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EFFECT OF THE LOADS SELECTIVE PERIODIZATION ON PHYSICAL PERFORMANCE AND HEMATOLOGICAL PARAMETERS IN HANDBALL PLAYERS

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ABSTRACT

Introduction: The pre-season should be planned by technicians and physical trainers to achieve maximum physical performance and to decrease the negative effects of the training process in the handball players. Objective: This study evaluated the effect of the loads selective periodization on physical performance and hematological parameters during the pre-season in handball players. Methods: Sixteen Under-16 male handball players from the Caçador team (Brazil) participated in the study. The periodization of pre-season was composed of 3 mesocycles of training. Variables of physical performance, erythrogram and leukogram in the beginning of the pre-season and in the final pre-season were evaluated. Results: Using selective loads periodization, the body composition improved in the final pre-season compared to the beginning of the pre-season ($p<0.01$). Periodization increased maximum isometric strength by 6.4%, muscle endurance during sit-up and push-up tests by 9.6% and 26.2%, respectively, muscle power of the lower and upper limbs by 6.6% and 5.7%, respectively, and flexibility by 7.6% in the final pre-season when compared to the beginning of the pre-season ($p<0.05$). Furthermore, the periodization improved the agility of the athletes reducing the time by 3.1% when compared with the beginning of pre-season ($p<0.05$). White blood cells and red blood cells did not modify during all pre-season ($p>0.05$). Conclusion: Selective loads periodization is effective to improve physical performance during pre-season in Under-16 male handball players.

Key words*:* Athletes. Training. Planning. Hematology.

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RESUMO

Efeito da periodização de cargas seletivas no desempenho físico e parâmetros hematológicos em jogadores de handball

Introdução; A pré-temporada deve ser planejada por técnicos e treinadores físicos para alcançar o máximo desempenho físico e diminuir os efeitos negativos do processo de treinamento nos jogadores de handebol. Objetivo: Este estudo avaliou o efeito da periodização seletiva de cargas no desempenho físico e nos parâmetros hematológicos durante a pré-temporada em jogadores de handebol. Métodos: Dezesseis jogadores masculinos de handebol menores de 16 anos da equipe Caçador (Brasil) participaram do estudo. A periodização da pré-temporada foi composta por 3 mesociclos de treinamento. Foram avaliadas variáveis de desempenho físico, eritrograma e leucograma no início da pré-temporada e na pré-temporada final. Resultados: Utilizando periodização de cargas seletivas, a composição corporal melhorou na pré-temporada final em comparação com o início da pré-temporada ($p <0,01$). A periodização aumentou a força isométrica máxima em 6,4%, a resistência muscular durante os testes de abdominais e flexões em 9,6% e 26,2%, respectivamente, a força muscular dos membros inferiores e superiores em 6,6% e 5,7%, respectivamente, e a flexibilidade em 7,6% % na pré-temporada final quando comparado ao início da pré-temporada ($p <0,05$). Além disso, a periodização melhorou a agilidade dos atletas, reduzindo o tempo em 3,1% quando comparado ao início da pré-temporada ($p <0,05$). Os glóbulos brancos e os glóbulos vermelhos não se modificaram durante toda a pré-temporada ($p> 0,05$). Conclusão: A periodização de cargas seletivas é eficaz para melhorar o desempenho físico durante a pré-temporada em jogadores de handebol masculinos menores de 16 anos.

Palavras-chave: Atletas. Treinamento. Planejamento. Hematologia.

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INTRODUCTION

Handball is an Olympic team sport that requires significant physical preparation in order to complete 60 minutes of competitive play (Moncef and collaborators, 2012).

In addition, the handbal players may train two, three times per day, followed by a relative short recovery period, wich could cause an imbalance between training and recovery (Halson, 2014).

Frequently, athletes show high disease and infection incidence, increased injury risk during competitive season (Walsh and collaborators, 2011).

In order to decrease the negative effects of the comptitive season, the athletes should in the pre-season maximizing the physical and fitness parameters (Milanese and collaborators, 2014).

To achieve this level of performance in the handball players, a model of training periodization should be used by technicians and physical trainers during pre-season. Periodization is the appropriate manipulation of training stress to optimise gains in physical performance (Moreira and collaborators, 2015).

The classic model of periodization proposed by Matveev has been used in most team sports, however, many publications declare that this model does not meet the demands and needs of modern sports (Kiely, 2010).

Others periodization models have been applied to the team sports, such as the Selective Loads periodization model.

The selective loads periodization model was organized in order to fulfill the calendar of soccer teams, because players have 57 to 85 matches during the season, hampering the distribution of training loads in the macro cycle (Moreira, 2010).

This model arises because in soccer there is not enough time to adequately prepare the athletes before the onset of the official games. This model of periodization aims to improve the speed capabilities, with unchanged volume and monthly adjustments of physical capacity during the competitive cycle (Moreira, 2010).

Our group and others studies has previously shown that loads selective periodization improves physical performance and does not modify hematological parameters during the pre-season in futsal (Rocha, Nunes and Venera, 2015; Thiengo and collaborators, 2013; basketball (Moreira and collaborators, 2004) and volleyball players (Mazon and collaborators, 2013).

However, it is not known whether this model will reproduced similar findings in Under-16 handball players.

Here we investigate the effect of the loads selective periodization on physical performance and hematological parameters during the pre-season in Under-16 handball players.

We hypothesize that this model of periodization will be able to improve physical performance and decrease hematological adverse effects in Under-16 handball players.

MATERIALS AND METHODS

Participants

Sixteen Under-16 male handball players (age: 15.0 ± 0.8 years; body mass: 75.0 ± 10.9 kg; body height: 1.75 ± 0,03 m) from the Caçador team (Brazil) participated in the study.

All players had at least two years of experience in handball and took part in the following competitions during the 2017 season in Santa Catarina: Santa Catarina Championship, State Championship and Student Olympiad Catarinense.

Exclusion criteria were missing three training sessions for any reason, missing any testing session, noncompliance with the prescribed protocol, and performing physical training outside of normal practice or strength training sessions.

All players trained for two hours (one hundred twenty minutes), four times per week (Monday, Tuesday, Thursday and Friday).

The athletes were previously informed of all experimental procedures and provided written informed consent. This investigation was performed in accordance with the Declaration of Helsinki (2013).

The research was approved by the Research Ethics Committee of Instituto Universitário italiano de Rosario (08/13).

Design and Procedures

Periodization of the pre-season was based on the Selective Loads model, with minor modifications. The pre-season began in the second week of February and finished seven days before the beginning of the first competition (in the third week of April), totaling

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10 microcycles and 3 mesocycles of training. The first and the last mesocycle were composed of 3 weeks, divided in 3 microcycles of 7 days. The second mesocycle was composed of 4 weeks, divided in 4 microcycles of 7 days.

The first mesocycle was designed to develop aerobic endurance, localized muscular endurance and flexibility from athletes. This cycle was called the Basic Phase.

The methods of training used were interval training, circuit aerobic, small-sided games, muscular resistance training and the Proprioceptive Neuromuscular Facilitation Technique to the flexibility.

The tactical and technical training was composed of pass and reception exercises, offensive and finalizations moves.

During second training mesocycle the emphasis was focused on speed, agility, upper and lower limb muscle power and the maintenance of physical capacities mentioned above. The training consisted of: pliometric exercises, agility and speed circuit and sprints combined with especific elements of the game.

The tactical and technical training was composed of exercises passes with movement, movement of athletes and ball during offensive moves, fintas with finalization and games.

The aim of the third mesocycle was to improve the technical and tactical abilities, to improve marking and (team)attacks, and to correct deffense errors; and finally, to maintain the physical capacities developed previously.

The table 1 shows the distribution of the training content along different capacities during the preparatory period in each mesocycle of training:

Table 1 - Distribution of the training content along different physical capacities and length of training in each mesocycle during preparatory period periodization.

Physical Capacities	**M1**		**M2**		**M3**	
	%	**Minutes**	**%**	**Minutes**	**%**	**Minutes**
Especial endurance	25	360	15	288	10%	144
Speed/Agility	15	216	25	480	25%	360
Especial strenght	20	288	25	480	20%	288
Flexibility	25	360	15	288	10%	144
Tactical/Technical	15	216	20	384	35%	504
Total	100	1440	100	1920	100	1440

Notes: M - mesocycle.

All assessments of physical performance, biochemical parameters and body composition were carried out: a) at the beginning of the pre-season (BPS), that comprised the first day the athletes met to begin training (second week of February); and b) at the end of final pre-season (FPS), seven days before the beginning of the Santa Catarina Championship (third week of April, 48 hours after the last exercise training).

The athletes could not present diseases and injuries throughout the assessment period. It was recommended to the athletes to keep their usual diets. The use of ergogenic substances were not controlled.

The assessments of hematological parameters (day 1) were carried out in the clinical analysis laboratory Madalozo Camatti Ltda (Caçador, Brazil).

The physical and performance tests were carried out in the evening (19:00 to 22:00 hours) in the multisport court of Alto Vale University of Rio do Peixe, (UNIARP); they were conducted over two days: a) day 2 – explosive power, agility, isometric maximum strength, muscular endurance; b) day 3 – body composition, aerobic capacity (VO_2 max) and flexibility.

Body composition

The body composition assessment was carried out in the evening (19:00 to 22:00 hours) in a reserved room at the sports arena where the players trained. The following sequence was used to evaluate body composition: height, total body mass and skinfold.

To evaluate the height and total body mass, a compact stadiometer (*Sanny*®) was used with accuracy of 0.1 cm and a scale (*Filizola®, Model 31, Brazil)* with accuracy of 100 g, according to the procedures described by Gordon, Chumlea and Roche (1988).

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To evaluate skinfold a scientific plicometer (Cescorf, Brazil) with accuracy of 0.1 mm was used, according to the procedures described by Harrison and collaborators (1988).

Four skinfolds (subscapularis, abdominal, triceps and mid-axillary) were measured. The equation of Forsyth and Sinning (1973) was used to estimate relative fat percentage (% fat).

Assessment of physical performance

Maximal oxygen uptake

Maximal oxygen uptake (VO_2 max) was indirectly obtained using a multistage 20-meters shuttle run test (Leger and Lambert, 1982).

Subjects ran between two lines 20 m apart following a specific time guided by a sound signal emitted by an audio cassette player. The frequency of the sound signals increased every minute. The test was finished when on three consecutive trials. The level attained and the number of shuttles at that level allowed a prediction of VO_2 max, according to Leger and Lambert (1982).

Isometric maximum strength

The leg and back dynamometer (Takey - TKK 5002, Type 2) test was used to measure the maximum isometric strength of the lower limbs and lower back muscles in accordance with the procedures by Bosco and collaborators (1995).

With the dynamometer calibrated and set to zero, the athletes were placed at the base of the dynamometer. The drawbar was placed at the level of inguinal fold and they performed a knee extension without bending the body. Two trials were performed with one minute of rest between them. Only the higher score (in kilogram) on the drawbar was recorded.

Lower limb muscle power

A standing long jump test was used to indirectly assess the lower limb muscle power in accordance with the procedures described by Bosco e collaborators (1983).

All players were instructed to perform a long jump from standing position. The players were given standardized instructions that permitted them to begin the jump with bent knees and swing their arms to assist in the jump.

A line drawn on a hard surface served as the starting line. The length of the jump was measured using a tape measure, which was affixed to the floor. Each player was given 3 trials, and the distance of the best jump was measured, to the nearest 1 cm, from the line to the point where the heel closest to the starting line landed. If the player fell backward, the distance where the body part closest to the starting line touched the ground was measured as the jump's length. Each player performed 3 jumps, whether or not a subject fell backward during an attempt. The longest jump was used as the test score.

Upper limb muscle power

The medicine ball throw test (MBT) was used to indirectly assess the upper limb muscle power in accordance with the procedures by Vossen and collaborators (2000).

For the test, the players remained seated on a bench (with adjustable height) stabilized on the ground , with their back supported against a vertical back support, with thighs horizontally supported, knees flexed at an angle of 90° and ankles fixed to the ground.

Athletes were affixed to the seat with elastic straps running around the trunk at mid chest level and under the armpits. This position was standardized during all throws to ensure greater stability and minimize movements of the trunk during performance.

For the throw, the three-kilogram medicine ball (Dynamax IncR. Dallas, TX) was positioned at the height of the sternum (A). The ball was thrown with both hands, without movement of the trunk on the support, and if the individual failed to follow the established standards, the attempt was disregarded.

The distance of the throw of the medicine ball from point A to its first contact with the ground (B) was measured. Each participant performed three throws, with five-minute breaks between them and, for analysis, the best result was used.

Upper body strength and endurance

Push-up and sit-up tests were used to measure the upper body strength and endurance in accordance with the procedures described by Pollock and Willmore (1993).

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The players started in the push up position - with the hands and toes touching the floor, the knees on the ground, feet slightly apart, and the arms at shoulder width, extended and at right angles to the body. The athlete lowers the body until there is a 90-degree angle at the elbows, with upper arms parallel to the floor, and then pushes himself back up. The number of correctly completed push-ups was recorded. For the sit-up test the athlete was laying on a cushioned, flat, clean surface with knees flexed at 90 degrees. The hands were placed by the side of the head, and the athlete raised his trunk in a smooth motion, keeping the arms in position, sitting up the desired amount. The trunk was lowered back to the floor so that the shoulder blades or upper back touched the floor. The number of correctly completed sit-ups in 1 min became the score.

Agility

The shuttle run test was used to measure the agility in accordance with the procedures described by Benvenuti and collaborators (2010).

Two lines, 9.14 meters apart, were marked on the floor, using marking tape. Two blocks were placed on the line opposite the line used as starting line. On the signal “ready,” the athletes placed their front foot behind the starting line. On the signal “go!” the athletes sprinted to the opposite line, picked up a block of wood, ran back and placed it on or beyond the starting line. Then, turning without a rest, they ran back to retrieve the second block and carried it back across the finish line. Two trials were performed. Only the best score was recorded in seconds.

Flexibility

The sit and reach test was used to measure the flexibility of the lower back and hamstring muscles in accordance with the procedures by Wells and Dillon (1952).

The athletes sat on the floor with legs out straight ahead. The feet (shoes off) were placed with the soles flat against the box, a shoulder-width apart. Both knees were held flat against the floor by the tester. With hands on top of one another and palms facing down, the athletes reached forward along the measuring line as far as possible. After three reaches, the fourth reach was held for at least two seconds while the distance was recorded. The score (in cm) was recorded to the nearest centimeter as the distance before or beyond the toes.

Biochemical assessment

Venous blood sampling

The blood samples of athlete were withdrawn from the antecubital vein in the morning in the fasting state after staying at least 15 min in a sitting position. A 5 ml sample of blood was collected in a glass Vacutainer tube containing the anticoagulant tripotassium ethylenediaminetetra-acetic acid (K3-EDTA) and used to determine full blood counts. Immediately after the collection, the blood samples were centrifuged for plasma separation. Plasma was quickly frozen and stored at -70°C. Whole blood count and some plasma and clinical parameters were measured in samples according to the laboratory standard operating procedures.

Hematology

Hemoglobin concentration, red blood count (RBC), percentage of reticulocytes, mean cell volume (MCV), mean corpuscular hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were determined by using the automated system Sysmex K-1000 (TOA Medical Electronics Co. Ltd.).

Leukocyte differential counts

Leukocytes [white blood cells (WBC)] numbers were analyzed in EDTA whole blood using the Sysmex K-1000 (TOA Medical Electronics Co. Ltd.). Coefficients of variation (CV) for neutrophils and lymphocytes counts were < 4%.

Statistical analyses

The results are presented as mean ± standard deviation (SD). Data distribution was analyzed by the Shapiro-Wilk test. In order to analyze the effects of training periodization at different periods (pre- *vs.* post-traning), the paired t-test was applied. The value of $p < 0.05$ indicates statistical significance. All data were analyzed using the Graph Pad Prism software, version 6.0.

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RESULTS

Periodization of training in the final pre-season reduced body fat by 8.1% (Table 2) when compared with beginning of pre-season ($p<0.01$).

The lean body mass increased by 3.6% in the final pre-season when compared with the beginning of pre-season ($p<0.01$) and there was a reduction in the fat body mass of 9.1% in the final pre-season compared to beginning of pre-season ($p<0.01$) (Table 2).

Periodization of training did not change maximal oxygen uptake (VO_{2max}) in the final pre-season (p>0.05) (Table 2).

However, in the final pre-season the periodization increased maximum isometric strength by 6.4%, muscle endurance during sit-up and push-up tests by 9.6% and 26.2%, muscle power of the lower and upper limbs by 6.6% and 5.7%, and flexibility by 7.6% when compared to beginning of pre-season ($p<0.05$) (Table 2).

Furthermore, the periodization of training increased the agility of the athletes reducing the time by 3.1% when compared with beginning of pre-season ($p<0.05$) (Table 2).

Periodization of training did not modify the leucogram (Table 3).

In the final pre-season the total count of leucocytes, neutrophils, lymphocytes, monocytes, eosinophils and basophils did not change when compared to the beginning of pre-season (p>0.05) (Table 3).

Periodization of training decreased the mean cell hemoglobin concentration by 3.6% (Table 3) when comparing final preparatory period with the beginning of pre-season ($p<0.01$), however, the value was in normal range.

There was no significant difference for the erythrocytes, hemoglobin, mean cell volume, and mean corpuscular hemoglobin in the final pre-season compared to the beginning of pre-season ($p>0.05$) (Table 3).

Table 2 - Effect of the selective loads periodization on body composition and physical capacities in Under-16 male handball players in the beginning of the pre-season (BPS) and final pre-season (FPS).

	BPS	FPS
Body fat (%)	13.6 ± 4.8	12.5 ± 4.2**
Fat body mass (kg)	10.9 ± 4.9	9.9 ± 4.9**
Lean body mass (kg)	63.5 ± 6.4	65.8 ± 5.5**
VO_2 máx. (ml.kg^{-1}.min^{-1}.)	50.2 ± 3.8	51.2 ± 3.7
LLMI strenght (kg)	101.5 ± 20.1	108.0 ± 20.1*
Sit-up (rep.)	52.8 ± 4.6	57.9 ± 5.9*
Push-up (rep.)	21.0 ± 9.4	26.5 ± 8.6*
Horizontal jump (cm)	236.6 ± 18.7	252.3 ± 18.7*
MBT test (cm)	466.8 ± 49.8	493.7 ± 50.1*
Agility (s)	9.5 ± 0.3	9.2 ± 0.3*
Flexibility (cm)	35.3 ± 5.9	38.0 ± 6.5*

Notes: Values are expressed as mean ± SD. LLMI = lower limbs maximum isometrics. ULMI = upper limbs maximum isometrics. rep. = repetition. Values are expressed as mean ± SD. *$p<0.05$ compared to the PP **$p<0.01$ compared to the PP.

Table 3 - Effect of the selective loads periodization on leucogram and erytrogram in Under-16 male handball players in the beginning of the pre-season (BPS) and final pre-season (FPS).

	Normal range	BPS	FPP
Total Leucocytes (10^3/µL)	3.8 – 9.8	6.9 ± 1.1	7.3 ± 0.9
Neutrophils (10^3/µL)	2.5 – 7.5	3.0 ± 0.9	3.5 ± 0.7
Lymphocytes (10^3/µL)	1.2 – 3.3	2.9 ± 0.7	2.6 ± 1.1
Monocytes (10^3/µL)	0.2 – 0.7	0.5 ± 0.1	0.6 ± 0.1
Eosinophils (10^3/µL)	0.0 – 0.3	0.2 ± 0.1	0.2 ± 0.0
Basophils (10^3/µL)	0.0 – 0.1	0.0 ± 0.0	0.0 ± 0.0
Eritrocytes (M/µL)	4.3 – 5.7	5.2 ± 0.2	5.2 ± 0.2
Hemoglobin (g/dL)	13.5 – 15.7	14.6 ± 0.4	14.6 ± 0.4
MCV (fL)	81.0 – 95.0	83.2 ± 3.0	85.8 ± 2.7
MCH (pg)	26.7 – 33.7	28.0 ± 1.3	27.8 ± 1.8
MCHC (g/dL)	31.0 – 36.0	33.6 ± 0.5	32.4 ± 1.0*

Notes: M = millions. Values are expressed as mean ± SEM. *p<0.01 compared with the PP.

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DISCUSSION

The aim of this study was to evaluate, during pre-season, the effects of selective loads periodization on physical performance and hematological parameters in a Under-16 male handball players team.

The main finding was that, with selective loads periodization, the physical performance of the handball players improved, and that the biochemical parameters remained within the normal ranges during pre-season.

Selective loads periodization in the Under-16 male handball players decreased body fat (%) and fat body mass, and increased the lean body mass in the FPS compared with the beginning PS (Table 2).

The training and game performance of high level competitive handball is characterized by high neuromuscular demand, because handball players execute bursts of high-intensity action of short duration such as sprinting, jumping and throwing (Chelly and collaborators, 2017).

Therefore, the increase in lean mass and decreased fat mass, allows for better performance. Milanese and collaborators (2014) highlights that excess adipose tissue acts as dead weight to the handball players and may cause damage in the performance of players.

In the present research, the muscle strenght and endurance,upper and lower limb muscle power, agility and flexibility, improved with selective loads periodization in the FPS compared to the begginning PS (Table 3).

On the other hand, the maximal oxygen uptake (VO_2 max) did not improve with selective loads periodization (Table 3).

We infer that no observed changes in the aerobic capacity of Under-16 handball players with periodization, may be explained by the high VO_2 max (50.2 $ml.kg^{-1}.min^{-1}$.) presented in the begginning of pre-season. According to Rousanoglou, Noutsos and Bayios (2014) values of VO_2 max between 50 a 60 $ml.kg^{-1}.min^{-1}$ are reported for national younger handball players.

It is important to emphasize that the performance of the handball players in a match has been linked to the aerobic capacity, agility, power, strength, flexibility and a sustained ability to repeat short high intensity bursts.

Aerobic capacity is required for a fast recovery between intermittent high-intensity sprinting and jumping efforts (Povoas and collaborators, 2012).

Agility is important to sprinting over short distances, with stops and directional changes, with and without ball-possession (Buchheit and collaborators, 2010).

Strength and muscle power are used for jumping, hitting, blocking and pushing (Mohamed and collaborators, 2009).

High flexibility is required for handball-specific movements (e.g. shoulder flexibility for throwing).

Therefore, it is essential to improve the physical capabilities during the pre-season in order to be able to withstand all the demands imposed by game-performance, as well as by technical/tactical training.

To our knowledge, our study is the first to report the effect of the loads selective periodization on Under-16 handball players during pre-season.

The concentration of white blood cells is related to the status of the immune system. When an immunosuppression of the white blood cells occurs, increase the risk of infections diseases (Handschin and Spiegelman, 2008; Walsh and collaborators, 2011).

In the present research, the white blood cell concentration did not change in the FPS compared to the beginning PS with training periodization (Table 4).

The literature shows conflicting results concerning to white blood cell concentrations in young athletes. For example, a study with eleven adolescent male basketball players, showed there were not changes in the white blood cell concentrations at the end of the pre-season, corroborating our results (Brunelli and collaborators, 2014).

Another investigation with twelve young male basketball athletes showed that after 8 weeks of a periodization training during the pre-season, there was a significant decrease in monocytes and there were no significant changes in the total leukocyte, neutrophil and lymphocyte counts (Brunelli and collaborators, 2012).

In another study with twenty elite teenage tennis athletes, the neutrophils counts were lower during competition and intense training periods compared to the non-athletes (Henson, Nieman, Kernodle, 2001).

We highlight that keeping the concentration of white blood cells within normal ranges during the preparatory period with training periodization, may represent a protective factor for handball players that reduces the risk of injury and infection during

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the most intense training phases and during the competitive season.

Total hemoglobin, hematocrit and total red blood cell count in circulation, has been found to correlate directly with aerobic performance in athletes. On the other hand, the reduction these hematological parameters, results in lower VO_2 max and endurance performance, due to the reduction of the O_2 carrying capacity of blood (Bachero-Mena, Pareja-Blanco and Gonzalez-Badillo, 2017).

In this study, loads selective periodization did not alter the hematological indices in Under-16 male handball players in the final pre-season compared to the beggining of the pre-season (Table 5). In a study with thirty female adolescent handball players (mean age of 12.5 years) that participated of a training program during 1 year, the results showed that hemoglobin, mean corpuscular hemoglobin and mean cell hemoglobin concentrations decrease in the final training program, wich did not happened in our study.

In another investigation, twelve young male professional Brazilian soccer players participated in a training periodization for six weeks.

The results showed that erythrocyte and hemoglobin concentrations increased and mean corpuscular hemoglobin and mean cell hemoglobin concentrations did not change during the final periodization period, partly corroborating our finding (Silva and collaborators, 2008).

Nineteen male soccer players with mean age of 17.6 years were submitted to 45 days of periodization training. The results showed that hemoglobin concentration decreased while the other hematological parameters did not change during periodization (Andelkovic and collaborators, 2015).

The differences between our results and the previously reported studies could be related to the high VO_2 max. found at the beginning of the preparatory period and the periodization of training applied on handball players.

The high VO_2 max. parameters for hemoglobin, MCV and MCHC remained unchanged. With the control of overload training (volume, intensity and recovery) carried out with periodization during all pre-season, the hematological indices remained within the normal range.

Although the present study provides evidence that the periodization model of selective loads is an effective approach to improve the physical performance of Under-16 handball players in the pre-season, some limitations should be considered. Since the model not was applied during the competitive period, we cannot infer that the physical performance would be maintained and/or improved up to the final competitive period.

Furthermore, with the lack of a control group we cannot exclude that other models of training periodization would find similar results.

CONCLUSION

Our data show that the selective loads periodization model adapted to the Under-16 male handball players is an effective way to improve physical performance in the pre-season.

Another important feature of this study was that hematological parameters remained within normal ranges during periodization program.

Additional studies, focused on young handball players, should address further performance parameters for training periodization models throughout the competitive season in order to increase the scientific data to this field.

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