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Knee Strength of Professional Basketball Players

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ABSTRACT

The influence of intensive and systematic training on the lower-extremity strength of professional basketball players has not yet been defined. The purpose of this study was to evaluate professional basketball players' concentric strength of knee extension and flexion and the full range of motion, using an isokinetic dynamometer at 60 and 180°·s^{-1}. The sample consisted of 12 male basketball players, all members of the same professional basketball team that has players in all playing positions. According to the results, there was no statistically significant difference between the dominant and the nondominant limb on the measures of peak torque, peak torque per body weight, work per repetition, and work per repetition to body weight ratio. There was a statistically significant increase in the ratio of peak torque in concentric flexion and extension of the knee with the increase in velocity. At the same time, the flexion-extension ratios of knees at 60 and 180°·s^{-1} are outside the limits of the literature. Therefore, we conclude that hamstrings in these athletes present higher-than-normal values in strength when compared with the literature. At the velocity of 180°·s^{-1}, in flexion and extension, the values of peak torque and peak torque per body weight demonstrate greater strength in the nondominant limb in relation to the dominant. These results provide information about the existing relation between the dominant and the nondominant limb and the relation of flexors and extensors in concentric action, which seems to increase with the increase of velocity. The research encourages further study on basketball athletes and, more specifically, on the relation of flexors and extensors of the knee.

Key Words: knee extension, knee flexion, concentric strength

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Introduction

Participation in team basketball demands the continuous improvement of the players in the 2 most important physical elements of the sport: technical ability level and physical condition. According to the competition level, each of these elements must be highly developed, especially in professional players. This can be achieved after strenuous and systematic training.

Various measuring techniques have been used to define muscle strength, endurance, and velocity. For these measures, research has been based on isometric, constant load variable speed exercise, and isokinetic actions (2, 12, 32, 54).

Especially during the past few years, calculation of muscle strength has been based on isokinetic dynamometers, which provide a stable angular velocity along the full range of motion. The main goal of this kind of apparatus is the athletes' rehabilitation from injuries, but advanced technology (e.g., the ability to connect athletes with computers) provides much more information (22, 55). We can now have maximum production of muscle strength in the whole range of motion in conflict with the constant load variable speed exercise and isometric actions (17, 27, 38).

Many researchers have tried to present the features and advantages of this kind of exercise regarding movement velocity, body position (35), or even isometric and constant load variable speed exercise actions (50). Some other authors have studied subjects who present with serious problems that demand rehabilitation (8, 24, 30, 33, 41). Most research subjects are athletes of a specific sport, e.g., volleyball (49), tennis (53), professional football (16, 36, 39, 46), gymnastics (13), or speed running (3, 43).

The results of a regular training program on professional basketball players or the level of their physical condition has not been defined with accuracy. Especially when the measures required were probably made by the team managers, who were not able to present a level of scientific information such as the isokinetic devices could provide.

In basketball, regular and intensive practice of the sport leads to a large increase in athletic injuries (4, 9, 21, 23). These injuries can be syndesmotic, muscular, or concerning the bones and may be caused by lack of muscle balance between athletes lower limbs, where most of the injuries appear (18, 37, 42, 48).

Table 1. Means and *SDs* for height, weight, age, and the distribution of dominance of the limbs in a sample of 12 basketball players.

Variable	Mean	*SD*
Age (y)	20.92	±3.03
Height (cm)	87.92	±15.34
Weight (kg)	191.33	±11.15
Dominant right	11	—
Dominant left	1	—

Assuming that muscular balance problems could be a result of the training process and less the result of genetic-anthropomorphic factors, this study was based on athletes with high physical condition who follow a steady training program.

The main aim of this study was to provide specific data concerning professional basketball athletes by the means of quadriceps and hamstrings strength, using an isokinetic dynamometer. Therefore, this study of a particular team of professional basketball players was made to define the following: (a) the level of strength as expressed by peak torque, peak torque per body weight, work per repetition, and work per repetition to body weight ratio in concentric flexion and extension of the knee; (b) the ratio of the knee flexors and extensors at the testing speeds of 60 and $180°\cdot s^{-1}$; and (c) lower-limb range of motion at the testing speeds of 60 and $180°\cdot s^{-1}$. This will be followed by an examination of the strength relationship between the dominant and nondominant limbs of the athletes.

The definition of dominant limb is a matter of controversy among scientists (56). For most (35, 45), the dominant limb was defined as the leg with which the player would kick a ball. In this research, the same definition of dominant was followed.

Methods

The study sample consisted of 12 professional basketball athletes who were the main roster of a A2 National League team in Greece.

Of these athletes, 4 were playing the guard position, 4 were forwards, and 4 were centers. This sample covered all the possible play positions, moves, and physical abilities of the athletes, since these types of athletes have notable differences in height, weight, and particularly strength. For example, players who play in the center position have large somatomorphic differences from players who play as guards. In addition, forwards are not as tall or heavy as centers or as quick and flexible as guards.

The physical characteristics of the athletes are presented in Table 1. None of them had prior injuries that would eliminate them from participation during the last year.

During the championship period, these athletes were submitted to a constant weekly program that included 5 training sessions concerning technique and tactic and 1 game and 3 training sessions concerning the maintenance or improvement of their physical condition, 2 of which were weight training and the other one anaerobic or aerobic endurance training. Seven of the athletes had previous experience with an isokinetic measurement.

Dynamometric Analysis

Lower-limb strength was measured with Cybex-1200 (Division of Lumex Inc., Ronkonkoma, NY) in the ergometric and rehabilitation center Ikaros in Thessaloniki, Greece.

The athletes were positioned on the examination chair according to the instructions in the Cybex manual. The hips were placed in 90° of flexion, and the thighs and the trunk were secured by straps. The pad of the lever arm was placed on the crossing of the upper two-thirds and one-third of the down side of the leg (approximately 5 cm superior to the medial malleolus). The height of the dynamometer was set in a way that its rotation axis corresponded to the rotation axis of the knee. The athlete kept the opposite leg fixed, and his 2 arms were held firmly by handles placed left and right on the device.

Of course, the stabilization of the athlete was very important. Without stabilization, the relationship between the angle of the joint and the angle of the Cybex lever arm would have been changed. At different joint angles, different muscle groups or muscle fibers could affect the production of the force (13). In case the athlete made a large effort during the test, the researcher added his own resistance, helping to hold back the leg to reduce slipping of the leg.

Test Protocol

The tests were made on extension and flexion of the knee. A preliminary bout of isokinetic measurement was made for each athlete to become familiar with the testing procedure.

After calibration, adjustments of the various subject positions and gravity compensation were made (5). The different tests were initially made for every limb separately with concentric practice. The selection of the leg that was examined first (dominant or nondominant) was made randomly.

We followed the previously described definition of limb dominance. Of the sample, only 1 player had left dominant limb. All the rest had right dominant limb.

Before any testing procedure, a warm-up took place for each athlete, using an ergometric cycle (Hory Ergocycle, Panatta Sport) for 6 minutes with 150-W tension (26), followed by stretching exercises for the quadriceps and hamstrings muscle group. A pretest performance on the isokinetic device took place with

Figure 1. Isokinetic dynamometer measuring.

10 repetitions at 240°·s^{-1}. The preliminary test included 2 submaximal and 1 maximal repetition at each velocity.

Athletes were measured under visual (6, 14) and lectural feedback (26), where the researcher encouraged the athlete to make an even bigger effort. This way the highest possible measurements could be made.

The concentric exercise, which was considered ideal (57), was made at the velocity of 60°·s^{-1} with 6 maximum repetitions and at 180°·s^{-1} with 9 maximum repetitions (11).

A 2-minute interval between the tests was considered sufficient (26, 57). The tests were applied first to the one limb in all testing speeds and then to the other (Figure 1).

Although some theories prefer to perform high-angle velocity measures first followed by low-velocity ones to avoid possible fatigue of the limb, we chose the opposite procedure, since the high strength level of these athletes could protect them from fatigue problems (14, 34, 51).

Parameters Measured

The following parameters were measured for every athlete at 2 different velocities for each limb: (a) peak torque of the knee flexors and extensors (58), (b) peak torque per body weight of the knee flexors and extensors, (c) work per repetition of the knee flexors and extensors, (d) work per repetition to body weight ratio of the knee flexors and extensors, (e) flexors-extensors ratio, and (f) each limb's range of motion.

It must be mentioned that the presentation of these parameters related to the body weight was imposed by the significant differences in the somatomorphic values of athletes, which are due to the nature of the sport. The athletes of the sample have large differences in height and weight values, since they have different positions and activities in the game (1, 15). We assume, for example, that the tallest players would give higher values at peak torque or at work per repetition because of their muscle mass, which is much more than the other players (10).

In every measurement, the best repetition was used to adjust the data, because Cybex-1200 has the capability to automatically choose the best repetitions from which the highest values for peak torque and work per repetition can be selected. Reliability of Cybex-1200 has already been proved by passed technology devices (52); therefore, the test-retest was not necessary for the validity of the results (26).

Statistical Analysis

We used the statistical package SPSS_PC ± 6.1(Windows version). Initially, we calculated the descriptive statistics (means and *SDs*) of every parameter. The statistical analysis for the comparison between the mean values of every variable was the paired *t*-test, where a high level of significance was adopted ($p = 0.005$). The variables compared at *t*-tests are dominant vs. nondominant limb and testing speeds of 60 vs. 180°·s^{-1}.

Results

Means and *SDs* of the concentric peak torque, peak torque per body weight, work per repetition, and work per repetition to body weight ratio for the dominant and nondominant limb are presented in Table 2. The means for the flexors-extensors ratio are also presented in Table 2.

Comparison Between Dominant and Nondominant Limb at 60°·s^{-1} in Flexion

No statistically significant difference was noticed between dominant and nondominant limb in flexion at 60°·s^{-1} concerning peak torque ($p = 0.54$), peak torque per body weight ($p = 0.48$), work per repetition ($p = 0.59$), and work per repetition to body weight ratio ($p = 0.58$).

Comparison Between Dominant and Nondominant Limb at 60°·s^{-1} in Extension

No statistically significant difference was noticed between dominant and nondominant limb in extension at 60°·s^{-1} concerning peak torque ($p = 0.131$), peak torque per body weight ($p = 0.226$), work per repetition ($p = 0.229$), and work per repetition to body weight ratio ($p = 0.311$).

Comparison Between Dominant and Nondominant Limb at 180°·s^{-1} in Flexion

No statistically significant difference was noticed at this angular velocity concerning peak torque ($p = 0.923$), peak torque per body weight ($p = 0.904$), work

Table 2. Means and *SDs* of the knee flexors and extensors at peak torque parameters, peak torque per body weight, work per repetition and work per repetition to body weight along with the flexors-extensors ratio and range of motion in the dominant and nondominant limbs.

	Dominant limb		Nondominant limb	
Angular velocity	Flexors	Extensors	Flexors	Extensors
Peak torque (Nm)				
$60°\cdot s^{-1}$	187.66 (44.64)	287.16 (62.94)	174.916 (48.93)	274.08 (51.54)
$180°\cdot s^{-1}$	127.25 (29.22)	151.66 (37.53)	127.58 (33.04)	154.75 (41.82)
Peak torque per body weight ($Nm\cdot kg^{-1}$)				
$60°\cdot s^{-1}$	213.416 (31.24)	326.66 (44.93)	198.50 (38.46)	315.91 (49.34)
$180°\cdot s^{-1}$	145.416 (26.29)	172.166 (28.54)	144.916 (27.12)	174.33 (33.02)
Work per repetition (J)				
$60°\cdot s^{-1}$	211.50 (51.42)	315.916 (85.61)	194.25 (50.25)	303.75 (64.44)
$180°\cdot s^{-1}$	136.75 (28.25)	172.91 (37.37)	130.83 (28.28)	170.58 (41.26)
Work per repetition to body weight ratio ($J\cdot kg^{-1}$)				
$60°\cdot s^{-1}$	240.16 (40.28)	356.75 (66.31)	221.58 (48.69)	346.25 (53.68)
$180°\cdot s^{-1}$	157.08 (29.103)	205.00 (38.60)	149.83 (27.89)	203.75 (44.20)
Flexors-extensors ratio				
$60°\cdot s^{-1}$	65.500 (6.30)	—	63.16 (9.54)	—
$180°\cdot s^{-1}$	84.66 (8.64)	—	83.16 (10.06)	—
Range of motion				
$60°\cdot s^{-1}$	98.75 (9.781)	—	98.50 (7.96)	—
$180°\cdot s^{-1}$	117.00 (7.443)	—	113.818 (7.561)	—

per repetition (p = 0.066), or work per repetition to body weight ratio (p = 0.06).

Comparison Between Dominant and Nondominant Limb at 180°·s⁻¹ in Extension

No statistically significant difference was noticed in this angular velocity concerning peak torque (p = 0.3290), peak torque per body weight (p = 0.488), work per repetition (p = 0.570), and work per repetition to body weight ratio (p = 0.785).

Flexors-Extensors Ratio

Concerning the flexors-extensors ratio at the angular velocity of 60 and $180°\cdot s^{-1}$, no statistically significant difference appeared between the dominant and nondominant limb (p = 0.31 and p = 0.629, respectively).

Angular Velocity Correlation

The comparisons of the parameters of peak torque, peak torque per body weight, work per repetition, and work per repetition to body weight ratio between the angular velocities of 60 and $180°\cdot s^{-1}$ revealed statistically significant differences regarding flexion and extension of the limb. In every parameter, the values were much higher at the velocity of $60°\cdot s^{-1}$. Concerning the flexors-extensors ratio, a statistically significant difference presented between these 2 velocities. The ratio increased in respect to the increase of angular velocity.

Comparison Between Dominant and Nondominant Limb at Range of Motion

The comparison between dominant vs. nondominant limb for the parameter of total range of motion at the angular velocity of $60°\cdot s^{-1}$ revealed no statistically significant difference (p = 0.923). But the comparison of range of motion between the 2 limbs at the angular velocity of $180°\cdot s^{-1}$ presented a statistically significant difference with p = 0.008, where the dominant limb presented the largest range of motion.

Discussion

No significant differences were found between the lower limbs concerning the strength of the muscles that control knee flexion and extension in this sample of professional basketball players. This result was the same at both testing speeds, which expresses athletes' different muscle strength.

The same conclusion was reached when the parameter of strength per body weight was considered.

According to the results of the research, when we refer to professional basketball players who participate in a regular training program, there is no point in discriminating dominant and nondominant limb, because the training process does not lead to such circumstances. Similar results have also been reported by others (7, 40) in samples of normal nonathlete populations

(19), top-level tennis players (53), and football players (36).

Similar results were presented by Holmes and Alderink (28) using the same testing speeds during an endurance test, whereas Hageman et al. (25) reached the same conclusion with a sample of nonathletes. Klopfer and Greij (31), however, presented differences between dominant and nondominant limb, using higher velocities throughout testing procedure.

These results are important, since the strength of a healthy leg in the case of an athletic injury is a point of reference (23, 47, 49, 53). Based on the data provided by this research, there is the ability to create a rehabilitation program that considers the strength of the healthy leg as a normative level before the incidence of injury (23, 47, 49, 53).

Concerning the apparent statistically significant difference between the variables at the different velocities of 60 and 180°·s^{-1} for every limb, we can conclude that the increase of angular velocity leads to a reduced level of absolute strength. The result in this case was, more or less, predictable, and it had already been demonstrated (47, 51). Previous research, however, referred to different populations and angular velocities (13).

Similar results appeared for the flexors-extensors ratio, where in the comparison between dominant and nondominant limb in both testing speeds there was no significant difference. This ratio change significantly from 60 to 180°·s^{-1}, since the ratio increases with the increase of the angular velocity (Table 2). We can assume that with the increase of velocity greater activation of the hamstrings appeared as action of antagonist muscle, leading to a greater increase of the ratio (20, 44, 59).

The flexors-extensors ratio, in both sides, presented as 65.5% for the dominant limb and 63.166% for the nondominant limb at 60°·s^{-1}, whereas at 180°·s^{-1} the ratio was 84.66% for the dominant limb and 83.166% for the nondominant one. These ratios were higher than the boundary values that are set by previous research (17, 19, 29, 47). This may be an indication that these athletes (basketball players) tend to have stronger hamstrings than the allowed limits in relation to other sports (53). Perhaps the strength demands of basketball need a different level of this ratio compared with other sports.

Considering the means of the parameters measured for the athletes, the values were high, representing the exceptional physical condition demanded by the sport (29).

Concerning the range of motion, there was a statistically significant difference between the dominant and the nondominant limb ($p = 0.008$) at the velocity of 180°·s^{-1}, with the dominant limb giving the highest values.

Another important point was the presentation of the comparison in peak torque between the 2 limbs. For 4 cases, the dominant limb was 10% stronger (the ultimate allowable limit) (19, 58) than the nondominant limb, and in 5 cases, concerning the parameter work per repetition, both had slow angular velocities (60°·s^{-1}). However, at the angular velocity of 180°·s^{-1} in both flexion and extension, the parameters of peak torque and peak torque per body weight presented higher mean averages for the nondominant limb.

Even though basketball players seem to be bilateral athletes, observing thoroughly the technical execution of the exercises, we will assume that in basketball the dominant limb could be the opposite to the one stated herein, since these players act mainly as jumpers.

It is logical for the dominant limb to be the opposite of the one they would kick a ball with, since the opposite limb is trained more in the training process. Applying isokinetic measures on much higher speeds that could reach actual performance could possibly prove this.

The results of this research are difficult to compare with other research, since not many studies dealing with professional basketball players exist. More studies with similar samples, or even bigger populations, are necessary to present the actual flexors-extensors ratio and the correct definition about limb dominance.

Practical Applications

During tests using an isokinetic device among athletes of a professional basketball team (12 athletes), no significant differences appeared between the 2 limbs in strength concerning the parameters of peak torque and work per repetition in absolute and relative values (per body weight).

According to the flexors-extensors ratio at different testing speeds, we found that the particular population tends to present slightly higher strength values than allowed in hamstrings, something that should be seriously considered in the future.

The definition of the dominant and the nondominant limb in basketball should be the subject of further research based on the biomechanics of the particular sport.

In conclusion, these results are most important in regard to strength, since they can be used as a guideline for a rehabilitation program of the lower extremities or for a preventive control program before the beginning of championship training period.

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