

# ANAEROBIC POWER AND REPETITIVE MUSCLE WORK CAPACITY OF OLDER ELITE AND DEVELOPING YOUNG BASKETBALL PLAYERS

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## ABSTRACT

*Research background and hypothesis.* Players need to repeat performance of highly intensive work for a particular time combining it with rest intervals. The muscle power and anaerobic repetitive muscle work capacity of elite basketball players is higher than those in young athletes.

*Research aim* was to investigate anaerobic power and repetitive muscle work capacity of older elite ( $n = 13$ ) and young basketball players ( $n = 12$ ) and to carry out comparative analysis of indicators in these groups.

*Research methods.* During competition period, laboratory  $5 \times 6$  s repeated effort test with rest intervals of 24 s was employed. The average indicator of power during each work interval was provided and fatigue index was calculated. Three minutes after the physical load, the concentration of lactate in the blood was measured.

*Research results.* A statistically significant difference was observed for absolute muscle power of elite and young basketball players in the first sprint ( $p < 0.004$ ). The research on relative indicators for one kilogram of the body mass showed that the power of elite ( $13.06 \text{ W}\cdot\text{kg}^{-1}$ ) and young players ( $11.74 \text{ W}\cdot\text{kg}^{-1}$ ) did not differ statistically ( $p < 0.09$ ). The fatigue index investigated in both groups did not differ ( $p < 0.77$ ).

*Discussion and conclusions.* The research revealed that relative indicators of muscle power of elite basketball players did not significantly differ from those of young athletes. The same anaerobic repetitive muscle work capacity was observed in both groups.

It was established that the concentration of lactate in the blood increased after physical load more than to  $9 \text{ mol}\cdot\text{l}^{-1}$  and did not differ in the two groups. This means that working for 6 seconds at maximum strength and relaxing 4 times longer, repeating this work five times, PCr is not enough for ATP resynthesis and, therefore, anaerobic glycolic reactions are activated.

**Keywords:** fatigue, lactate, recovery, muscles.

## INTRODUCTION

During the basketball game the duration of work may vary from a momentary throw or a pass to repetitive work that lasts for several hours. A player is referred to as possessing high endurance if he/she is able to demonstrate technical-tactical abilities and skills as well as physical possibilities during the match (Bompa, Haff, 2009). Muscular endurance is the capacity to sustain a static contraction or repeated muscle contractions (Wilmore et al., 2008)

Taking into account the content of basketball players' work, that is, duration and intensity of

play actions (Trninić et al., 2000), proportions of breaks with work, emotional effect on the organism (Karipidis et al., 2001), the dominant role is assumed by repetitive work power and specific capacity (Hargreaves et al., 1992). This embraces an ability to cope with fatigue striving for achievement of the best results under specific conditions of play (Mendes, Janeira, 2001).

Players need to repeat performance of highly intensive work for a particular time combining them with rest intervals. This is predetermined by the rules of the game: size of basketball court,

duration of attack, duration of match, timeouts and other breaks during the play (Krause et al., 2008). The biggest role is played by the ability of the player's organism to recover fast (Buceta, 2000; Wissel, 2004). The situations, when players are given different time to play are characteristic of basketball (Carter et al., 2005). Such indicators as speed of recovery of energetic substances in muscles, functional power of circulatory and respiratory systems are among the most important indicators of basketball players' capacity (Foster et al., 1996; Kraemer, 2000). We have established that while playing basketball energy is generated resynthesizing ATP from PCr and from mixed energy source PCr – glycogen, without oxygen, i. e. working very intensively for a short period of time (Paulauskas et al., 2010). However, the repetitive work capacity of players has not been extensively analyzed all over the world. Being aware of repetitive work power and endurance, we could evaluate and more efficiently develop and train players.

**The aim of our study** was to investigate repetitive muscle work power and specific capacity of elite and young basketball players and to carry out comparative analysis of indicators in these groups.

## RESEARCH METHODS

**Participants.** Elite basketball players ( $n = 13$ ), who regularly trained 8 times per week and played in competitions of Lithuanian Basketball League (LBL) and Baltic Basketball League, were researched. Their age was  $25.6 \pm 0.6$  years, height –  $195.9 \pm 1.7$  cm and body mass –  $94.7 \pm 4.3$  kg.

The sample also included young basketball players ( $n = 12$ ), who regularly trained 4 times a week and played in school learners' competitions. Their age was  $14.1 \pm 0.2$  years, height –  $183.7 \pm 3.4$  cm and body mass –  $69.5 \pm 2.2$  kg. The participants and, if necessary, their guardians were informed about the aims and procedures of the study before providing their written informed consent. The study was approved by Lithuanian Bioethics Committee, according to Resolution #30/2008.

**Procedures.** During the competition period, laboratory  $5 \times 6$  s repeated effort test with rest intervals of 24 s was employed (Ward, 1991; Fitts et al., 1993). The veloergometer "Monark Ergonomic 894 Ea" was used for this test. The average muscle power during each work interval

was provided in watts (W) and fatigue index (FI) was calculated applying the formula:

$$FI (\%) = 100 - (P5 / P1 \times 100)$$

Three minutes after the physical load, the concentration of lactate in the blood was measured applying the blood lactate test meter "Lactate Pro".

**Statistical analysis.** All data were analyzed using *SPSS for Windows v. 14.0*. The results were processed applying methods of descriptive statistics: Mean values were calculated, dispersion was evaluated calculating standard deviation of sample ( $s$ ) and according to coefficient of variation ( $CV$ ), providing parameters (Min and Max) of dispersion area. Dispersion analysis (ANOVA) was used to compare the two groups. Statistical significance was set at  $p < 0.05$ .

## RESEARCH RESULTS

Average muscle power was the highest during the first sprint and then gradually decreased in both groups (Figure 1). A statistically significant difference was observed for absolute muscle power of elite and young basketball players in the first sprint ( $p < 0.004$ ) (Table 1). Significant dispersion of indicators was characteristic of both groups: coefficient of variation ( $CV$ ) exceeded by 20%. The research on relative indicators for one kilogram of the body mass showed that the power of elite ( $13.06 \text{ W} \cdot \text{kg}^{-1}$ ) and young players ( $11.74 \text{ W} \cdot \text{kg}^{-1}$ ) did not differ statistically ( $p < 0.09$ ). The dispersion of indicators of young basketball players totalled 10.5%, whereas it amounted to 18.2% in the group of elite basketball players.

The most significant difference in muscle power was recorded in both groups during the second work interval. The absolute indicators of higher performance basketball players were higher by 436.2 W ( $p < 0.0001$ ), the same tendency was observed in the values of relative indicators, which were by  $1.7 \text{ W} \cdot \text{kg}^{-1}$  bigger in the group of elite players ( $p < 0.02$ ).

Power indicators decreased at similar rate in both groups during the third, fourth and fifth work intervals. The absolute muscle power of elite basketball players remained statistically higher during these work intervals, whereas relative power did not differ. Dispersion of power indicators around the mean changed insignificantly in all the intervals of work.

Table 2 presents the values of muscle capacity. The change observed between the first and second

work intervals showed anaerobic ATP-PCr muscle power capacity. The difference in the relative muscle power of elite basketball players totalled by  $0.32 \text{ W}\cdot\text{kg}^{-1}$  and that of young players equalled to  $0.75 \text{ W}\cdot\text{kg}^{-1}$ . Significantly smaller fatigue index ( $p < 0.03$ ) was identified in the group of elite players compared to young players, which revealed greater anaerobic ATP-PCr muscle power capacity.

Evaluating repetitive work capacity, the difference between the first and fifth work interval was calculated. The absolute muscle power of elite basketball players totalled  $128.2 \text{ W}$  and that of young athletes was lower by  $76.9 \text{ W}$ . The difference between the two groups was statistically significant

( $p < 0.05$ ). The fatigue index investigated in both groups did not differ.

After the physical load, the lactate concentration in the blood was measured, which was  $9.1 \text{ mmol}\cdot\text{l}^{-1}$  in the group of young basketball players, whereas the lactate concentration in the blood of professional basketball players equalled to  $9.5 \text{ mmol}\cdot\text{l}^{-1}$ . No statistically significant difference was recorded in both groups. As it can be seen from the results, very large dispersion about the mean  $\text{CV} = 41.4\%$  was observed in the group of young players. Dispersion of these indicators in the group of professionals was smaller compared to the other group but it still remained large ( $\text{CV} = 25.5\%$ ).

Figure 1. Change in absolute muscle power (W) of elite and young basketball players performing  $5 \times 6 \text{ s}$  repeated effort test

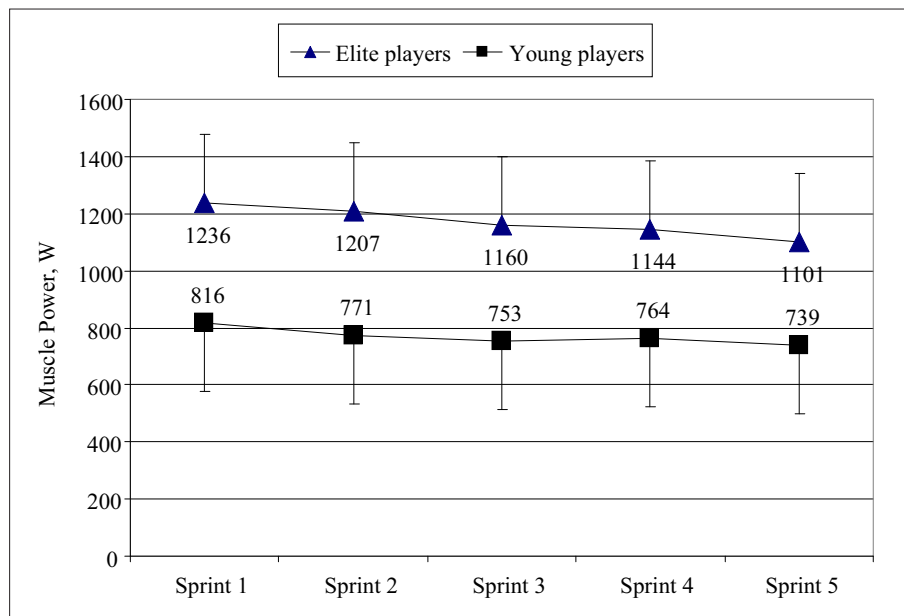


Table 1. Muscle power of elite and young basketball players performing  $5 \times 6 \text{ s}$  repeated effort test

Sample		Sprint 1		Sprint 2		Sprint 3		Sprint 4		Sprint 5	
		W	$\text{W}\cdot\text{kg}^{-1}$	W	$\text{W}\cdot\text{kg}^{-1}$	W	$\text{W}\cdot\text{kg}^{-1}$	W	$\text{W}\cdot\text{kg}^{-1}$	W	$\text{W}\cdot\text{kg}^{-1}$
Elite basketball players	Mean	1235.8	13.06	1207.08	12.78	1160	12.28	1144.2	12.11	1101.2	11.65
	S	289.08	2.37	264.24	2.22	272.77	2.33	265.58	2.21	249.15	2.04
	CV%	23.39	18.17	21.89	17.39	23.51	18.97	23.21	18.28	22.62	17.52
	Min	973	9.67	966	9.62	890	8.77	883.00	8.97	842.00	8.87
	Max	1909	16.7	1809	15.87	1846	16.20	1848	16.2	1749.0	15.34
Young basketball players	Mean	816.00	11.74	770.83	11.09	752.75	10.81	763.75	10.94	739.08	10.59
	S	210.61	1.24	203.98	0.99	211.04	1.13	215.50	0.88	216.29	1.13
	CV%	25.81	10.52	26.46	8.91	28.04	10.43	28.22	8.07	29.26	10.66
	Min	598.00	9.83	617.00	9.57	584.00	9.17	579.00	9.57	558.00	9.07
	Max	1392	14.1	1370	13.15	1364	12.66	1388	12.7	1363	12.6
<b>P-value</b>		<b>&lt; 0.004</b>	<b>0.098</b>	<b>&lt; 0.0001</b>	<b>&lt; 0.024</b>	<b>&lt; 0.004</b>	<b>0.061</b>	<b>&lt; 0.0007</b>	<b>0.099</b>	<b>&lt; 0.008</b>	<b>0.12</b>

Note: CV – coefficient of variation.

Table 2. Muscle power decrement of elite basketball players and young players between work interval 1 and 2 as well as between 1 and 5, as well as concentration of lactate in the blood

Sample		Sprints 1–2			Sprints 1–5			La mmol·l <sup>-1</sup>
		W	W·kg <sup>-1</sup>	FI (%)	W	W·kg <sup>-1</sup>	FI (%)	
Elite basketball players	Mean	28.77	0.32	2.05	128.23	1.35	10.11	9.48
	S	31.29	0.27	1.79	71.80	0.70	4.42	2.42
	CV%	108.75	85.69	87.23	55.99	52.33	43.77	25.52
	Min	3.00	0.04	0.36	38.00	0.38	3.85	5.40
	Max	100.00	0.87	6.24	287.00	2.96	18.77	13.30
Young basketball players	Mean	51.67	0.76	6.32	76.92	1.15	9.74	9.12
	S	35.91	0.51	4.02	38.08	0.57	4.65	3.77
	CV%	69.51	67.63	63.62	49.51	49.79	47.77	41.40
	Min	17.00	0.19	1.58	29.00	0.26	2.08	5.60
	Max	128.00	1.83	15.15	143.00	1.92	17.46	15.20
<b>P-value</b>		<b>&lt; 0.143</b>	<b>&lt; 0.003</b>	<b>&lt; 0.031</b>	<b>&lt; 0.038</b>	<b>0.505</b>	<b>0.990</b>	<b>0.772</b>

Note: CV – coefficient of variation.

## DISCUSSION

The study shows that absolute indicators of muscle power were higher in the group of elite athletes compared to the same indicators of young players (Figure 1). However, differences in relative muscle power were observed only in the second work interval. This means that 14-year-old players equalled to elite athletes in relative power of short muscle work. It can be stated that the average relative anaerobic alactic muscle power of professionally trained athletes is not sufficient. However, both relative and absolute anaerobic alactic muscle powers are significant because in play situations an athlete has to overcome not only the power of their own body gravity, but also to cope with a personal contact with an opponent.

L. Ellis et al., (2000) point out that in game situations high average indicator is of utmost importance during all the five work intervals. He stated that the average relative muscle power of elite ice hockey players totaled to 13.2 W·kg<sup>-1</sup>, whereas that of the researched elite basketball players equaled to 12.4 W·kg<sup>-1</sup>, and the average relative muscle power in the group of young basketball players totalled to 11.1 W·kg<sup>-1</sup> (Figure 2).

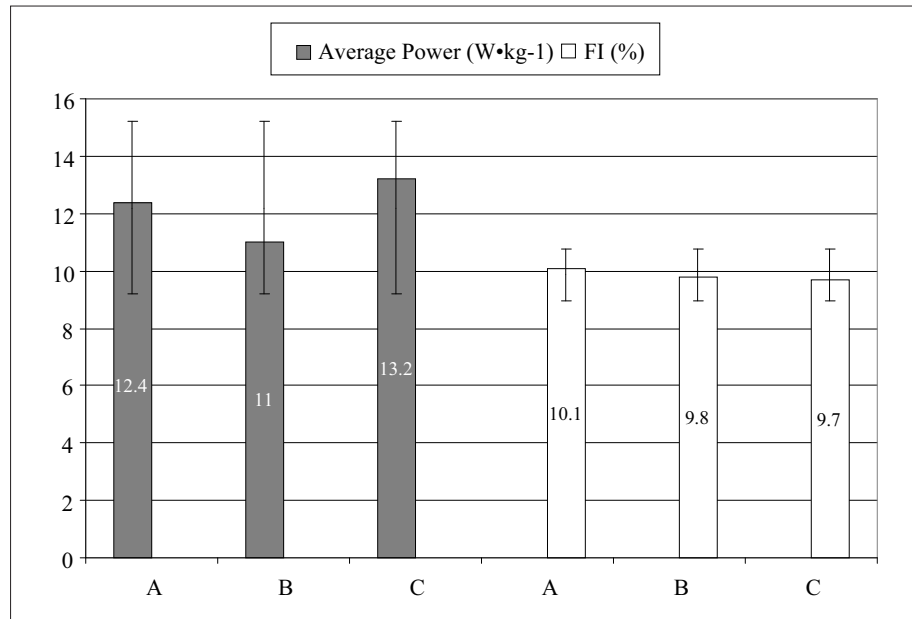
Applying this test it was necessary to evaluate the change in the power of short muscle work under conditions of short recovery time. A decrease in work power is expressed through fatigue index (FI), where lower value refer to better endurance of muscle power. Table 2 contains the fatigue index of anaerobic alactic muscle power, which

is particularly important in basketball and other sports games. It can be seen that young players fall behind adult ones. P. Astrand and K. Rodahl (1986), J. Wilmore et al. (2008) point out that the prevailing duration of anaerobic alactic energy production reactions ranges from 6 to 10 s. Working at maximum intensity for such a period, phosphocreatine (PCr) resynthesizes ATP enough. According to the authors mentioned above, recovery depends on a big number of factors but the main processes occur within 1.5–3 min. During the conducted research, the rest period between work intervals amounted to 24 s. Therefore, the main factor predetermining better capacity of anaerobic alactic muscle capacity could be a bigger reserve of PCr accumulated in muscles as well as higher activity of creatine-kinase (Kraemer, Ratamess, 2005).

The fatigue index was the same in both groups. A. Stapf (2000) suggests that good fatigue index of repetitive work capacity of elite Australian basketball players equaled to 5%. The FI of elite basketball players in the research sample was 10.1%, similar to that of young players (9.7%).

Fatigue index is not correlated with a large number of indicators of physical development and physical fitness (Fitzsimons et al., 1993). Evaluating the effect of repetitive work on the activity of glycolytic reactions in muscles, the concentration of lactate in the blood was measured. The concentration in the blood of all

Figure 2. Average working power during  $5 \times 6$  s repeated effort test ( $W \cdot kg^{-1}$ ) and fatigue index FI (%)



Note. A – elite basketball players, B – young basketball players, C – elite ice hockey players (Ellis et al., 2000).

the basketball players considerably exceeded lactate accumulation threshold (LAT) and was the same in both groups. This shows that the amount of PCr, which is necessary for ATP resynthesis, starts decreasing during repetitive work and the activity of anaerobic glycolytic reactions increases. However, the dispersion of indicators around the mean show that contribution of energy sources to capacity of repetitive work is very individual.

## CONCLUSIONS AND PERSPECTIVES

1. The research revealed that relative muscle power of elite basketball players did not differ from those of young athletes.
2. The same anaerobic repetitive muscle work capacity was observed in both groups.
3. It was established that the concentration of lactate in the blood increased after physical load and did not differ in the two groups.

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## DIDELIO MEISTRISKUMO IR JAUNŪJŲ KREPŠININKŲ ANAEROBINIS RAUMENŲ PAJĖGUMAS IR KARTOTINIO DARBO IŠTVERMĖ

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### SANTRAUKA

*Tyrimo pagrindimas ir hipotezė.* Žaidėjai darbo metu turi atlikti labai intensyvų kartotinį darbą ir trumpų pertraukėlių metu greitai atsigauti. Manoma, kad didelio meistriškumo krepšininkų anaerobinis darbo galingumas ir kartotinio darbo ištvėrmė yra didesnė nei jaunųjų krepšininkų.

*Tikslas* – nustatyti didelio meistriškumo ( $n = 13$ ) ir jaunų žaidėjų ( $n = 12$ ) anaerobinį pajėgumą ir kartotinio darbo ištvėrmę bei atlikti lyginamąją analizę.

*Metodai.* Varžybų laikotarpiu buvo atliktas  $5 \times 6$  sekundžių kartotinio darbo testas darant 24 s poilsio pertraukas. Buvo paskaičiuotas kiekvieno darbo intervalo vidutinis galingumo rodiklis bei nustatytas nuovargio indeksas. Po fizinio krūvio praėjus trimis minutėms, buvo nustatyta laktato koncentracija kraujyje.

*Rezultatai.* Absoliutaus raumenų pajėgumo rodikliai didelio meistriškumo žaidėjų buvo statistiškai reikšmingai didesni visų darbo intervalų metu. Tačiau santykiniai darbo galingumo rodikliai, išreikšti viename kilogramui kūno masės, statistiškai nesiskyrė. Pirmuoju darbo intervalu didelio meistriškumo žaidėjų jis buvo  $13,06 \text{ W}\cdot\text{kg}^{-1}$ , jaunųjų krepšininkų –  $11,74 \text{ W}\cdot\text{kg}^{-1}$  (skirtumas  $p < 0,09$ ). Nuovargio indekso rodikliai abiejų grupių tiriamųjų nesiskyrė ( $p < 0,77$ ), statistinio skirtumo tarp laktato koncentracijos rodiklių taip pat nebuvo ( $p < 0,778$ ).

*Aptarimas ir išvados.* Nors absoliutūs raumenų pajėgumo rodikliai didelio meistriškumo žaidėjų ir buvo didesni, žaidžiant krepšinį svarbūs santykiniai rodikliai (kur reikalinga įveikti kūno masės pasipriešinimą) statistiškai patikimai nesiskyrė. Po krūvio abiejų grupių laktato koncentracija viršijo  $9 \text{ mmol}\cdot\text{l}^{-1}$ . Vadinas, dirbant 5 kartus po 6 sekundes ir 4 kartus ilgiau ilsintis KF atsargų ATP resinzei nepakanka, todėl yra aktyvuojamos anaerobinės glikolitinės reakcijos.

**Raktažodžiai:** nuovargis, laktatas, atsigavimas, raumenys.

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