Bilateral Isokinetic Peak Torque, Torque Acceleration Energy, Power, and Work Relationships in Athletes and Nonathletes

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Abstract:

Clinicians frequently assume the uninjured extremity can be used as a predictor of preinjury strength for return of the injured extremity to a normal state during rehabilitation. The purpose of this study was to examine differences in bilateral isokinetic peak torque (PT) at 60 and 180 ° /sec, and torque acceleration energy (TAE), average power (AP), and total work (TW) at 180 °/sec during knee extension and flexion, shoulder extension and flexion, and shoulder internal and external rotation in right hand dominant pitchers, swimmers, and nonathletes. PT values were greater for the right than left sides ($p < 0.05$) for shoulder extension (60 and 180°1 sec) for all three groups. Right side internal rotation (780 °/sec) TAE, AP, and TW values were greater than left ($p < 0.05$) for pitchers but not for swimmers and nonathletes. These findings question the efficacy of assuming bilateral equivalency for PT, TAE, AP, and TW measures in the prescription of therapeutic exercise for all muscle groups in all athletic and nonathletic populations.

Article:

It has been assumed by many sports medicine clinicians that peak torque, torque acceleration energy, power, and work values for the uninvolved extremity can be used as goals for return of the injured extremity to a normal state during rehabilitation. That is, the prescription of therapeutic exercise for rehabilitation of injuries is based on bilateral equivalency. However, the differential influence of handedness and of the neuromuscular demand of various athletic performances on bilateral muscle group relationships questions the efficacy of this prescription process.

A considerable amount of attention has been given to the measurement of isokinetic torque of the lower extremities in athletic and nonathletic populations.[2,4-6,9,13,15] Research describing upper extremity bilateral peak torque relationships has been less extensive.[8,10,12] The results of these investigations involving both the upper and lower extremities have been inconsistent with regard to bilateral torque differences in both of these populations. [1,2,8,10,12,14,15]

The interfacing of microprocessors with isokinetic dynamometers has enabled the rapid and reliable quantification of muscular forces including torque acceleration energy, power, and work." This capability has become commonplace in many sports medicine settings. However,

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while bilateral peak torque relationships have been reported. virtually no research has examined bilateral torque acceleration energy, power, and work relationships.

The purpose of this investigation was to examine differences in bilateral isokinetic peak torque (PT) in pitchers, swimmers, and nonathletes. It was expected that two primary mechanisms would account for observed bilateral differences, i.e., normal extremity dominance and neuromuscular adaptation from sport performance. As such, subject samples were selected that would allow exploration of these two mechanisms. Pitchers demand neuromuscular adaptation for sport performance in a bilaterally asymmetrical manner. Nonathletes should exhibit bilateral strength relationships reflecting normal extremity dominance.

An additional purpose of this investigation was to determine if bilateral torque acceleration energy, power, and work measures were consistent with observed bilateral peak torque relationships. To that end, torque acceleration energy (TAE), average power (AP), and total work (TW) measures were also obtained from the sample populations (Table 1).

MATERIALS AND METHODS

Fifteen male intercollegiate baseball pitchers, 15 male intercollegiate swimmers, and 15 male nonathletic college students between the ages of 18 and 27 years (X = 19), and weighing between 64 and 95 kg — 77), participated as subjects in the study. Only right hand dominant (dextral) subjects were used. Each subject was medically screened for previous injury to the knee or shoulder, and only individuals who were free of such clinically significant injuries were allowed to participate. Subjects gave their written consent to participate. All experimental procedures were approved by an Institutional Review Board for Biomedical Research.

Bilateral strength was measured with a Cybex II Isokinetic Dynamometer (Cybex, Ronkonkoma, NY) equipped with an Upper Body Exercise and Testing Table (UBXT). The Cybex II dual channel recorder and dynamometer were interfaced with the Cybex Data Reduction Computer (CDRC) for analysis of test results. Each subject underwent isokinetic testing for the right and left knee extensor and flexor, shoulder extensor and flexor, and shoulder internal and external rotator muscle groups. Subjects were stabilized with straps during testing, and the joint's axis of rotation was aligned with the input shaft of the dynamometer. To provide gravity correction during knee testing, the gravitational moment of the Cybex arm, shank, and the leg were determined by the CDRC.

TABLE 1
Definitions

Peak Torque: the highest torque produced during a given contraction
Torque Acceleration Energy: the work performed in the first one-eighth second of torque production
Average Power: the total work divided by actual total contraction time
Total Work: the sum total of area under all the torque curves in the test repetitions

Shoulder extension and flexion strength were assessed with subjects in the supine position. Adapters were used to block flexion at 165° and extension at 0°. Shoulder internal and external rotation were assessed with subjects in the supine position and the shoulder abducted to 90°. Internal rotation and external rotation were each blocked with adapters at 90°. In contrast to the lower extremities, upper extremity mass relative to total body mass does not necessitate gravity correction during testing.

Each subject was verbally oriented to the fixed speed, accommodating resistance concept of isokinetic exercise. After setting the apparatus for the appropriate joint, the subject underwent a warm-up session at 60°/sec. Warm-up consisted of three submaximal and three maximal repetitions, followed by a 1-minute rest period prior to testing. Testing at 60°/sec included four maximal repetitions. A 2-minute rest period occurred prior to the warm-up for the next testing speed. The warm-up for testing at 180°/sec consisted of three submaximal and three maximal repetitions, followed by a 1-minute rest period. Testing at 180°/sec included 25 maximal repetitions. A 2minute rest period was allowed prior to testing for the next joint movement.

The order of testing for muscle groups was determined by random selection. The order of the side to be tested was determined by restricted randomization using a counterbalanced design. PT measures were obtained at both testing speeds, and TAE, AP, and TW measures were obtained during the 25 repetition work test at the fast speed of contraction. All isokinetic measures were obtained during one test session in a laboratory controlled environment. Subjects were in a 3-hour postabsorptive state, and had not engaged in other exercise on the day of testing.

In order to determine if bilateral differences existed between specific muscle groups, 12 two-way analyses of variance (ANOVA) were computed for measures at both 60 and 180°/sec. Six were for PT at 60°/sec and six for PT at 180°! sec. Eighteen two-way ANOVAs were computed at 180°/sec. Six were computed for each measure of TAE, AP, and TW. The unit of measurement for PT, TAE, and TW was newton-meters, and measurement of AP was in watts.

RESULTS

PT measures were obtained at test speeds of 60 and 180°/sec. Statistically significant differences were not found between right and left sides in all three groups for PT during knee extension and flexion, shoulder internal and external rotation, and shoulder flexion at both test speeds. Bilateral PT measures for knee extension and flexion were within 4% for all three subject populations. PT values were greater for the right than left sides ($p < 0.05$) for pitchers, swimmers, and nonathletes during shoulder extension at both test speeds (Figs. 1 and 2). Although not statistically significant, bilateral differences for shoulder internal rotation approached 10% at both test speeds for pitchers. PT values were within 5/0 for swimmers and nonathletes,

TAE, AP, and TW measures were obtained at 180°/sec. No bilateral differences were found for TAE, AP, and TW during knee extension and flexion, shoulder extension and flexion, and shoulder external rotation for all three groups. With the exception of shoulder extension, these findings for TAE, AP, and TW were consistent with observations for PT measures obtained at 180°/sec.

TAE, AP, and TW during shoulder interval rotation were greater for the right than left sides ($p < 0,05$) for pitchers but not for swimmers and nonathletes (Figs. 3-5). Values were on average 15% greater for the right than left sides in the pitchers for each isokinetic measure. TAE, AP, and TW bilateral measurements were within 5% for swimmers and nonathletes.

DISCUSSION

Lower extremity bilateral PT relationships have been reported previously in baseball players[3] and non-athletes[2,7] but not swimmers. The lower extremity bilateral PT relationships observed in this investigation were consistent with observations of no significant difference in baseball players reported by Coleman.[3] However, the relative bilateral symmetry in lower extremity peak torque in nonathletes in this investigation is inconsistent with previous reports by Wyatt and Edwards[15] and Charteris and Goslin.[2] Bilateral differences have also been reported for athletic populations.[1,12] This descrepancy among reports of lower extremity bilateral strength may be attributed to the variation among authors in the definition of an appropriate bilateral relationship.

It was expected that neuromotor dominance would have an effect on the difference in peak torque between right and left sides of the body for upper extremity peak torque measures. Further, the demand an athlete places on specific muscle groups during the throwing technique should produce a larger difference between right and left sides in pitchers than swimmers and nonathletes. It was expected that right side shoulder internal rotation and shoulder extension would be greater than left in pitchers as a result of the neuromuscular specificity of their sport. Pedegana et al[10] observed that the dominant side shoulder extensor and internal rotator muscle groups in professional baseball players were greater than the nondominant side. However, this investigation found greater peak torque values for right side shoulder extension in all three subject groups. These findings suggest that for the shoulder extensors, normal extremity dominance may be the primary determinant of bilateral differences rather than the throwing motion. Although not statistically significant, shoulder internal rotation values indicated right side PT was nearly 10% greater than left for pitchers while being within 5% for swimmers and nonathletes. This observation is more consistent with the findings reported by Pedegana et al.[10] for the shoulder internal rotator muscle group, and suggests a neuromotor adaptation to the throwing technique.

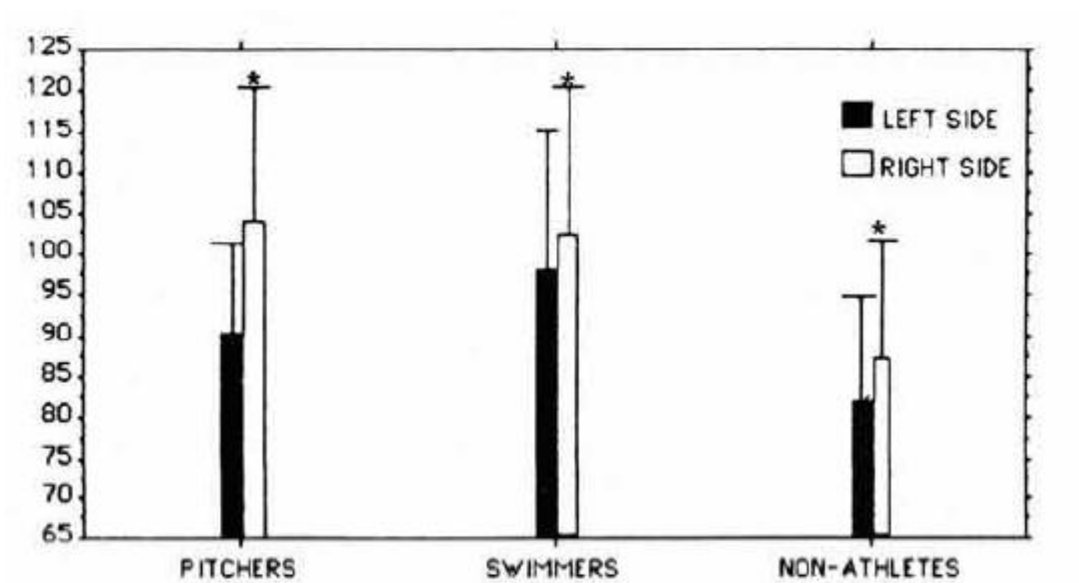

Fig. 1. A comparison of right and lett side peak torque during shoulder extension at 60°1sec for pitchers, swimmers, and nonathletes (mean ± SD). Asterisks indicate right side value significantly greater than left ($p < 0.05$).

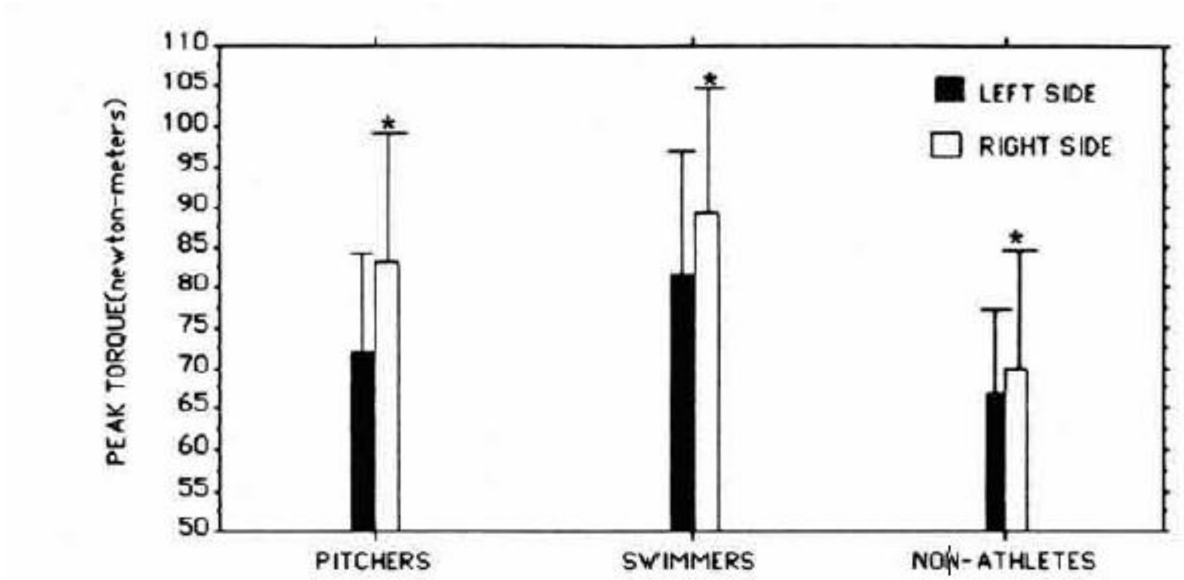

Fig. 2. A comparison of right and left side peak torque during shoulder extension at 180'7sec for pitchers, swimmers, and nonathletes (mean ± SD). Asterisks indicate right side value significantly greater than left ($p < 0.05$).

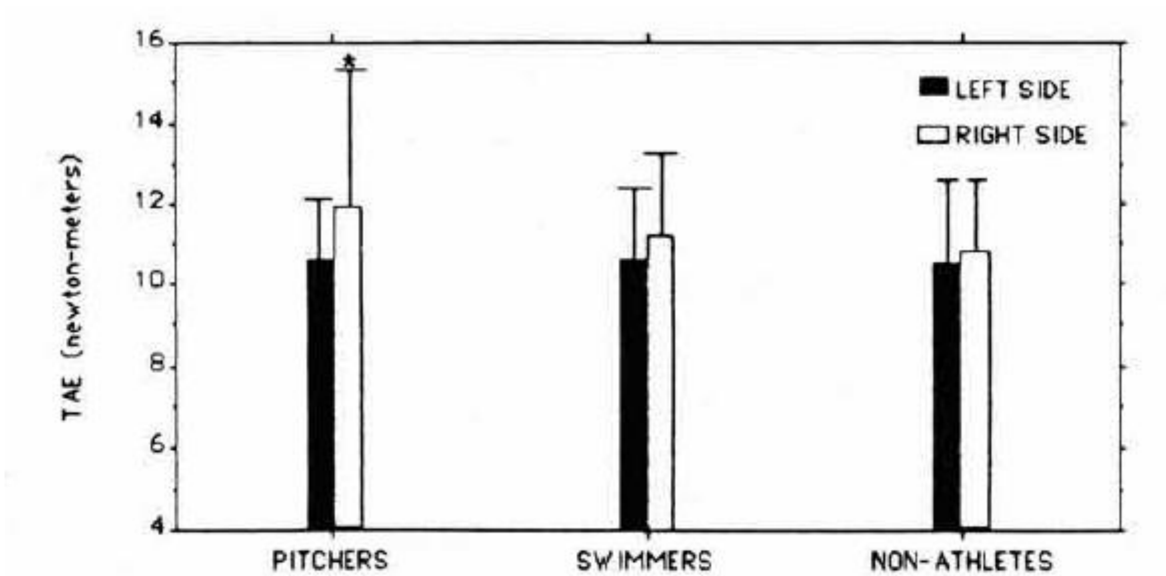

Fig. 3. A comparison of right and left side torque acceleration energy during shoulder internal rotation at 180° /sec for pitchers, swimmers, and nonathletes (mean ± SD). Asterisk indicates right side value significantly greater than left ($p < 0.05$).

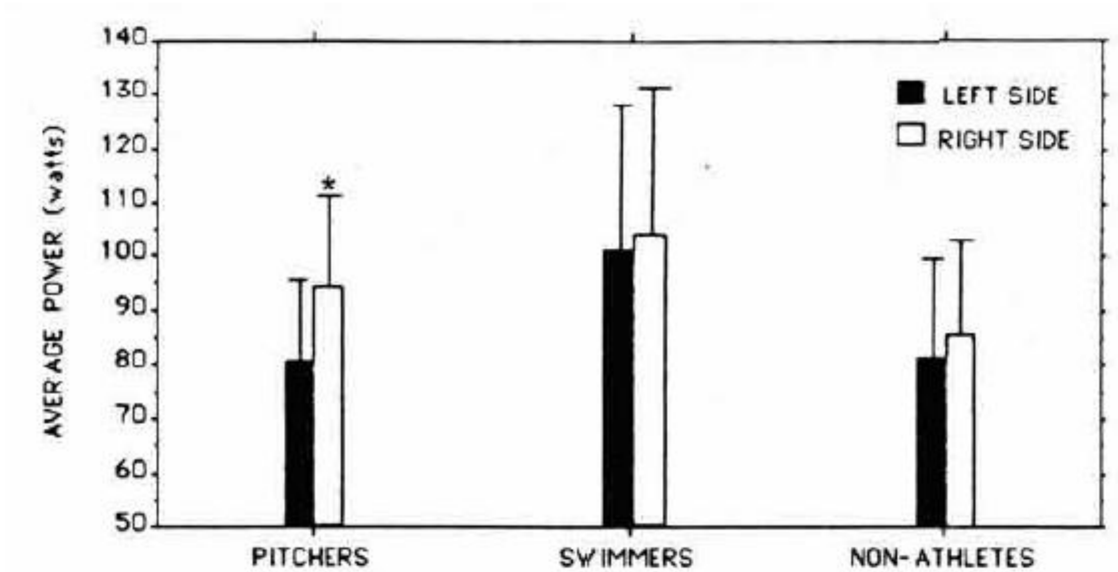

Fig. 4. A comparison of right and left side average power during shoulder internal rotation at 180° /sec for pitchers, swimmers. and nonathletes {mean ± SD). Asterisk indicates right side value significantly greater than left (p < 0_05)

Observations of no significant difference for TAE, AP, and TW were consistent with PT at 180°/sec during knee extension and flexion, shoulder flexion, and shoulder external rotation for all three subject groups. However, although right side shoulder extension PT was greater than left for pitchers, swimmers, and nonathletes, no significant differences were observed for shoulder extension TAE, AP, and TW for any of the subject populations.

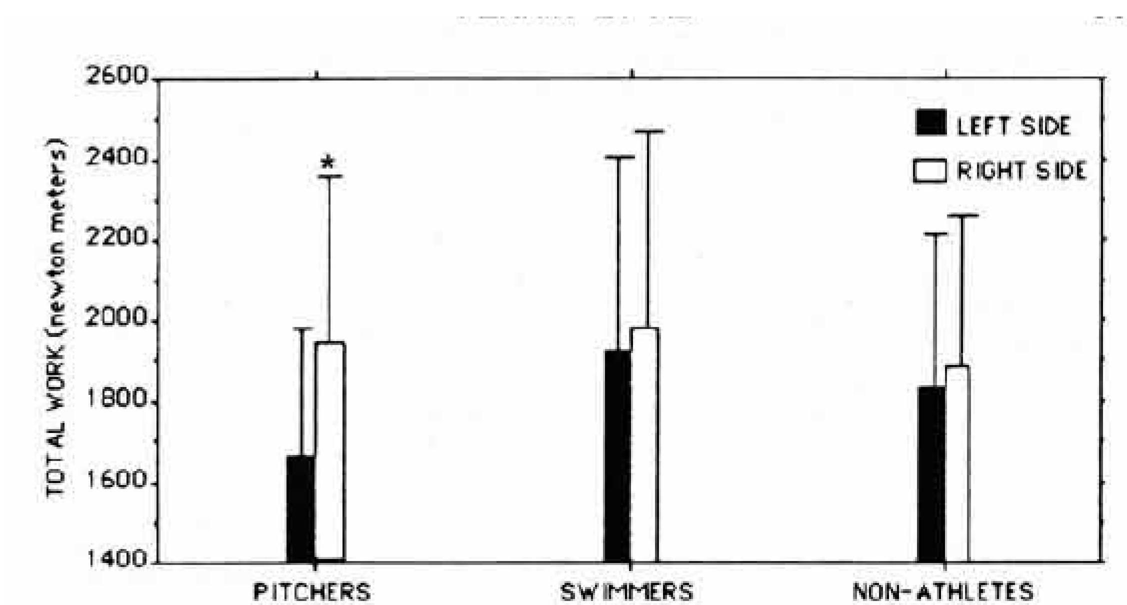

Fig. 5. A comparison of right and left side total work during shoulder internal rotation at 180° /sec for pitchers, swimmers, and nonathletes (mean ± SD). Asterisk indicates right side value significantly greater than left (p < 0.05).

TAE, AP, and TW during shoulder internal rotation were greater for the right than left sides ($p < 0.05$) for pitchers but not for swimmers and nonathletes (Figs. 3-5). Right side values were 15% greater than left for pitchers, but did not differ by more than 5% for swimmers and nonathletes. These bilateral differences are even more pronounced than for PT during shoulder internal rotation. Right side PT values were W% greater for pitchers while bilateral PT for swimmers and nonathletes was within 5%. These bilateral relationships Illustrate a neuromuscular adaption that can be attributed to a specific athletic skill rather than to normal dextral activities.

CONCLUSION

The purpose of this investigation was to examine for bilateral differences in peak torque, torque acceleration energy, average power, and total work during knee extension and flexion, shoulder extension and flexion, and shoulder internal and external rotation in pitchers, swimmers, and nonathletes_ Dominant side values were greater than the nondominant side for shoulder extension peak torque for all three subject populations. A similar bilateral muscle group relationship was observed for shoulder internal rotation peak torque, torque acceleration energy, average power, and total work, but only for the pitchers.

The implication of these findings is that while the assumption of bilateral equivalency as a goal of therapeutic exercise may be appropriate for some muscle groups in some athletic and nonathletic populations, this principle does not neces sarily apply to all populations and all muscle groups. Further, while bilateral peak torque relationships may be consistent with torque acceleration energy, power, and work measures for some muscle groups, such a state cannot be assumed for all muscle groups. This phenomenon may especially pertain to the injured muscle group undergoing therapeutic exercise. Additional compilation of normative peak torque, torque acceleration energy, power, and work data for bilateral muscle groups for these and other sport samples would enable clinicians to more accurately set guidelines for rehabilitation of a wide range of athletic groups with varying physical characteristics. Normative data should be collected especially for athletes participating in sports in which selected bilateral muscle groups are used in an asymmetrical manner.

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