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# Effects of stretching and strength exercises on speed and power abilities in male basketball players

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**Abstract**. Recent data, especially related to the molecular structure of muscle tissue and the neurophysiological processes that control muscular speed and force have questioned the benefits of stretching exercises performed prior to dynamic physical activities such as sprinting or jumping. On the other hand strength exercises with various types of muscle contraction and different training loads have proven effective in developing running speed and jumping performance. The present work attempted to verify the hypothesis concerning the detrimental influence of stretching on running speed and anaerobic power of lower limbs, while confirming the benefits of strength exercises on these motor abilities. The main objective of the study was to evaluate the short-term effects of stretching and strength exercises on running speed and jumping performance in competitive basketball players. The results showed significant changes in all of six variables used to evaluate lower limb power and running speed. Vertical jump performance showed increased tendencies in a microcycle without stretching, yet with strength exercises focused on lower limb extensors and flexors. Take-off speed, maximal jump height, work output and power during this microcycle were significantly higher in comparison to a weekly cycle were stretching was incorporated in the warm-up and prior to testing. In the case of running speed, the 3 treatments revealed significant differences, yet once again strength exercises compared to stretching allowed reaching of faster times for the 5 and 20 m sprint, respectively.

Keywords: Basketball, stretching, strength exercises, power, running speed

## 1. Introduction

The influence of stretching exercises performed during a warm-up, the main part of a training session or before competition on speed and power is a significant issue in competitive sport, and has been studied throughout the world, with different results and conclusions [1–3].

Stretching exercises are traditionally implemented as part of a warm-up in order to increase the range of movement around a joint without causing pain, and as a further aim, to gain better results and/or decrease the risk of injuries [4–6]. Coaches, as well as other specialists, including physiotherapists, recommend that players and patients stretch before performing strength and speed exercises. However, authors of numerous studies suggest that stretching exercises before the main motor task *do not* decrease the risk of injury [4,6,7]. They also claim that static stretching before the main exercises *has a detrimental influence* on the force and speed of muscle contraction. Therefore, stretching may change several performance variables, such as sprinting [8, 9], vertical jump [10,11] kicking and striking movements [12,13], balance and the speed of reaction [14, 15] as well as lower limb power [16].

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On the other hand, previous and recent studies have shown significant benefits of strength exercises on running speed and jumping performance. Research indicates that most strength training protocols, including lower limb exercises with maximal and supramaximal loads (100–150%1RM), plyometrics and those with a low external load (10–30%1RM) yet high velocity of movement improve the above mentioned abilities [17–20].

The mechanisms which are responsible for loss of strength and power after static stretching have been presumed to involve both mechanical and neurophysiological changes [7,21]. Intense stretching exercises lead to damaged contractile proteins in skeletal muscles which reduce their capability for regeneration after physical effort. Smith et al. [22] confirmed muscle injuries in human tissues as early as 24-h after a series of stretching exercises. This has led to a conclusion that stretching caused delayed onset muscular soreness (DOMS). However, other research projects indicate a lack of negative effects of static stretching on selected neuromuscular variables [8,23,24].

In contradiction to static stretching, many experts consider ballistic stretching as an effective part of a warm-up procedure, especially before athletic performance based on speed-strength abilities [2,5,16,25,26]. Strength exercises performed in the second part of the warm-up or in the main part of the training session show positive effects on starting speed and jumping performance yet the improvements in these abilities depend on the type of muscular contraction, muscle groups involved, exercise intensity and total training load [17–20,49]. Therefore a verification of the influence of stretching exercises on running speed and jumping performance of athletes seems important from an empirical and practical points of view. This seems especially justified in basketball, were elite players perform over 100 sprint starts and between 200–250 jumps during a game.

The main aim of this work was to determine the influence of stretching and strength exercises on running speed and power in basketball players. These effects were considered with regard to short-term adaptive changes that occur within a 1-week training cycle.

## 2. Methods

### *2.1. Subjects*

Fourteen male Division I basketball players (age 23.2 $\pm$ 3.8 years, training experience 6.8 $\pm$ 2.9 years) volunteered to participate in the study, which was approved by the Institutional Ethical Board of the Academy of Physical Education in Katowice. All basketball players were informed of the procedures, potential risks and benefits, before signing an informed consent form. The athletes were free of injury and well conditioned. The testing was performed during the pre competitive period, after 8 weeks of general and specific training.

### *2.2. Experimental design*

The 3 week experiment was divided into subsequent 1-week microcycles. Starting and absolute speed at 5 and 20-meter distances were measured, as well as power during a counter movement jump (CMJ) performed on a force platform. During each microcycle, the players practiced twice a day. Each practice session was preceded by a routine warm-up lasting 15-min. In the first microcycle the participants conducted static stretching exercises for lower limbs (hip, knee, ankle extensors and flexors) in the second part of the warm-up (8-min) and just before speed and power evaluations. Four stretching exercises were performed with 3 repetitions of each lasting 10-s at an intensity of 80–90% of the full range of motion. On the last day of each microcycle, starting and absolute speed at 5 and 20-m distances were measured, as well as power during a CMJ performed on a force platform. During the second microcycle, stretching exercises were eliminated, while in the third microcycle, the players did isometric strength exercises for hip extensors and dynamic strength exercises for hip and knee extensors and flexors, after a typical warm-up and just before the evaluations, in order to increase lower limb muscle tension and stiffness. The strength exercises included half squats and toe raises with (80–85% 1-RM) and maximal voluntary isometric hamstring contractions. Two sets of 3 repetitions of each exercise with a 2-min rest interval were performed.

A routine warm–up (15-min) consisting of continuous running, agility drills and accelerations was done before the absolute speed and power measurements. The speed test consisted of 2 $\times$ 20 m sprints, separated by four minutes of active recovery. Sprint times were recorded using a laser diode system LDM 300-Sport (Jenoptic, Jena, Germany) which provided online measurement of the required distance-versus-time and velocity-versus-time relationships as well as selected kinematic parameters (velocity at 5 and 20-m [s], stride length [m] and stride rate [s/s]).

In the power test, subjects jumped from a standing position using a countermovement 3 times, each trial separated by a 30-s rest interval. (Force platform (AMTI, AccuGait, USA). The time that elapsed from the end of the stretching or strength exercise until the speed and power evaluations was approximately 5-min. The trial with the greatest jump height was recorded for further analysis.

The following performance variables were recorded: force impulse [N/s], take-off velocity [m/s], height of the jump [m], average work [J], average power [W], maximal power [W], relative average work [J/kg], relative average power and relative maximal power [W/kg]. The structure of training sessions and the practice priorities in the second and third microcycle were identical to the first, which increased measurement reliability. The afternoon sessions lasted 90-min and included technical and tactical drills, while morning sessions lasted 60–70-min and were directed at agility and specific basketball skills of perimeter and pivot players.

### 2.3. Statistical analysis

The data was processed statistically using basic descriptive statistics. The significance of differences between measurements was evaluated by ANOVA with repeated measures. In order to determine the relationship between variables the Pearson's correlations were calculated. For all data the significance level was established at $p < 0.05$. Post hoc analysis was used to determine differences between interactions of stretching, isometric and dynamic strength exercises and speed-power variables. The analysis was performed using Statistica, StatSoft version 8.

## 3. Results

Pearson product-moment correlation coefficient between all variables measured to construct a confidence interval around r that has a given probability of containing $\rho$, showed a very low values stride length [m], stride rate [s/s], force impulse [N/s], average work [J], average power [W] and maximal power [W]. Therefore, only the remaining six variables have been selected for further analysis.

The results of a 1-way ANOVA showed significant changes in all of the 6 variables used to evaluate running speed and lower limb power. The relative average power ($F = 0.29$, $p = 0.007$), velocity at 5-m ($F = 0.36$, $p = 0.005$), 20-m ($F = 0.13$, $p = 0.008$), relative average work ($p = 0.011$), height of the jump ($p = 0.034$) and take-off velocity ($p = 0.025$) were significantly affected by the 3 treatments (Table 1).

Table 1
Progress value of variables (before and after strength exercices) and the results of a 1-way ANOVA to evaluate variables considered in the study

| Variables | Values | | $F$ | $p$ |
|---|---|---|---|---|
| | Before | After | | |
| Take off velocity [m/s] | 2.779 | 2.859 | 0.128 | 0.025 |
| Height of jump [m] | 0.405 | 0.462 | 0.156 | 0.034 |
| Relative average work [J/kg] | 4.960 | 5.160 | 0.158 | 0.011 |
| Relative average power [W/kg] | 38.637 | 40.383 | 0.292 | 0.007 |
| Velocity at 5m (s) | 1.170 | 1.081 | 0.362 | 0.005 |
| Velocity at 20m (s) | 3.261 | 3.192 | 0.125 | 0.008 |

*significance level $p < 0.05$.

Additionally, the results showed that all six variables were significantly greater in the microcycle that included strength exercises, and eliminated stretching. These differences reached 0.08 s, 0.07 s, 0.08 m/s, 0.07 m, 0.10 J/kg and 1.75 W/kg respectively (Figs 1–6).

The results of ANOVA were verified using the post hoc Tukey (HSD) test and confirmed the significance of differences between interactions of stretching, isometric and dynamic strength exercises and speed-power variables with scores 0.678, 0.987 and 0.979 respectively.

As far as vertical jump performance is concerned there was a tendency towards obtaining better results in the microcycle where strength exercises focused on lower limb extensors and flexors while stretching was eliminated. Changes in running speed following the stretching treatments were marginal; after the application of strength exercises they reached high values of $F$ and were significant.

## 4. Discussion

The main objective of this work was to assess the influence of stretching and strength exercises on running speed and anaerobic power in basketball players. This was verified in relation to acute adaptive changes within a 1-week training cycle. Stretching exercises are commonly used in basketball and other team sports because they are believed to enhance performance (speed and jumping abilities) and reduce the number of injuries. Competitive basketball players typically execute 200 jumps and 150–250 explosive activities, including accelerations, changes of pace and direction, as well as sudden stops and starts during a game. This makes the game extremely demanding and requires a high level of

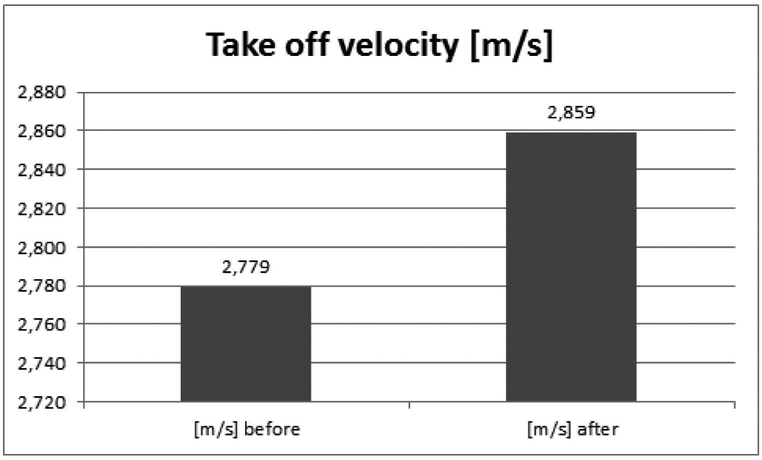


Fig. 1. The value of take-off velocity (before and after strength exercises).

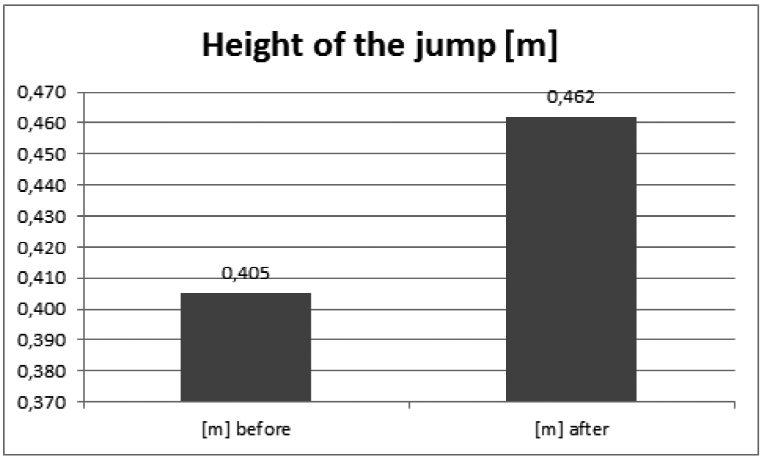


Fig. 2. The value of height of the jump (before and after strength exercises).

agility and lower limb power [27]. Elite athletes in the NBA register an average power output of 100 W/kg of body mass on the jumping platform, with vertical leaps often exceeding 100 cm [28].

The results indicated significant changes in all of 6 variables used to evaluate lower limb power and running speed during this experiment (Table 1, Figs 1–6). However it must be underlined that for the vertical jump performance significantly better results were reached during the microcycle without stretching exercises but with strength exercises focusing on lower limb extensors and flexors performed during the warm-up and prior to the evaluations. Take-off speed, maximum jump height, work output and power were significantly higher in this microcycle. Running speed results were also significantly better after the microcycle that included strength exercises in comparison to the one with stretching. Despite the short duration of stimuli (1 week), significant differences in the post-training effects were observed after the three treatments. It seems, that intensive stretching exercises performed before the vertical jump and during a microcycle preceding that trial, decreased the possibilities of maximal power development. The use of isometric tension and dynamic strength exercises directed at the lower limbs increased power output and jumping performance. The first phase of the experiment confirms the results of other authors who recorded a decline of power and a decrease of jumping performance after intensive stretching exercises, especially static ones [29–32].

The practice of strength and stretching exercises is widely recommended for basketball players in conditioning programs, especially during the warm-up. Therefore, an understanding of the influence of strength

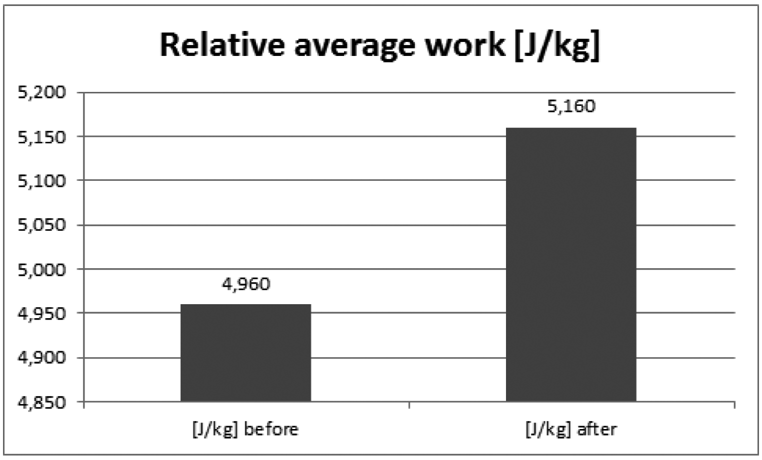


Fig. 3. The value of relative average work (before and after strength exercises).

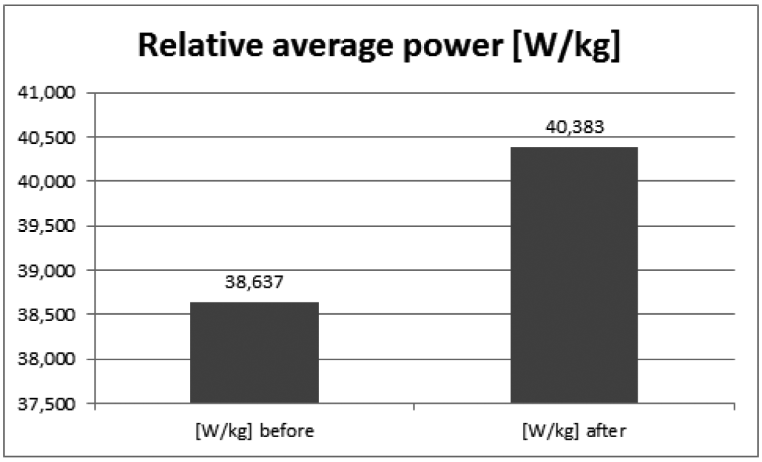


Fig. 4. The value of relative average power (before and after strength exercises).

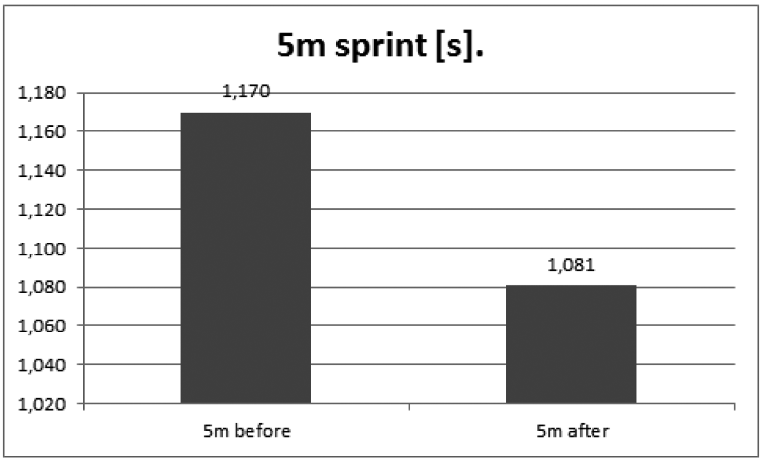


Fig. 5. The value of 5-m sprint (before and after strength exercises).

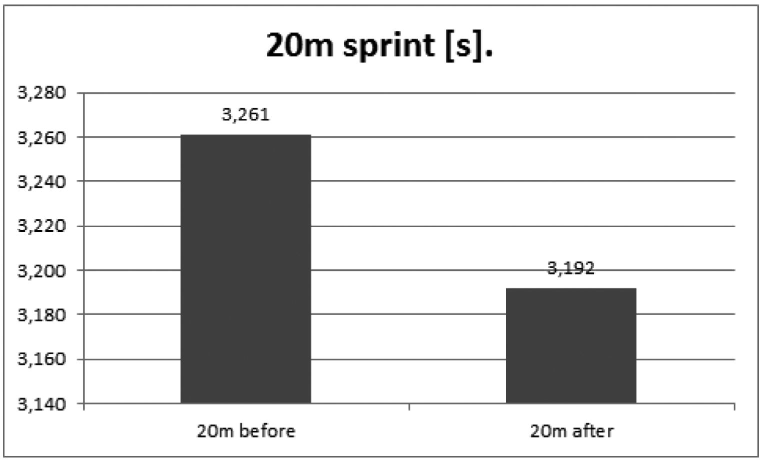


Fig. 6. The value of 20-m sprint (before and after strength exercises).

and stretching exercises on athletic performance is crucial for sports in which speed and power requirements are high. While the different aspects of strength and power training are well described and most experts agree about their positive impact on sport performance [17,27,33], both static and ballistic stretching exercises cause much controversy. This is of particular concern in sport disciplines demanding a high level of speed, strength, coordination, and exeptional technical skills. Faulkner et al. [34], found a beneficial impact of strength exercises, such as the squat, lunge, push press and deadlift, with maximal and submaximal loads on speed abilities. This was explained by increased activity of the fast twitch motor units, partial hypertrophy of most involved muscles and better inter-muscular coordination. Similar results were observed when evaluating the impact of strength exercises with maximal and submaximal loads on jumping performance in various sport disciplines, where this ability is crucial for success (volleyball, basketball, ski jumping, high jump, (vertical) and long jump (horizontal) components. Baechle and Earle [33] revealed particular efficacy of eccentric training with supra-maximal resistance (120–150% 1 RM) in case of vertical jumping performance. This effect is explained by the aid of intensive activation of selected motor units, increased stiffness of lower limb tendons and increased stretch reflex.

Several studies have demonstrated the beneficial influence of dynamic strength exercises performed with low and medium loads and high speed of movement on the rate of force development. Incresed RFD was significantly correlated with improvements in vertical and horizontal jump performance [17,35,36]. This is explained by increased Achilles tendon stiffness, stretch reflex, and restricted inhibiton of muscle action by reflex protective mechanism of the Golgi tendon organs. Such changes allow for enhanced RFD, which seems crucial in improving jumping abilities through strength exercises [31].

Young and Behm [37] emphasized also the meaning and benefits of plyometric training based on the stretch–shortening cycle (SSC) of muscle tissue. They described the importance of two factors: the serial elastic components, which included the tendons, cross-bridging characteristics of the actin and myosin, which make up the muscle fibers and the sensors in the muscle spindles (proprioreceptors).

It seems that the influence of strength exercises on speed and jumping ability is widely diagnosed and described, and the results of the presented study confirm the carefully worded hypothesis in explaining the course of short-term adaptive changes.

Contemporary studies allow the examination of skeletal muscle structure and other tissues connected with changes caused by stretching exercises. For many years experts in sports conditioning and physiotherapy claimed that such exercises showed a positive effect on injury prevention and athletic performance. New studies indicate that intensive static stretching exercises reduce the speed and strength of muscle contraction and limit performance in sport disciplines where speed and jumping abilities play a significant role.

Several studies indicated that muscular performance was not different after static stretching [24,32,38,39]. Multiple variations of stretching programs following different structures of protocols (modes, intensities, frequencies, durations of stretches, recovery prior to performance) on numerous performance variables in recreational or relatively trained individuals were evaluated in these studies. The data obtained in our investigation is in part comparable to the above mentioned studies.

Some studies examined the acute effects of pre-participation warm-up stretching in sport specific kinetic tasks [27,40–43]. A number of methodological issues may have an impact on the discrepancy in the results showing that static stretching in different sports (tennis, golf, football, baseball) did not have a significant effect on specific sport kinetic performance [16, 23,32,40,43,44]. Little and Williams [9] also found no detrimental effects, after applying 30-s of stretching on performance outcome and further suggested that shorter durations of stretching may minimize the detrimental effects on subsequent performance. A possible explanation for the conflicting results of previous studies examining the acute effects of different stretching protocols in selected performance parameters is the rest period used between stretching and the testing of performance [45]. Similar results were found by Guissard and Duchateau [21], who also reported that the H-reflex recovered immediately after static stretching. Consequently, the time of the rest period (5-min) between stretching and strength phase or the speed and vertical jump test of the present study did not diminish any stretch and power induced physiological changes.

However, quite a number of studies revealed that intensive static streching exercises decreased skeletal muscle contraction by reducing the number of actin-myosin cross-bridges [4,13,32,46]. Therefore, some experts recommend the use of moderate intensive dynamic stretching exercises during the warm-up before the event, in sport disciplines with speed-power requirements. However, static stretching or PNF procedures are recommended at the end of practice or after games to enhance recovery and increase the range of motion, if necessary [3,21,47,48].

This study has several experimental drawbacks, which can be eliminated or addresed in new research projects. First of all different methods of stretching and strength protocols can be compared with respect to speed and power changes in athletes. Second, different treatments can be applied over a longer period of time (4–6 weeks) where chronic adaptive changes can be evaluated. Perhaps the most important aspect to consider for future research is the identification of the optimal time (1, 5, 15, 30-min) elapsing from stretching and strength exercises to speed and power evaluations a factor that is of imprtance to athletic performance.

## 5. Conclusions

1. Brief dynamic strength exercises of the lower limbs with sub-maximal loads performed in the second part of the warm-up, improve speed and power during competition or in drills conducted in the main part of the training session.
2. 5 and 20-m running speeds improve with the use of low volume, high intensity dynamic strength exercises of the lower limbs performed in the second part of the warm-up. Take-off speed, maximum jump height, work load and power are significantly higher in a microcycle where strength exercises are performed, while stretching is eliminated.
3. Intensive stretching exercises performed before the vertical jump and during a microcycle preceding that trial, decreased the possibilities of maximal power development. This confirms the results of other authors who recorded a decline in results of power trials after intensive stretching exercises, especially of a static nature.

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