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Abstract

Introduction: his study investigated the relationship between hip abductor strength (Abd), adductor strength (Add), straight accelerations and decelerations, and during changes of direction (COD 90°) performance in basketball players.

Material and Methods: Fourteen basketball players participated (age = 23.6 ± 4.4 years, body mass = 86.3 ± 5.9 kg, body height = 192.3 ± 6.2 cm, training experience = 6.7 ± 2.6 years). Straight running results and running with a change of direction (COD 90°) have been described as the time (s) obtained for a given length. Following tests were carried out: maximum isometric strength test, 20-m linear sprint and 20-m COD sprint with 90° direction change angles. Following the warm-up, all athletes performed two maximal 20-m linear sprints, interspersed with 5 min rest intervals. Following the 20-m linear sprint test, the participants were provided with a 5 min rest interval before completing the COD tests. Additionally, the balance in isometric strength of the dominant and non-dominant hip Abd-Add muscles were evaluated. Two maximum attempts interspersed with one-minute rest intervals were performed.

Results: The t-test revealed statistically significant higher absolute and relative isometric strength of AddR (adductor right) in comparison to AddL (adductor left).

Conclusion: The results of this study show that the maximum isometric force and the relative strength of the abductor muscle group have a significant effect on changing direction running. Moreover, hip Abd and Add are typical for strength bilateral strength imbalances. Therefore, the evaluation and development of these qualities are essential for coaches to monitor and prescribe adequate training regimens.

Keywords

agility, team sports, speed, groin, change of direction

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Article

Analysis of the adductors and abductors' maximum isometric strength on the level of speed and agility in basketball players

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Abstract: Introduction: his study investigated the relationship between hip abductor strength (Abd), adductor strength (Add), straight accelerations and decelerations, and during changes of direction (COD 90°) performance in basketball players. Material and Methods: Fourteen basketball players participated (age = 23.6 ± 4.4 years, body mass = 86.3 ± 5.9 kg, body height = 192.3 ± 6.2 cm, training experience = 6.7 ± 2.6 years). Straight running results and running with a change of direction (COD 90°) have been described as the time (s) obtained for a given length. Following tests were carried out: maximum isometric strength test, 20-m linear sprint and 20-m COD sprint with 90° direction change angles. Following the warm-up, all athletes performed two maximal 20-m linear sprints, interspersed with 5 min rest intervals. Following the 20-m linear sprint test, the participants were provided with a 5 min rest interval before completing the COD tests. Additionally, the balance in isometric strength of the dominant and non-dominant hip Abd-Add muscles were evaluated. Two maximum attempts interspersed with one-minute rest intervals were performed. Results: Statistically significant, large positive correlations were found between both absolute and relative AbdL and AbdR isometric strength and the COD test. Conclusion: The results of this study show that the maximum isometric force and the relative strength of the abductor muscle group have a significant effect on changing direction running. Moreover, hip Abd and Add are typical for strength bilateral strength imbalances. Therefore, the evaluation and development of these qualities are essential for coaches to monitor and prescribe adequate training regimens.

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1. Introduction

Basketball is a physically demanding team sport characterized by frequent high-intensity phases [1], during which neuromuscular factors are heavily taxed [2]. Players are frequently asked to accelerate, decelerate and change direction quickly during basketball games [1], which are characterized by lateral movements, jumping and landing, decelerations, and stops [3–4]. At the elite level, in an official game, players usually perform numerous short accelerations and decelerations, close to 1000 changes of pace and movement direction. It has also been determined that 30% of the game time, the players move

sideways, utilizing the defensive slide-step [5]. Change of direction (COD) and agility maneuvers are multidimensional skills requiring athletes to control individual components (body position, muscle activation, force production, cognitive interpretation) and manipulate the degrees of freedom of movement to enable constant adaptation within reactive, unpredictable environments [6–8]. These physical qualities are essential in basketball, as aggressive directional changes occur throughout a game when athletes compete for positional advantage. When changing direction, athletes must rapidly and systemically coordinate force and impulse application during the braking phase (eccentric), plant phases (isometric), and propulsive phase (concentric) of the movement. This performance is often improved by increasing an athlete's lower-body strength capacity, or more specifically, lean muscle mass, which has been shown to improve COD performance [9–10].

Recent research has demonstrated that greater vertical braking and propulsive force and impulse are required for a faster exit velocity during a 45° COD [9] and offensive and defensive agility movements [10].

Given the frequent changes of direction and high running loads required in basketball [11], athletes are at an increased risk for injuries to the hip and groin. Adductor injuries have been shown to account for 21.8% of all hip injuries in this population [12]. A review of the most common adductor injuries in the National Basketball Association group [13] showed groin and adductor injuries on frequent conspiratorial lost game time and reduced performance of athletes. Creating a stable pelvic base allows for a more efficient generation of strength through all hip muscles [14]. When it comes to the muscles of the hip adductor (ADD), Matsuo [15] suggested that muscle activity during fast sprints may indicate that they are also responsible for stabilizing the hip joint and have a relationship with straining groins and injuries to remedy [16–17]. In this link, the Add (hip adductor) and Abd (hip abductor) reinforcement effectively prevent groin injury [18]. The pelvic instability caused by the weakening of the hips may limit the ability to generate a horizontal force during the feet contact phase during the sprint and then improve the running speed [14]. Wiemann [19] indicated that adductor magnus, the hamstrings and the knee extensors have been identified as the most important ones, which are responsible for the acceleration and horizontal velocity of the body during sprinting at a maximum speed. Watanabe [20] stated that the volume of adductor muscles and major lumbar muscles significantly affect the efficiency of sprint. Results obtained by Yasuda [21] imply that the relationship between sprint time and the adductor brevis muscle volume may affect sprint running performance in female sprinters. In addition, abductors and adductors (Abd-Add) have been shown to play an important role in sprint running [14-15, 20–21]. However, it is unknown if their strength affects the speed of running in a straight line and running with a change of direction (COD) in basketball players. Thus, increasing a certain Abd-Add strength can increase running performance and prevent injuries. Studying the relationship between Abd-Add muscle strength and performance in straight running and changing direction can help explain the role of these muscles. Therefore, this study aimed to investigate the relationship between Abd-Add maximum isometric strength and performance in a straight and diversion run in basketball players. It has been hypothesized that Add, like the isometric force Abd, is related to straight running performance and COD.

2. Materials and Methods

2.1. Experimental Approach to the Problem

This study investigated an association of the maximum isometric strength of hip Abd-Add muscles and the change of direction in basketball. The following tests were conducted: the maximum isometric strength test, 20-m linear sprint and 20-m COD sprint with 90° direction change angles. Additionally, balance in isometric strength of the dominant and non-dominant hip Abd-Add muscles was evaluated.

2.2. Subjects

Fourteen professional basketball players participated in the study (age = 23.6 ± 4.4 years, body mass = 86.3 ± 5.9 kg, body height = 192.3 ± 6.2 cm, training experience = 6.7 ± 2.6 years). All players participating in the experiment had valid medical examinations and showed no contraindications to participate in physical fitness tests. The athletes were instructed to maintain their normal dietary habits over the course of the study and not to use any supplements or stimulants for the duration of the experiment. Furthermore, they were informed verbally and in writing about the experimental protocol, the possible risks and benefits of the study, and the possibility to withdraw at any stage of the experiment. The study protocol was approved by the Bioethics Committee for Scientific Research (3/2021), at the Academy of Physical Education in Katowice, Poland, and performed ac-cording to the ethical standards of the Declaration of Helsinki, 2013.

2.3. Procedures

One week prior to starting the experimental sessions, all athletes were familiarized with the testing procedures. The experimental sessions were conducted at the same time of the day (between 9:00 and 11:00 a.m.) 72 h apart. Both sessions were preceded by the same warm-up protocol, which included 5 minutes jogging, 5 minutes dynamic stretching, a single attempt of a 20-m linear sprint, interspersed with 5 min rest intervals and COD sprints (90°) at submaximal intensity. During the first experimental session, the athletes performed a 20-m linear sprint and 20-m COD sprint (90°), and they performed a maximum isometric strength test of the Adb -Add muscles. The entire research session was performed in the sports hall of the Academy of Physical Education in Katowice. The running times were recorded by two pairs of dual-beam Witty Gate photocells (Microgate, Bolzano, Italy) with the measuring precision of 0.01 s. The intraclass correlation coefficient for the test-retest reliability during linear sprinting and COD tests measured by the used photocells ranged from 0.96 to 0.99. Assessment of the maximum isometric strength of the Abd-Add muscles was performed with a use of the ForceFrame Hip Strength Testing System (Vald Performance, Albion, Australia). This device has been previously used to measure hip strength in scientific research [22].

2.3.1. Linear Sprint Test

Following the warm-up, all athletes performed two maximal 20-m linear sprints, interspersed with 5 min rest intervals. The athletes started with the front foot placed 0.5 m behind the first timing gate to prevent any early triggering of the start gate. The athletes started when ready to eliminate the reaction time effect. The faster time from both attempts was recorded for further analysis.

2.3.2. Change of Direction Tests

Following the 20-m linear sprint test, the participants were provided with a 5 min rest interval before completing the COD tests. The COD tests consisted of four 5-m sections marked with cones set at 90° (90°-COD), requiring the athletes to decelerate and

accelerate as fast as possible around each cone (Figure 1). The players executed two attempts of each COD test with 5 min rest intervals in between attempts and tests. The faster time from each COD test was recorded for further analysis.

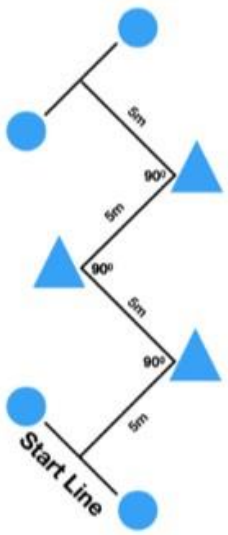

Fig. 1. Schematic presentation of the 90° change of direction test. Circles represent the positions of photocells [25].

2.3.3. Maximum Isometric Strength Test

After the standardized warm-up, 20-m linear sprint, and COD sprints (90°) at submaximal intensity, the athletes were given a 5-minute recovery break before performing the isometric strength test of the Abd-Add muscles. The athletes were positioned beneath the GroinBar Hip Strength Testing System (Vald Performance, Albion, Australia) in a supine position, and the bar height was customized for each athlete to ensure they maintained a knee joint angle of 45 degrees and a hip joint angle of 45 degrees during testing. Placing the femoral medial condyle of both knees on sensors (sample rate of 50Hz), the participants were given a verbal command to complete a single attempt at approximately 80% of their maximum effort. After that, two maximum attempts interspersed with one-minute rest intervals were performed. The athletes were asked to push their femoral medial condyles against the pads for five seconds. Previous studies have shown high reliability of intra-class correlation coefficients (ICC) of 0.94 [22].

2.4. Statistical analysis

All statistical analyses were performed using the SPSS (version 25.0; IBM, Inc., Chicago, IL, USA). Data are presented as means and standard deviations (SD) with 95% confidence intervals. The normality of the data was confirmed by the Shapiro-Wilk test. Pearson's correlation was used to determine the relationship between all measured variables with 95% confidence intervals. The common variance between variables was described with a coefficient of determination (r2). Correlations were evaluated as follows: trivial (0.0–0.09), small (0.10–0.29), moderate (0.30–0.49), large (0.50–0.69), very large (0.70–0.89), nearly perfect (0.90–0.99), and perfect (1.0). Furthermore, t-test comparisons between the maximum isometric strength of the Abd-Add muscles were conducted. The significance level for the correlation analysis was set as $p < 0.05$.

3. Results

Descriptive data for all the variables are shown in Table 1. The t-test revealed statistically significant higher absolute and relative isometric strength of Add_R in comparison to Add_L ($p < 0.046$ and 0.041, respectively). The comparison of isometric forces in the dominant and non-dominant limb did not show statistically significant results (Table 2). Statistically significant, large positive correlations were found between both absolute and relative Abd_L and Abd_R isometric strength and the COD test (Table 3). No statistically significant correlations were found for the rest of the measured variables.

Table 1. Descriptive data for all measured variables during the linear sprint.

Variable	Mean ± SD	95% CI
Linear Sprint [s]	3.01 ± 0.12	2.95 to 3.07
COD 90° [s]	7.21 ± 0.21	7.08 to 7.33

Mean ± standard deviation (SD); CI – confidence interval; COD 90°– change of direction 90°.

Table 2. A comparison between isometric strength of the dominant and non-dominant lower limb.

	Left	Right	Mean Difference	Mean Percentage Difference [%]
Add [N]	383 ± 61	395 ± 64	12	3.13
Abd [N]	336 ± 104	341 ± 111	5	1.49
R_Add [N/kg/b.m.]	4.30 ± 0.66	4.44 ± 0.75	0.15	3.50
R_Abd [N/kg/b.m.]	3.77 ± 1.23	3.82 ± 1.25	0.05	1.33

**significant difference between the left and the right limb p < 0.001; Add – adductor, Abd – abductor, R_Add – relative adductor; R_Abd – relative abductor.*

Table 3. Relationships between running performance and adductors and abductors isometric strength.

Variable		Add_L	Add_R	Abd_L	Abd_R	R_Add_L	R_Add_R	R_Abd_L	R_Abd_R
Linear Sprint	*r*	0.254	0.165	0.234	0.239	0.172	0.063	0.178	0.201
Linear Sprint	*p*	0.381	0.573	0.422	0.410	0.556	0.830	0.544	0.490
COD 90°	*r*	–0.097	–0.178	0.664**	0.662**	-0.302	-0.364	0.536*	0.562*
COD 90°	*p*	0.741	0.542	0.010	0.010	0.294	0.200	0.048	0.036
Linear Sprint	*r*	0.254	0.165	0.234	0.239	0.172	0.063	0.178	0.201

**statistically significant correlation p < 0.05; **statistically significant correlation p < 0.01; r – Pearson's correlation coefficient; Add_L – left adductor; Add_R – right adductor; Abd_L – left abductor; Abd_R – right abductor; R_Add_L – relative adductor left; R_Add_R – relative adductor right; R_Abd_L – relative abductor left; R_Abd_R – relative abductor right; COD 90°- change of direction 90°.*

4. Discussion

The results of the presented research have shown that the maximum isometric strength and the relative strength of the Abd muscles are related to the variables obtained during a run with a change of direction COD 90°. The strength of both muscle groups, Add and Abd, is also related to running in a straight 20 m, although it does not significantly change the speed of the run. The right Abd and Add muscles (dominant leg) were significantly stronger than those of the left limb (non-dominant leg). Therefore, we can assume that the dominant limb Abd and Add contribute more to propulsion in both straight and directional running than the non-dominant limb, leading to asymmetric loading and subsequent imbalance in lateral forces. Identifying the key factors influencing performance in

straight running and diversion is essential for strength and conditioning coaches to monitor and prescribe appropriate training regimens. At the same time, the association of hamstring, quadriceps and maximal gluteal muscles with sprinting performance has been extensively analyzed in terms of muscle size and strength [24–28, 21]. There is very little data on the relationship between Abd and Add muscles. Most often, they only concern the relationship between muscle size, activity and sprinting ability [14–15, 20–21, 28–30]. Our research will validate Abd's contribution to Directional Running performance, which is critical, Abd strength and their strength to Add ratio during fast actions with a change of direction and slide step in basketball. This is very important for basketball players, as they perform a defensive slide step 30% of their playing time [5]. To the best of the authors' knowledge, this is the first study to investigate the relationship between the variables of straight running performance and diversion running performance variables and Abd-Add maximum isometric hip muscle strength. Abd-Add hip muscles are primarily responsible for creating a stable pelvic base while running, which allows all hip muscles to generate strength more efficiently [14]. Moreover, during running and sprinting, the pelvis acts as a pivot between the counter-rotating shoulders and legs [31]. Furthermore, it seems reasonable that due to the increasing force of muscular contraction of appropriate muscles and/or muscle groups, acceleration and speed may improve in skills critical to basketball players, such as sprinting, changing pace, direction and turning [32]. There are some learning limitations that must be taken into account. One of the limitations of this study is that only the 90-angle and 20-m straight run were studied, and the isometric force relationship was investigated. Therefore, these relationships may differ from the dynamic force. Hence, future research should take into account the relationship between Abd-Add muscle strength and different angles of change of direction, not just 90°, and take into account other sports and a research group of women. Based on the conclusions of the research results, long-term training will be implemented to increase the strength of the Abd muscle group. At the same time, there were no differences in the balance between the Add and Abd strengths, so complementary training for the Add muscle group would be implemented.

5. Conclusions

The results of this study show that isometric force and relative Abd are related to changing running performance (COD 90). Therefore, strength and conditioning trainers and other practitioners should independently evaluate and develop Abd and Add muscle strength as direct support during COD. In addition, the role of Abd-Add muscle-focused training programs in injury prevention cannot be underestimated, as Abd-Add are typical of bilateral imbalances.

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