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(Research Article)

Effect of different forms of strength training on lower limb power and speed of professional soccer players

Angelina Ignatjeva *

Department of Sport Theory, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland.

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Abstract

Research objective: The main research objective is to analyze the effects of different forms of strength training on the lower limb power and speed of professional soccer players. The research involves the application of a variation strategy in strength training based on varying the intensity of training. The work focuses on comparing two strength training varying external loads.

Materials and Methods: The study material consisted of a group of 56 soccer players of the first Polish league, representing a similar sports level with a minimum of 4 years of training experience in the league and in the age range of 22 to 28 years. The study was carried out in the macro-cycle of the preparatory phase in the period after the end of the fall round league games. A 4-week training program was used, during which the players studied carried out an experimental training unit twice a week. One group worked with a load of 50-60% of 1RM (GB1), while the other group worked with a load of 70-80% of 1RM (GB2). The use of pneumatic devices the Keiser Leg Press A420 and Keiser Air Squat A300 (Keiser, Fresno, CA, USA) was used to measure the generated power of the lower limb muscles. A straight-line running test was used to measure speed abilities. A Microgate Witty photocell measurement system (Bolzano, Italy) was used to record running speed variables over a distance of 30 meters. Before the start of the training program, as well as after its completion, the level of locomotor speed and lower limb power were measured.

Results: Analyzing the levels of lower limb muscular power and locomotor speed during training with an external load of 50-60% 1RM versus training with an external load of 70-80% 1RM, statistically significantly better results were noted during training with an external load of 50-60% 1RM.

The GB1 group with training using an external load of 50-60% 1RM achieved significantly better results than the GB2 group with training using an external load of 70-80% 1RM for 9 variables: double-leg bench press, single-leg bench press (right limb), single-leg bench press (left limb), double-leg squat, single-leg squat (right limb), and sprints over distances of 5m, 10m, 20m, 30m. It was also possible to observe a certain increasing trend in the results in the single-leg squat (left limb), while not statistically significant.

Conclusions: Training with an external load of 50-60% 1RM during the preparatory period after the fall round league games is more effective in improving muscle power and speed than training with an external load of 70-80% 1RM.

Keywords: Strength training; The power of the lower limbs; The locomotive speed; Professional soccer players; Keiser; Microgate Witty

*Corresponding author: Angelina Ignatjeva

1. Introduction

Workouts aimed at improving the muscular power of soccer players have many advantages. A high level of muscular strength and power of specific muscle groups, especially the muscles of the lower limbs, is one of the attributes of a soccer player and, at the same time, guarantees the formation of other types of abilities, providing a kind of foundation for speed or muscular endurance [1]. On the strength and muscular power developed especially by the lower limbs, upper limbs and trunk, depend not only the rapid acceleration and high running speed of the soccer player, but also a variety of efficient movement in all directions [2].

Soccer is an endurance-velocity sport, in which a player during a match, on average, undertakes a high-intensity run every 30 seconds, and a sprint, every 90 seconds [3]. A high level of speed-endurance ability is required for competition at the professional level and essential for success. Without proper motor preparation, an athlete is unable to bring out his full potential, which manifests itself in performance and technical-tactical skills, among other things.

The increasingly high level of demands made in soccer makes many coaches expect the development of objective criteria for evaluating a player's fitness, allowing the comparison of achieved results to standard values and determining the size of deviations in measurable units [4]. Optimization of training, including the improvement of research methods, is due to the increasing requirements for motor preparation in soccer. The implementation of new research methods can have an impact on increasing the efficiency of the use of players' motor abilities.

A player's ability to generate maximal power is indicated as a determinant of success in soccer requiring an optimal ratio between power and speed [5,6]. In soccer, lower limb muscular power manifests itself in virtually every element of the game, primarily in short-term efforts. In order to improve the degree of training of the player in strength training, different types of strength exercises (e.g., resistance, plyometric, multi-joint or isolated, bilateral or unilateral), combinations of external loads (depending on the phase of training and its type) are used to improve motor tasks (e.g., sprint running, change of direction, jumping) [7].

A super-important factor that determines success and provides an advantage over opponents is locomotor speed [8]. Running the ball faster, changing the direction of the ball faster, running out to a position faster or jumping to the opponent faster depends on the explosiveness of the players and allows them to win the clashes with the opponent (e.g., a 1 × 1 clash). According to Chmura (2001), speed in soccer, is one of the leading and decisive abilities for the final outcome of a match, because the one who is even a dozen milliseconds faster at the ball, can turn out to be the decisive goal scorer or prevent the goal from being scored [9].

The considerations outlined above contributed to the present study to address issues related to the motor preparation aspect of professional soccer players. The subject of the study was the analysis of the effect of strength training on lower limb power and locomotor speed of soccer players of the first Polish league.

2. Material and methods

In the sampling process, the general population was defined first. In the analyzed research, it consisted of soccer players of the first Polish league. Taking into account the issues concerning, in particular, obtaining the consents of the authorities of all the clubs involved in the given games to participate in the research, it was concluded that conducting a representative random survey was not feasible. The sampling was therefore non-random selection - it was purposive. The study included players, representing a similar sporting level with a minimum of 4 years of training experience in a given league. The age of the study participants ranged from 22 to 28 years. The study group consisted of 60 participants, included in two clubs, but due to injury 4 players had to drop out of the study. Ultimately, the group was set at 56 soccer players of the central level (I League).

The study was conducted in the macro-cycle of the preparatory phase in the period after the fall round league games in the maximal strength phase I (nomenclature according to Bompa and Haff, 2010; Bompa, Buzzichelli, 2022) [10,11]. The subjects were divided into two equal groups: GB1 (n=28) and GB2 (n=28). The division into groups was realized by simple randomization without return. Both groups performed strength training 2 times in a seven-day microcycle (on Mondays and Wednesdays). The preparatory macro-cycle with the 3:1 load distribution used lasted four weeks.

The training plan for both groups was periodized in the same way in terms of:

type of exercise, rest interval between series and exercises, and number of repetitions. On the other hand, it differed in terms of the %1 RM range (maximal load for a single repetition). The first group performed training with an external load of 50-60% of 1RM, while the second group performed training with a load of 70-80% of 1RM (Table 1).

Table 1 Strength training parameters

	GB1	GB2
External load	50-60% 1RM	70-80% 1RM
Number of series	4	4
Number of repetitions	5	5
Interval time between series (s)	180	180
Interval time between exercises (s)	120	120

The strength training consisted of performing 5 exercises in the following order: *Back Squat (High Bar), Bench Press, Barbell Lunge*, *Pull ups* with pronated grip (2 series) and with supinated grip (2 series), forward support on forearms using TRX tape (in suspension) *Plank* (1 min). Exercises such as pull ups on the bar with pronated and supinated grip Pull ups and forward support on the forearms using TRX tape (in suspension) *Planks* were performed without external load.

One week prior to the main measurement session, body height was measured (using a Charder HM-200P PORTSTAD portable stadiometer) and the athletes' weight and body composition were analyzed using an *InBody 370 analyzer*. Measurements were taken under standard conditions, during fasted morning hours (8:00-09:00 - GB1, 9:00-10:00 - GB2), with a 72-hour training absenteeism and not consuming alcohol or fluids containing caffeine and carbohydrates. The following variables were recorded: body weight (*BM*), body mass index (*BMI*), fat mass (*FM*), fat-free mass (*FFM*), muscle mass (*MM*), body water content (*TBW*)

2.1. Measurement of muscular power of the lower limbs

Prior to the main measurement sessions, a measurement of maximal strength was carried out to determine the RM1 value for each exercise: bench press (double-leg and single-leg) using the *Keiser Leg Press A420* instrument, double-leg and single-leg squat using the *Keiser Air Squat* instrument with the *A300 diagnostic module*. Before the maximal strength test, there was a 20-minute general warm-up: riding on an *M3 Total Body Trainer* ergometer (10 min), jogging in place with knee lifts, forward and backward leg swings, jump squats, single-leg kneel, single-leg kneel with lateral deepening, supported kneel, frog position.

Subsequently, maximal strength tests were conducted based on the procedure of Baechle, Earle and Wathen (2008) [12]. To determine the maximal level of muscular strength, the athletes performed a test of 10 single repetitions in the form of double-leg and single-leg bench press, and 5 repetitions each in the form of double-leg and single-leg squat.

After 48 hours, maximal strength was measured to determine the value of 1 RM for two exercises: the *Bench Press* using *ELEIKO* instrumentation, and the *Barbell Lunge* using *ELEIKO* devices. Before the test of maximal strength, there was a general warm-up: riding on the *M3 Total Body Trainer* ergometer (10 min) and dynamic stretching (3-5 minutes). In order to familiarize themselves with the technique of barbell bench press, the subjects were also asked to perform 1 series of 15 repetitions using a 6 kg barbell. This trial series was a continuation of the general warm-up and prepared the subjects for the measurement of maximal strength (special warm-up). To minimize fluctuations in power output results, subjects were instructed to raise and lower the barbell at a constant rhythm. The repetition duration, expressed by four numbers 2/0/2/0, corresponded to a 2-second eccentric phase, no stop in the isometric phase, a 2-second concentric phase and no stop in the transitional phase. The lying barbell press was performed with a wide grip of the barbell (81cm). After a 5-minute rest break, barbell presses were performed with increasing weight according to the protocol of Saeterbakken et al. (2011): 20 repetitions with about 30% 1RM (1/3 body weight), 12 repetitions with about 50% 1RM (1/2 body weight), 6 repetitions with about 70% 1RM (1/1.4 body weight), 1 repetition with about 85% 1RM (1/1.2 body weight). The rest break between series was 5 minutes [13].

Then, after the 5-minute rest break, the subjects performed trials with acceptable loads. If the athletes performed more than 1 repetition with the expected load, the load was increased by 2.5-5 kg until the test subject could not perform the repetition at the correct pace and with correct movement technique. The last weight that was lifted successfully (the largest size) was determined as the maximal load for a single repetition (1RM).

The measurement of maximal force to determine the 1 RM value for the *Barbell Lunge* exercise began after 10 minutes of performing 10 repetitions using light weights around 30% of the 1RM. After a 3-minute rest break, the subjects performed 5 repetitions with 50% 1RM. After a 5-minute rest break, 2 repetitions with about 70% 1RM, and then the load was increased by 10% 1RM after each successful attempt. If the weight was not lifted successfully the load was reduced by 5% 1RM, until the maximal load was determined.

The second stage was conducted after the adaptation week. It consisted of measuring speed, as well as maximal power (1 RM) for two strength exercises: the bench press (both legs and single-leg) using the Keiser Leg Press A420 instrument, and the squat both legs and single-leg using the *Keiser Air Squat instrument with the A300* diagnostic module. Measurements were taken for GB1 between 8:00 a.m. and 12:00 p.m., and for GB2 between 1:00 p.m. and 5:00 p.m. Before the actual measurements were taken, a 20-minute general warm-up was performed.

2.2. Measurement of speed capabilities

A *Microgate Witty* photocell measurement system (Bolzano, Italy) was used to record variable running speeds over a distance of 30 meters. This tool allows precise data transmission to the timer with maximal accuracy (± 0.004 sec.), even when the signal is disturbed. The system consisted of 5 wireless photocells set up on the starting line and at 5m, 10m, 20m, 30m distances, and a wireless remote control for immediate reading and printing of data. The test subjects started the test in a straight line with the placement of the stride foot at a distance of 30 cm from the photocell set from the starting line (the distance from the starting line was clearly marked with tape). Competitors from the designated place performed a takeoff from a high position on the audible signal "Start." It was up to the contestants to choose the forefoot limb. Competitors performed two attempts with a two-minute rest break after the run.

2.3. Statistics

In the study, variables of a quantitative nature (quotient scale) were evaluated [14]. The analysis of such data has its own peculiarities, involving the use of adequate statistical tools for comparisons. In order to characterize the structure of the studied variables, basic descriptive statistics were calculated in the form of measures of position and variability [15], and the normality of the distributions of the analyzed variables was verified using the Lilliefors test. Homogeneity of variances was verified using Levene's test. Analysis of variance with repeated measures was used to verify the significance of differences [16]. In the course of the analyses, the assumption of sphericity was verified, using the Mauchley test when the assumption was not met the Greenhous-Geisser correction was applied. When significant differences were found in the analysis of variance, Tuckey's post-hoc multiple comparison tests for equal numbers were used to verify between which groups there were significant differences. The strength of the effect for the interaction was calculated using the coefficient $\eta 2$. The strength of the effect was classified as weak when $\eta 2$ belonged to the interval 0.01-0.059; average 0.06-0.137 and large >0.137 [17]. All analyses were performed using the Statistica 13.1 package. A significance level of 0.05 was assumed for all analyses [18].

3. Results

Table 2 Characteristics of anthropometric parameters of the study group

Parameter							
Number of participants				**56**			
Age [years]		AV ± SD		25.0 ± 2.5			
Body mass [kg]		AV ± SD		75.5 ± 5.45		76.9 ± 2.37	
Height [cm]		AV ± SD		180.6 ± 6.76			
BMI		Median		23.2			
Body composition		Before		After			
FM [kg]	11.4 ± 2.3	FM [%]	15.1	FM [kg]	10.8 ± 1.8	FM [%]	14.3
FFM [kg]	64.1 ± 3.15	FFM [%]	84.9	FFM [kg]	64.7 ± 4.14	FFM [%]	86.3

TBW [l]	48.4 ± 2.75	TBW [%]	64.2	TBW [l]	48. 5± 3.63	TBW [%]	64.2
MM [kg]	38.5 ± 9.4	MM [%]	51.1	MM [kg]	39.8 ± 7.7	MM [%]	52.7

FM Fat Mass - [kg]; FM (%) – Fat Mass [%]; FFM Fat Free Mass, kg; FFM (%) –Fat free mass; TBW Total Body Water, kg; TBW (%) – Total Body Water [%]; MM Muscle Mass, kg; MM (%) – Muscle Mass.

Table 2 shows the characteristics of the study group (the average age of the players was: 25.0 ± 2.5 years; mean body height was: 180.6 ± 6.76 cm). Analysis of the results of measurements of anthropometric parameters showed an increase in average body weight (75.5 ± 5.45 kg vs. 76.9 ± 2.37 kg), average muscle mass (38.5 ± 9.4 kg vs. 39.8 ± 7.7 kg), a decrease in average body fat percentage (15.1 vs. 14.3), while not statistically significant.

Table 3 shows the descriptive parameters and normality of the distribution of the studied variables, during the diagnostic measurement in the GB1 and GB2 groups before and after the training intervention, concerning the double-leg and single-leg bench presses.

Table 3 Descriptive parameters and normality of the distribution of the studied variables, during the diagnostic measurement in groups GB1 and GB2 before and after the training intervention – bench press

Variable	GB1				GB2			
	M	SD	V	p NR	M	SD	V	p NR
Double-leg bench press [60% 1RM] [W/kg] - before	27.39	3.86	14.09%	0.33	26.95	3.859	14.32%	0.47
RLL single-leg bench press [50% 1RM] [W/kg] - before	15.98	1.93	12.07%	0.38	15.54	1.929	12.41%	0.33
LLL single-leg bench press [50% 1RM] [W/kg] - before	15.27	1.94	12.73%	0.44	14.83	1.943	13.11%	0.28
Double-leg bench press [60% 1RM] [W/kg] - after	34.20	5.24	15.33%	0.088	27.56	4.895	17.76%	0.094
RLL single-leg bench press [50% 1RM] [W/kg] - after	22.33	2.72	12.16%	0.26	16.48	2.534	15.38%	0.29
LLL single-leg bench press [50% 1RM] [W/kg] - after	21.90	2.60	11.85%	0.15	16.08	2.423	15.07%	0.14

M- arithmetic mean, SD - standard deviation, V - coefficient of variation, p NR - test probability for Lilliefors normality of distribution test, RLL - right lower limb; LLL - left lower limb.

Analysis of the results in Table 3 gave reasons to conclude for all variables that there were no grounds to reject the null hypothesis of normality of the distribution of the analyzed variables p NR>0.05. So, analysis of variance with repeated measurements can be used for further analysis. The results of the analysis of variance for the variable Double-leg press [60% 1RM] [W/kg] gave rise to the finding of significant differences F=12.24; p=0.0011 and high strength of effect $\eta 2=0.23$. Tests of multiple comparisons showed that significant differences occurred between the results before and after in the GB1 group p=0.0002 (statistically significant increase in power after training) and between the results in the GB1 and GB2 groups p=0.0002 after training.

Based on the analysis of variance for the variable [50% 1RM] [W/kg] Single-leg RLL press, significant differences were found F=34.61; p<0.0001 and large effect strength $\eta 2=0.45$. Tests of multiple comparisons showed that significant differences occurred between the before and after results in the GB1 group p=0.0002 (statistically significant increase in power after the training) and between the results in the GB1 and GB2 groups p=0.0001 after the training. The GB1 group had a statistically significant higher power output after training than the GB2 group.

The results of the analysis of variance for the variable Single-leg LLL press [50% 1RM] [W/kg] found significant differences F=41.41; p<0.0001 and a large strength of effect $\eta 2=0.49$. Based on the results of the multiple comparisons tests, it can be observed that significant differences occurred between the results before and after in the GB1 group p=0.0002 (statistically significant increase in power after the conducted training) and between the results in the GB1 and GB2 groups p=0.0002 after the conducted training. The GB1 group showed a statistically significant higher power after the training than the GB2 group.

Similar analyses were performed for the squat.

Table 4 Descriptive parameters and normality of distribution of studied variables, during diagnostic measurement in groups GB1 and GB2 before and after training intervention - squat

Variable	GB1				GB2			
	M	**SD**	**V**	**p NR**	**M**	**SD**	**V**	**p NR**
Double-leg squat [60% 1RM] [W/kg] - before	15.58	2.31	14.81%	0.36	15.37	2.308	15.02%	0.21
RLL single-leg squat [50% 1RM] [W/kg] - before	8.74	1.17	13.41%	0.11	8.54	1.172	13.72%	0.23
LLL single-leg squat [50% 1RM] [W/kg] - before	8.01	1.98	24.77%	0.082	7.81	1.983	25.41%	0.098
Double-leg squat [60% 1RM] [W/kg] - after	22.84	2.67	11.67%	0.29	16.96	2.488	14.67%	0.25
RLL single-leg squat [50% 1RM] [W/kg] - after	9.23	0.74	7.98%	0.15	8.18	0.688	8.41%	0.099
LLL single-leg squat [50% 1RM] [W/kg] - after	9.09	0.71	7.84%	0.18	8.04	0.665	8.27%	0.088

M- arithmetic mean, SD - standard deviation, V - coefficient of variation, p NR - test probability for Lilliefors normality of distribution test. RLL - right lower limb right; LLL - left lower limb.

Based on the results in Table 4, it can be concluded that for all variables there is no basis for rejecting the null hypothesis of normality of the distribution of the analyzed variables p NR>0.05. And therefore, analysis of variance with repeated measurements can be used for further analysis. The results of the analysis of variance for the variable Double-leg squat [60% 1RM] [W/kg] revealed significant differences $F=87.05$; $p<0.0001$ and a large strength of effect $\eta2=0.67$. Tests of multiple comparisons showed that significant differences occurred between the results before and after in the GB1 group $p=0.0002$ (statistically significant increase in power after the training) and between the results in the GB1 and GB2 groups $p=0.0002$ after the training. The GB1 group had a statistically significant higher power output after training than the GB2 group.

The results of the analysis of variance for the variable RLL Single-leg squat [50% 1RM] [W/kg] gave rise to significant differences $F=4.34$; $p=0.04$ and the average strength of the effect $\eta2=0.094$. Based on the results of the multiple comparison tests, it can be observed that significant differences occurred only between the results in the GB1 and GB2 groups $p=0.003$ after the training. The GB1 group had a statistically significant higher power output after training than the GB2 group.

The results of the analysis of variance for the variable LLL Single-leg squat [50% 1RM] [W/kg] yielded no significant differences $F=1.74$; $p=0.19$ and a weak strength of effect $\eta2=0.039$. An increase in performance after the training was too small for the differences to be statistically significant.

Similarly, analyses were carried out for the locomotor speed of the tested athletes at the distances analyzed.

Table 5 Descriptive parameters and normality of distribution of studied variables, during diagnostic measurement in groups GB1 and GB2 before and after training intervention - speed

Variable	GB1				GB2			
	M	**SD**	**V**	**p NR**	**M**	**SD**	**V**	**p NR**
0-5m [m/s] - before	4.32	0.31	7.06%	0.19	4.30	0.31	7.09%	0.19
0-10m [m/s] - before	5.16	0.23	4.49%	0.16	5.14	0.23	4.51%	0.25
0-20m [m/s] – before	5.98	0.22	3.60%	0.33	5.96	0.22	3.62%	0.33
0-30m [m/s] – before	6.58	0.19	2.86%	0.10	6.56	0.19	2.86%	0.14
0-5m [m/s] – after	4.75	0.26	5.48%	0.26	4.42	0.26	5.89%	0.23
0-10m [m/s] – after	5.58	0.24	4.25%	0.44	5.23	0.21	3.94%	0.28
0-20m [m/s] – after	6.35	0.21	3.36%	0.35	6.09	0.21	3.51%	0.36

0-30m [m/s] – after	6.92	0.18	2.63%	0.10	6.64	0.18	2.74%	0.15

Analysis of the results in Table 5 gave grounds to confirm for all variables that there were no grounds to reject the null hypothesis of normality of the distribution of the analyzed variables p NR>0.05. And therefore, analysis of variance with repeated measurements can be used for further analysis.

The results of the analysis of variance for the variable Speed 0-5m [m/s] gave grounds for finding significant differences F=6.34; p=0.016 and a large strength of effect η2=0.131. From the results of the multiple tests, it was noted that significant differences occurred between the results before and after in the GB1 group p=0.0003 (a statistically significant increase in speed after the training) and between the results in the GB1 and GB2 groups p=0.0014 after the training. The GB1 group had a statistically significant higher speed after training than the GB2 group.

The results of the analysis of variance for the variable Speed 0-10m [m/s] found significant differences F=10.78; p=0.002 and a large strength of effect η2=0.20. Based on the results of multiple comparisons tests, it was observed that significant differences occurred between the results before and after in the GB1 group p=0.0001 (a statistically significant increase in speed after the training) and between the results in the GB1 and GB2 groups p=0.0002 after the training. The GB1 group had a statistically significant higher speed after training than the GB2 group.

The results of the analysis of variance for the variable Speed 0-20m [m/s] also yielded significant differences F=7.58; p=0.008 and a large strength of effect η2=0.153. The results of the multiple comparisons tests showed that significant differences occurred between the results before and after in the GB1 group p=0.0002 (statistically significant increase in speed after the training) and between the results in the GB1 and GB2 groups p=0.0008 after the training. The GB1 group had a statistically significant higher speed after training than the GB2 group.

The results of the analysis of variance for the variable Speed 0-30m [m/s] found significant differences F=8.02; p=0.007 and a large strength of effect η2=0.159. Based on the results of multiple comparisons tests, it was observed that significant differences occurred between the results before and after in the GB1 group p=0.0002 (a statistically significant increase in speed after the training) and between the results in the GB1 and GB2 groups p=0.0001 after the training. The GB1 group had a statistically significant higher speed after the training than the GB2 group.

4. Discussion

Adequate diagnostics supported by a properly periodized macrocycle results in an increase in muscle power, which can be achieved through appropriate modeling of training with both high and low external loads, depending on the stage the team is in during the annual training plan [19]. In the literature, the highest values of muscle power build-up rates for the lower extremities are extensive, ranging from 45-85% of 1RM [20,21]. The breadth of the results depends in particular on the experience of the athletes, training seniority and the type of exercise (e.g., multi-joint or isolated, bilateral or unilateral) [22,23,24,25,26].

In the present dissertation, analyzing the levels of muscular power and speed during training with an external load of 50-60% 1RM versus training with an external load of 70-80% 1RM, significantly better results were noted during training with an external load of 50-60% 1RM. In the course of the study, it was determined that soccer players generate significantly greater lower limb power and achieve significant improvements in locomotor speed results with a load of 50-60% 1RM.

The obtained values of the analyses prove that when performing training with an external load of 50-60% of 1RM, it was possible to observe a significant improvement in the results after a 4-week training intervention for 8 variables: double-leg press, single-leg press (right limb), single-leg press (left limb), double-leg squat, sprint at distances of 5m, 10m, 20m, 30m. It was also possible to observe a certain increasing trend in the results in the single-leg squat (right limb, left limb), although not statistically significant.

The results of the study indicate that when performing training with an external load of 70-80% of 1RM, one could observe a certain increasing trend in the results after the 4-week training intervention for all variables (except the variable Single-leg squat right limb), but not statistically significant.

The results of the study conducted in this dissertation showed that the GB1 group with external load training at 50-60% 1RM achieved significantly better results than the GB2 group with external load training at 70-80% 1RM for 9 variables: double-leg press, single-leg press (right limb), single-leg press (left limb), double-leg squat, single-leg squat (right limb), sprint distances of 5m, 10m, 20m, 30m. It was also possible to observe a certain increasing trend in the results in the single-leg squat (left limb), while not statistically significant. The results of the study were confirmed in a scientific paper by Drozd (2020), which shows that MMA athletes generate peak power at a load of 50-70% of 1RM, both for the lower limb of the cornering limb and the stepping limb. In terms of peak power, in the intermediate group of fighters, maximal power was recorded at 50% 1RM. On the other hand, in the other groups, taking into account the sports level, the peak power value was 60% of 1RM.

Izquierdo et al. (2002) conducted a study on comparing the effects of long-term training on maximal strength and upper and lower extremity power in athletes participating in various sports. The study included 70 subjects: barbell athletes (n=11), handball players (n=19), amateur road cyclists (n=18), middle-distance runners (n=10) and an age-matched control group (n=12). The subjects performed half squats and bench presses during a 12-week training period at loads ranging from 30-100% of 1RM. This study found that peak power during the performance of the half squat was recorded at an external load of 60% of 1RM for handball players, middle-distance runners and an age-matched control group [27]. Also, a study by Cormie et al. (2007) showed that peak power can be achieved with an external load of 50-60% of 1RM when performing squat and half squat [28]. According to other authors, the application of an external load for squat and half squat around 50 1RM induces a gain in muscle power in the range of 21 to 51.7% [29,30,31].

The literature suggests that the use of much lower loads of 55-70% 1RM in resistance training induces similar or even greater neuromuscular performance than the use of higher loads [32,33,34,37,38]. Bird et al. (2005) concluded that moderate loads (50-70% of 1RM) provide a more effective stimulus than heavy loads (greater than 80% of 1RM) for improving sprint performance in various sports [36]. Resistance training with a load greater than 75-80% of 1RM is considered a prerequisite for maximal strength gains, while performing a series of exercises to muscle decline is associated with greater hypertrophy [35,36].

5. Conclusion

Training with an external load of 50-60% 1RM in the preparatory period after the fall round league games is more effective in improving muscle power and locomotor speed than training with an external load of 70-80% 1RM.

The method of using moderate to heavy load applied in the maximal strength phase I in the winter preparation period is an effective solution for improving the performance of football players' generated power and locomotor speed.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declare there are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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