RELATION BETWEEN GROWTH RATE, SERUM SOMATOMEDIN AND PLASMA TESTOSTERONE IN YOUNG BULLS

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SUMMARY

Twenty "Red Danish" bulls were tested for rate of gain, linear growth, longissimus muscle area and efficiency of feed utilization from the age of 1½ to 12 months. These variables were correlated to blood concentrations of testosterone and somatomedin, which were measured at 4 to 5 months, 6 to 7 months and/or 8 to 10 months of age.

Average testosterone concentrations of bulls above 6 months of age were found to be correlated negatively (P<.05) with feed utilization (feed units/kg gain). Average somatomedin activities throughout the test period were positively correlated with rate of gain (P<.05) and linear growth (P<.05), and negatively to feed utilization (P<.05). Also, the somatomedin activity was found to increase significantly from 6 to 7 months up to 10 months of age (P<.05). No significant correlation between testosterone and rate of gain, linear growth or longissimus muscle area was found, and, likewise, there was no significant correlation between somatomedin activity and longissimus muscle area.

It is concluded that the blood level of somatomedin at an early age may represent a possible indicator of future growth capacity in young bulls.

(Key Words: Growth rate, Somatomedin, Testosterone, Bulls.)

INTRODUCTION

Various mechanisms are considered to be involved in regulation of linear growth and rate of gain of mammals. The effect of exogenous testosterone in promoting deposition of muscle protein and establishing a positive nitrogen balance in castrated animals is well known (Hale and Oliver, 1973), while its effect on intact males is uncertain. The higher rate of gain seen in intact males as compared to castrates of the same species (Gortsema et al., 1974) is, however, presumably related to differences in endogenous testosterone levels.

Also, the significance of growth hormone and the family of growth hormone dependent hormones, the somatomedins (Daughaday et al., 1972), on gross somatic growth, remains to be established (Hall and Luft, 1974, Van Wyk et al., 1974). It is presumed, however, that one of the somatomedins, Somatomedin A, is mainly involved in the regulation of skeletal growth, since a positive correlation between body length and serum somatomedin activity has been demonstrated both in man (Hall and Filipson, 1975) and in pigs (Lund-Larsen and Bakke, 1975).

If a positive correlation exists between gross somatic growth and defined biochemical characteristics, such as blood-concentrations of certain hormones, the early determination of these hormone levels, in addition to other criteria, may represent a valuable tool for the identification of superior breeding animals. Thus, the objective of the present study was to determine the relationship in bulls between rate of gain, feed consumption per kilogram weight gain and longitudinal growth, and the blood levels of testosterone and somatomedin A.

MATERIALS AND METHODS

Twenty bull calves of the "Red Danish Cattle" breed were tested for weight gain, linear growth (wither height and chest girth), "muscle area" (cross-sectional area of the longissimus muscle), and feed utilization at the Egtved Breeding Station for Beef Production, Den-
The breeding value for daily gain is expressed in terms of a Growth Index (Andersen and Lykke, 1974). The Growth Index is equal to $h^2 (P_X - \bar{P}) + \bar{P}$, where $h^2$ is the heritability coefficient for daily gain (.6), $P_X$ is the weight gain of the bull in percent of the breed’s average at the station, and $\bar{P}$ is the breed’s average at the station (100). Feed utilization is expressed as Scandinavian Feed Units consumed per kilogram weight gain. A Scandinavian Feed Unit is equivalent to the net energy content of 1 kg of barley with 85% dry matter. Both values were estimated on the basis of repeat measures on the same bulls tested from 1½ to 12 months of age. Height at withers and chest girth were measured at 12 months, and the cross-sectional area of the longissimus muscle was estimated by ultrasonic scanning between the first and second lumbar vertebrae at 11 months of age (Andersen, 1975).

Blood samples for the estimation of somatomedin activity were collected once in the morning, and for the determination of testosterone both in the morning and in the afternoon for 2 consecutive days. The samples were taken at ages of 4 to 5 months, 6 to 7 months and/or 8 to 10 months from the same animals, and stored for 1 to 2½ years at $-18^\circ$ C before analysis. The 20 bulls studied were selected from a larger number of tested bulls in order to form three groups with the widest possible difference in growth index: a low index group (scores 91 to 97, six animals) a medium index group (scores 99 to 101, seven animals) and a high index group (scores 107 to 112, seven animals). Data on the physical characteristics of the three groups of bulls are given in table 1. The differences between chest girth and feed utilization of the high and low index groups were significant ($P<.01$ and $P<.05$, respectively), while differences in height and “muscle area” were not.

Plasma testosterone was measured by use of radioimmunoassay according to Sanwal et al. (1974) as modified by Sundby et al. (1975). Serum somatomedin activity was measured by the method of Hall (1970) with modifications according to Lund-Larsen and Bakke (1975): pelvis rudiments from 11-day-old chicken embryos were preincubated for 2 hr at 37 $^\circ$ C in a medium consisting of: Tris-HCl 50 mM, pH 7.5; NaCl 100 mM; KCl 5 mM; Glucose 5.6 mM and bovine serum albumin, grade V, 1% (Armour Pharmaceutical, Chicago, U.S.A.). After blotting, the pelvis leaflets were each transferred to

<table>
<thead>
<tr>
<th>Muscle area</th>
<th>Breed value for daily gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>SE</td>
</tr>
</tbody>
</table>

Table 1: Physical Characteristics of Three Groups of Bulls Tested

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of animals</th>
<th>Chest girth (cm)</th>
<th>Height (cm)</th>
<th>Feed units consumed/kg weight gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>6</td>
<td>176b</td>
<td>124</td>
<td>8</td>
</tr>
<tr>
<td>Medium</td>
<td>7</td>
<td>179</td>
<td>125</td>
<td>8</td>
</tr>
<tr>
<td>High</td>
<td>7</td>
<td>166</td>
<td>126</td>
<td>8</td>
</tr>
</tbody>
</table>

*a For definition of growth index (TINDEX) see Andersen and Lykke, 1974.
*b Low index group vs high index group, $P<.01$.
*c Low index group vs high index group, $P<.05$. 
a small glass vial containing: 1 μCi Na\textsuperscript{35}SO\textsubscript{4} (Spec. act. 5.0 mCi/.8-1.0 ml, from the Institute of Atomic Energy, Kjeller, Norway), 50 IU Penicillin + 50 μg Streptomycin (Procamycin, Apothekernes Laboratorium, Norway), the serum to be tested, and Eagles enriched basal medium with Hank's salt (Biocult, Scotland). To Eagles medium was added .7 mmole/liter of glutamine and .35 mmole/liter of serine before use. The final fluid volume in each vial was .800 milliliter. The vials were incubated for 15 to 16 hr at 37°C in a waterbath with slow shaking. Incubation was terminated by cooling the samples to 0°C. The leaflets were washed 40 times in distilled water, solubilized in 200 μl Soluene (Packard) and counted in a Packard Liquid scintillation spectrometer after the addition of 5 ml Diluene (Packard). Each serum sample was assayed in quadruplicate at two different concentrations (3.2% and 5.0%). In each experiment a pooled human serum, collected from 10 healthy men and women, was used as a standard. The assay response is expressed as a function of the logarithm of the dose of somatomedin. A linear portion of the dose response curve is selected and regression lines are calculated for the standard and for each set of unknowns. The assay is valid only if the lines exhibit parallelity within arbitrarily chosen probability limits (P<.05). The horizontal distance between the standard line and each unknown line is expressed as a potency ratio. One unit of somatomedin activity is defined as the sulfation activity of 1 ml of the standard serum and equals a potency ratio of 1. Serum inorganic sulfate was estimated by routine atomic absorption spectrometry (Perkin/Elmer/mod. 103, spectrometer) with Ba\textsuperscript{2+} as the standard, and acetylene-air as the oxidant. The concentration of serum inorganic sulfate ranged from 1.10 to 1.70 mM/liter with a mean value of 1.36 ± .032 (SE) mM/liter and was not significantly correlated with growth index. No correction for serum sulfate was made in the calculation of serum somatomedin activity.

RESULTS

Testosterone. Plasma testosterone ranged from .3 to 9.5 ng/ml with a mean of 2.9 ± .46 (SE) ng/ml in 4- to 5-month-old bull calves. During the next period (6 to 7 months) the mean concentration rose to 4.2 ± .46 ng/ml, range .3 to 11.1 ng/ml, with no further increase during the rest of the sampling period up to 10 months of age (mean 4.0 ± .46 ng/ml, range .3 to 13.3 ng/ml). During the first age interval, only half the animals (seven out of 12) had mean testosterone concentrations above 2 ng/ml, the rest still being immature. Therefore this age-group was not included when plasma testosterone concentration was related to growth variables.

In figure 1 the correlation between feed utilization and plasma testosterone concentration is shown. Each animal is represented by a single testosterone concentration based either on the mean concentration of the second or third test periods (○—○), or on the maximal testosterone concentration found in either period (●—●). Both the mean and maximal plasma testosterone concentrations were negatively correlated to feed utilization with \( r = -.52 \) (P<.05) and \( r = -.67 \) (P<.01), respectively. None of the other growth variables tested (rate of gain, "muscle area", chest girth and height) were significantly correlated with plasma testosterone.

Somatomedin. In figure 2A the standard curve obtained with the human reference serum is shown. Mean values from five four-point assays, each run in quadruplicate, are used. In figure 2B the corresponding curves for the test animals are shown. The dose response curves are parallel to that of the human reference
serum. Thus, the relative increase in sulfation activity with increasing serum concentration is the same for the standard serum and the bovine sera (figure 3).

A significant (P<.05) increase in serum somatomedin activity in bulls was found after 6 to 7 months of age (table 2). The regression of somatomedin on age was calculated within animals and was .11 U/ml per month (P<.01).

In table 3 the mean somatomedin activity for the three index groups is shown. An analysis of variance for somatomedin activity is shown in table 4. The residual mean square was .16 which means that the within animal standard deviation was as high as .4 U/ml (table 4). The within-index group and the residual mean

![Figure 2A](image1)
![Figure 2B](image2)

**Figure 2A.** Incorporation of $^{35}$S into cartilage proteoglycans of pelvis rudiments from 11-day-old chicken embryos. Sulfation activity of the human reference serum. The dose-response curve represents mean values of five four-point assays ± SE.

**Figure 2B.** Average sulfation activity of sera from three groups of 4- to 10-month-old, growing bulls of the Red Danish breed with, respectively, high (○-○; seven animals; 17 assays), medium (○-○; seven animals; 17 assays) and low (△-△; six animals; 11 assays) rates of gain. Each serum is assayed in quadruplicate at two different concentrations, and the dose-response curves represent mean concentrations ± SE of the animals of each group.

![Figure 3](image3)

**Figure 3.** Relative increase in sulfation activity with increasing serum concentrations. A serum concentration of 3.2% is arbitrarily chosen as 100% activity. ○: Human standard serum. Average of five assays ± SE. □: Sera from young bulls. Average of 46 assays (20 animals) ± SE.

**TABLE 2. RELATION BETWEEN AGE AND SERUM SOMATOMEDIN ACTIVITY IN YOUNG BULLS**

<table>
<thead>
<tr>
<th>Item</th>
<th>4 to 6 months</th>
<th>6 to 7 months</th>
<th>8 to 10 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of animals</td>
<td>12</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Somatomedin activity</td>
<td>.91 ± .083</td>
<td>.91 ± .063</td>
<td>1.29 ± .14</td>
</tr>
</tbody>
</table>

*The same animals were tested two or three times from 4 to 10 months of age.*
TABLE 3. SERUM SOMATOMEDIN ACTIVITY IN RELATION TO GROWTH INDEX IN THREE GROUPS OF YOUNG BULLS WITH LOW, MEDIUM AND HIGH RATES OF GAIN

<table>
<thead>
<tr>
<th>Index group</th>
<th>No. of animals</th>
<th>Growth index</th>
<th>Somatomedin activity, U/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Low</td>
<td>6</td>
<td>96</td>
<td>91-97</td>
</tr>
<tr>
<td>Medium</td>
<td>7</td>
<td>100</td>
<td>99-101</td>
</tr>
<tr>
<td>High</td>
<td>7</td>
<td>108</td>
<td>107-112</td>
</tr>
</tbody>
</table>

<sup>a</sup>Low index group vs high index group, P<.05.

Squares were pooled because the within-index group mean square was smaller than the residual mean square, and the F-value was calculated as the ratio of between-index group to pooled mean square (table 4). A significant difference (P<.05) was found between the low and high index groups (table 3).

Significant (P<.05) correlations were found between mean somatomedin activity corrected for age effect and height at 12 months (r = .54), chest girth at 12 months (r = .52) and feed utilization (r = -.50). The correlation between somatomedin activity and “muscle area” was not significant.

Discussion

Testosterone is known to exert anabolic effects under defined conditions, as shown by Hale and Oliver (1973) by implantation of testosterone in Zebu steers and by Gortsema et al. (1974) by comparison between normal and short scrotum bulls and steers. However, the significance of endogenous testosterone levels in gross growth promotion in bulls is not settled.

Marked spontaneous diurnal variation in testosterone levels in bulls have been reported (Katongole et al., 1971; Sanwal et al., 1974). Thus the limited sampling in this investigation may not have been sufficient for the full evaluation of testosterone levels in the animals tested. Nevertheless, the results presented suggest a possible relationship between endogenous testosterone levels and feed utilization in young growing bulls.

Somatomedin has been shown to possess marked insulin-like properties in vitro in addition to specific stimulation of cartilage growth (Salmon and DuVall, 1970; Underwood et al., 1972). The biological significance of the former is not known. The positive correlation found in the present study between rate of gain, skeletal growth and serum somatomedin activity in young bulls is in accordance with the concept of somatomedin being a serum factor with insulin-like activity and with a specific stimulating action on cartilage growth.

The possibility of selecting breeding animals at an early age depends upon the detection of a series of objective and easily applicable criteria. Somatomedin, whose level of activity in bulls does not seem to change significantly during the first 6 months of age, whose diurnal variation probably is modest, due to the relatively long estimated half-life (Daughaday et al., 1968), and whose positive correlation to gross somatic growth has been demonstrated, might represent a promising indicator for this purpose.
LITERATURE CITED


