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SELECTED BIOMECHANICAL CHARACTERISTICS OF MALE AND FEMALE BASKETBALL NATIONAL TEAM PLAYERS

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Biomechanical features of male and female basketball players (24 each) playing at different floor positions were studied. A force plate with an amplifier, A/D converter and minicomputer were used to measure the maximum external power, absolute and per kg body mass, and the height of rise of body mass center, in the counter-movement jump (CMJ). The best results of jump parameters were recorded in male and female wingers, the male ones having highest muscle torques. Lowest absolute external power values were seen in male centre players and female play-makers, and lowest relative power and height of rise of body mass center values - male and female centre players. The latter ones and male play-makers had lowest arm and trunk muscle torques, while lowest leg muscle torques were seen in all centre players.

Key words: Countermovement jump (CMJ) - Mechanical power - Muscle torque - Basketball

Introduction

An accurate assessment of physical capacity of an athlete is a basic criterion in verifying the effectiveness of the applied training loads. This assessment enables setting optimum limits of developing physical traits, as well as determining a relation

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between the present fitness level and results attained at competition or training. This is particularly important in sport team games in which the results depend on both individual fitness and cooperation [14]. The individual fitness development depends on the assigned floor position and task. In basketball [6,7], the main tasks of wing players are: intercepting balls from the backboard, medium and long distance shots, passes, and in defence - countering passes and countering shots at the backboard. The tasks of play-makers are organizing action in a position attack and long-distance shots, and in defence - countering shots and passes. For centre players it is play under the basket, short-range shots and tip-ins, and in defence - countering shots and play at the backboard. The diversity of tasks, and therefore of training and competition specificity, may be reflected in the levels of physical features of players assigned different positions. Verification that hypothesis was the aim of this work.

Materials and methods

Male and female Basketball National Team players (24 each) participated in the study. Their basic characteristics are contained in Table 1. The following measurements were carried out: muscle torques in static conditions, height of rise of body mass center, and leg power on a force plate. Muscle torque

Table 1

Characteristics of basketball players

Players	Age (yrs.)	Training (yrs.)	Body mass (kg)	Height (cm)
Male n=24	23.0±0.6	10.0±0.6	91.3±1.5	198.7±1.4
Female n=24	23.8±0.5	10.3±0.6	72.3±3.0	181.0±4.8

Means ± SD

measurements in static conditions were performed as described in an earlier paper [3]. Twenty muscle groups were studied - flexors and extensors of shoulder, elbow, hip, knee and upper ankle joints and of the trunk. The computed torques were expressed per kg body mass.

$$Mn = F \cdot r / m$$

Legend: Mn - muscle torque of relative forces (N · m / kg)
F - external force (N ; dynamometer reading)
r - distance between the rotation axis and force application point
m - body mass

In measuring dynamic parameters the method described by B a r t o s i e w i c z [1] was used, employing the counter-movement jump (CMJ) on a force plate. The measuring set consisted of force plate (Kistler), amplifier and minicomputer (Neptune 184) with an A/D converter. From the ground forces vs. time function the following parameters were computed: maximum power (P_{max}), mean power (P/m), and height of rise (h) of mass center (for details concerning formulas see [4]). For all studied parameters means, S.D.'s and correlation coefficients were computed. Student's t-test was used to verify the significance of differences.

Results

The results of CMJ analysis in different players are presented in Table 2. The best jump parameters can be seen in wing players from both groups. Maximum power was lowest in male centre players and in female play-makers and lowest mean power and jump height values were observed in all centre players. Different floor positions did not affect significantly the jump results. The muscle torques in different groups are presented in Fig. 1.

Highest muscle torque values were seen in centre players, and the loweas ones - in play-makers. The latter ones differed from other players ($p<0.05$) regarding mean sums of torques for legs

Table 2

Mean values of sums of absolute (Mm_1) and relative (Mm_2) muscle torques of upper (kkg) and lower (kkd) extremities, trunk (t), of all 20 muscle groups (total), of maximum power - absolute (P_{max}) and per kg body mass (P/m), and of the elevation of the body mass center (h) in counter-movement jump

A. Male players

Parameters		Position	Attack n = 8	Wing n = 10	Centre n = 8
Mm_1	kkg	(N·m)	781.6 ± 52.1	884.1 ± 113.0	926.7 ± 102.7
	kkd	(N·m)	2620.6 ± 222.5	2869.0 ± 539.8	2819.4 ± 298.7
	t	(N·m)	837.0 ± 143.7	1083.5 ± 194.1	1108.0 ± 236.5
	total		4227.1 ± 299.1	4784.3 ± 682.7	4808.2 ± 507.0
Mm_2	kkg	(N·m/kg)	9.3 ± 3.5	9.5 ± 0.9	9.6 ± 4.3
	kkd	(N·m/kg)	31.1 ± 8.5	31.4 ± 7.9	28.8 ± 9.5
	t	(N·m/kg)	10.2 ± 3.9	11.8 ± 3.9	11.5 ± 5.1
	total		50.3 ± 15.3	52.5 ± 6.8	49.1 ± 19.7
P_{max}		(W)	3428.0 ±1296.0	3478.0 ±1159.0	3168.0 ±1417.0
P/m		(W/kg)	20.2 ± 7.6	19.8 ± 6.5	16.5 ± 7.4
h		(m)	0.50± 0.19	0.50± 0.17	0.45± 0.20

B. Female players

Parameters		Position	Attack n = 7	Wing n = 9	Centre n = 8
Mm_1	kkg	(N·m)	475.3 ± 141.0	473.6 ± 50.2	517.4 ± 78.0
	kkd	(N·m)	1605.3 ± 266.4	1740.0 ± 205.1	1912.0 ± 167.8
	t	(N·m)	504.2 ± 143.3	648.3 ± 126.7	640.7 ± 152.9
	total		2521.8 ± 428.2	2875.7 ± 337.8	3206.0 ± 561,8
Mm_2	kkg	(N·m/kg)	6.7 ± 3.0	6.7 ± 2.7	6.4 ± 2.8
	kkd	(N·m/kg)	25.8 ± 11.5	24.7 ± 10.1	24.6 ± 11.0
	t	(N·m/kg)	8.1 ± 3.6	9.1 ± 3.7	7.6 ± 3.4
	total		40.5 ± 18.1	40.5 ± 16.6	38.6 ± 17.2
P_{max}		(W)	1938.0 ± 867.0	2258.0 ± 922.0	2023.0 ± 905.0
P/m		(W/kg)	17.8 ± 8.0	17.4 ± 7.1	15.3 ± 6.8
h		(m)	0.39± 0.18	0.39± 0.16	0.34± 0.15

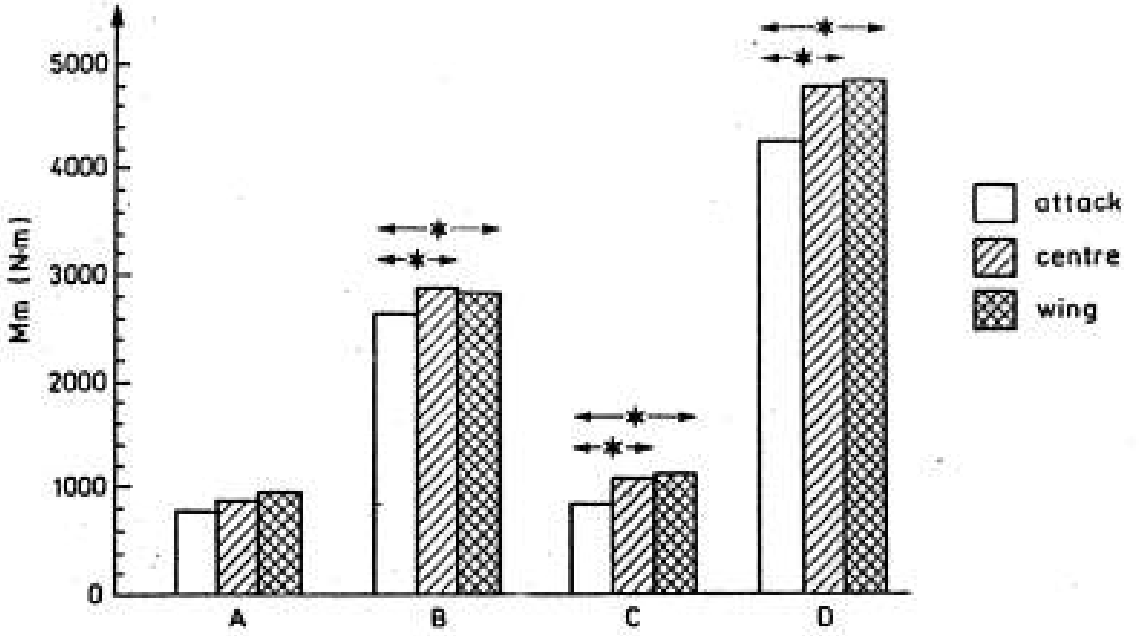

Fig. 1. Mean values of sums of muscle torques of upper (A) and lower (B) extremities, of trunk (C) and of all 20 muscle groups (D) in male players from different floor positions

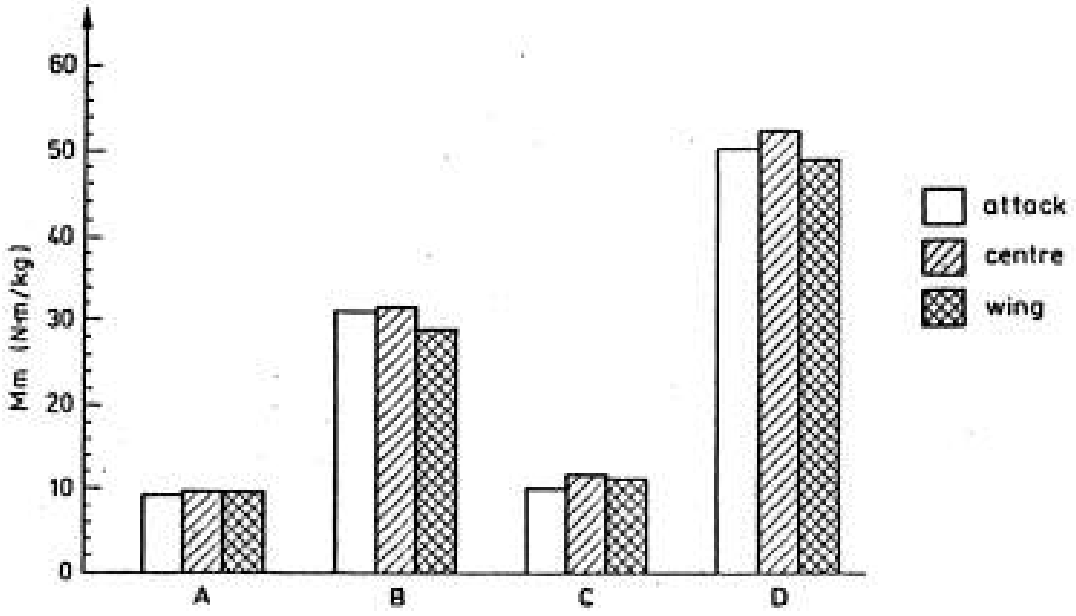

Fig. 2. Mean relative values of sums of muscle torques of upper (A) and lower (B) extremities, of trunk (C) and of all 20 muscle groups (D) in male players from different floor positions

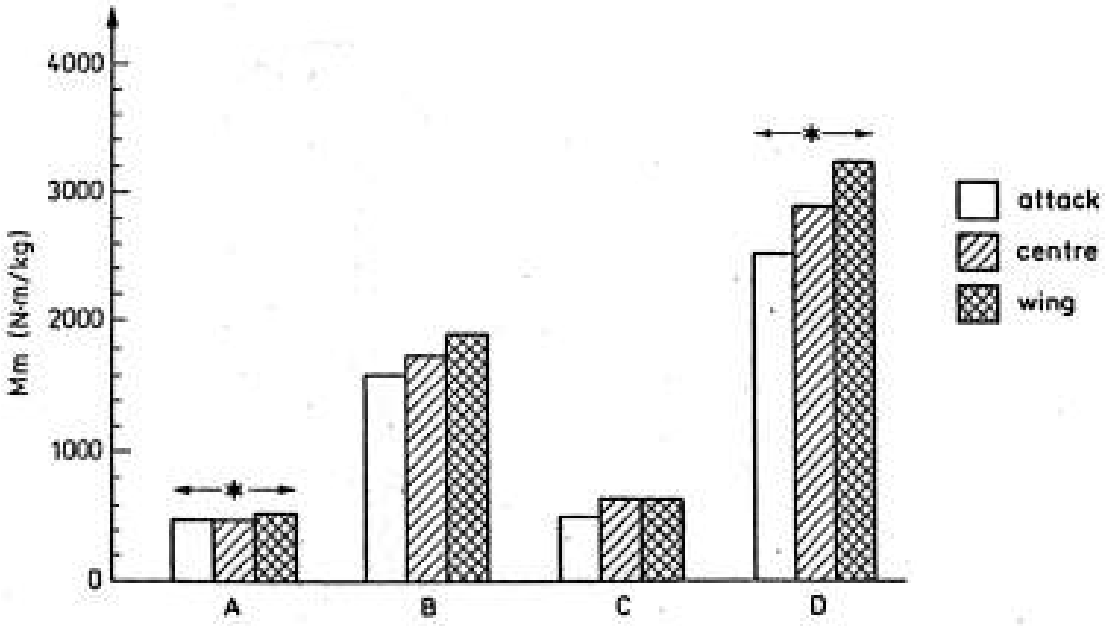

Fig. 3. Mean values of sums of muscle torques of upper (A) and lower (B) extremities, of trunk (C) and of all 20 muscle groups (D) in female players from different floor positions

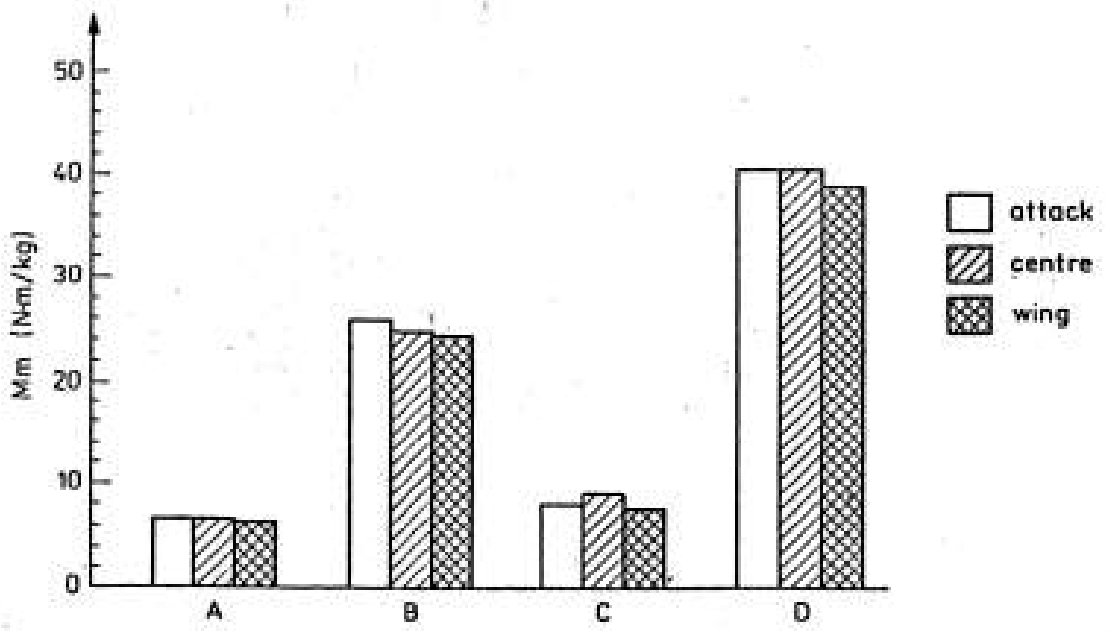

Fig. 4. Mean relative values of sums of muscle torques of upper (A) and lower (B) extremities, of trunk (C) and of all 20 muscle groups (D) in male players from different floor positions

(kkd), trunk (t), and for the total sums of 20 muscle groups. Regarding relative values (per kg body mass), highest values for legs had female play-makers (cf. Fig. 4), and lowest totals - in centre players. Female wing players and play-makers were similar regarding relative arm and total torques. No significant correlations were found between absolute or relative leg muscle torques and jump parameters in male players (cf. Fig. 3). In female players, on the other hand, those leg torques correlated ($p<0.05$) with the height of rise of body mass center. Significant correlation was also found between maximum power and leg torques in wing players.

Table 3

Linear correlation coefficients between mean sums of absolute (kkd_1) or relative (kkd_2) leg muscle torques and jump parameters - maximum power (P_{max}), body mass center elevation (h), and mean power per kg body mass (P/m)

A. Male players

		P_{max}	h	P/m
Attack	kkd_1	-0.031	0.340	0.075
n = 8	kkd_2	-0.227	0.675	0.108
Wing	kkd_1	0.113	0.220	0.296
n = 10	kkd_2	0.015	0.201	0.228
Centre	kkd_1	-0.081	-0.012	-0.605
n = 6	kkd_2	-0.340	-0.612	-0.001

A. Female players

		P_{max}	h	P/m
Attack	kkd_1	0.511	0.951*	0.468
n = 8	kkd_2	0.448	0.764*	0.450
Wing	kkd_1	0.711*	0.795*	0.239
n = 10	kkd_2	0.768*	0.655	0.577
Centre	kkd_1	0.692	0.882*	-0.147
n = 6	kkd_2	0.574	0.822*	0.346

Discussion

Measurements of muscle torques in static conditions and counter-movement jump are frequently used in determining biomechanical features of athletes from different sport disciplines [5,9,11 - 13]. B a r t o s i e w i c z and co-workers [1] reported that in voleyball national team members the maximum power ranged from 2975 to 4320 W, and the body mass center rise in the CMJ - from 0.326 to 0.639 m, while K o m i et al. [5] found in similar studies a mean value of 0.434 ± 0.052 m. Similar values were also observed in basketball players. In this study no significant correlations between the muscle torques in static conditions and jump parameters were found in players from different floor positions except female players, in which a correlation was found between leg muscle torques and body mass center rise. No such correlations were found either by B a r t o s i e w i c z et al. [2] in fencers. According to one report [10] a 400 % increase in leg muscle torques was attained following a 3 year training, a finding not supported by the test-jump results. This speaks against a relation between static torque values and dynamic parameters of legs as measured in CMJ. A comparision of our present results with those obtained in basketball representation, in which muscle torques of 11 muscle groups were studied [9], did not reveal significant differences. This may suggest a stability of developing that feature in basketball players. The task diversity of those players, and hence different training specificity, were not reflected in the levels of their biomechanical features. Highest forces developed in both static and dynamic conditions were observed in male wing players, while in females - the centre ones had highest muscle torques. However, they were the worst ones when the results were expressed per kg body mass and the remaining ones were alike regarding the relative force torques. The lowest dynamic parameters were found in centre players, both male and female. A poor jump technique (low P/m value) and low height of rise of body mass center might have resulted from excessive weight of centre players and from an insufficient force training.

The following conclusions may be drawn from the presented findings:

1. The floor position does not seem to differentiate the team with respect to the biomechanical features studied.
2. In basketball players there is no clear causal relationship between muscle torque values in static conditions and dynamic parameters of the counter-movement jump.
3. Male and female wing players display the best preparation regarding biomechanical features.

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Streszczenie

W pracy przedstawiono rezultaty cech biomechanicznych koszykarzy i koszykarek grających na różnych pozycjach. Do pomiaru mocy użyto platformy dynamometrycznej, wzmacniacza, mikrokomputera z przetwornikiem A/C. Rejestrowano moc maksymalną, moc średnią na kilogram masy ciała, wysokość uniesienia środka masy w wyskoku CMJ. Na podstawie pomiaru momentów sił 20 zespołów mięśniowych w statyce określono siłę statyczną badanych. W badaniach uczestniczyło: 24 zawodniczki i 24 zawodników kadry narodowej piłki koszykowej. Nie stwierdzono testem t-Studenta i korelacją liniową istotnych statystycznie zależności między momentami sił mięśniowych w statyce a parametrami szybkościowo-siłowymi mierzonymi w wyskoku CMJ. Najlepsze rezultaty parametrów wyskoku osiągnęli zawodnicy i zawodniczki grający na pozycjach skrzydłowych, a największe momenty sił rozwijali skrzydłowi. Najmniejszą moc maksymalną rozwinęli środkowi rozgrywający, a najmniejszą moc średnią na kilogram masy ciała i najniżej skakali środkowi w obu grupach. Najniższe wartości sumy momentów sił względnych kończyn górnych i tułowia rozwijali rozgrywający i środkowe, a kończyn dolnych środkowi. Nie stwierdzono istotnych

statystycznie różnic pomiędzy grającymi na różnych pozycjach w obu grupach ($p<0.05$).

РЕЗЮМЕ

В работе представлены результаты изучения биомеханических характеристик баскетболистов и баскетболисток, выступающих в различных игровых амплуа. Для изучения мощности использована динамометрическая платформа, усилитель, микрокомпьютер с преобразователем А/С. Регистрировалась максимальная мощность, средняя мощность на килограм веса тела, высота подема центра массы тела при прыжке в высоту CMJ. Изучались моменты сил 20 групп мышц при испытаниях в статичном положении. В исследованиях участвовало: 24 спортсменки и 24 спортсмена, играющих в сборной команде ПНР по баскетболу. Не подтвержена Т-критерием Стьюдента и не обнаружена статистически достоверная корреляция между моментами сил мышц в статике и скоростно-силовыми параметрами изученными CMJ при выпрыгивании. Наиболее высоких значений параметров выпрыгивания достигали спортсменки и спортсмены, играющие крайними нападающими, у них же зафиксированы и наибольшие моменты сил. Наименьшую максимальную мощность в обеих группах развивали разыгрывающие, при отмечаемой у них наименьшей средней мощности на килограмм массы тела и минимальном среднем прыжке. Наименьшую величину суммы моментов сил относительно верхних конечностей и туловища развивали разыгрывающие и центровые, а нижних конечностей - центровые. Не обнаружено достоверной разницы между игроками различных амплуа в обеих группах ($P<0.05$).