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# Intramuscular Tenderness Variation Within Four Muscles of the Beef Chuck

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## Summary

To evaluate the potential for steak production from beef chuck muscles, we evaluated intramuscular tenderness variation within four beef chuck muscles: infraspinatus (IF), supraspinatus (SS), triceps brachii (TB), and serratus ventralis (SV). The IF, SS, TB, and SV muscles were cut into 1-in-thick steaks perpendicular to the long axis of the muscle. An identification tag was placed on each steak consisting of a muscle identification number, steak number, and orientation of the steak. Steaks were vacuum-packaged and stored at -8° F until used. Steaks were thawed at 34° F and broiled on electric broilers to an internal temperature of 160° F (medium degree of doneness). One core was removed from each square inch section parallel to the muscle fiber and sheared once to determine Warner Bratzler shear (WBS) force. The SS had an overall WBS force mean of 11.97 lb with no tenderness difference ($P > 0.05$) among steak locations. The IF had an overall WBS force mean of 6.97 lb with no tenderness difference ($P > 0.05$) among steak locations. The SV had a mean WBS force value of 9.64 lb with significant tenderness variation among steak locations. These tenderness variations were dispersed throughout the SV in no particular pattern. The TB had a mean WBS force value of 9.08 lb with significant tenderness variation among steak locations. The TB had lower ($P < 0.05$) shear force in the middle region of the muscle with the distal and proximal ends being tougher ($P < 0.05$). The data presented in this study provides a reasonably detailed mapping of the tenderness regions within the IF, SS, TB, and SV muscles. This information could be utilized to add value to the beef chuck through alternative fabrication and marketing of the muscles to fabricate steaks from consistently tender regions.


## Introduction

The primary reason consumers like meat, specifically beef, is because of the taste. Previous studies have revealed that tenderness, or meat texture, is the single most important factor affecting taste or consumer perception of taste (Morgan et al., 1991). Tenderness has been identified as the most important palatability attribute of meat and, thus, the primary determinant of meat quality (Huffman et al., 1996).

For years, the beef industry has used the USDA grading system as a means of classifying tender meat from less tender meat. Generally, it has been assumed that as intramuscular fat content increases (resulting in a higher quality grade) the overall tenderness of that cut of meat also increases. However, the National Beef Tenderness Survey (1991) illustrated that USDA quality grade failed to reduce the variation in panel ratings or shear force values to the degree necessary to ensure consistent beef products to the consumer (Morgan et al., 1991).

The chuck portion of a carcass provides approximately 27% of the total carcass weight and is constructed of 47 different muscles, all-varying in size, shape, and composition (Jones et al., 2000). Traditionally, the beef chuck has been merchandised in the form of low-priced roasts and steaks consisting of a number of different muscles and various quantities of intermuscular fat (Kukowski, 2003). Currently, the beef industry is attempting to increase value of the underutilized and undervalued beef chuck and round through single-muscle separation in an attempt to decrease the retail spread between the middle and end meats. The National Cattlemen's Beef Association is marketing chuck muscles as single-muscle

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steaks with retail names of the Flat Iron Steak and the Ranch Cut Steak. These value-added steaks have the potential to fill the void between premium steaks and ground beef. For chuck muscles to be competitive as value-added steaks, a thorough knowledge of those muscles is essential. Therefore, this study was conducted to define intramuscular tenderness variation within four muscles of the beef chuck: infraspinatus (IF), supraspinatus (SS), triceps brachii (TB), and serratus ventralis (SV).

## Materials and Methods

Ten of each of the following muscles, IF, SS, TB, and SV were obtained from USDA Choice boxed beef subprimals and aged at 36°F for 14 d from box date and frozen at -15°F. The frozen IF, SS, TB and SV muscles were cut into one-inch thick steaks on a band saw across the length of the muscle (perpendicular to the long axis). The SS and TB steaks were cut from the distal end of each muscle to the proximal end, IF steaks were cut from the proximal end of the muscle to the distal end, and the SV steaks were cut from the cranial end of each muscle to the caudal end. All steaks were numbered, beginning at the distal, proximal, or cranial ends, through the number of steaks obtained ending at the proximal, distal, or caudal end of each muscle group._An identification tag was placed on each steak consisting of a muscle identification number, steak number, and orientation of the steak. Steaks were vacuum packaged and stored (-8°F) until shear force determination.

*Shear Force Determination.* Steaks were thawed at approximately 34°F for 24 h, raw weights were obtained, and steaks were broiled on Farberware Open Hearth electric broilers (Farberware, Bronx, NY). Steaks were turned every 4 minutes until an internal temperature of 160°F was reached. During cooking, steaks were turned in a specific way relative to their identification tag to maintain orientation throughout cooking and shearing. Internal temperature was monitored by inserting a thermocouple probe (Model 31308-KF, Atkins Technical, Inc., Gainesville, FL) into the center of each steak. Cooked weights were obtained for each steak. Steaks were cooled at 34°F for 2 hours, and then allowed to equilibrate to room temperature, which took approximately 45 minutes. Once the steaks reached room temperature, each steak was divided into one-inch square sections using a ruler. First, the steak was bisected horizontally into one-inch sections. Then vertical coordinates were determined each arranged one-inch from one another. The number of sections within each steak depended upon the size of the steak and varied from steaks that originated at the cranial and distal end of the muscle to the caudal and proximal end, and from one muscle group to the next. One 0.5-inch diameter core was removed from each square inch section parallel to the muscle fiber orientation. A single peak shear force value was obtained for each core using a Warner-Bratzler shear machine.

*Statistical Analysis.* Two analyses of WBS force values were conducted to map tenderness variation within the SS, IF, TB, and SV. The first analysis evaluated tenderness variation across the long axis of each muscle by averaging the shear force values for each steak within a subprimal. Least squares means for steak within each subprimal were determined and variations within tenderness were evaluated using a paired t-test. This analysis indicated if there were differences from "top to bottom" for each muscle. In addition, to evaluate "side to side" variation within each muscle, sections within steak were also analyzed. Sections within steak were defined as the intersection of each one-inch row by each one-inch column within each steak. Least squares means were calculated for each section within steak, least squares means were determined and separated using a paired t-test. To construct simplified TB steak figures least squares means from adjoining cores were averaged to give a single shear value for a given area of approximately 2 to 4-sq-in. SV steak figures were constructed to illustrate column effects within each steak. Least squares means within a given column were averaged to give a single shear force value.

## Results and Discussion

*Supraspinatus.* Least squares means for WBS force for steak and within steak are reported for the SS in Figure 1. There were no significant differences in WBSF among individual steaks of the SS. According to Miller et al. (2001) practical WBS tenderness threshold levels are as follows: < 6.6 lb = tender; 6.6-10.1 lb = slightly tender/slightly tough; > 10.1 lb = tough. In the case of the SS, the whole muscle is classified as tough with an average shear force value of 11.97 lb. This high shear force for the SS results in the SS not being an ideal muscle to market as single-muscle steaks. Johnson et al. (1988) found total collagen in a muscle to be positively correlated with WBS values and Jones et al. (2000) reported collagen content of the SS was 17.77 mg/g, which is comparable to other muscles considered to be tough. High collagen content greatly affects WBS values as muscle fiber networks become more durable as they connect to collagen; also collagen does not solubilize and tenderize well under dry cooking conditions, which were used in this study. The high WBS values of the SS may be a result of location and function. The SS is located along the juncture of the humerus and scapula lying on top of the blade bone (NCBA, 2000) and functions to extend the shoulder joint while preventing shoulder dislocation (Jones et al., 2000). Muscle fibers that connect with multiple bones are more resilient and have more detailed cross-linking patterns to aid in proper attachment. Muscle fibers taper slightly at the ends resulting in muscle banding patterns becoming less obvious and myofibrils to become continuous with strands of connective tissue. This narrowing of muscle fibers and increased strength effectively forms a network that attaches muscles to another component and can cause meat to be tougher. Both functions of the SS require strong networks of muscle fibers, which can result in higher WBS values.

*Infraspinatus*. There were no significant differences among WBS values when evaluating IF steaks; however, unlike the SS, the IF was consistently tender throughout the muscle with average steak shear of 6.97 lb. Figure 2 shows the means WBSF value of each steak. This consistency in tenderness indicates the IF would be a suitable muscle in which single-muscle steaks could be marketed. The IF may be consistently tender due to muscle function and collagen content. The IF abducts the arm of an animal, rotating it outward (Jones et al., 2000). In terms of general movement, cattle do not extend their front limbs outward to any great extent, instead, the front limbs mainly move in a forward/backward movement; resulting in the IF to not be utilized extensively as a locomotion muscle. The IF has a collagen content of 8.72 mg/g (Jones et al., 2000), a much lower content than the SS. This low collagen content may be another factor contributing to the IF to be consistently tender throughout the muscle.

*Triceps brachii***.** The TB had significantly different WBS values among steaks (Figure 3). The mean steak WBS value was 9.08 lb. The first four steaks, originating at the distal end of the muscle, and the last steak located at the proximal end of the muscle were tougher ($P < 0.05$) than the middle steaks. In addition, the steaks from the distal and proximal ends have shear force values of 9.1 lbs, characterizing them as slightly tough or tough according to the tenderness ranges used by Miller et al. (2001). Possible factors causing shear force differences among TB steaks include the basic physiological "tapering" of muscle fibers as they reach their point of attachment. Like the IF, the TB has little responsibility to actual physical movement of an animal. The TB functions to extend the elbow joint and flexes the shoulder joint. Extending of the elbow and flexing the shoulder joint may account for the steaks located at the distal and proximal ends of the TB to have higher WBS values than the remaining middle steaks. The outer portions of the TB are used in attachment while the middle section may only be utilized for stability; possibly resulting in more tender middle steaks. When evaluating an objective technique for tenderness determination according to location within a steak, Zuckerman et al. (2001) observed higher shear force values at the edges of steaks. This may be a result of an increased rate of chilling while the muscle was still on the carcass or a temperature increase during the cooling process or differences in skeletal attachment, cooling gradient effects, or inconsistent cooking (Dugan and Aalhus, 1998).

*Serratus ventralis.* There was a difference ($P < 0.001$) in tenderness values throughout the SV; however, the was no consistent pattern of tenderness (Figure 4). The mean steak WBS value of the SV was 9.64 lb. The SV contained locations with intermediate WBS values intermixed with high WBS values. The middle five steaks of the SV produced significant column effects with the ventral side of those steaks being more tender ($P < 0.05$) than the dorsal side. This variation in tenderness could be a result of the physical construction of the muscle as a whole and its function. The SV is a large, fan-shaped muscle lying from the dorsal region just over the ribs ventral towards the sternum or brisket (NCBA, 2000). Although the SV is not used in true locomotion, it functions to protract and retract the shoulder and flexes the neck when acting unilaterally (Jones et al., 2000). The muscle fibers run parallel to the long axis of the SV with heavy sheets of surface connective tissue (NCBA, 2000). Some of the tender regions found in the SV may be a result of it not functioning as a heavily utilized motility muscle, allowing some muscle fibers to be more tender. As mentioned earlier, muscle fibers become stronger and more concentrated when they connect with connective tissue; therefore, with a lot of connective tissue dispersed throughout the SV, it is clear to see why there would be no true mapping pattern of tenderness. Due to the ventral side of the SV steaks being more tender than the dorsal side and the size of these steaks, it may be possible to fabricate and market those regions as single-muscle steaks. However, further tenderness mapping of this muscle is needed to determine if the more tender region of these steaks are adequate enough in relative size to validate single-muscle fabrication. Consequently, the SV is not an ideal muscle to utilize in an effort to produce single-muscle steaks.

## Implications

This study is a reasonably detailed mapping of the tenderness regions within the infraspinatus, supraspinatus, triceps brachii, and serratus ventralis. The infraspinatus and triceps brachii had regions of acceptable tenderness as steak cuts; whereas the supraspinatus and serratus ventralis had relatively higher WBS values and no useful tenderness patterns. The results of the present study could be utilized to add value to the beef chuck by using those muscles with consistently tender regions and fabricating and marketing those regions as single-muscle steaks.

## Literature Cited


Dugan, M. E. R., and J. L. Aalhus. 1998. Beef tenderness: within longissimus thoracis et lumborum steak variation as affected by cooking method. Can. J. Anim. Sci. 78:711-714.

Huffman, K. L., M. F. Miller, L. C. Hoover, C. K. Wu, H. C. Brittin, and C. B. Ramsey. 1996. Effect of beef tenderness on consumer satisfaction with steaks consumed in the home and restaurant. J. Anim. Sci. 74:91-97.

Johnson, R.C., C. M. Chen, T. S. Muller, W. J. Costello, J. R. Romans, and K. W. Jones. 1988. Characterization of the muscles within the beef forequarter. J. Food. Sci. 53:1247-1250.

Jones, S., C. Calkins, K. Podany, J. Sherrill, R. Roeber, A. Guru, C. Chen, V. Singh, D. Selendic, N. Kapetanovic, and B. Gwartney. 2000. Bovine Myology. Online. Available: http://animalscience.unl.edu/document.cgi?docID=144. Accessed Dec. 8, 2003.

Kukowski, A. C. 2003. Evaluating consumer acceptability and willingness to pay for various beef chuck muscles. M.S. Thesis, South Dakota State Univ., Brookings.

Miller, M. F., M. A. Carr, C. B. Ramsey, K. L. Crockett, and L. C. Hoover. 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79:3062-3068.

Morgan, J. B., J. W. Savell, D. S. Hale, R. K. Miller, D. B. Griffin, H. R. Cross, and S. D. Shakeford. 1991. National Beef Tenderness Survey. J. Anim. Sci. 69:3274-3283.

NCBA. 2000. Muscle profiling. National Cattleman's Beef Association. Denver, Co.

Zuckerman, H., B. W. Berry, J. S. Eastridge, and M. B. Solomon. 2001. Shear force mapping: a tool for tenderness measurement. J. Muscle Foods 13:1-12.

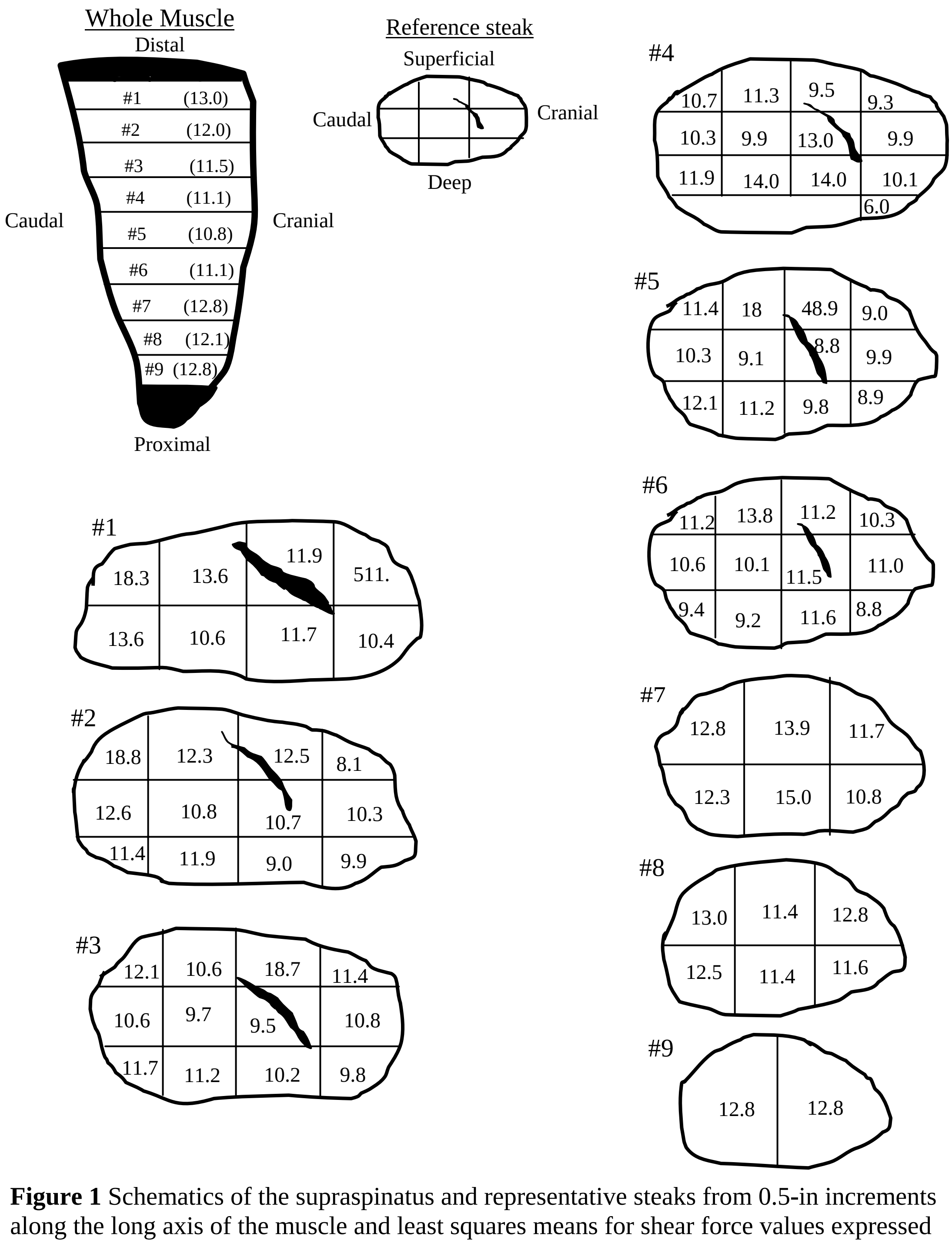


**Figure 1** Schematics of the supraspinatus and representative steaks from 0.5-in increments along the long axis of the muscle and least squares means for shear force values expressed in kg. Parenthetical data represents steak average shear force (SE = 0.51 for steak 4; SE = 0.52 for steak 3; SE = 0.55 for steaks 2, 5; SE = 0.59 for steak 6; SE = 0.66 for steak 1; SE = 0.65 for steak 7; SE = 0.80 for steak 8; SE = 1.6 for steak 9). No significant differences were found when evaluating WBS shear force values between or within steaks.

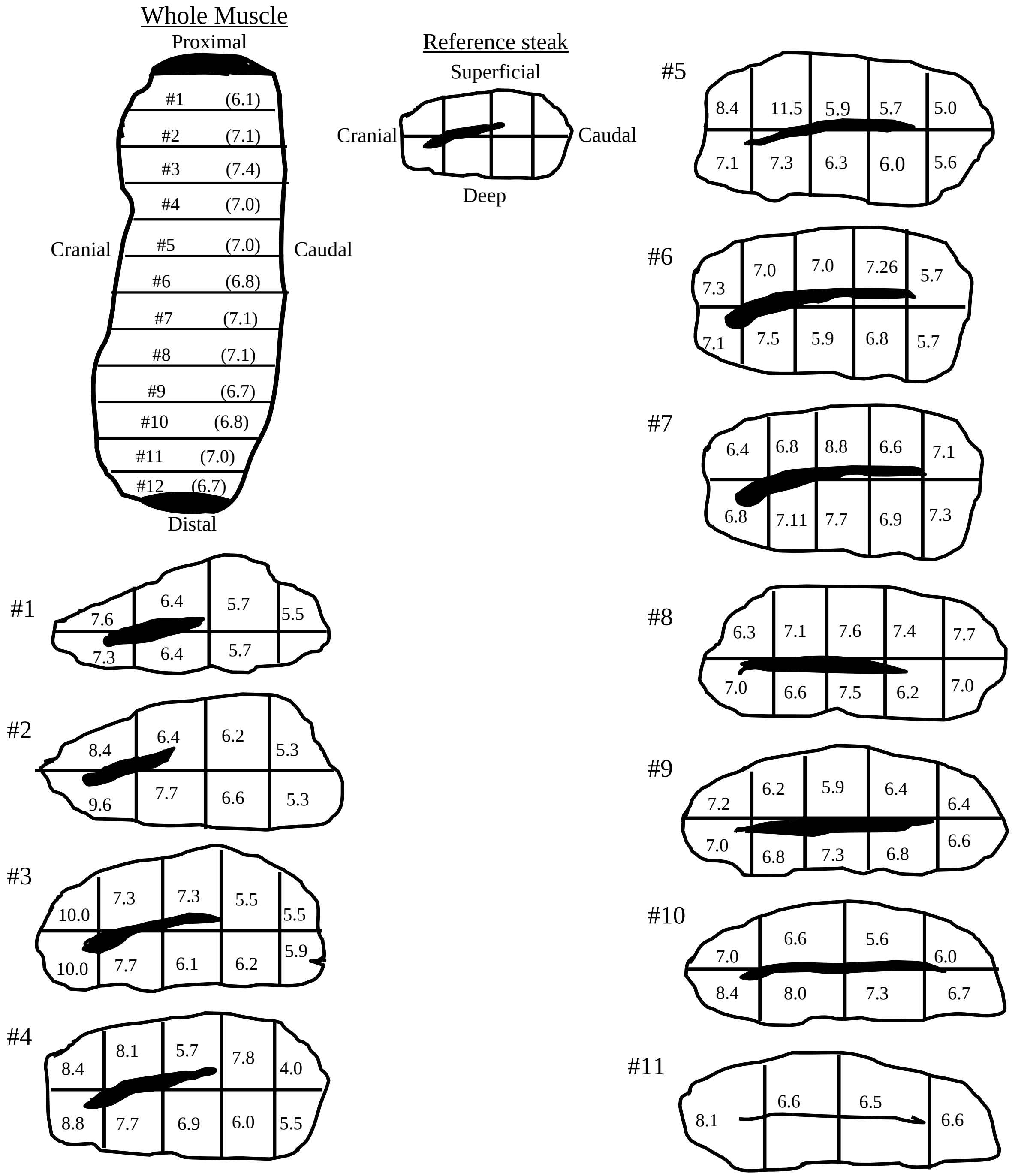


**Figure 2** Schematics of the infraspinatus and representative steaks from 0.5-in increments along the long axis of the muscle and least squares means for shear force values expressed in kg. Parenthetical data represents steak average shear force (SE = 0.24 for steak 5; SE = 0.28 for steaks 3-4, 6-9; SE = 0.31 for steak 2; SE = 0.33 for steak 10; SE = 0.35 for steak 1; SE = 0.57 for steak 11; SE = 1.2 for steak 12). No significant differences were found when evaluating WBS shear force values between or within steaks.

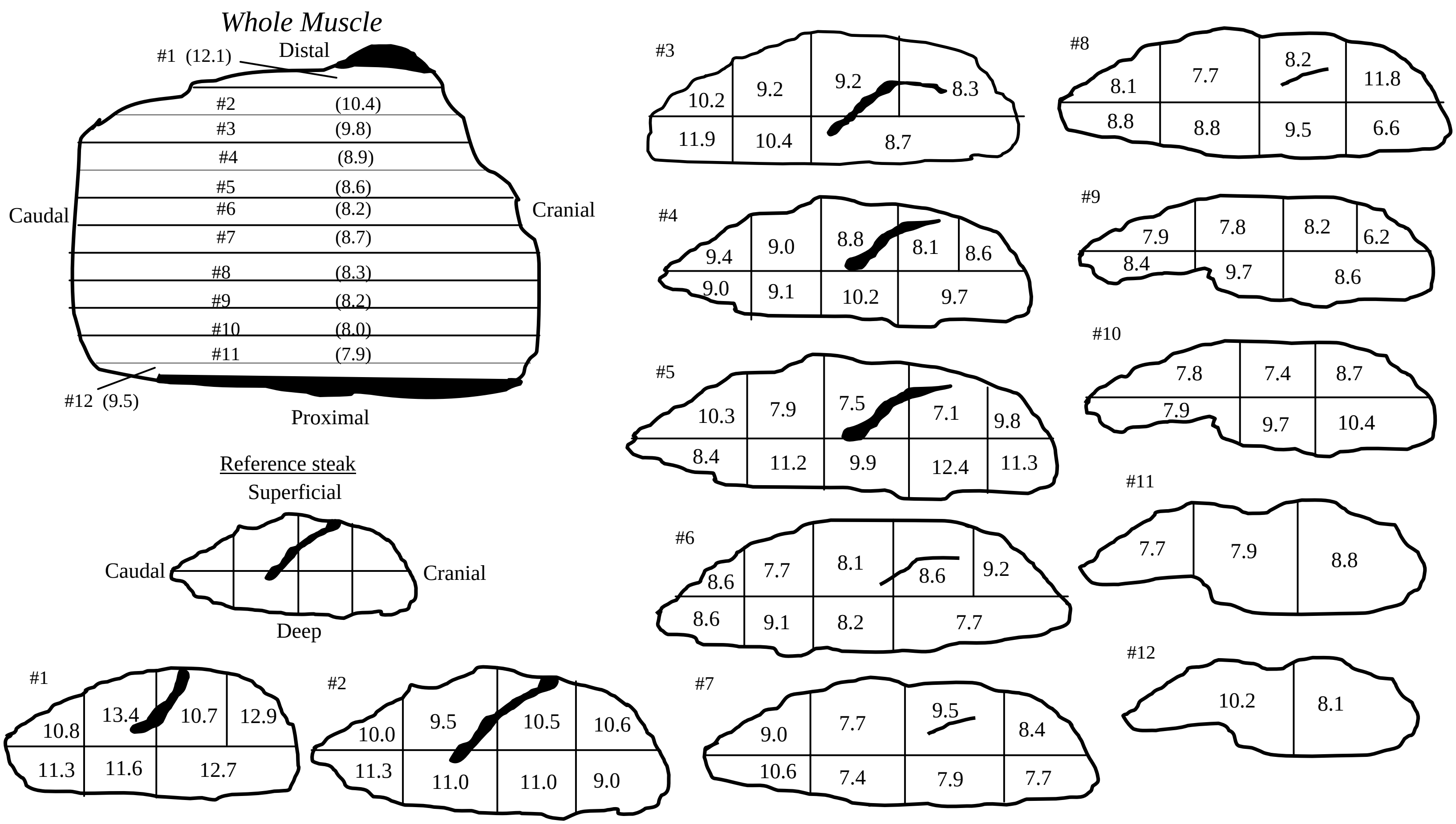


**Figure 3** Schematics of the triceps brachii and representative steaks from 0.5-in increments along the long axis of the muscle and least squares means for shear force values expressed in kg. Parenthetical data represents steak average shear force (SE = 0.18 for steaks 7-10; SE = 0.20 for steaks 6, 11; SE = 0.22 for steak 5; SE = 0.32 for steaks 4, 12; SE = 0.26 for steak 3; SE = 0.39 for steak 2; SE = 0.57 for steak 1). Representative steak shear force values expressed as an average value for the given area. WBS shear force values differed ($P < 0.05$) between steaks.

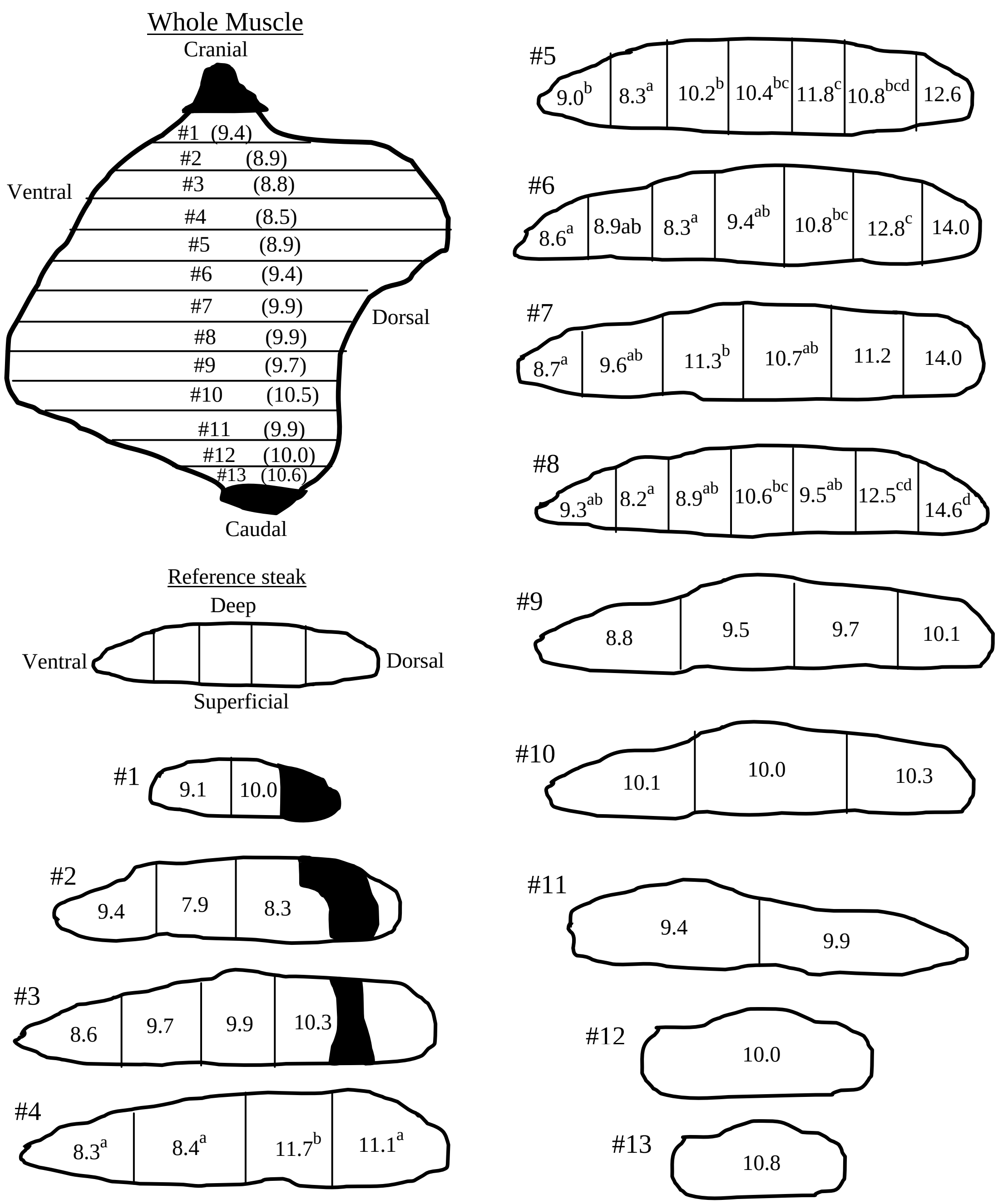


**Figure 4** Schematics of the serratus ventralis and representative steaks from 0.5-in increments along the long axis of the muscle and least squares means for shear force values expressed in kg. Parenthetical data represents steaks average shear force (SE = 0.28 for steaks 6,7; SE = 0.31 for steak 8; SE = 0.33 for steak 5; SE = 0.35 for steak 4; SE = 0.37 for steak 9; SE = 0.40 for steak 3; SE = 0.48 for steak 2; SE = 0.52 for steak 10; SE = 0.76 for steak 1; SE = 1.1 for steak 11; SE = 1.4 for steak 12; SE = 1.7 for steak 13). Representative steak shear force values expressed as an average value for the given area. WBS shear force values differed ($P < 0.05$) between steaks. Numbers within steaks lacking a common superscript differ ($P < 0.05$).