SHEAR FORCE AND SARCOMERE LENGTH IN FIVE PELVIC SUSPENDED MUSCLES FROM DIFFERENT BOVINE GENDERS

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Key Words: Beef, Sarcomere length, Shear force, Pelvic suspension, Tenderness

Introduction

Differences in tenderness and other quality aspects exist among muscles with different function and location in the live animal. These differences generally can be explained by a variation in collagen content, proteolytic activity and in contraction or stretching during rigor mortis (King *et al*., 2003). Pelvic suspension is known to stretch muscles in the hind leg and thereby improve tenderness (Hostetler *et al*., 1970). In previously reported data (Lundesjö Ahnström *et al*., 2003) we found that pelvic suspension significantly reduced Warner-Bratzler shear force in *M. longissimus dorsi*, *M. gluteus medius* and *M. adductor* from young bulls but no equivalent reduction in shear force was found for the same muscles from heifers. Since pelvic suspension has been shown to stretch sarcomeres this study was made to see how sarcomeres and shear force values responded to pelvic suspension.

Objectives

The objective of this study was to investigate the combined effects of gender and pelvic suspension on sarcomere length and shear force of beef from five different muscles.

Methodology

Carcasses from Swedish Red and White cattle were selected on the slaughter line and met the following criteria; 7 heifers (age 24-28 months, weight 249-301 kg), 7 young bulls (*young bulls 24mo*, age 22-28 months, weight 235-310 kg), 7 young bulls (*young bulls 34mo*, age 32-35 months, weight 300-349 kg) and 6 cows (age 47-88 months, weight 261-317 kg). All carcasses were electrically stimulated (low voltage, 30 sec) within 30 minutes after bleeding. The left side from each carcass was hung by the pelvic bone approximately 60 minutes after exsanguination while the right side was hung by the Achilles tendon. The carcasses were chilled (50 min) in a chilling tunnel, starting at -2^{O}C, passing a zone at -4^{O}C and then back again to -2^{O}C. The carcasses were stored at 2-4^{O}C for 2 days and then fabricated. To avoid DFD-carcasses, the pH was measured in the

centre of the *M. longissimus dorsi* at the 11th rib using a probe electrode. The whole muscles, *M. semimembranosus* (SM), *M. longissimus dorsi* (LD), *M. psoas major* (PM), *M. gluteus medius* (GM) and *M. adductor* (AD), were vacuum-packed and aged for 7 days at 4^{O}C. Then samples for Warner-Bratzler measurements were removed and frozen at –20^{O}C. GM was cut into two pieces along the thick connective tissue band in the central part of the muscle and only the smaller piece was used for analyses.

Samples for sarcomere length measurements were removed from the middle part of the muscles after 7 days of ageing, put in glutaraldehyde fixative and prepared according to Cross *et al*. (1980). The lengths of 10 sarcomeres were measured in 10 myofibrils from each sample.

Warner-Bratzler (WB) shear forces (Honikel, 1998) were used for measurement of tenderness. WB samples were thawed over night at 4^{O}C and then placed in a water bath (20^{O}C) for 1 hour. The samples were vacuum-packed and heated in a water bath for 2 h at 70^{O}C. The weight of the meat samples were recorded before freezing, after thawing and after cooking. The cooked meat samples were stored at 4^{O}C until the measurement of shear force was performed the next day. From each sample, strips (40 x 10 x 10 mm) were cut following the muscle fibre structure. A minimum of 8 strips from each sample were analysed using a Stable Micro System Texture Analyser HD 100 (Godalning, UK) equipped with a Warner-Bratzler shear force blade with a rectangular hole (Honikel, 1998). Statistical evaluation was performed using the Procedure Mixed in SAS (Version 8e, SAS Institute Inc., Cary, NC, USA). The statistical analyses were made separately for each muscle. The model contained the fixed effects of sex and suspension method and the interaction between these, and the random effect of animal.

Results

The investigated muscles were affected differently by pelvic suspension depending on gender. The genders also responded differently to pelvic suspension. The cows and heifers were not affected as much as the bulls. Of the investigated muscles, SM and AD were stretched the most after pelvic suspension with an increase in muscle length of 36% and 46% respectively. Our earlier results have shown a 30% increase in length of SM in young bulls (Lundesjö, 2001).

M. semimembranosus

In the SM a 1µm increase in sarcomere length was found in pelvic suspended sides compared with achilles suspended sides for young bulls 24mo, young bulls 34mo and cows ($p<0.001$) whereas the heifers had a 0.3µm increase ($p=0.007$) in sarcomere length. This increase in sarcomere length was not clearly related to the values for Warner-Bratzler shear force where we found a strong relationship in the bull groups and a slightly less pronounced effect in the heifer/cow groups (Figure 1a). Pelvic suspension compared with achilles suspension gave a 24% decrease ($p<0.001$) in maximum shear force for the young bulls 24mo and 29% ($p<0.001$) decrease for young bulls 34mo whereas the heifers had a decrease of 17% ($p=0.006$) and the cows had no significant decrease in shear force for pelvic suspended sides. There were no significant differences in shear force between genders after pelvic suspension. The variation between samples, across genders, within treatment decreased from 21% in achilles suspended SM to 12% in pelvic suspended SM.

Of the genders young bulls 24mo had the greatest reduction in variation with a 66% decrease in shear force variation for pelvic suspended sides followed by a 52% reduction found in cows (Figure 2a). The within sample variation did not decrease in any gender or treatment due to pelvic suspension.

M. longissimus dorsi

Maximum shear force in LD was reduced in all four genders due to pelvic suspension. No significant differences in shear force occurred between genders after pelvic suspension. The effect was largest in young bulls 24mo where shear force was reduced 35% ($p<0.001$) followed by a 22% difference ($p=0.006$) for young bulls 34mo (Figure 1 b). Heifers and cows had no significant reductions in maximum shear force, which does not agree with previous findings (Lundesjö Ahnström *et al*., 2004) where a significant reduction in LD shear force due to pelvic suspension was found for both Charolais and Aberdeen Angus heifers. The variation in shear force between samples, across genders and within treatment decreased from 32% for achilles suspended sides to 16% for pelvic suspended sides. Large reductions in variation due to pelvic suspension could be seen in young bulls 24mo, young bulls 34mo and cows, which had smaller variations in shear force by 70, 60 and 50%, respectively (Figure 2b). The response in sarcomere length did not follow the same pattern as the shear force since the cows had a 20% increase in sarcomere length of the LD from pelvic suspended carcasses ($p<0.001$). However, in heifers, sarcomere length change was not significant. The young bulls 24mo and 34mo had significant increases in sarcomere length of 12% ($p=0.002$) and 19% ($p<0.001$), respectively.

M. adductor

For the AD, pelvic suspension (compared to achilles suspension) reduced shear force by 9% ($p=0.1$) for young bulls 24mo. The same group also had a reduction in between sample variation in shear force of 15% in achilles suspended sides compared to 7% for pelvic suspended sides. The cows had an opposite effect where the achilles suspended sides had an 8% ($p=0.007$) lower shear force value but no difference in variation for the different treatments. The heifers and young bulls 34mo showed no significant differences in shear force due to suspension method. The sarcomere lengths for young bulls 24mo and heifers (data not collected for the other groups) had a significant increase of 70% ($p<0.001$) in sarcomere length for pelvic suspended muscles from young bulls whereas the heifers did not have any significant changes in sarcomere length.

M. psoas major

Heifers and cows had slightly higher shear force values for pelvic suspended sides than achilles suspended sides. This can be expected since PM could contract due to pelvic suspension. Although no significant differences in shear force could be attributed to suspension method in any of the genders, it is interesting that the young bull groups had lower shear force value for pelvic suspended sides. This is contradictory to the female groups. However, in young bulls, this reduction in shear force was not confirmed by the sarcomere length measurements that showed a 15% decrease in sarcomere length for

pelvic suspended sides. No significant differences were found in sarcomere length for heifers although the length increased by 8% for pelvic suspended sides.

M. gluteus medius

GM had an inconsistent response to pelvic suspension in different genders. For young bulls 24mo and 34mo, the shear force decreased 23% ($p=0.004$) and 35% ($p<0.001$), respectively. The sarcomere length for young bulls 24mo was 0.9µm (52%) longer for pelvic suspended sides ($p<0.001$). For heifers and cows, pelvic suspension did not affect shear force or sarcomere length.

Discussion

The aim of our study was to diminish variation in tenderness in different cuts from different genders. Earlier work (Lundesjö et al., 2001) has shown that the variation in shear force between animals decreased from 26% for achilles suspended sides to 12% for young bulls suspended by their pelvis. Pelvic- compared to achilles suspension diminished variation in shear force for all muscles in the present study. The greatest reductions in variation were found in the male groups. The males also had the greatest response to pelvic suspension for shear force values where muscles from pelvic suspended sides were more tender compared to achilles suspended sides. This was not the case for the female groups where some of the muscles were less tender after pelvic suspension (heifers, negative response in PM and GM and cows in AD and PM). The differences between treatments were also smaller in the female group. This could be related to the relatively low shear values and good tenderness in these genders. The sarcomere length generally was longer in pelvic suspended sides. The bull groups had the greatest lengthening of sarcomeres, but contradictory to the shear force results the cows showed a large response to pelvic suspension leading to longer sarcomeres for those sides. We propose that greater stretching occurred in the sarcomeres in young bulls, but the same increase in sarcomere length in cows did not result in additional improvement of tenderness. One explanation of these differences might be due to differences within the pelvic region between genders and between females before and after calving. This could result in different angles of the hind leg during pelvic suspension and therefore different impact on the muscles. Another explanation could be differences in collagen stability between sexes which could interact with sarcomere stretching during rigor development.

Muscles were affected differently by pelvic suspension, which is in agreement with Barnier and Smulders (1994) who investigated effects of pelvic suspension on shear force values of five beef muscles. Although treatment increased sarcomere length of all muscles, the effect on the shear force ranged from positive, to negligible, to negative between muscles. Hostetler *et al*. (1970) also showed inconsistency in response to the treatment by different muscles where similar changes in sarcomere length did not produce proportionate changes in tenderness. Our results across genders showed an increase in sarcomere length ranging from 48% (SM, $p<0.0001$) > 30% (GM, $p<0.0001$) > 24% (AD, $p=0.001$) > 13% (LD, $p<0.0001$) to a negative response of -4% (PM, $p=0.34$). This can be compared to the results for shear force which ranged from 22% (LD, $p<0.0001$) > 20% (SM, $p<0.0001$) > 17% (GM, $p=0.0001$) > 0.07% (PM, $p=0.97$) > -0.1% (AD, $p=0.98$). However, it should be emphasized that the interaction, gender x

suspension method was significant for both sarcomere length and shear force in all muscles (with an exception for shear force in LD).

Conclusions

Pelvic suspension is a useful tool when the goal is to reduce tenderness variation in beef muscles. It has a more pronounced effect for muscles from carcasses from bulls compared to cows and heifers. Shear force and sarcomere length does not respond equally to the treatment.

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Figures

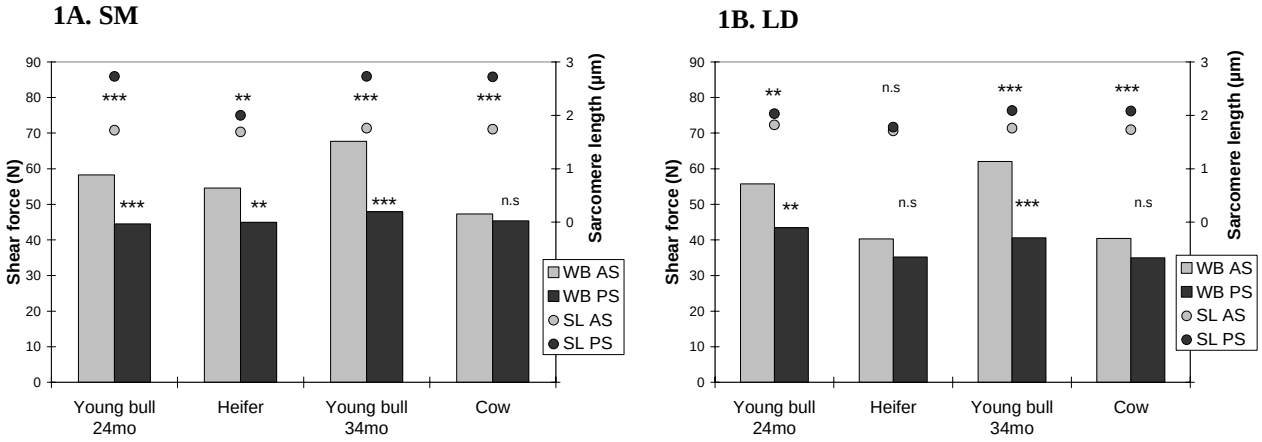

Figure 1 A & B.
The effect of pelvic (PS) and achilles (AS) suspension on WB Shear force (WB) and sarcomere length (SL) in four genders and two muscles A) SM and B) LD
(Levels of significance: ns = p > 0.10; ** = p ≤ 0.01; *** = p ≤ 0.001.)

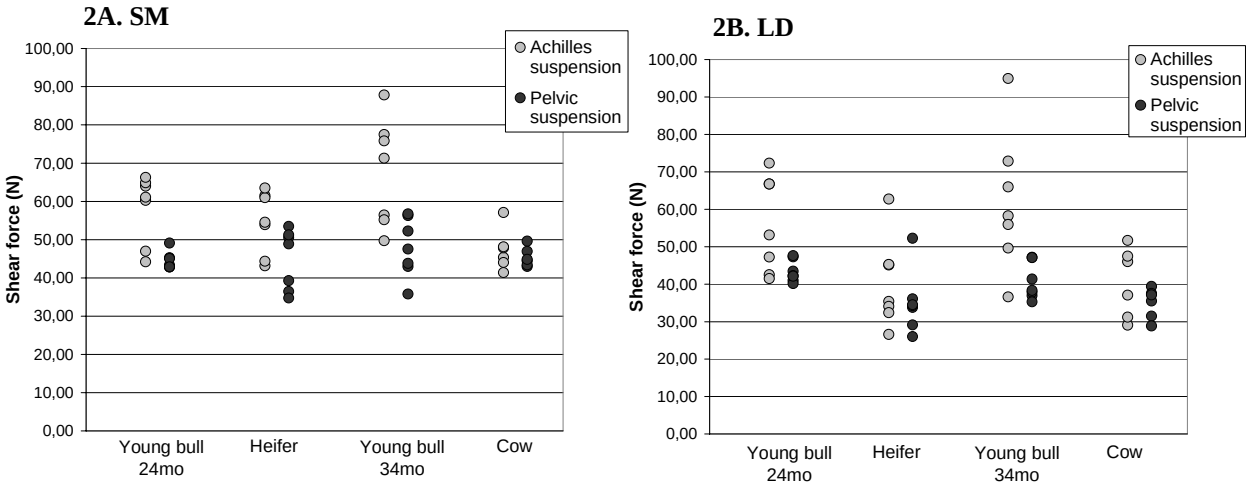

Figure 2 A & B
The variation in shear force for two achilles and pelvic suspended muscles from four genders, A) SM, B) LD.