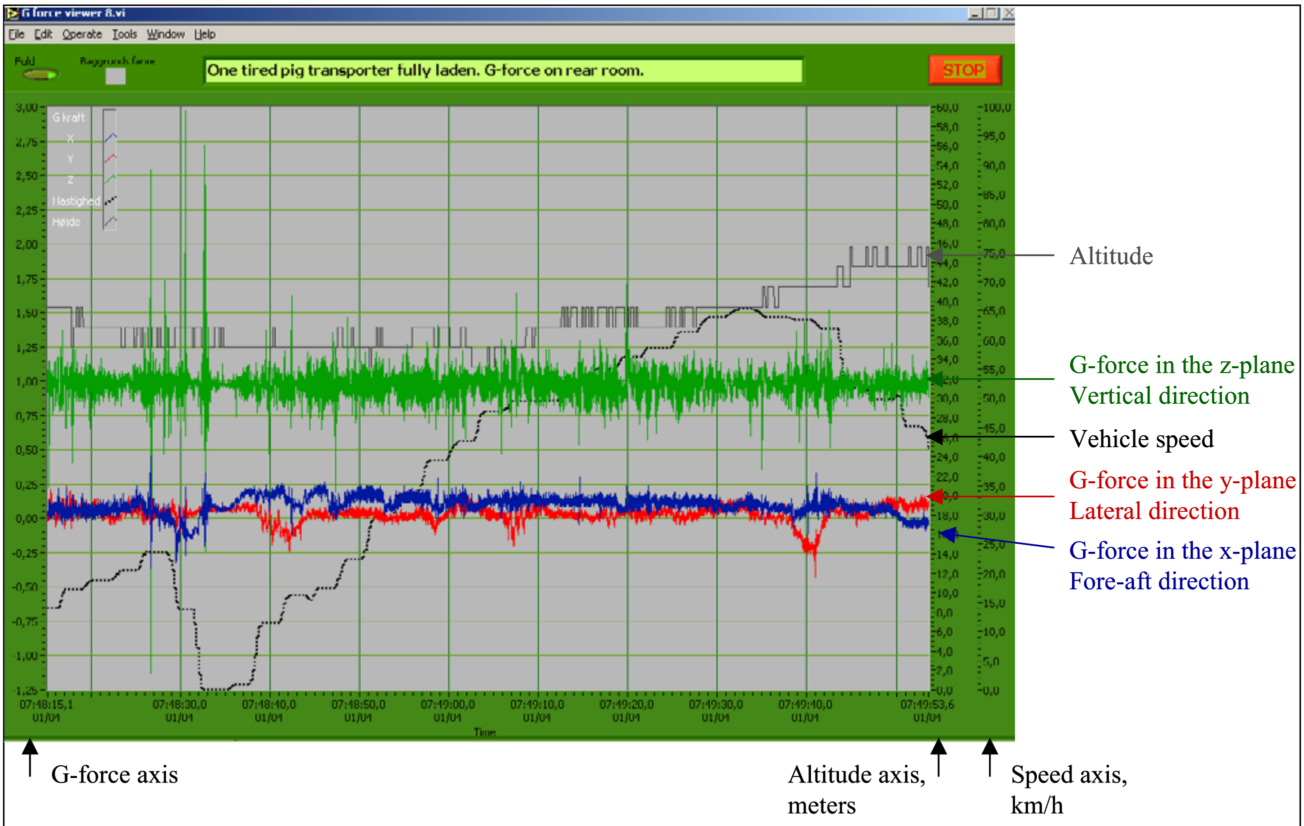

Figure 3. Screen display with only graphs. Data from rear pen. Raw data without filter. The graph for the resultant force has been omitted for clarity.

References

Bradshaw, R.H., Parrot, R.F., Goode, J.A., Lloyd, D.M., Rodway, R.G. & Broom, D.M. (1996). Behavioural and hormonal responses of pigs during transport: effect of mixing and duration of journey. Animal Science, 62, p.547-554.

BSI, 1987. Measurements and evaluation of human exposure to whole-body mechanical vibration and repeated shock. BS6841, London: British Standards Institution. pp22.

Griffin, M.J. 1990. Handbook of human vibration. London Academic Press, pp988.

Leheska, J. M., Wulf, D. M. & Maddock, R. J. (2002). Effects of fasting and transportation on pork quality development and extent of postmortem metabolism. Journal of Animal Science, 80, 3194-3202.

Perremans, S., Randall, J., Ville, H., Stiles, M. Duchateau, W., and Geers, R. 1995. Quantification of pig response to vibration during vertical motion. Proceedings of the EU-seminar “Methods of improving pig welfare by reducing stress and discomfort before slaughter” 29-30 June 1995, Mariensee, Germany: 135-141

Perremans, S., Randall, J.M., Allegaert, L., Stiles, M.A., Rombouts, G., and Geers. R. 1998. Influence of vertical vibration on heart rate of pigs. Journal of Animal Science 76:416-420.

Perremans, S., Randall, J.M., Rombouts, G. Decuypere, E., and Geers, R. 2001. Effect of whole-body vibration in the vertical axis on cortisol and adrenocorticotropic hormone levels in piglets. Journal of Animal Science 79:975-981.

Randall, J.M., and Bradshaw, R.H. 1998. Vehicle motion and motion sickness in pigs. Animal Science 66:239-245.

Randall, J.M., Stiles, M.A. Geers, R., Schütte, A., Christensen, L. and Bradshaw, R.H. 1995. Vibration on pig transporters: implications for reducing stress. EU Seminar “Methods of improving pig welfare by reducing stress and discomfort before slaughter”. 29-30. June, Mariensee, Germany.

Rosenvold, K. & Andersen, H.J. (2003). Factors of significance for pork quality - a review. Meat Science, 64, p.219-237