RESEARCH ARTICLE

Sokoto Journal of Veterinary Sciences

(P-ISSN 1595-093X/ E-ISSN 2315-6201)

Hena *et al.* /*Sokoto Journal of Veterinary Sciences* (2017) 15: 74 - 79.

http://dx.doi.org/10.4314/sokjvs.v15i4.11

Determination of perimysial and fascicular diameters of triceps brachii, biceps brachii and deltoid muscles in Zebu cattle and one-humped camels

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Abstract

In this study, forelimbs from 25 male camels and 25 male cattle between the ages of 6 months to 7 years were obtained from Sokoto Municipal Modern abattoir. Triceps brachii, biceps brachii and deltoideus muscles were dissected out, and $1cm^2$ from each muscle type was fixed in 10% formalin for normal H&E histological preparation. The prepared slides were viewed using a microscope and photomicrographs obtained which were further transferred into a computer for histometric evaluation. In this study, it was observed that all the muscles studied presented normal histomorphology of a typical skeletal muscle, it was discovered that the biceps brachii muscle from camel aged 7 years had higher and significant value for the perimysial diameter compared to that of cattle. Similarly, it was shown that there is an overall significantly higher value of perimysial diameter in the camel than the cattle generally. Fascicular diameter revealed that the triceps brachii of cattle aged 7 years had the highest significant value, however, the general overall average value for the fascicular diameter proved the camel to have highest significant values, indicating larger muscular tissues. Knowledge obtained in this study could find application to clinical histopathologist and also help in bridging the paucity of information in this subject area.

Keywords: Biceps brachii, Deltoideus, Fascicular diameter, Perimysial, Triceps brachii

Received: 31-12- 2016 Accepted: 27-04-2016

Introduction

Camels are greatly utilized as a source of meat, which is considered to have less fat comparable to other animal types (Dawood & Alkanhal, 1995; Kurtu, 2004). Cattle, on the other hand is also another important animal mainly used as source of meat, milk and as an agricultural animal used for traction and other utilities (Agada *et al*., 2010; Pelletier *et al*., 2010). Majority of meat from these animals comes from the skeletal muscles. Skeletal muscle tissue is named due to its attachment to bones. Skeletal muscle mass represents about 30-40 per cent of the total body weight, and has important roles in locomotion and metabolism and in food animals skeletal muscle constitute the bulk of the meat being consumed. According to Hoppeler & Fluck, (2003) skeletal muscle is covered externally by some connective tissue bands known as epimysium, and internally the muscle is traversed by some connective tissue spaces called perimysium thereby separating the muscles into fascicles, with each muscle fascicle being constituted by several muscle cells which are being separated together by the endomysium (Hoppeler & Fluck, 2003; Goldspink, 1996). Measures of muscle architecture such as muscle thickness and muscle fascicle size are used to describe a muscle's function. In musculoskeletal models, muscle thickness is assumed to remain constant and the force a muscle fascicle transmits to its tendon is a function of its location on the force-length curve and the cosine of the pennation angle, thus muscle morphology affects the characteristics of muscle contraction (Davies, 1997).

Literature searches made on the perimysial and fascicular diameters of the triceps brachii, biceps brachii and deltoideus muscles in camel and cattle was not seen. Hence, the present work was aimed at bridging the gap due to the paucity of information in this area. Knowledge obtained in this study could find application by clinical practitioners more especially in histopathology and muscle biopsies, as well as for teachers and researchers in anatomy field.

Materials and Methods

Forelimbs from 25 male camels (*Camelus dromedarius*) and 25 male Zebu cattle aged 6 months, 1 year, 3 years, 5 years and 7 years were obtained from Sokoto Municipal Modern abattoir, Sokoto state, Nigeria. Prior to slaughter of the selected animals, their ages were determined using the method of Wilson (1984) and Dyce *et al.* (2010), while evaluation to exclude any animal with musculoskeletal deformity or diseases was done through physical examination. The live body weights of the animals were estimated using linear body measurement based on the formula of Yagil (1994).

The samples (forelimbs) were obtained and stored in polythene bags, then they were transported to the Veterinary Anatomy Laboratory of the Usmanu Danfodiyo University, Sokoto, where the triceps brachii, biceps brachii and deltoideus muscles were all carefully dissected out using the methods of Chibuzo (2006) as slightly modified by Sonfada (2008) after most of the connective tissues ensheathing the muscle were trimmed off. The origins and insertions of each muscle were equally observed while dissecting.

The triceps brachii, biceps brachii and deltoideus muscles were dissected out and 1cm^2 from each muscle type was taken from the middle part of the muscle bellies and fixed in 10% formalin for normal H&E histological preparation (Drury *et al*., 1967). After histological preparations, the slides prepared were viewed using an electric microscope (Olympus® CH 23, Germany) at different magnifications (×40, ×100, ×400) thereafter photomicrographs were obtained using a Samsung Digital Camera (Samsung® ES10, 8.1 Mega Pixels). The photomicrographs obtained were further transferred into a computer (Compac® Laptop, HDM, Presario CQ60) for further evaluation and detailed histometric studies. The method of Sivachelvan (1981) was used to determine the perimysial and fascicular diameters from each sampled muscle of both animal species.

Numerical data obtained were reported as mean ± SD and presented in form of tables. Data generated from the study were analyzed using a two way ANOVA and the General Linear Model, equally Pearson's correlations were done to determine if relationship exist between the variables. Statistical significance of experimental observations were set at $p<0.01$ and $p<0.05$ where appropriate. All data analyses were done with the aid of SPSS (Version 16.0, 2007).

Results

In this study, it was observed that all the muscles studied presented normal histomorphology of a typical skeletal muscle, this is as represented by Plate 1, gross pictures of the triceps brachii, deltoideus, and biceps brachii muscles from the forelimbs of both camel and cattle were also presented on Plates 2, 3, 4 and 5. It was discovered that the biceps brachii muscle from camel aged 7 years had higher and significant value for the perimysial diameter compare to that of cattle (Table 1). Similarly, it was shown that there is an overall significantly higher value of perimysial diameter in the camel than the cattle generally (Table 2).

Fascicular diameter evaluation revealed that the triceps brachii of cattle aged 7 years had the highest significant value (Table 1), however, the general overall average value for the fascicular diameter proved the camel to have highest significant values (Table 2). It was further observed that there is a significant positive correlation between fascicular diameter and perimysial diameter across both species and muscles studied (Table 3).

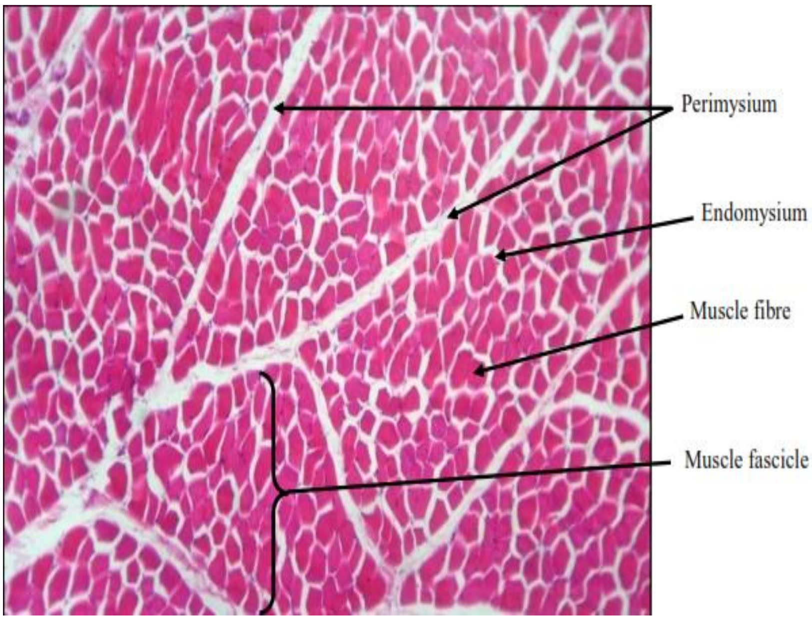

Plate 1: A photomicrograph of a cross section of a typical skeletal muscle of a camel showing different muscle features such as the muscle Perimysium and Fascicle as analyzed in the study (H&E x100

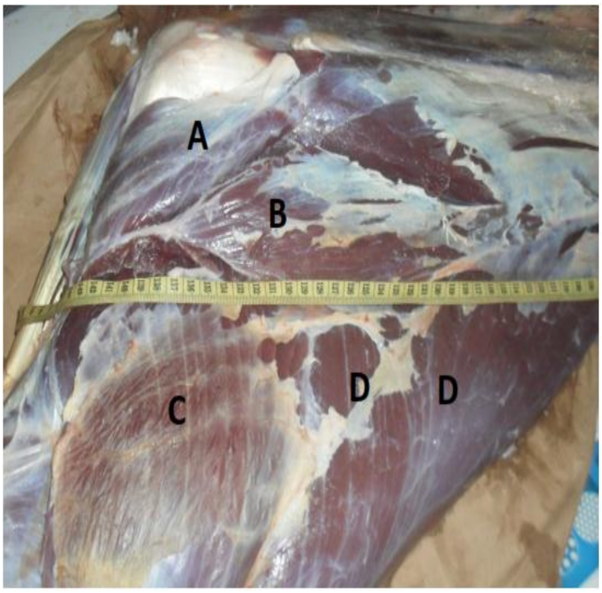

Plate 2: Gross appearance of the *Triceps brachii* (**C** = Lateral head; **D** = Long head) and *Deltoideus* (**A**=Acromial part; **B** = Scapular part) muscles of the one-humped camel. ×125

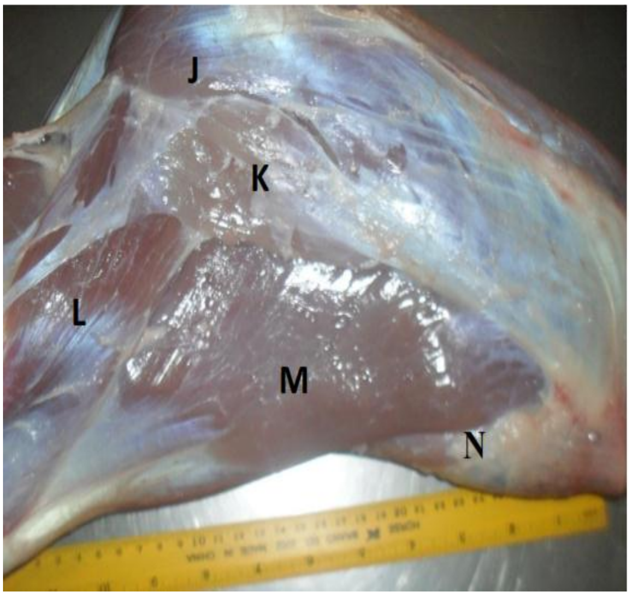

Plate 3: Gross appearance of the *Deltoideus* (**J** = Acromial part; **K** = Scapular part) and T*riceps brachii* (**L** = Lateral head; **M** = Long head) and *Tensor fasciae antebrachii* (**N**) muscles of the Cattle. ×125

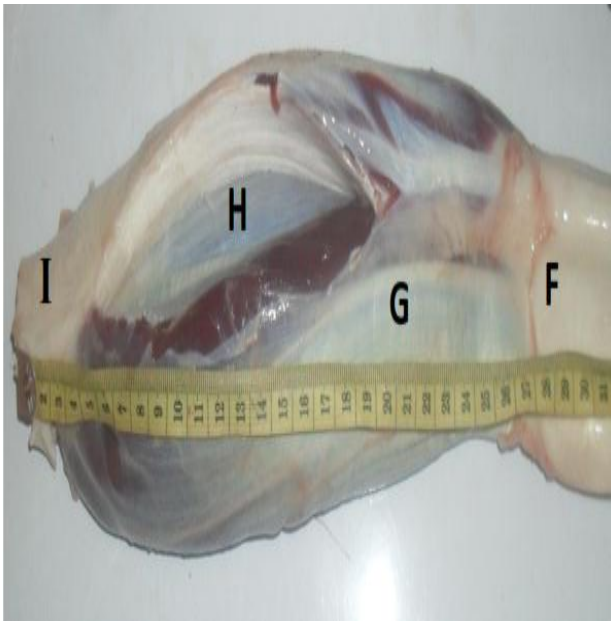

Plate 4: Gross appearance of the *Biceps brachii* muscle of the one-humped camel (**F** = Tendon of origin; **G, H** = Muscle heads; **I** = Tendon of insertion). ×125

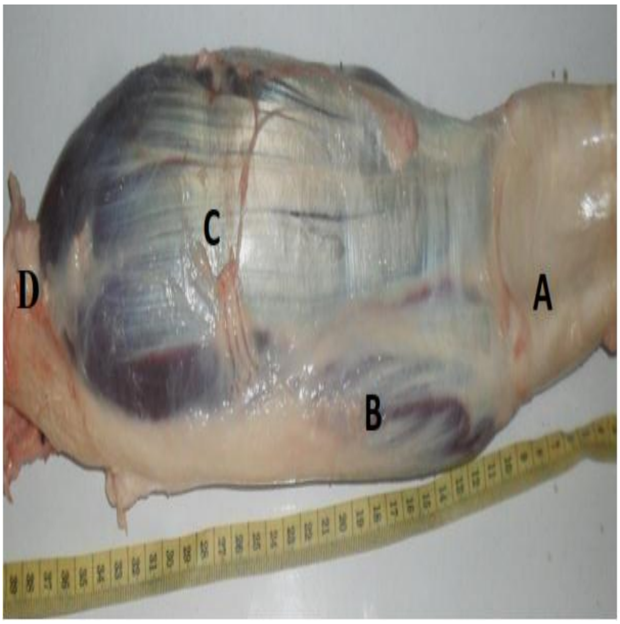

Plate 5: Gross appearance of the *Biceps brachii* muscle of the cattle (**A** = Tendon of origin; **B, C** = Muscle heads; **D** = Tendon of insertion). ×125

Discussion

In agreement to Bailey & Light (1989), the present work demonstrated that the muscles studied were divided into bundles (fascicles) and invested by perimysium; with endomysium observed surrounding the individual muscle cells. The observed larger perimysial diameter from the biceps brachii of the camel than across other muscles and species could be attributed to the role being played by this muscle and by the utility of the camel species in draught and traction. The perimysial diameter, being the connective tissue spaces surrounding each muscle fascicle is believed to be a major component of the muscle's connective tissue (Mobini, 2013) and is known to grow with increased animal activity. Generally there was an observed increase in the fascicular diameter with corresponding chronological age advancement in both camel and cattle studied, this observation is in par with the observations of Albrecht *et al.* (2014) where they reported increased muscle fibre bundles (fascicles) of different breeds of cattle during growth. However, correlation of fascicular diameter with perimysial

Table 1: Mean perimysial diameter and fascicular diameter of biceps brachii, deltoideus and triceps brachii of camel and cattle (Mean ± SD)

Age/ Muscle	Perimysial Diameter (μm)		Fascicular Diameter (μm)	
	Camel	Cattle	Camel	Cattle
6 months old				
BB	57.54±1.77	62.60±4.53	714.72±35.29 [b]	898.12±53.47 [a]
D	49.84±1.71 [a]	34.02±2.78 [b]	606.26±33.12	1173.86±15.84
TB	39.50±1.03	40.26±3.89	677.26±18.30 [b]	1202.26±35.77 [a]
1 Year old				
BB	51.22±3.32	41.76±1.91	1457.62±146.05 [a]	1432.38±22.32 [b]
D	52.46±1.75 [a]	38.94±1.36 [b]	1733.34±57.53 [a]	1674.70±60.81 [b]
TB	39.12±0.80	31.24±1.19	1993.54±4.75 [a]	1498.98±38.35 [b]
3 years Old				
BB	62.58±0.89 [a]	33.76±1.28 [b]	1787.04±49.30	1471.06±186.39
D	37.82±1.06	33.00±0.36	1663.16±141.83	1764.98±50.32
TB	43.22±1.01	35.02±1.14	2027.12±18.38	1691.26±5.36
5 Years Old				
BB	71.94±1.24	48.14±2.17	2129.48±96.85	1952.52±29.64
D	38.08±1.57	39.04±0.72	2029.84±18.17 [a]	1707.36±31.89 [b]
TB	33.04±0.81	34.14±0.87	2008.22±3.10	1689.18±84.66
7 Years Old				
BB	72.72±0.95 [a]	54.14±0.71 [b]	2158.28±66.28	2268.04±257.09
D	35.70±0.57	38.34±2.39	2020.56±31.64 [b]	2168.92±89.78 [a]
TB	42.00±1.60	38.30±0.88	1986.78±11.53 [b]	2326.32±223.08 [a]

[ab] Means bearing different superscript in the same row within a subclass differ significantly ($p<0.05$)
Key: BB = biceps brachii; D = Detoideus; TB = Triceps brachii

Table 2: The overall mean fascicular and perimysial diameters of the whole muscles in camel and cattle

	Perimysial diameter (μm)	Fascicular diameter (μm)
Species		
Camel	48.45 [a]	1666 [a]
Cattle	40.18 [b]	1661 [b]
SD	0.79	26.41
Interactions		
S x A	*	**
S x M	**	NS
A x M	**	**

diameter revealed positive correlation. It thus implies that diameter of the muscle fascicle and the diameter of the perimysium both increased isometrically. This probably could be a mechanism to allow more space for muscle fascicles to be accommodated within a muscle tissue. The observed concurrent increase in muscle fascicular diameter and the perimysial diameter, could be an indication of growth as it has been observed that at postnatal life of camel and cattle, growth of muscle transverse sectional area, connective tissue proportion, perimysial and fascicular diameter are closely related (Albrecht *et al*., 2014; Luteino, 2006).

Fascicular diameter is a measure indicating growth of muscle fascicle which also is an indicator of muscle growth and the general growth of the animal, this agreed with Sonfada (2008) in the camel, where it was reported that there were progressive isometric growth of muscles with chronological age advancement. The accurate assessment of skeletal muscle mass has a significant role in physiology, nutrition and clinical medicine (Baumgartner *et al*., 1998), hence its quantification would provide new and important insights (Kuriyan *et al.,* 2008).

The external work performed by a muscle is the product of force it generates and the distance that its free attachment moves. The external work is also related to the length of the muscle fibres since most muscles can contract to about one-third of their resting state. Skeletal muscle responds to the amount and type of activity that is imposed upon it, with different training protocols inducing different results in the recruitment of muscle fibres (Fukunaga *et al*., 1997; Hodges *et al*., 2003), although this present study did not evaluate the mechanics. Muscle fibres can hypertrophy,

Table 3: Correlation coefficients of Fascicular diameter and Perimysial diameter

Correlated characteristics of muscles	Coefficient of correlation (r)	P value (2- tailed)
FD and PD	0.171*	0.036

Key: ** = p<0.001; * = p<0.05; NS = Not significant; FD = Fascicular diameter and PD = Perimysial diameter

increasing fibre diameter, which increases force production. This increased muscle fibre diameter was however observed in this study, these mechanisms are crucial to differentiate specialization of a muscle for postural and locomotor behaviours more especially as they relate to the animal models used in this study. Animal posture and motion are achieved by forces produced within the muscles (Sivachelvan, 1981). A muscle as seen in this study, consist of a large number of fibres arranged in fascicles, in such a way that a force is developed between the two ends of the muscles when the fibres are stimulated by electrical impulses coming from nerves. This force may cause movement, but if the force is not greater than opposing forces either within the animal's body (i.e. from antagonist muscles) or acting externally on the animal's body (such as the force of gravity), no movement will then occur (Marini & Veicsteinas, 2010). Although out of the context of the present study, mechanical and heat energy are known to be generated from the chemical energy supplied as nutrients to muscles, if no movement results from the generation of a muscular force, then no mechanical work is done, and all the energy must be released as heat to adjacent muscle tissues, thus the recycling mechanism of energy within elastic tissues (Davies, 1997). Based on the patterns of fascicle arrangement, skeletal muscles can be classified in several ways. What follows are the most common fascicle arrangements. Generally fascicle arrangement by perimysia is correlated to the force generated by a muscle; it also affects the range of motion of the muscle (Fry *et al*., 2004).

Knowledge obtained in this study could find application to clinical histopathologist and also help in bridging the paucity of information in this subject area. Further work is hereby being recommended to be performed in the same area using electron microscopy so as to be able to establish the ultrastructural details of these muscles in these animal models.

Acknowledgement

We acknowledge the efforts of Mr. Ibrahim Mangzhia Wiam for preparing the histological slides used in this research. Mr. Mustapha Jimoh of the Department of Veterinary Anatomy Laboratory, Usmanu Danfodiyo University, Sokoto, is acknowledged and appreciated for the sample preservations and assisting in sample processing.

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