Original Article

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Development of muscle power of the lower limbs as a result of training according to the model of modified tactical periodization in young soccer players

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Abstract: *Introduction:* Muscular power of the lower limbs is an important element in the success of football players. Therefore, the purpose of this work is to evaluate the effect of training according to a modified wave periodization model on the power of lower limbs measured by the length of the long jump of young soccer players. *Methods*: The study was performed in 2018-2022 in June (test A) and December (test B) of a given year. The measurement was carried out in the form of measuring the length of the long jump from the spot using a measuring tape with an accuracy of ±0.01 m. *Results:* There was an increase in the length of the long jump between the results of test B compared to the results of test A by an average of 8.32 cm ($p<0.01$). In general, there is an upward trend in subsequent years. The exception is 2019. It can be noted that the older the athlete, the better the results. No correlation is observed between the position of the athlete and the result of the test conducted. The results from December correlate strongly with the results from June. *Conclusions:* Based on the conducted research, it can be assumed that the applied training based on the wave periodization model improved the muscular power of the lower limbs of the players of the RKS Raków Częstochowa Academy. This change is important from the point of view of match practice. It was noted that the COVID-19 pandemic affected the deterioration of performance. It can be presumed that the biological development of the subjects influences the increase of the tested physical fitness ability.

Keywords: Soccer, Power, Periodization, Tactical periodization, LTAD

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INTRODUCTION

Muscular power of the lower limbs is an important element in the success of football players [1,2]. It has been noted that football teams that win more often are characterized, among other things, by a higher efficiency of this physical fitness [3]. Players cover an average distance of more than 10000 meters per game [4], in which they repeatedly perform sprints of different lengths with many changes of direction [5]. It turns out that the level of this physical ability affects various aspects of the game, such as shots on goal, ball interception, dribbling, as well as the ability to compete effectively during physical duels on the field [6].

Therefore, the measurement of this indicator is an important part of assessing the preparation of these athletes in sports competition [7–9], since its effective analysis allows us to understand the ability of muscles to generate force. One of the popular and simple to carry out tests for measuring power is based on testing selected jumps [10–12]. One of these is the long jump, which is a movement characteristic of many sports, including athletics, but also has applications in analyzing the performance of football players [13,14]. In this technique, the athlete performs a maximally extended jump over a distance, which requires significant muscle involvement and the generation of a lot of force. Therefore, the long jump can be used as an indicator of lower body muscular power. It has its limitations, of course, but nevertheless, its simplicity and accessibility make it a valuable tool that can be used for diagnostic and training planning purposes. By understanding the importance and methodology of measuring power using the long jump, coaches and players can make more informed training decisions, which can ultimately help improve players' performance on the field.

Developing the muscular power of soccer players requires properly planned and structured training that takes into account players' individual predispositions and goals [9,11]. One such program is a scheme for working with soccer players based on the so-called "tactical perodization" [15]. This program is used to train soccer players in the context of the tactical realities of the game. It is a hybrid of training techniques and focuses on training without an isolation component according to the "train as you play" principle. It is currently gaining popularity due to the success of top European teams which claim to have used this way of training.

In work described above, muscle power training is carried out by building training tasks based on small-sided games from 1v1 to 5v5, changing the pitch size to maintain a constant area of play of 75m2 on a player. The players assume that a given activity intends to perform with maximal engagement (maximum intensity possible on a given day).

The aim of the work is to assess the impact of the modified wave periodization model on the long jump on the example of the players of the RKS Raków Academy in the years 2018-2022. The following research questions were posed:

1. How did the conducted training change the average distance jump lengths?
2. What is the correlation of the conducted tests with age?

MATERIAL AND METHODS

Subject

The players of the RKS Raków Częstochowa Academy (Poland) aged 12 to 16 with training experience ranging from 4 to 8 years were analyzed. In Table 1 contains information on the number of observed players in particular years and in a given year. The structure of the microcycle was as follows: 6 training sessions (4 team training units, 1 formation training, 1 match). Classic training loads are 90 minutes of strength training, 370 minutes of training on the football field and sports competition in the range of 45 - 90 minutes (depending on the level of competition). It should be noted that this is a scheme (model madness), and during the monitored period of 5 years, there were situations causing deviations from the pattern. In this case, the authors assumed that such random situations could not permanently affect the change of power parameters in the long-term observational perspective. All of them have been included in the modified program of the wave periodization model. The goalkeepers were part of the tested teams. During the research period, there were no players who trained in the developed system for less than a year.

Protocol

The athletes underwent an approximately 12-minute warm-up before the tests, conducted according to a fixed RAMP protocol (R - raise: increase body temperature/ A - activate: muscle activation/ M - mobilise: increase ranges of motion/ P - potentiate: neuromuscular stimulation). After the warm-up, they proceeded with motor skills tests. Two tests were performed during each year, one in June (Test A) and the other in December (Test B). Each test took place after the completion of the starting round in a specific microcycle with a structured testing protocol. The tests were always implemented in the capacity microcycle on MD+3 (the third day after the match) relative to the match. The day before the tests there was a recovery training session. All tests took place in the same sports hall with a constant temperature of 20 °C.

Working model

The players worked according to the following scheme: MD+1 Day Off; MD+2 Recovery training; MD+3 Small Games; MD -3 Medium Games/ Large Games; MD -2 Day Off, MD -1 Pre-match preparation.

The curriculum is a training mezocycle consisting of four microcycles: capacity, explosiveness, mixed and regenerative. The microcycle follows tactical and technical assumptions which comprise actions in particular phases of the game, zones and sectors.

Measurement

Measurement was carried out in the form of measuring the length of the long jump from the spot using a measuring tape with an accuracy of ±0.01 m. The athletes made two attempts. The best result was entered into the sheet. The result was given with an accuracy of 1 cm.

Statistical analysis

The mean value and standard deviation were calculated for all determined indicators. Normality of distribution was checked using the Shapiro-Wilk test. Due to the lack of normality of distribution, the differences between the compared groups were evaluated using Friedman ANOVA. Spearman's rank correlation coefficients were calculated for selected indicators. Statistical significance was assumed at $p<0.01$. All calculations were performed using Statistica 13.

Table 1. The number of tested players in particular years.

Age of the players (years)	Years and number of the players				
	2022 (n)	2021 (n)	2020 (n)	2019 (n)	2018 (n)
16	24	17	22	18	17
15	21	21	22	20	18
14	18	20	20	20	23
13	20	18	19	20	20
12	16	20	23	20	18
Total	99	96	106	98	96

n - number of the players

Table 2. Types of training exercises used in individual micro cycles used on the day "MD+3" (small games).

Day	Form	Capacity*	Explosives*	Mixed*	Regenerative*

Tuesday (MD+3)	volume and intensity	(3x3) x 4 rep 60s w : 30s r (4x4) x 4 rep 90s w : 45s r (5x5) x 6 rep 120s w : 60s r	(1x1) x 6 rep 30s w: 30 r (2x2) x 6 rep 45s w : 45s r (3x3) x 6 rep 60s w : 60s r	(1x1) x 6 rep 30s w: 30 r (3x3) x 6 rep 60s w: 45s r (5x5) x 4 rep 120s w: 90s r	fragments of games - free-form of games

*During the 5-year analysis period, members had the right to modify the initial indications for the construction of small games, taking into account, for example: "the advantage of one player; games with goalkeepers; the area per player was always constant = 75m2. Other elements were consistent with the mesocycle. (W-work time; R-rest time; Rep-repetitions)

Ethics

All participants were thoroughly informed about the content of the study, its objectives, possible risks and benefits. The tasks and tests conducted in this study were exercises that are usually performed during training (sprints and jumps). All participants had a federation license, so parents signed a document at the beginning of the season authorizing them to participate in the club's soccer activities. This type of intervention does not alter normal soccer training or involve motor activities that differ from normal training and matches; therefore, the intervention never posed any additional risks beyond those associated with normal soccer practice. Moreover, all participants underwent medical examinations before the start of the season, and the tests were conducted without injury or physical discomfort. The testing complied with the requirements of the Declaration of Helsinki. The tests were part of a routinely conducted testing process (or assessment of fitness levels) in the arena.

RESULTS

Table 3 contain the average results of the tests conducted between 2018 and 2022 in the 12-16 age groups. Figure 1 graphically shows a comparison of the average values of the long jump results according to the date of the tests conducted. Figure 2 shows the results of long jump tests for the study group. The red line shows the average results of tests conducted in June (Test A), while the blue line shows tests conducted in December (Test B). It can be seen that in 2019 there is a clear decrease in the length of the long jump compared to the previous year. In the following years, there is a gradual increase in the length of the jump, only to get the best results on average in 2022. There is a statistically significant difference between the tests (p<0.001). Table 4 include the correlation coefficients with the age of the subjects and the type of athlete (position on the field) with the length of the long jump. It can be seen that the older the athlete, the better the results in both the A and B trials. No correlation is observed between the position of the athlete and the result of the test performed. The results from December correlate strongly with the results from June.

Table 3. Summary of long jump test results by age group of trials conducted (p<0.001).

Age [years]	Long jump lenght [cm] - Test A				Long jump lenght [cm] - Test B				statistical significance
	Mean	SD	Min	Max	Mean	SD	Min	Max	
12	187.07	14.77	162.00	230.00	194.04	14.78	166.00	236.00	F=41.78; p<0.001
13	200.48	17.55	166.00	260.00	206.03	24.37	238.00	260.00	F=37.50; p<0.001
14	214.24	16.98	178.00	252.00	224.52	20.04	186.00	312.00	F=70.56; p<0.001
15	224.01	15.02	190.00	284.00	230.75	14.29	197.00	283.00	F=44.45; p<0.001
16	225.41	17.17	140.00	264.00	235.34	16.07	190.00	287.00	F=48.16; p<0.001
Total	210.54	21.81	140.00	284.00	218.45	23.94	238.00	312.00	F=239.75; p<0.001

SD – standard deviation, Min – minimum, Max - maximum

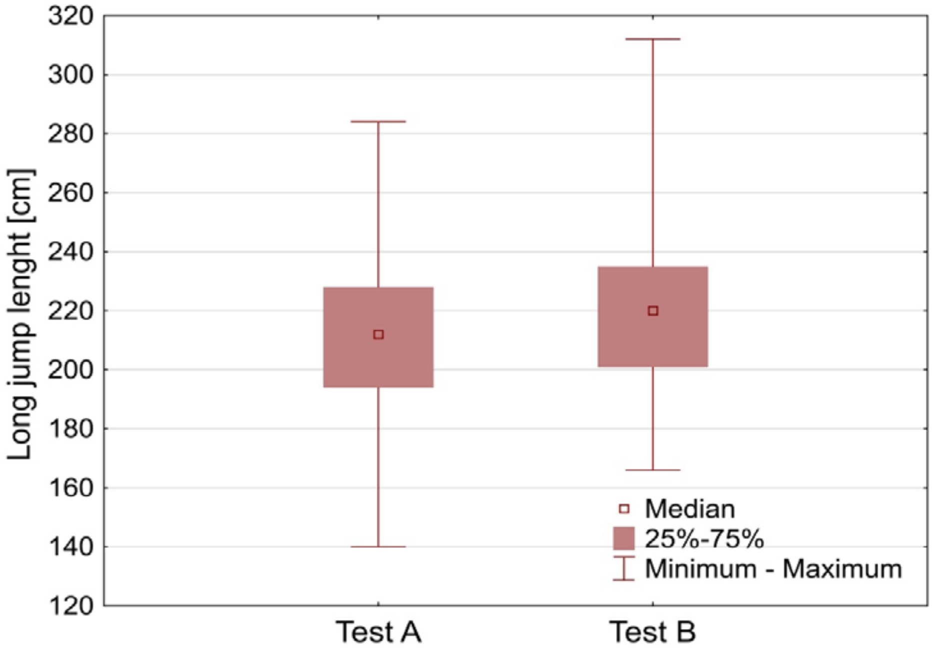

Figure 1. Average values of the length of the long jump according to the date of the test carried out (Z=15.43; p<0.001). Test A - average results of tests conducted in June of a given year, Test B - average results of tests conducted in December.

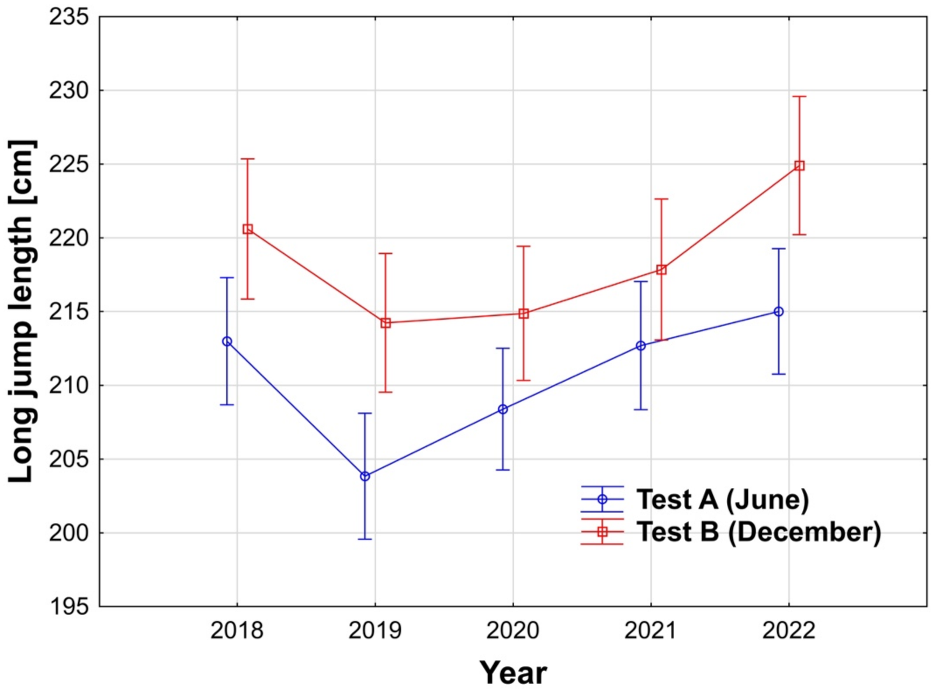

Figure 2. Graphical representation of the average results of long jump tests over five years conducted in June (Test A) and December (Test B) (p<0.001).

Table 4. Spearman rank correlation table of selected indicators.

Indicator	Long jump length (Test A)	Long jump length (Test B)
Year of research	0.077	0.066
Age	**0.656***	**0.671***
Player	-0.076	-0.098*
Long jump lenght (Test A)	-	**0.907***

* $p < 0.05$; bold - strong correlation

DISCUSSION

Based on the results of the study, it can be assumed that the applied training based on the wave periodization model significantly increased the power of the lower limbs of the players of the RKS Raków Częstochowa Academy (p<0.01). The recorded average values of long jump length show that the athletes increased their reach by 7.91 cm over the studied period (Figure 1). It can be observed that in each year between 2018 and 2022, the applied 6-month training intervention increased the subjects' lower limb power. The exception is the year 2019, in which a decrease in performance is observed. The training process during the described period was disrupted by the reconstruction of the training infrastructure at the club (i.e. lack of a full-size field, variable timing of training units, unsystematic access to training in the gym). The impact of such a factor on a soccer player's individual development is confirmed by the available literature [16]. In 2020, the year to which the COVID-19 pandemic falls, little difference is observed between Test A and Test B. During this period, conducting regular activities was excluded. At the same time, this may provide evidence of an impact on the quality of the training provided, as its disruption caused a clear deterioration in performance.

Increasing players' power is extremely important in the practice of team games [3]. Because achieving high values of this ability increases the effectiveness of, among other things: the efficiency of shots on goal, or the ability to effectively fight between rivals on the field [6]. Thus, it seems appropriate to train and test the muscular power of soccer players.

The analysis conducted indicates that the age of the athletes positively correlates with the length of the long jump. Thus, this confirms the previous knowledge that the biological development of these athletes affects the manifestation of their physical fitness, which is consistent with the results of other studies [17,18]. In addition, it can be noted that the tasks that players perform on the field or, otherwise, the position on which players play do not affect the distance of the long jump. Unsurprisingly, it can be seen that the length of the jump registered in June is co-dependent with the values recorded after six months of training, i.e. December. This indicates a correct training process. In addition, it can be noted that the year of the tests carried out does not affect the results of the tests carried out.

In conclusion, it can be said that the use of training on the wave periodization model is an effective method for long-term planning and development of lower limb muscular power. The available literature shows that training based on this method results in full involvement of athletes not only in the physical area, but also in many other areas [15].

By analyzing the results of our research and available scientific achievements, this article aims to enrich the knowledge regarding the impact of a modified training periodization model on the formation of muscle power of athletes included in a long-term development program. This can contribute to more effective training and better sports performance on the field. The analysis conducted is in line with the observed trends of coaches and researchers and confirms the need to monitor the progress of athletes [19–21]. The authors hope to fill the gap in knowledge regarding the long-term observation of young soccer players at a leading soccer club in Poland with an analysis of the impact of training based on tactical periodization conducted.

Limitations of the study

In the above study, the authors limited themselves to analysing only one parameter (motor feature). Certainly, a comparison of other parameters of speed or endurance would give a more complete picture of the impact on the athlete's performance according to the work pattern defined as wave periodization. The holistic view and its application are general and may not work with an individual (single player). The results apply only to the long-term approach and multi-year estimates of the organization of sports training in team games.

Future research

The next research directions will be related to the analysis of speed and endurance in the concept of wave perdiodization training. In the future, we want to analyze the results of fitness tests in relation to position on the pitch.

Practical application

The effectiveness of the work model analyzed on the example of the Academy players, which is wave periodization created in response to tactical periodization, has been confirmed in the field of shaping power in the long term. Thus, motor preparation coaches working with youth can freely adapt the tested model to plan and implement an increase in players' performance in all team games. Trainers working on implementing this research project are fully open to any additional questions related to the mechanisms of implementing wave periodization. Recommendations and tips obtained in the work suggest that long-term and multi-year strategic work is effective.

Conflicts of Interest: The authors declare no conflict of interest.

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