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Norms for High School Football Players Derived from Cybex Data Reduction Computer

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Three hundred and forty-two male high school football players, ranging in age from 15 to 17, were screened for muscular imbalances and joint abnormalities about the knee using a Cybex II Isokinetic Dynamometer and Cybex Data Reduction Computer. Each player was tested at speeds of 60, 240, 300, and 300° per second for muscular work. The athletes were classified by position (quarterback, runningback, tight end, wide receiver, linemen, linebacker, and defensive back). Several parameters were reported: peak torque with gravity effect for both extensors and flexors, peak torque to body weight, opposing muscle group ratios, torque acceleration energy, work over a preselected number of repetitions, endurance ratio, and agonist-antagonist work ratios.

The purpose of the screening was to provide data beneficial for the prevention of injury from muscular imbalance and joint instability, data useful as clinical guidelines for rehabilitation and return to play, and suggestions for strength training programs.

Previous articles have been published showing peak torque, and quadriceps and hamstring ratios, as a means of preventing injury due to muscular imbalance. However, until the introduction of the Cybex® Data Reduction Computer, authors had no way of taking the effect of gravity on the lower limb into consideration when presenting their findings. Hamstring-quadricep ratios, once thought to be ideal at 60% or better at 60° per second are now better set at 50 to 55% with gravity effect at 60° per second. The intent of this paper is not to draw any specific conclusions but to present meaningful data for the purpose of preseason screening to prevent injuries and to aid in strength-training programs.

Three hundred and forty-two male high school football players were tested for muscular imbalance and joint abnormalities during knee extension and flexion using a Cybex Dynamometer® and Cybex Data Reduction Computer (Cybex, Division of Lumex, Inc., Ronkonkoma, NY 11779).

The evaluations were done as part of a screening program to help prevent injuries and to aid in strength-training programs. Each athlete was measured for peak torque over four repetitions at 60, 240, and 300° per second, and for work at 300° per second over 20 repetitions, with a sample of the first five and last five repetitions giving an endurance ratio. The Cybex II Recorder and Data Reduction Computer were calibrated before each testing, using certified calibration weights and Cybex instructions.[2]

Subjects were tested in the sitting position with the knee stabilized. Athletes were allowed proper warm-up and were given instructions to familiarize them with the apparatus and test program. The lower limb was weighed for its effect of gravity against extension and with flexion automatically recorded by the computer. This was accomplished by slowly dropping the relaxed lower leg from extension to a point in the range of motion where there was no tension on the hamstrings and quadriceps.

The Cybex Data Reduction Computer gives instantaneous analysis of all Cybex II dual channel tests. While many are familiar with peak torque and agonist-antagonist ratios,[1,3–8,10] total work, torque acceleration energy, work endurance ratio, and work flexion-extension ratios have not been reported. For both agonist and antagonist muscle groups, the following data was collected. Total

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work data is derived by multiplying torque times distance or the total area under the torque curves over a preselected number of repetitions. Torque acceleration energy is the measure of the amount of energy expended in the first one-eighth of a second during torque production, or the rate at which motor unit-fiber recruitment takes place. Endurance ratio is a new measure comparing the work performed in the first and last preselected number of repetitions during the work test. Before this endurance test was possible, the "number of repetitions to 50% fatigue" method was used.

Test results performed are listed in Tables 1 and 2. Table 1 shows results by position for peak torque in extension and flexion plus the percentage of that peak torque to body weight. As previously stated,[3,5,7,9] torque decreased as the speed of movement increased. Since most of the schools tested use the same players on offense and defense, to draw any definite conclusions as to who develops the greatest amount of torque for extensors compared to their body weight is difficult. For example, running backs are also generally used as linebackers. However, running backs, wide receivers, and linebackers did exhibit the greatest amount of torque at all speeds of contraction, as can be expected, since they are in general the leanest in body weight, the fastest, quickest, and best athletes on the team. In contrast, linemen develop the least amount of torque for extensors compared to their body weight. Flexors generally followed the same pattern, except at the slow speed (60° per second), where tight ends developed greatest torque to body weight. However, this could be attributed to the relatively small number of tight ends tested as compared to players in other positions.

In Table 2, torque acceleration energy (TAE), total work over 20 repetitions (W-20), endurance ratio (E-ratio), and flexion extension work ratios are shown. There are no significant differences in TAE or endurance ratios for both extensors and flexors. However, there were differences in total work where running backs and linebackers were prevalent.

Table 3 shows hamstring-to-quadriceps ratio, which is one of the more, if not the most, important factors of consideration. The previous conventional methods of deciphering Cybex data has yielded hamstring-to-quadricep ratios of a higher percentage. Using the Data Reduction Computer, and weighing the lower limb for its effect against gravity in extension and with gravity in flexion,

TABLE 1

Position averages for torque and body weight

Position/No.	60°/sec* (%)	Extension	% to Body Wt	Flexion	% to Body Wt	20°/sec* (%)	Extension	% to Body Wt	Flexion	% to Body Wt	300°/sec* (%)	Extension	% to Body Wt	Flexion	% to Body Wt
QB (26)	55	169	113	93	63	69	94	65	65	43	68	80	54	54	37
RB (39)	55	177	116	98	61	67	102	67	68	45	71	84	56	60	39
TE (28)	58	180	113	105	64	68	103	63	70	43	69	84	52	57	35
WR (61)	53	158	117	84	60	64	90	66	58	43	63	81	56	51	37
Linemen (120)	55	179	102	98	55	65	103	58	67	38	66	87	48	57	33
LB (33	52	180	115	94	60	64	103	66	66	42	66	86	55	57	36
DB (35)	52	165	114	85	59	65	93	64	60	41	68	78	54	53	37
Average	54	173	113	94	60	66	98	64	65	42	67	83	54	56	36

* Hamstring-to-quadriceps ratio.

TABLE 2
Position averages for work

Position	W 300°/Sec Column Extension	TAE*	W-20*	E*-Ratio	Flexion	TAE	W-20	E-Ratio	F/E* Work Ratio
QB (26)		35.82	1286	68		29.15	1293	75	102
RB (39)		37.26	1421	68		29.97	1331	70	99
TE (28)		38.67	1317	68		32.47	1333	70	102
WR (61)		33.30	1205	70		27.70	1204	71	102
L (120)		38.21	1388	68		30.41	1310	71	96
LB (33)		37.66	1413	69		30.20	1317	71	94
DB (35)		35.18	1295	68		27.26	1280	74	101
Average		36.59	1332	68		29.59	1295	72	99

* TAE, torque acceleration energy; W-20, total work over 20 repetitions; E, endurance; F/E, flexion/extension.

TABLE 3
Hamstring-to-quadricep ratios (%) by position

Position	60%/sec	240°/sec	300°/sec
QB	55	69	68
RB	55	67	71
TE	58	68	69
WR	53	64	63
Linemen	55	65	66
LB	52	64	66
DB	52	65	68
Average	54	66	67

has changed those percentages. The author found that by measuring the peaks on the graph paper with the Cybex chart card, and comparing those ratios to the computer ratios, the difference averaged between 8 to 12 percentage points lower for the computer at all three speeds. There was no significant difference in hamstrings/quadriceps ratios between all positions at each speed.

This article provides normative data for screening of high school football players between the ages of 15 to 17. The methods of testing, protocol, instrumentation, and results are presented. This article describes new applied methods for using the Data Reduction Computer as a meaningful instrument for preseason screening of athletes and procedures for establishing clinical guidelines for rehabilitation and return to play.

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REFERENCES

1. Bailey D: Strength imbalance common in young gridders. USSA News 4:11
2. Cybex—Computer and dynamometer calibration instruction—Isolated joint testing and exercise, 1983.
3. Elliott J: Assessing muscle strength isokinetically. JAMA 240:2408–2410, 1978
4. Gilliam TT, Sady SP, Freedson PS, Villanacci MS: Isokinetic torque levels for high school football players. Arch Phys Med Rehabil 60:110–114, 1979
5. Goslin BR, Charteris J: Isokinetic dynamometry: Normative data for clinical use in lower extremity (knee) cases. Scand J Rehabil Med 2:105–109, 1979
6. Miyashita M, Kanehisa H: Dynamic peak torque related to age, sex, and performance. Res Q Exerc Sport 50:249–255, 1979
7. Molnar G, Alexander J: Objective, quantitative muscle testing in children: a pilot study. Arch Phys Med Rehabil 54:224–228, 1973
8. Schlinkman B: Isokinetic torque levels for high school, college, and professional football players (unpublished data), Dallas, TX
9. Thorstensson A, Brimby G, Karlsson J: Force-velocity relations and fibre composition in human knee extensor muscles. J Appl Physiol 40:12–16, 1976
10. Wyatt MP, Edwards AM: Comparison of quadriceps and hamstring torque values during isokinetic exercise. J Orthop Sports Phys Ther 3:48–56, 1981