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Abductor and adductor strength relation to sprint performance in soccer players

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Abductor and adductor strength relation to sprint performance in soccer players

Abstract

Wprowadzenie: Siła mięśni bioder odgrywa ważną rolę w sprintach i urazach bezdotykowych, w których należy rozpoznać ich rolę w piłce nożnej. Badanie to miało na celu zbadanie związku między siłą porywacza biodra (Abd), przywodzicielem stawu biodrowego (Dodaj) i wydajnością sprintu liniowego (5 mi 35 m). Szesnastu profesjonalnych piłkarzy (Druga Liga Polska) uczestniczyło w badaniu (wiek = 24 ± 3,2 lat, masa ciała = 75,3 ± 9,58 kg, wysokość = 179 ± 5,6 cm, doświadczenie w treningu piłki nożnej = 8 ± 2,9 lat). Sprint liniowy 5 mi 3 m został opisany przez: przyspieszenie szczytowe, prędkość szczytową (PV), względną siłę szczytową (PF), i względna szczytowa moc wyjściowa. Wytrzymałość na biodro Abd i Add została przetestowana za pomocą maksymalnych testów izometrycznych na obu kończynach dolnych. Testy T wykazały statystycznie istotne różnice między siłą prawej i lewej Add i Abd, (p < 0,001, dla obu). Regresja stopniowa wykazała, że model bioder Abd, Add i ich stosunek przewidują PV ($R.^{2)}$ = 37%) i PP ($R^{2)}$ = 36%) w sprincie 35 m, a biodro Abd ze współczynnikiem Abd / Add może przewidzieć PF ($R^{2)}$ = 16%) i przyspieszenie ($R^{2)}$ = 14%) w sprincie 5 m. Wyniki niniejszego badania wskazują, że maksymalna wytrzymałość izometryczna Abd-Add i 5 m, a także bieg sprintu 35 m, są powiązanymi właściwościami sportowymi. Co więcej, biodro Abd i Add są typowe dla obustronnej nierównowagi siły siły siły. Dlatego ocena i rozwój tych cech są niezbędne dla trenerów do monitorowania i określania odpowiednich schematów szkolenia.

Keywords

agility, team sports, speed, groin, isometric, team sports

Cover Page Footnote

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Article

Abductor and adductor strength relation to sprint performance in soccer players

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Abstract: Introduction: The hip muscle strength plays an important role in sprinting and non-contact injuries, where their role in soccer players needs to be recognized. This study aimed to examine the relationship between the strength of hip abductor (Abd), hip adductor (Add) and linear sprint performance (5 m and 35 m). Sixteen professional soccer players (Second Polish League) participated in the study (age = 24 ± 3.2 years, body mass = 75.3 ± 9.58 kg, height = 179 ± 5.6 cm, soccer training experience = 8 ± 2.9 years). 5 m and 3 m linear sprint performance was described by: peak acceleration, peak velocity (PV), relative peak force (PF), and relative peak power output. Hip Abd and Add strength was tested by maximum isometric tests on both lower limbs. T-tests revealed statistically significant differences between strength of right and left Add and Abd, ($p < 0.001$, for both). Stepwise regression showed that the model of hip Abd, Add and their ratio predict the PV (R^2 = 37%) and PP (R^2 = 36%) in 35 m sprint, and hip Abd with Abd/Add ratio can predict PF (R^2 = 16%) and acceleration (R^2 = 14%) in 5 m sprint. Results of the present study indicate that Abd-Add maximum isometric strength and 5 m, as well as 35 m sprint running, are related athletic performance qualities. 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, isometric, team sports.

1. Introduction

Sprint running is an essential ability in most team sports, such as soccer, rugby, American football, and basketball [1–4]. The soccer players cover more than 200 m short sprints [5, 6] where linear sprinting is the most frequent action before goals in scoring and assisting player [7, 3]. In addition, faster athletes will have an advantage during competition, since they are able to win ball possession or pass a defending player. Considering that sprinting can determine success in many sport disciplines, there is a significant interest of strength and conditioning coaches, to assess and develop this motor ability. The hip extensors and flexors are considered major muscles in sprint [8]. The triple powerful extensions of the hip, knee, and ankle joints (gluteus maximus, quadriceps, gastrocnemius) are the main accelerators of body mass at the beginning of the sprint start [9]. While, the hamstrings, adductor magnus, and gluteus maximus contribute start [9]. Numerous studies across a wide range of sports have analyzed the relationships between sprinting performance and lower limb strength and muscle size [10–15]. Some have monitored the efficacy of different training regimes [16, 17], while others have considered muscle mechanics during sprinting [18–20]. However, those studies have mainly focused on exercises that involve the hamstring muscles. This focus is reasonable given the fundamental role that the hamstrings play in generating horizontal ground reaction forces during the propulsive part of the stance phase in sprinting [21]. For example, Wisløff et al. [14] showed that the results of the half squats are strongly related with sprint performance in elite soccer players. Moreover, Morin et al. [19] showed that the highest level of horizontal ground reaction force was generated by participants who had the highest torque production ability of the hip extensors and the highest hamstring electromyography activity which indicates the importance of hamstring force and activation during sprinting. Furthermore, an investigation by Contreras et al. [16] demonstrated that 6-week hip thrust training was superior in improving 10 and 20 m sprint times in comparison to front squat training. Additionally, González-García et al. [17] found that strength improvement after 7-week hip thrust training was effective in 10 and 20 m sprint performance enhancement in comparison to back squat training. Since, the hip thrust exercise involves greater gluteus maximus activation in comparison to the squat or deadlift exercises [22], and previous studies indicated high efficiency of these exercises [16, 17] it can be concluded that the development of the gluteus maximus muscle may have a strong transfer to sprinting performance.

The hip abductor (Abd) muscles: tensor fasciae latae, gluteus medius, and gluteus minimus abduct and medially rotate the thigh. The action of these muscles helps stabilize the pelvis and counteract the action of lateral thigh rotators, mainly the gluteus maximus [23]. Creating a stable pelvis base allows for more efficient force generation by all hip muscles [23]. Regarding the hip adductor (Add) muscles, Matsuo et al. [24] suggested that the muscle activity during high-speed sprinting may indicate that they are also responsible for stabilizing the hip joint, and they are related to the groin strain and adductors injuries [25, 26]. In this link, the Add and Abd strengthening is effective to prevents the groin injuries [27]. Pelvic instability due to weakening of the hip muscles may limit the ability to generate horizontal force during the foot contact phase during sprinting and then improve running speed [25]. Moreover, some studies pointed out that the adductor magnus which acts as an important hip extensor, and along with the rest of the Add's (pectineus, gracilis, adductor brevis and longus) as hip flexors [28, 29] can play a significant role during sprinting [30,15]. Watanabe et al. [30] found that the muscle volume of the hamstrings, adductors, and psoas major muscles contribute significantly to sprint performance. In agreement, results obtained by Yasuda et al. [15] imply that due to the relationship between sprint time and the adductor brevis muscle volume, it may contribute to sprint running performance in female sprinters. Moreover, it cannot be ruled out that Abd and Add muscle involvement may vary depending on the running distance, since acceleration is substantially greater between 0-10m than between 10–30 m [31].

Additionally the abductors and adductors (Abd-Add) have also been shown to play an important role during sprint running in sprinters [23, 24, 30, 15], yet it is un-known if their strength affects sprint ability in soccer players. Thus, increasing specific Abd-Add strength may augment sprint performance and injury prevention. Investigating the relationship between the Abd-Add muscle strength and sprinting performance could help to clarify the role of these muscles. Therefore, the aim of the current study was to examine the relationship between the Abd-Add muscle maximal isometric strength and sprinting performance in soccer players. It was hypothesized that Add, as well as Abd isometric strength, is associated with sprint performance.

2. Materials and Methods

2.1. Experimental Approach to the Problem

This study investigated the association of maximum isometric strength of hip Abd-Add muscles with chosen 5 m and 35 m linear sprint variables: sprint time, relative peak values of velocity (PV), force (PF), power output (PP) among elite professional soccer players. Additionally, the balance in isometric strength of the dominant and non-dominant hip Abd-Add muscles were evaluated.

2.2. Subjects

Sixteen professional soccer players (Second Polish League) participated in the study (age = 24 ± 3.2 years, body mass = 75.3 ± 9.58 kg, height = 179 ± 5.6 cm, soccer training experience = 8 ± 2.9 years). All of the athletes were right leg dominant. The experiment took place at the beginning of the pre-season. The athletes were instructed to maintain their normal hydration and dietary habits as well as not to use any performance enhancing supplements or stimulants 24 hours prior to the experiment. Further, they were instructed not to engage in exhaustive physical activity 48 hours prior to the experiment. Moreover, 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. All athletes gave their written consent for participation and had valid medical examinations and showed no contraindications to participate in physical fitness tests. 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 before the start of the experiment, all athletes were familiarized with the testing procedures. The experimental sessions were carried out 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 min of jogging, dynamic stretching, and several accelerations over 10-20 m. Afterwards, the athletes performed a single attempt of a 35 m linear sprint at submaximal intensity. After the warm-up, during the first experimental session, the athletes performed a maximum isometric strength test of the Abd-Add muscles and the 35 m linear sprint during the second experimental session. All sprint tests were performed on an indoor court. The running times and kinematic variables of the 35 m linear sprint were recorded by the robotic pulley device (1080 Sprint, Lidingö, Swe-den). To assess maximum isometric strength of the Abd-Add muscles the ForceFrame Strength Testing System (Vald Performance, Albion, Australia) was used. This device has been previously used to measure hip strength in scientific research [32].

2.4. Maximum Isometric Strength Test

After the standardized warm-up, the athletes performed the isometric strength test of the Abd-Add muscles. Athletes were positioned beneath the ForceFrame 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 load cells (sample rate of 50Hz), athletes 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. Athletes were asked to push their femoral medial condyles against the pads for five seconds. Previous studies have shown high reliability of intraclass correlation coefficients (ICC) of 0.94 [32].

2.5. 35-m Linear Sprint Test

Following the isometric strength test, all athletes performed 2 maximal 35 m linear sprints, interspersed with 5 min rest intervals. The athletes started with the front foot placed 0.5 m behind the first cone, to prevent any early triggering of the photocells. (SmartSpeed, Vald Performance, Albion, Australia). The athletes started when ready to eliminate the reaction time effect. The running times as well as PV, PF, and PP obtained during 35 m linear sprint were recorded by the robotic pulley device (1080 Sprint, 1080 Motion, Lidingö, Sweden) for 5 m and 35 m. The relative values of kinematic variables of the fastest time from both attempts were retained for further analysis. This technology has been previously used to measure the time of sprint results in scientific research with high ICC from 0.84 to 0.93 [33] and reliability [34].

2.6. 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 and both limbs with 95% confidence intervals followed by stepwise forward regression. For regression analyses were isometric strength values set as independent variables (predictors) and sprint performance characteristic as dependent predicants, where isometric strength included absolute and relative hip Abd and Add strength and their strength ratio. The common variance between variables was described with the coefficient of determination (R^2). 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, the t-test comparisons between maximum isometric strength of the Abd-Add muscles were conducted. The significance level for the correlation and regression analysis was set as $p < 0.05$.

3. Results

Descriptive data for all the variables is shown in Table 1. The t-test revealed statistically significant differences between AddL (adductor left) and AddR (adductor right), as well as between AbdL and AbdR ($p < 0.001$, Table 2). The correlation showed moderate to large relationship between abductors strength and Add/Abd strength ratio to the performance variables during linear sprint at 5 m and 35 m (Table 3), moreover some small and moderate correlation values of adductors strength were found with no significant p values. The regression analyses showed that prediction model of hip Abd with Add/Abd ratios can predict the 5 m sprint and model including Add, Abd and Add/Abd can predict the 35 m sprint performance characteristics (Figure 1)

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

Variable	0–5 m Mean ± SD	95% CI	0–35 m Mean ± SD	95% CI
Time [s]	0.99 ± 0.36	0.81 to 1.17	4.88 ± 0.2	4.78 to 4.98
PV [m/s]	6.52 ± 0.33	6.36 to 6.68	8.78 ± 0.42	8.57 to 8.98
PF [N/kg/b.m.]	0.74 ± 0.08	0.7 to 0.78	0.73 ± 0.07	0.69 to 0.76
PP [W/kg/b.m.]	4.24 ± 0.72	3.89 to 4.59	5.37 ± 0.91	4.92 to 5.82

Mean ± standard deviation (SD); CI - confidence interval; PV – peak velocity; PF – relative peak force; PP – relative peak power.

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

	Left	Right	Mean Difference	Mean Percentage Difference [%]
Add [N]	413 ± 68	432 ± 71*	-19 ± 12	8.2 ± 7.7
Abd [N]	403 ± 67	435 ± 71*	-32 ± 26	± 2.8
Add [N/kg]	5.54 ± 1.12	5.80 ± 0.76	0.25 ± 2.6	4.37 ± 2.6
Abd [N/kg]	5.38 ± 1.11	5.80 ± 0.74	0.42 ± 3.4	8.21 ± 7.23
Add/Abd [%]	103 ± 22			

* significant difference between left and right limb $p < 0.001$.

Table 3. The relationship between sprint performance and isometric strength values of hip abductors and adductors. Values are correlation coefficient by Spearman r

	Relative to body weight						Absolute Values					
Muscle	Adductors		Abductors		Add/Abd		Adductors		Abductors		Add/Abd	
Distance	5 m	30 m	5 m	30 m	5 m	30 m	5 m	30 m	5 m	30 m	5 m	30 m
Weight [kg]	-0.52		-0.17		-0.37		0.075		0.56		-0.37	
Total time [s]	-0.03	-0.21	-0.26	-0.44	0.14	0.029	0.32	0.08	0.06	-0.05	0.14	0.029
Peak Speed [m/s]	0.20	-0.04	0.11	0.40	0.12	-0.21	-0.09	-0.19	-0.15	0.19	0.12	-0.21
Peak Force [N]	-0.17	0.23	0.08	0.04	-0.15	-0.24	0.05	0.12	0.38	0.51	-0.15	-0.24
Peak Power [W]	0.21	-0.14	0.26	0.14	0.06	-0.27	0.07	-0.17	0.14	0.23	0.06	-0.27
Relative Peak Force [N/kg]	0.55	-0.14	0.27	-0.02	0.42	-0.10	0.04	0.09	-0.35	0.33	0.42	-0.10
Relative Peak Power [W/kg]	0.53	0.50	0.25	0.29	0.36	0.25	0.04	-0.05	-0.31	-0.32	0.36	0.25
Peak Acceleration [m/s-2]	-0.14	0.29	-0.02	0.32	-0.10	0.04	0.09	-0.15	0.33	-0.15	-0.10	0.04

Add/Abd = isometric ratio of hip adductors and abductors. Significant values are in bold at $p < 0.05$. The values between two relative variables were not included in the meaningful results.

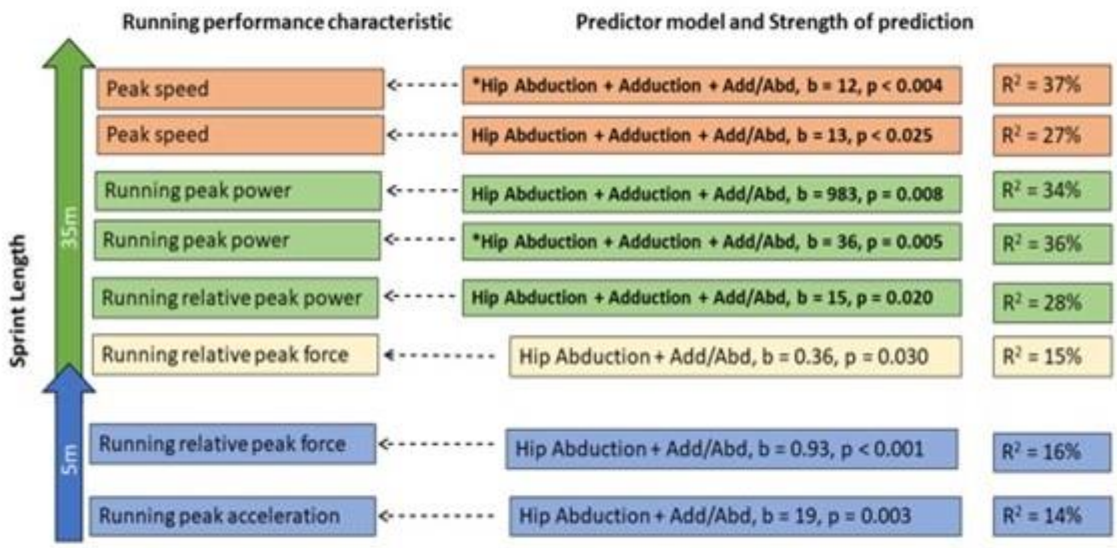

Figure 1. Models of running performance among the variables of hip muscles strength

4. Discussion

The results of the presented study demonstrated that the maximum isometric strength of the Add and Abd muscles of both lower limbs are associated with variables obtained during the 5 m and 35 m sprint. Moreover, hip Abd and their ratio to Add is more important for 5 m sprint, while both muscle group strength relates more to the 35 m sprint. However, it remains unclear whether absolute or relative strength are better predictors of sprint performance. In addition, the right Abd and Add muscles (dominant leg) were significantly stronger than those of the left limb (non-dominant leg). Therefore, we might assume that dominant limb Abd and Add contribute more for the sprint propulsion than non-dominant limb which leads to the asymmetric loading and successive lateral strength imbalances.

Determining the key factors underlying sprint performance is essential for strength and conditioning coaches to monitor and prescribe proper training regimens. While the association of hamstrings, quadriceps, and gluteus maximus muscles with sprint performance has been extensively analyzed in terms of muscle size and strength [10–15], the data conducted on the relationship between the hip Abd-Add muscles is scarce. Most often they are limited only to the relationships between muscle size, activity and sprinting ability [23, 24, 13, 8, 30, 15]. The authors found that having larger hip adductor muscles relative to body size is beneficial for better 30-metre sprint performance running [13]. Furthermore, a study by Tottori et al. [8] confirmed that the cross-sectional area of Add's has a significant relationship with 50m sprint times in preadolescent boys. Our study confirms the Add and Abd contribution on sprint performance and showing that for short distance acceleration is crucial the strength of Abd and their strength ratios to the Add. This is very important for the soccer players, since 5 m sprint is often apply in the game during overtaking the ball.

To the best of the authors' knowledge, this is the first study that examined a relationship between sprint performance variables and maximum isometric strength of the hip Abd-Add muscles for short 5 m sprint in soccer players. The Abd-Add hip muscles are primarily responsible for creating a stable pelvic base during sprint running which allows for more efficient force generation by all hip muscles [23]. Pelvic instability due to weakening of the hip muscles may limit the ability to generate horizontal force during the foot contact phase of sprinting and then decrease running speed. Moreover, during running and sprinting the pelvis performs as a pivot between the counter-rotating shoulders and legs [35]. Furthermore, it seems reasonable that due to the increasing force of muscular contraction in appropriate muscles and/or muscle groups, acceleration and speed may improve in skills critical to soccer such as sprinting, changing pace, direction and turning [36]. By our reported coefficient of determination, it is reasonable to conclude that the strength of Abd-Add muscles is more related to the 35 m than 5 m linear sprint performance, and that they are two relatively independent qualities among soccer players. Thus, it seems that the separate evaluation and development of these qualities are of substantial importance. Such results may be related to movement strategy changes depending on acceleration requirements and running speed. As indicated by Novacheck [35] and Canavese [37], the Abd-Add muscles are primarily active during the stance phase. As the speed increases, time spent in the stance phase decreases while the swing phase increases, which may cause the pro-pulsion involvement of the Abd-Add muscles. The function and motion of the pelvis differs between walking, running, and sprinting due to the relative contribution from each of these muscle groups, thus changes occur also in the gait cycle of sprinting [35].

Although strength imbalance of Abd-Add muscles was not the main aim, the role of training regimens targeting the Abd-Add muscles in preventing injury cannot be overlooked. Hip and groin injuries contributed 1812 out of 12 736 injuries (14%), with adductor-related injury as the most common of hip and groin injuries (63%) [25]. Moreover, previous studies showed that the imbalance of strength between the Abd-Add muscles is a risk factor for groin injuries. The Add/Abd strength ratios of less than 80% are considered as a relative risk of an Add strain [38, 26]. Further, it should be mentioned, that there were differences in Abd-Add strength within lower limbs reported among subjects of this study. Therefore, the results of the research conducted on a group of soccer players with Abd-Add strength imbalance may differ from those obtained in the current study [39].

There are certain study limitations that should be acknowledged. One limitation of this study is that only straight sprint was investigated and the relationship of isometric muscle strength was assessed, thus these relationships may vary if dynamic strength was evaluated. Moreover, since the hip Add muscles primarily provide adduction of the thigh, changes in the strength of hip Add muscles may affect soccer players' cutting movements or other lateral change of direction. Thus, future research should consider the relationship between the strength of the Abd-Add muscles and different angles of direction changes. Additionally, evaluation of the electromyographic activity of hip muscles during sprinting and change of direction could shed a new light on the Abd-Add involvement in this type of movements. Furthermore, it would be of great interest to examine the relationship between Abd-Add strength and running economy at submaximal speeds, as well as the effectiveness of change of di-rection among athletes with a strength imbalance of Abd-Add muscles.

5. Conclusions

The results of this study illustrate that the Abd-Add isometric strength are associated with sprint performance at 5 m and 35 m in professional soccer players. Therefore, strength and conditioning coaches and other practitioners should independent evaluation and development of Abd and Add muscles strength as direct support of 5 m and 35 m linear sprint. Moreover, the role of training programs targeting the Abd-Add muscles in preventing injuries cannot be underestimated since Abd-Add are typical for bilateral imbalances.

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