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MAXIMAL ISOMETRIC LOWER BODY STRENGTH AND VERTICAL JUMP PERFORMANCE IN STARTING AND BENCH SEMI-ELITE MALE BASKETBALL PLAYERS

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INTRODUCTION

Basketball is a court-based sport consisting of high intensity, powerful activities such as jumping, change of direction (COD), sprinting as well as sport specific movements (10). Research has found that different basketball playing positions showcase different strength, power, speed and agility characteristics relative to their demands (2) and that individuals who are stronger, jump higher, are faster or more agile in general played more minutes than other individuals in their position (4). The optimal development of a basketballer's strength, power, speed and COD would thus appear to be beneficial to performance. The interaction between strength, power and COD is gaining more attention of late from both researchers and strength and conditioning practitioners who are all looking to give their athletes the edge (1, 6). A number of these studies have investigated the relationship between isometric strength and power to vertical jump performance (7, 11). However, to the authors' knowledge, the differences in maximal isometric lower body strength and vertical jump performance in starting and bench basketball players has not been examined before. Therefore, the comparison of isometric lower body strength and power is required to identify whether specific physical qualities differentiate between these athletes. This will allow coaches to identify weaknesses within muscular performance and implement specific training protocols to develop these qualities to an appropriate standard.

METHODS

Participants

Ten (n=10) male basketball athletes; five starting (age: 24.8 ± 3.7 yrs; height: 196.2 ± 9.6 cm; body mass: 96.96 ± 16.82 kg), and five bench players (age: 20.6 ± 1.5 yrs; height: 196.2 ± 6.2 cm; body mass: 90.36 ± 14.33 kg) were recruited for this study. Athletes were placed in the starting group (SG) if they started in 60% or more of the total games in the season with anyone starting less than this placed in the bench group (BG). All athletes had a minimum of one year experience playing at the semi-elite level with strength training, COD and jumping movements forming part of the regular training regime. Athletes were free from injury at the time of testing and informed consent and ethical approval was obtained prior to testing.

Lower Body Power Assessment

Athletes performed a series of squat jumps (SJ) and countermovement jumps (CMJ), on a portable forceplate sampling at 600 Hz (400 Series Performance Plate, Fitness Technology, Adelaide, Australia). Both tests required the athletes to position their hands on their hips, with their feet positioned shoulder width apart, and to jump maximally during each attempt. The SJ condition required the athletes to start in a self-selected depth squat position held for three seconds, before performing the explosive concentric only action. For the CMJ the athletes were required to start in a standing position, descend into a self-selected depth squat and jump as high as possible. Variables of interest including jump height (m), peak force (N), peak velocity ($m.s^{-1}$), peak power (W) were measured and calculated using the Ballistic Measurement system software (Fitness Technology. Adelaide, Australia), with the average of three trials of SJ and CMJ each retained for analysis.

Lower Body Isometric Strength Assessment

The isometric mid-thigh pull (IMTP) was performed on a portable forceplate sampling at 600 Hz (400 Series Performance Plate, Fitness Technology, Adelaide, Australia) located in a power rack to ensure the desired testing position where relative knee angle was held at approximately 130°, the bar positioned below the hip crease and the trunk in an upright position. Athletes were instructed to place their hands on the bar and upon the instructor's verbal instructions pull against the bar with maximal effort as quickly as possible for three seconds. Variables of interest including isometric peak force (N), maximal rate of force development ($N.s^{-1}$), impulse 100 (N.s), impulse 200 (N.s), impulse 300 (N.s) and total impulse (N.s) was collected and calculated using the Ballistic Measurement system (Fitness Technology. Adelaide, Australia), with the average of three trials retained for analysis.

Statistical Analysis

Reliability of performance measures was assessed by intraclass correlation coefficient (ICC), coefficient of variation (%CV), typical error (TE) and calculation of the relative percentage change in mean (5). Data was analysed, using descriptive statistics, and absolute and relative (measurement / body mass) results summarised as mean ± standard deviation (SD). Athletes were grouped into starter (n = 5) and bench (n = 5) groups based on their normal playing roles. Two-tailed independent *t* tests were used to assess the differences between the means of the starter and bench groups. Effect sizes were also calculated according to Cohen's *d* formula. Effect sizes were interpreted as trivial (< 0.19), small

(0.20 – 0.59), moderate (0.60 – 1.19), large (1.20 – 1.99), and very large (2.0 – 4.0)(3). Additionally, 95% confidence intervals were used to ascertain the certainty with which effects occurred.

RESULTS

The ICC's, %CV, TE and percentage (%) change in the mean for each IMTP, CMJ and SJ variable are shown in Table 1.

Table 1 - Reliability data for IMTP, CMJ, and SJ variables.

Reliability Variable	ICC (90% CI)	%CV (90%CI)	TE	Change in mean (%)
Isometric mid-thigh pull				
IPF (N)	0.99 (0.96-1.00)	2.0 (1.5-3.4)	57.29	0.8
mRFD ($N.s^{-1}$)	0.99 (0.96-1.00)	7.3 (5.3-12.3)	623.91	1.0
I100 (N.s)	0.91 (0.79-0.97)	6.3 (4.8-10.0)	6.58	1.4
I200 (N.s)	0.97 (0.91-0.99)	5.5 (4.3-8.8)	13.29	1.5
I300 (N.s)	0.98 (0.96-0.99)	3.3 (2.4-5.5)	18.04	3.2
Total Impulse	0.97 (0.93-0.99)	2.0 (1.5-3.3)	214.06	0.1
Countermovement jump				
PV ($m.s^{-1}$)	0.75 (0.49-0.87)	5.0 (3.8-7.6)	0.12	2.8
PF (N)	0.98 (0.94-0.99)	2.5 (1.9-3.8)	47.92	1.7
PP (W)	0.97 (0.93-0.99)	2.2 (1.7-3.3)	97.2	0.8
Jump Height (m)	0.97 (0.93-0.99)	2.9 (2.2-4.4)	0.01	1.6
Squat jump				
PV ($m.s^{-1}$)	0.94 (0.83-0.98)	2.0 (1.6-3.2)	0.05	0.2
PF (N)	0.74 (0.50-0.85)	7.7 (5.9-12.2)	164.37	-1.9
PP (W)	0.91 (0.88-0.94)	5.1 (3.9-8.0)	58.3	-2.2
Jump Height (m)	0.91 (0.69-0.97)	8.2 (5.7-15.2)	314.15	8.8

IPF = isometric peak force; mRFD = maximum rate of force development.
CI = confidence intervals; PV = peak velocity; PF = peak force; PP = peak power

The means and SDs for strength and power performance variables of the isometric IMTP, CMJ and SJ in absolute and relative terms are shown in Table 2.

Table 2 - Absolute and relative performance variables for strength and power measurements in the isometric mid-thigh pull, countermovement jump, and squat jump for a semi-professional basketball population (*n* = 10).

	Absolute		Relative
Isometric mid-thigh pull			
IPF (N)	2809.83 ± 388.52	$N.kg^{-1}$	30.30 ± 3.96
mRFD ($N.s^{-1}$)	12712.57 ± 4365.94	$N.kg^{-1.s-1}$	138.80 ± 55.36
I100 (N.s)	106.88 ± 18.08	N.kg.s	1.15 ± 0.15
I200 (N.s)	229.13 ± 51.45	N.kg.s	2.47 ± 0.54
I300 (N.s)	366.79 ± 101.85	N.kg.s	3.98 ± 1.14
Total Impulse (N.s)	7996.65 ± 1004.69	N.kg.s	85.93 ± 6.04
Countermovement Jump			
PV ($m.s^{-1}$)	2.69 ± 0.15		
PF (N)	2154.23 ± 263.09	$N.kg^{-1}$	23.17 ± 2.18
PP (W)	4607.22 ± 492.03	$W.kg^{-1}$	49.77 ± 5.45
Jump Height (m)	0.35 ± 0.04		
Squat Jump			
PV ($m.s^{-1}$)	2.74 ± 0.24		
PF (N)	2399.14 ± 247.88	$N.kg^{-1}$	26.12 ± 4.52
PP (W)	5105.02 ± 938.76	$W.kg^{-1}$	54.77 ± 5.45
Jump Height (m)	0.34 ± 0.06		

Values are expressed as mean ± SD
mRFD = maximum rate of force development; PV = peak velocity; PF = peak force; PP = peak power; IPF = isometric peak force.

Differences between starting and bench player relative means are presented in Table 3. A statistically significant difference ($p \leq 0.05$) was found between SJ relative peak velocities for the two groups. Large effect sizes were found for age, relative I100, relative I200 and relative I300.

Table 3 - Comparison between starting and bench semi-professional basketball players in relative isometric mid-thigh pull, countermovement jump, and squat jump force-time velocity-time variables.

	Starters (*n* = 5)	Bench (*n* = 5)	*p value*	Cohen Effect Size [95% CI]
Body Mass (kg)	96.96 ± 16.82	90.36 ± 10.28	0.52	0.47 [-13.73, 26.93]
Age (years)	24.80 ± 3.71	20.60 ± 1.50	0.09	1.48** [0.07, 8.33]
Isometric mid-thigh pull				
IPF ($N.kg^{-1}$)	29.77 ± 2.68	30.84 ± 4.85	0.71	-0.27 [-6.78, 4.64]
mRFD ($N.kg^{-1}.s^{-1}$)	152.06 ± 69.00	125.54 ± 31.87	0.51	0.49 [-51.86, 104.90]
I100 (N.kg.s)	1.23 ± 0.13	1.07 ± 0.11	0.09	1.33** [-0.02, 0.34]
I200 (N.kg.s)	2.79 ± 0.57	2.16 ± 0.26	0.09	1.42** [-0.02, 1.28]
I300 (N.kg.s)	4.63 ± 1.21	3.33 ± 0.54	0.10	1.39** [-0.07, 2.67]
Total Impulse (N.kg.s)	85.33 ± 7.18	86.53 ± 4.55	0.79	-0.20 [-9.97, 7.57]
Countermovement Jump				
PV ($m.s^{-1}$)	2.74 ± 0.12	2.63 ± 0.17	0.34	0.75 [-0.10, 0.32]
PF ($N.kg^{-1}$)	22.74 ± 1.70	23.61± 2.5	0.58	-0.41 [-3.99, 2.25]
PP ($W.Kg^{-1}$)	50.08 ± 4.51	49.47 ± 6.24	0.88	0.11 [-7.33, 8.55]
Jump Height (m)	0.35 ± 0.02	0.36 ± 0.05	0.79	-0.26 [-0.07, 0.05]
Squat Jump				
PV ($m.s^{-1}$)	2.89 ± 0.2	2.58 ± 0.16	0.04*	1.71** [0.05, 0.57]
PF ($N.kg^{-1}$)	27.22 ± 5.07	25.03 ± 3.58	0.50	0.50 [-4.21, 8.59]
PP ($W.Kg^{-1}$)	56.87 ± 6.22	52.84 ± 8.08	0.45	0.56 [-6.49, 14.55]
Jump Height (m)	0.36 ± 0.03	0.31 ± 0.07	0.26	0.93 [-0.03, 0.13]

Values are expressed as mean ± SD.
IPF = isometric peak force; mRFD = maximum rate of force development; I100 = impulse 100 ms; I200 = impulse 200 ms; I300 = Impulse 300 ms; PV = peak velocity; PF = peak force; PP = peak power
* Significant difference at $p \leq 0.05$.
** Large magnitude of effect size

DISCUSSION

The aim of the current study was to assess the differences in IMTP and vertical jump performance exhibited by starting and bench semi-elite male basketball players. Findings from the study indicate that starting players demonstrate significantly greater relative SJ PV ($p \leq 0.05$). The magnitude of effect size show large effect sizes for age, relative I100, relative I200, relative I300 and SJ PV and moderate effect sizes for CMJ PV and SJ jump height. There was no significant difference in force production for the two groups during the study for any of the tests. The greater relative impulses and mRFD exhibited by the starting group shows that starters generate force faster than bench players which may lead to faster execution of skills on court. The findings of this study are similar to previous research indicating that elite athletes exhibited greater RFD and impulses than less experienced athletes (9). A limitation in this study may be the small subject pool and age range of the subjects who participated in this research. Future research should focus on investigating the determining factors that can improve performance on these variables.

PRACTICAL APPLICATIONS

According to the results of this study strength and conditioning coaches should aim to maximise impulse and RFD by designing programs which incorporate explosive weighted and un-weighted exercises e.g. plyometric and Olympic lifts (7, 8). In addition, the testing of RFD and impulses as part of an informed physiological testing battery is also advised when working with higher level athletes.

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