0196-6011/83/0501-0002$02.00/0
THE JOURNAL OF ORTHOPAEDIC AND SPORTS PHYSICAL THERAPY

Descriptive Analysis of Quadriceps and Hamstrings Muscle Torque in High School Football Players*

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The purpose of this study was to establish a range of acceptable torque values for competition in high school football. The results indicated that body weight can be used as an acceptable predictor of lower extremity muscular torque. Therefore, it was concluded that body weight can be utilized to produce an average range of desirable torque values for participation in high school football.

In recent years many sports medicine clinics and universities have been using isokinetic equipment to assess quadriceps and hamstrings torque. These evaluations have been utilized to evaluate the muscular status of athletes during preseason screening sessions and rehabilitation programs.

The minimum muscular torque value required for athletic competition should be a major concern of the isokinetic assessment. Ascribing a minimum quadriceps and hamstrings torque for a high school football player is a difficult task. This is true because muscular torque is affected by age, height, and weight.[5] Watson and O'Donovan[13] have shown that isometric and isotonic muscular strength are best predicted by height and weight. On the other hand, Gilliam et al.[5] observed that weight made the most significant contribution to the quadriceps and hamstrings torque of high school football players. Thus, the weight of the athlete should be considered in the determination of a minimum value for competition. Further, attention should also be given to the comparison of individual torque values to population averages. Average torque values for the sports of hockey,[11] baseball,[2] and football,[4,5] have been reported in the literature. However, these thorough studies do not present a definitive picture of how the sports therapist can evaluate the quadriceps and hamstrings torque of the high school football player relative to body weight.

The purpose of this study was to assess the average quadriceps and hamstrings torque of the high school football player. An additional purpose of the study was to establish a range of acceptable torque values for the athlete through the evaluation of the relationship of torque to total body weight.

MATERIALS AND METHODS

Eighty-four high school football players were selected for this study. The subjects were males ranging in age from 15 to 18 years. Each subject gave informed consent and reported for one measurement session on a Cybex II isokinetic dynamometer (Lumex, Inc., Ronkonkowa, NY).

A method previously reported by Parker[10] was used to position the subjects on the dynamometer. Once positioned, each subject completed four submaximal knee extension and flexion movements to become familiar with the apparatus at the test speed. Following a 45-second rest, each subject completed three maximal quadriceps and hamstrings contractions at a limb speed of 54° per second. The greatest of the three efforts was recorded as peak torque in the dimensions of foot-pounds.

Utilizing the method of Moffroid et al.,[8] the

* Presented at the 1982 Annual Meeting of the American College of Sports Medicine, Minneapolis, MN 55360.

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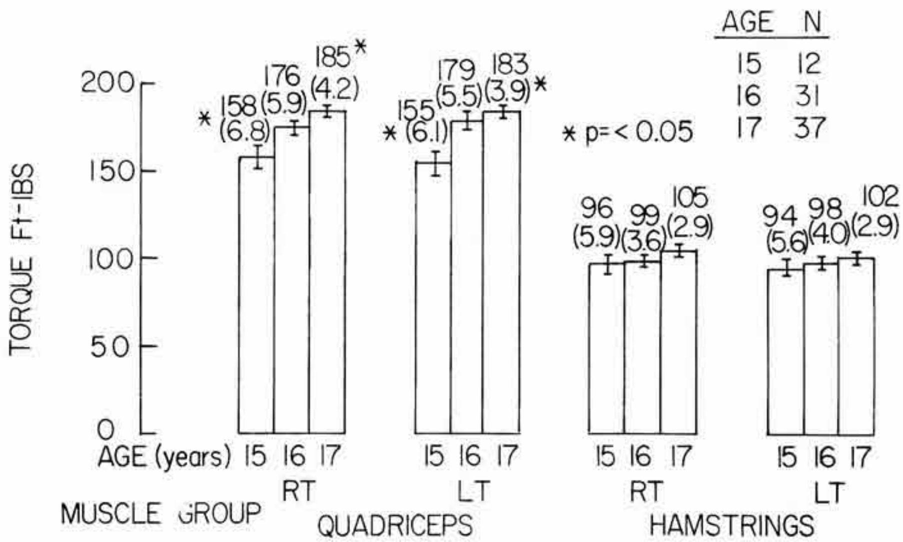

Fig. 1. *Mean quadriceps and hamstrings torque ± SE versus age.*

Cybex dynamometer was calibrated on the 360 foot-pound channel with the chart recorder damped at a setting of 3. During actual data collection, the chart recorder was damped at a setting of 2. The calibration yielded a validity coefficient of $r = 0.99$ between the predicted and measured torque values.

STATISTICS

A 1 × 3 (torque × age) analysis of variance was used to evaluate the interaction of peak torque with age. If statistical significance was observed, a Scheffé follow-up test[7] was administered to determine where significant differences existed among the means.

A linear regression analysis[7] was completed for measured quadriceps and hamstrings torque versus total body weight. Pearson correlations[12] were calculated on each variable. The probability of committing a Type I error (α) was set at 0.05 for all statistical tests.

RESULTS

The mean quadriceps and hamstrings torque ± SE as a function of age are presented in Figure 1. The analysis of variance of peak quadriceps torque revealed a significant difference ($P < 0.05$) across the sampled age range (Tables 1 and 2). The Scheffé test indicated that the right and left quadriceps torque generated by the 17-year-old age group was significantly different ($P < 0.05$) from the quadriceps torque generated by the 15-year-old group. On the other hand, the

TABLE 1

Analysis of variance of peak right quadriceps torque

Source of variation	SS	DF	MS	F
Between groups	6,870.06	2	3,435.03	4.16*
Within groups	63,485.82	77	824.49	
Total	70,355.88			

* Significant at the 0.05 level.

TABLE 2

Analysis of variance of peak left quadriceps torque

Source of variation	SS	DF	MS	F
Between groups	7,505.13	2	3,752.57	5.34*
Within groups	54,062.75	77	702.11	
Total	61,567.88			

* Significant at the 0.01 level.

Scheffé test indicated that the 16-year-old age group generated a mean right and left quadriceps torque which was not significantly different ($P > 0.05$) from the 15- and 17-year-old age groups. Further, the analysis of variance of peak right and left hamstrings torque demonstrated that no significant differences ($P > 0.05$) existed across the sampled age range (Fig. 1). Due to their small sample size ($N = 4$), the 18-year-old age group was deleted from this part of the statistical evaluation.

The relationship between left and right quadriceps torque is illustrated in Figure 2. The correlation coefficient between these two variables was $r = 0.86$ ($P < 0.05$). The mean bilateral torque difference ± SD was 6.0 ± 5.0% ($P > 0.05$).

The relationship of total body weight to right and left quadriceps torque is presented in Figures 3 and 4, respectively. The correlation between peak quadriceps torque and total body weight was significant ($P < 0.05$) and generated coefficients of $r = 0.68$ and $r = 0.74$ for the right and left musculature, respectively. The regression equations describing these relationships are presented in the *insets* of Figures 3 and 4. The standard error of the predicted right and left quadriceps torque was ± 21.8 and ± 19.2 foot-pounds, respectively.

The correlation between peak hamstrings torque and body weight was similar for both the right and left musculature (Figs. 5 and 6). The correlation coefficients for the right and left hamstrings were $r = 0.56$ and $r = 0.55$, respectively. The linear expressions describing the relationship between hamstrings torque and body weight are presented in the *insets* of Figures 5 and 6. The standard error of prediction for the right and

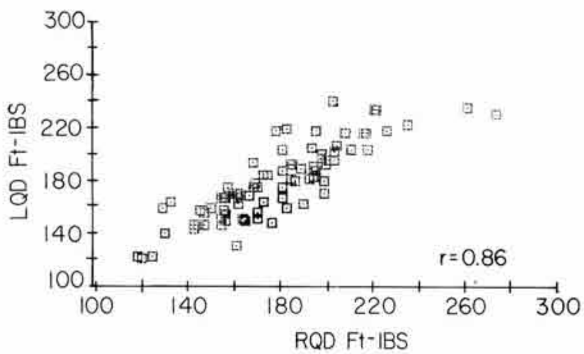

Fig. 2. *Left quadriceps torque versus right quadriceps torque for all subjects.*

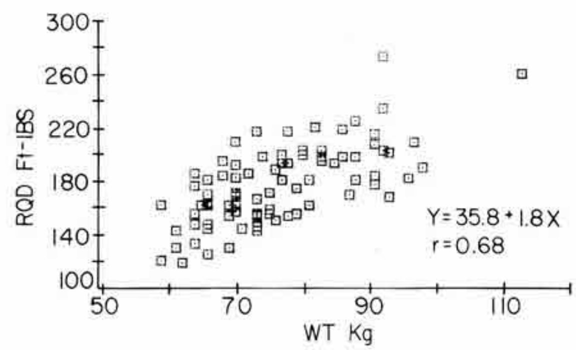

Fig. 3. *Right quadriceps torque versus total body weight for all subjects. The linear regression equation and the correlation coefficient are presented in the inset.*

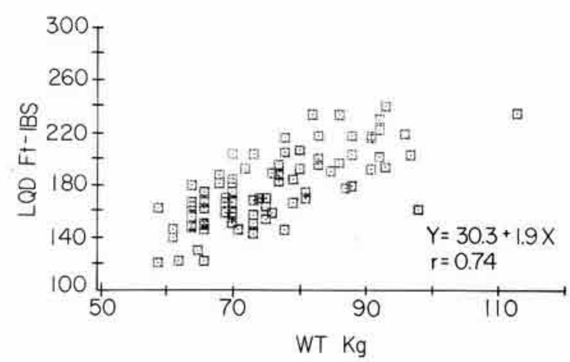

Fig. 4. *Left quadriceps torque versus total body weight for all subjects. The linear regression equation and correlation coefficient are presented in the inset.*

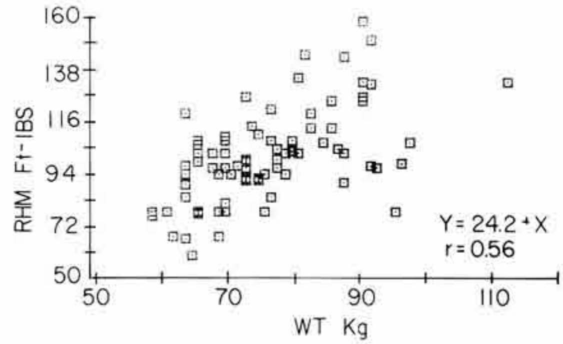

Fig. 5. *Right hamstrings torque versus total body weight for all subjects.*

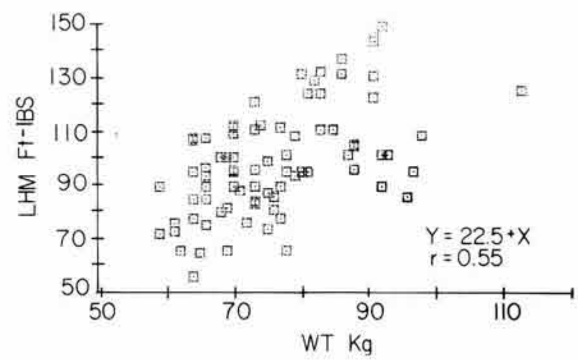

Fig. 6. *Left hamstrings torque versus body weight for all subjects.*

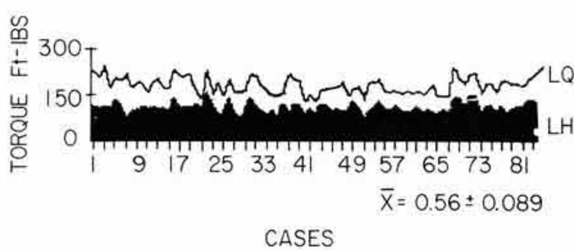

Fig. 7. *Left quadriceps and hamstrings torque for each subject. The mean ± SD is presented in the inset for all subjects (N = 84).*

left hamstrings torque was ±16.4 and ±16.8 foot-pounds, respectively.

The mean right hamstrings to quadriceps ratio of all subjects ± SD was 0.57 ± 0.084. The left ratio was similar at 0.56 ± 0.089 and is representative of the right relationship in Figure 7. In addition, the relationship between the hamstrings and quadriceps torque for the right and left musculature generated correlation coefficients of $r = 0.68$ and $r = 0.58$, respectively.

DISCUSSION

The purpose of this study was to evaluate the average quadriceps and hamstrings torque of the high school football player. Another purpose of this study was to evaluate the relationship between peak torque and total body weight. These variables were studied to help determine the minimal muscular torque values for participation in high school football.

The average quadriceps and hamstrings torque measured in this study agreed well with values reported by other investigators. For example, Gilliam et al.[5] sampled the right quadriceps and hamstrings torque of 115 high school football players at a limb speed of 30° per second. For the 15-, 16-, and 17-year-old athletes, the investigators reported mean peak quadriceps torques ± SE of 150.4 ± 3.6, 174.6 ± 5.06, and 185 ± 5.06 foot-pounds, respectively. Furthermore, they reported mean right hamstrings torque values at 93 ± 2.9, 99.8 ± 2.2, and 110 ± 3.6 foot-pounds, respectively. There is little difference between these values and the measurements reported in this study (Fig. 1). Thus, the data in the present study are taken to be representative of the muscular performance of the average high school football player. In addition, Murray et al.[9] reported the mean leg extension torque ± SE measured at a limb speed of 36° per second from a relatively inactive 20- to 35-year-old age group at 184 ± 8.4 foot-pounds. Therefore, it appears that the average extension torque of this age group is quite similar to the extension torque of the 17-year-olds in the present investigation.

The test velocity in the present study was 54° per second. Gilliam et al.[5] and Murray et al.[9] tested at a slower limb speed than the selected speed in the present study. Thus, one would have expected lower measured torque values in the present investigation due to the effect of the preselected velocity on force.[10] A possible tentative explanation for this unexpected observation may be that these subjects generated peak torques at similar angles of knee joint flexion. Also, it is possible that the subjects tested in the 30 to 36° per second velocity range experienced discomfort and due to pain were caused to generate less torque than would be predicted by the force-velocity relationship.[3]

It was not surprising that the right and left quadriceps torque correlated closely to one another. Other investigators[2, 5, 11] have observed only minimal nonsignificant bilateral torque differences. For example, Gilliam et al.[5] and Coleman[2] reported bilateral torque differences which amounted to only 2 to 3% of the contralateral limb. In addition, Gilliam et al.[5] reported that correlations between the right and left leg torque were better than $r = 0.82$. In the present investigation, the correlation between the right and left quadriceps produced a coefficient of $r = 0.86$. On the other hand, Wyatt and Edwards[14] observed that males generated significantly greater muscular torque in the dominant limb than the nondominant limb. At a limb speed of 60° per second, the investigators reported a mean absolute quadriceps and hamstrings torque difference ± SD of 12 ± 10 and 10 ± 9 foot-pounds, respectively. The present study was completed blind with regards to extremity dominance and the absolute mean quadriceps and hamstrings torque difference was in agreement with the data of Wyatt et al.[14] at 11 ± 10 and 9.6 ± 8.1 foot-pounds, respectively.

It is of interest and significant application that total body weight was an acceptable predictor of quadriceps torque. The use of total body weight in the predictive method is a simple technique and has recently been shown to correlate as well with knee extension and flexion torque as lean body weight.[1] In this connection, body weight may be used to predict a so-called *normal* quadriceps torque range. For example, the standard error of the estimate was ± 21.8 foot-pounds for the right quadriceps musculature. This means that a clinician can expect 68% of the measured cases to fall ± 21.8 foot-pounds from the weight-predicted quadriceps value. Thus, if a high school football player generates a quadriceps torque that is greater than 1 standard error below his predicted value, the clinician should evaluate this athlete for possible lower extremity disorders. This would not be unreasonable, since at least 84% of the athletes tested would be expected to generate more quadriceps torque than an individual who scores greater than 1 standard error below his weight predicted value. Obviously, this method of evaluation has great application to the preseason physical assessment of high school football players.

The hamstrings to quadriceps torque ratio has been reported to fluctuate between 50 and 72% in selected populations.[4-6, 14] Davies et al.[4] reported ratios between 51 and 64.9% for professional football players. Wyatt et al.[14] observed ratios between 61 and 72% when the torque was measured at 60° per second. Gilliam et al.[6] has calculated ratios in the 40 to 70% range for children between the ages of 7 and 13 years. Thus, the hamstrings to quadriceps ratios reported in the present investigation agree well with other values reported in the literature.

CONCLUSIONS

The average quadriceps torque increased significantly ($P < 0.05$) in athletes between the ages of 15 and 17 years. In addition, an acceptable relationship was observed between the total body weight and the peak quadriceps torque. However, when using body weight to predict a so-called *normal* quadriceps torque, the clinician must consider that a measured torque value $\pm$ 19.2 and $\pm$ 21.8 foot-pounds of the predicted value would be an acceptable minimal value for the left and right musculature, respectively. This information may be useful for the identification of high school football players who have had musculotendinous injuries or direct trauma to the knee joint.

Further, when evaluating bilateral torque differences, these data indicate that the clinician can expect to observe a torque difference of 1 to 11% between the quadriceps and 2 to 16% between the hamstrings.

Finally, these data demonstrated that the high school football player has a hamstrings to quadriceps ratio between 47 and 65%.

SUMMARY

This information may be useful for the identification of high school football players which have had a past history of trauma to the lower extremity. The clinician can apply the information presented in this paper for screening criteria during the preseason assessment of the high school football player.

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