MINISTRY OF EDUCATION AND SCIENTIFIC RESEARCH
UNIVERSITY "BABEŞ-BOLYAI" CLUJ-NAPOCA
PHYSICAL AND SPORT EDUCATION FACULTY
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STRATEGIES FOR OPTIMIZING THE PHYSICAL TRAINING FOR ELITE JUNIOR HANBALL PLAYERS

PhD Thesis Summary

Coordinator:
Prof. univ. dr. Gheorghe Monea

PhD student:
Cristian Stelian Fenici

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Table of content

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Synthesis of chapter 1. Research issues

Handball has reached an impressive level of popularity in the world. Since the 1960s, handball has proven to be one of the most popular team sports. The development of the current handball game implies a maximum efficiency of all players in the team that would lead, implicitly, to the increase of sports performances.

Improving the training process of high-performance handball players, in order to further increase the performance is done on the one hand with the help of factors that lead and ensure the basic conditions of handball activity, and on the other hand, through the intervention of scientific research, which directly contributes to the continuous improvement of all the components of the training and of the organizational and management aspects, of the technical-material basis necessary for the practical activity.

The process of preparation and training, the particular framework within which the athlete is perfected, in order to ensure victories, to achieve exceptional performance, is a scientifically guided process, built according to its own system, using rules, methods, means and conditions specific to the purpose. In this framework, in handball a series of subassemblies are developed, especially in the system of rules and methodical means determined by the characteristics of the effort specific to the positions from which handball is formed.

The essential elements that underlie the training programming and planning are designed taking into account the general principles and rules that govern performance sports. The current performance in handball, both nationally and internationally, has obvious progress in terms of game dynamics in all phases of its development in attack and defense, characterized by the speed and complexity of the game throughout the game.

In handball, the performance ability is acquired in a relatively long period of time, through an effort that is often not easy, the road to performance being often winding. "Human material" plays an important role in the performance. However, without a training program aimed at optimizing the process of physical training of handball players, which ultimately ensures the efficiency of the activity is more difficult to achieve. Therefore, the use of scientific methods to eliminate the hazard in the training of handball players, the application of the latest developments in the field, are benchmarks from which any physical therapist or coach must start in order to streamline the training process.

The approached topic highlights that sports performances are the result of combining the selection of talented elements, with the latest developments in the science of physical education and sports. It is considered that one can no longer aspire to superior performance without a systematic, scientific training in compliance with biological and psycho-pedagogical requirements. The aim of this work refers to the elaboration of training models that are in fact operational models, methodical models whose purpose is to try to eliminate as much as possible the hazard in the training of handball players. These models must allow planning, measuring the demands, like the effort made in the training as well as its consequences, like its effectiveness on performance. As any training model, the completion is materialized in the achievement of the maximum sports form and implicitly of the performances at the established dates.

Synthesis of chapter 2. Scientific basis

The handball is a team sport that requires high-intensity and short-term physical effort, as well as a special ability to generate and repeat explosive muscle contractions. During a handball game, over 825 high-intensity actions can be performed, requiring a high level of strength (Karcher & Buchheit, 2014; Wagner et al, 2014; Manchado et al, 2013). Maximum power, endurance and throwing speed are considered to be determinants of success in performance of handball players. Therefore, handball coaches should also perform high-intensity exercises, such as resistance training, to develop these physical qualities. Determining players' strengths and weaknesses can be a valuable tool in identifying talent, assigning game positions, and optimizing the design of endurance and conditioning of training programs (Karcher & Buchheit, 2014; Fieseler et al., 2017; Schwesig et al., 2017). Several studies have reported significant differences between playing positions for various physical and anthropometric characteristics (Srhoj et al., 2002; Šibila and Pori, 2009; Zapartidis et al., 2011; Rousanoglou et al., 2014; Fieseler et al., 2017; Schwesig et al., 2017).

Anthropometric parameters and physical tests have been identified as fundamental to determine the success of handball performance (Karcher & Buchheit, 2014; Fieseler et al., 2017; Schwesig et al., 2017, Šibila & Pori, 2009). A study showed that body composition also has an influence on performance, namely, a larger hand size creates better ball control, or a larger arm span creates a higher level of space occupancy in defensive and offensive actions. (Karcher & Buchheit, 2014). Granados et al. (Granados et al. 2008) showed that higher fat-free body mass values led to higher performance, mainly due to increased muscle strength. Another study evaluated motor skills as decisive factors of performance, showing that motor skills in the upper limbs could be essential for performance (Srhoj et al., 2002).

The literature also reports that psychological attributes and mental abilities contribute to athletic success. In fact, motivation is one of the components of athletic success and has been studied extensively in sports psychology.

The vertical jump in power assessment is one of the most important common standard measurement methods in which the "explosive" performance is assessed. The ability to assess strength, jumping can also be useful in assessing sports development or in determining the training program (Sayers et al., 1999).

Unfortunately, the correct determination of power requires expensive devices, such as power platforms. Therefore, a correct and reliable method is needed to predict the strength of the vertical jump. Normative data for vertical jump and muscle strength are available for young adults (Patterson & Peterson, 2004). To date, various equations based on a number of variables, including jump height and body mass, have been developed to estimate the energy generation obtained by indirect methods (Gomez-Bruton et al., 2019; Sayers et al., 1999; Canavan & Vescovi, 2004; Johnson & Bahamonde, 1996; Lara et al., 2006; Tufano et al., 2011; Amonette et al., 2012; Harman et al., 1991; Quagliarella et al., 2011, Duncan et al. , 2013; Shetty et al., 2002; Janz et al., 2015; Duncan et al., 2013; Lara-Sánchez et al., 2011).

Differences in the morphological structures of people of different age groups require the development of new equations that can be used to predict the power of the vertical jump for an estimate as real and accurate as possible.

In addition to physical characteristics, coaches need to consider and analyze the ability of players to interact with the environment and make the best individual and collective decisions in the game (Araújo, 2006).

Physical training is an essential component of athletic performance at every level. To help athletes achieve optimal performance, coaches should have a basic understanding of how the body works in terms of exercise and the physical requirements of their particular sport. Effective fitness training should develop energy systems suitable for sports. Warm-up, recovery and flexibility are also important components of the athlete's physical training. In addition, coaches should have a basic knowledge of nutrition, to advise their athletes and to further improve their athletic performance.

Of the essential parts of training, physical training is the most extensive and comprehensive part. It consists of physical exercises designed to improve physical (motor) skills such as strength, endurance, speed, flexibility and agility. These motor skills are based on the appropriate physiological requirements, which are also subject to improvement. There are fundamental criteria to consider when scheduling and organizing fitness training.

Handball is a very demanding physical sport, which requires a high physical condition, which has become an integral part of handball training, as tactics and game systems have changed over the years. Indeed, counterattacks and defense are key elements of the modern high-pace game, and achieving high levels of fitness are essential to success. Today's players are faster, stronger and more resilient than ever. In fact, one of the most important differences between high-class players and mediocre players is the amount of high-intensity actions they perform during a game.

The greater contribution of fitness to the performance of the game of handball has placed additional emphasis on the planning and implementation of effective training programs. Several factors are taken into account in the development of these programs, and the most important is the understanding of the different physical requirements of this sport.

Handball is multidimensional and dynamic, incorporating speed, agility, balance, endurance, strength, as well as repeated sprinting skills and it is essential that handball coaches choose exercises that approach the game situations.

Today, handball is played at a fast pace, for 60 minutes, without being tired. During the game, players must perform a sprint repeatedly. This clearly shows the aerobic and anaerobic endurance requirements for handball players. High-intensity training involves periods of high-intensity exercise, interspersed with periods of recovery. The intensity of the exercises is usually above VO_2max of an athlete and due to the intense nature of this training method, the duration of repetitions is relatively short (30 seconds to 5 minutes), with rest intervals of 15-120 seconds.

Coaches try to optimize training through the duration and intensity of both the repetition and the recovery phase. Such optimization depends on the specifics of the event in which the athlete

performs. High-intensity training improves repeated sprinting and endurance. This allows the athlete to perform at a higher intensity for a longer time before the debilitating effects occur.

Specific physical training is the process of educating the physical skills specific to the game of handball. This activity is carried out in conditions as close as possible to the game conditions and is carried out in a close interdependence with the acquisition of technical-tactical skills. Specific physical training cannot replace general physical training, the two aspects of physical training being closely related.

In handball, as in many other team sports, the design and methodological application of strength training modalities should address two main objectives: injuries prevention and performance improvement.

Given the intense nature of the team's handball discipline, involving high-intensity short-term activities such as sprinting, jumping, turning, pushing, blocking, throwing, and the ability to perform effective defensive interventions (Michalsik & Aagaard, 2015), a systematic and progressive strength training plan could lead to the improvement of specific skills that is the physical premise for successful participation at the elite level (Cormie, McGuigan & Newton, 2001).

The career of a handball player in a team can easily extend for about 20 years and, consequently, long-term athletic training and development programs should be designed. Strength training is widely recognized as a potential tool for improving athletic performance and has been widely correlated with specific motor loads and the physical requirements of athletic models of interest.

Scientific studies generally report that strength training is an effective means of improving components dependent on explosive neuromuscular impulse, such as acceleration, jumping, sprinting, resilience, and throwing (Hermassi et al., 2010; Hermassi et al. , 2010; Markovic & Mikulic, 2010)

Synthesis of chapter 3. Preliminary research on the physical training of elite handball players at junior and senior level

At handball players, in addition to technical-tactical skills, anthropometric characteristics and strength, power and speed of throwing are important factors for competitive success (Gorostiaga et al., 2006). Player profiling is a valuable tool for identifying a new talent, determining strengths and weaknesses, assigning the game position and optimizing the training program.

The preliminary study is a starting point for a larger study related to the optimization of handball training at junior level. The aim of the research was to establish an effective testing protocol in order to evaluate the physical training of elite handball players in order to develop a specific complementary physical training that will be applied to the experimental group in the main research.

The preliminary research aimed the comparison of the anthropometric characteristics, the specific strength of the upper and lower limbs, strength and endurance between senior and junior handball players. Such profiling studies are used in a variety of sports in an attempt to develop baseline data and to standardize testing procedures.

The preliminary research involved 14 athletes from the handball club SCM Politehnica Timișoara, of which 7 from juniors (national champions at juniors I) aged 16-17 and 7 athletes from seniors aged 21 - 35 years.

Following the results obtained in the preliminary research, the following were highlighted:

- In the case of tests for measuring the body composition, there was a significant difference between the two groups (seniors and juniors) only for the BF index ($p = 0.029 < 0.05$, 95% confidence), while for the other parameters, like weight ($p = 0.063 > 0.05$, 95% confidence) and BMI body mass index ($p = 0.180 > 0.05$) differences are statistically insignificant. The effect size index has a medium level for the BMI index ($r = 0.35$) and a high level for the weight ($r = 0.49$) and the BF index ($r = 0.58$).
- in the case of muscle characteristics, the differences are statistically insignificant, the specific strength at vertical jump ($p = 0.749 > 0.05$, 95% confidence level), vertical jump height ($p = 0.749 > 0.05$, degree of jump 95% confidence), CMJ height ($p = 0.655 > 0.05$, 95% confidence), SJ specific strength ($p = 0.749 > 0.05$, 95% confidence), and SJ height ($p = 0.306 > 0.05$, 95% confidence level). The effect size index has a low level for muscle characteristics, specific vertical jump strength ($r = 0.08 < 0.1$), vertical jump height ($r = 0.08 < 0.1$), CMJ jump height ($r = 0.11 \approx 0.1$), the specific power jump SJ ($r = 0.08 < 1$), and an average level for and height jump SJ ($r = 0.27 < 0.3$).
- in the case of the strength test there was a statistically significant difference ($p = 0.038 < 0.05$, 95% confidence). The effect size index has a high level ($r = 0.55 > 0.5$).

- in the case of the endurance speed test, there was a statistically significant difference between the two groups ($p = 0.002 < 0.01$, 99% confidence). The effect size index has a high level ($r = 0.83 > 0.5$).

Recent studies have shown that professional handball players have a higher average strength of the upper limbs (+ 22%) and lower limbs (+ 16%) compared to amateur players. A positive correlation was also established between the speed of the ball in the throw and 1RM (1 maximum repetition) (Gorostiaga et al. 2005; Chelly et al. 2006). The strength and power of the upper and lower limbs are very important in the game of handball, to increase performance and to prevent decreased performance during the game.

The height of the jump is also an important factor, both for the attack phase and for the defense. In defense, the jump is important to block the rival offensive player during the throw, and in the attack to reach a high vertical position to throw over the block of rival defensive players or to have more time to throw (an increase in time flight) to mimic or react to the goalkeeper's movements. The height of the jump in the game of handball is often measured during a CMJ counter-movement jump or VJ vertical jump. In the literature, the average values for height in the case of CMJ and SJ jumps are 47 cm and 42 cm, respectively. Compared to the results of the initial tests, a significant difference was found compared to the reference values.

The endurance of handball players is determined by measuring the maximum oxygen consumption VO2max, the maximum aerobic speed (VMA) and the total distance covered while running on the treadmill or during specific shuttle or sprint tests. A limitation of these studies was that these parameters are measured under standardized conditions that do not reflect or reflect to a small extent the situation during the game. During the game, handball players need a high aerobic capacity to recover during the low intensity phases to ensure the game at a high level in the high intensity phases. Wagner et al. (2014) reported that during a handball game, the athlete needs a maximum amount of VO2max oxygen of 55-60 [ml / kg / min].

Although seniors scored better on testing, the difference is statistically insignificant. Similar results were obtained by performance athletes (Gorostiaga et al, 2005). Statistically significant differences were obtained in the case of strength and endurance tests.

The senior group scored better compared to the junior group in all assessments. The hypothesis was confirmed by the results that showed that the parameters obtained by juniors are below the level of seniors, the difference in physical training being an impediment to be able to cope in senior competitions. Following the analysis of the obtained data, the objective was established to optimize the physical training of the junior elite handball players through a specific strength training. Based on the test results and the interpretation of the results, the general and individualized training program was created for each motor quality: speed, skill, endurance, strength and optimization of body structure.

Synthesis of chapter 4. Methodological approach of experimental research

Premises and aim of the research

Coaches and physical trainers strive through various testing processes to identify appropriate short-term training techniques to achieve the greatest improvements in sports performance in the shortest possible time. Therefore, studies are needed to evaluate the effects of handball-specific training on selected physical abilities (speed, agility, explosive power, and explosive arm strength) and physiological variables (body fat, body mass, capacity, maximum heart rate, anaerobic endurance). of male handball players.

Conducting specific tests in handball and developing a training strategy customized to the positions and individualized to the players is a necessity given that within the FRH there is no database, specific scales, test batteries and training methodology by age / sex / level of training so as to streamline technical and tactical actions at the level of modern play. Testing must precede, accompany and complete the training process so that the coach knows where the players are physically in relation to international standards, but also to the initial values of testing.

The main purpose of the research was to develop a complementary strength training program for the development of physical training of professional handball players at junior level, as well as the selection of a test batteries to assess fitness.

Research objectives

Specific research objectives:

- carrying out a complementary strength training program to improve physical training.
- conducting an experimental study that aims at the effectiveness of training on selected physical skills and physiological variables of male handball players at junior level.
- highlighting the efficiency of training on certain fitness and physiological variables of male handball players.

Research hypotheses

It is assumed that by applying the complementary strength training program, significant improvements are made in certain fitness and physiological variables of male junior handball players.

Organizing and conducting research

The personal research was carried out over a period of 12 months, during which time the complementary training program for the experimental group were applied, while the control group performed a normal training program. During these months we tried to observe if the selected program influence the specific parameters of physical training of the experimental group.

The personal research began in June 2020 and was completed for retest in June 2021.

Personal research began with the following tests:

- test for measuring body composition;
- dynamometric tests
- strength tests for setting 1RM (1 maximum repetition)
- field test to establish physical endurance

The final test was performed under the same conditions and using the same tests as in the initial test.

Research subjects

Subjects who participated in the personal research were divided into two groups:

The experimental group, consisting of 16 junior I athletes aged 16-18, from the handball club SCM Politehnica Timișoara. On them was applied in addition to the normal training program an additional training program to increase the strength and endurance. The number of workouts planned during a week was 6 / week with a day off.

The control group, was formed of 16 junior I athletes aged 16-18, from the CSM Resita handball club.

Tests

The tests aimed at evaluating the following parameters: body composition, strength of the lower and upper limbs, specific strength, specific energy or aerobic fitness.

Synthesis of chapter 5. Complementary physical specific training used in experimental research

Adaptation to effort through systematic endurance training (running, cycling, rowing, skiing, stairs, swimming) leads to extraordinary progress regardless of age of the group. Increasing exercise tolerance has beneficial effects on the performance.

On the experimental group was applied in addition to the normal training program, a complementary training program to increase the strength and endurance. The number of workouts planned during a week was 6 / week with a day off. The proposed training program to optimize the physical training for elite handball players is presented below.

Workout DAY 1
CHEST AND ARMS 1 - 70% Intensity

1. Dumbbell chest press 3x10 reps
2. Dumbbell biceps 3x10 reps
3. Triceps 3x10 reps
4. Inclined dumbbell press 3x10 reps
5. EZ bar curl 3x10 reps
6. Bodyweight pushups 3x10 reps
7. 90° leg raises 20 rep x 4 series

Workout DAY 2
LOWER LIMBS 1- 70% Intensity

1. Front squat 3x12 reps
2. Heel raises 3x12 reps
3. Leg extension 3x12 reps
4. Leg press 3x8 reps

Workout DAY 3
BACK AND SHOULDERS 1- 70% Intensity

1. Neck strain exercises 3x12 reps
2. Seated pushups 3x12 reps
3. Wide grip tractions 3x12 reps
4. Seated dumbbell shoulders 3x12 reps
5. Dumbbell push press 3x12 reps

a. Knee to chest raise 10x4 series

Workout DAY 4
CHEST AND ARMS 2- 65% Intensity

1. Incline chest press 3x10 reps
2. Tractions 3x10 reps
3. Sitting triceps 3x10 reps

4. Triceps rope pulldown 3x10 reps
5. Proprioceptive pushups 3x20 reps

Workout DAY 5

LOWER LIMBS 2- 65% Intensity

1. High bar squats 3x12 reps
2. Forward lunge 3x12 reps
3. Adductions and abductions of the lower limbs 3x12 reps
4. Jumping at different heights 3x10 reps
5. Candle raises 10x4 series

Workout DAY 6-

BACK AND SHOULDERS 2 65% Intensity

1. Seated dumbbell shoulders 3x10 reps
2. Shoulder plate rotation 3x10 reps
3. Cable face pull 3x10 reps
4. Pushups 3x10 reps

Workout DAY 7- rest

Synthesis of chapter 6. Analysis and interpretation of research results

The personal research aimed at analyzing the effectiveness of specific strength training for 12 months and highlighting changes in selected physical skills and physiological variables of junior I handball players.

The tests in the personal research aimed to evaluate the following parameters: body composition, strength of the lower and upper limbs, specific strength, specific energy or aerobic fitness.

Following the results obtained in personal research we can highlight the following:

- in the case of tests for measuring body composition, there were no significant differences between the initial and final testing for either the experimental or the control group.
- in the case of weight, the mean value for the experiment group is 0.88 lower and for the control group 0.12. The difference in progress between the two groups is 0.76 kg in favor of the experimental group.
- in the case of body fat, the mean value for the experiment group is lower by 0,39%, while for the control group it is higher by 0,05. The difference in progress between the two groups is 0.44% in favor of the experimental group.
- in the case of the body mass index, the average value for the experiment group is higher by 0.74, and for the control group by 0.17. The difference in progress between the two groups is 0.57 kg in favor of the experimental group.
- in the case of strength tests there were statistically significant differences for all parameters only in the experimental group
- the average value for 1RM squats in the experiment group is higher by 8.44, and for the control group it is lower by 0.62. The difference in progress between the two groups is 9.06 kg in favor of the experimental group.
- in the case of 1RM deadlifts with the Olympic bar, the average value for the experiment group is higher by 7.19 at the final test, while for the control group it is higher by only 0.94. The difference in progress between the two groups is 6.25 kg in favor of the experimental group.
- for 1RM bench press with the Olympic bar, the average value for the experiment group is higher by 9.06, and for the control group by 1.25. The difference in progress between the two groups is 7.81 kg in favor of the experimental group
- in the case of dynamometric tests, there were statistically significant differences for all parameters only in the experimental group.
- for Specific Energy_VJ, the average value in the experiment group is higher by 4.99, and for the control group it is higher by 0.1. The difference in progress between the two groups is 4.89 J / kg in favor of the experimental group.
- in the case of Specific Power_VJ, the average value for the experiment group is higher by 2.71 at the final test, while for the control group it is higher by only 0.02. The difference in progress between the two groups is 2.68 W / kg in favor of the experimental group

- for height_VJ, the average value for the experiment group is higher by 2.48 and for the control group by 0.04. The difference in progress between the two groups is 2.44 cm in favor of the experimental group.
- for Specific Energy_SJ, the average value in the experiment group is higher by 0.89, and for the control group it is higher by 0.02. The difference in progress between the two groups is 0.87 J / kg in favor of the experimental group.
- in the case of Specific Power_SJ, the average value for the experiment group is higher by 2.48 at the final test, while for the control group it is higher by only 0.07. The difference in progress between the two groups is 2.41 W / kg in favor of the experimental group.
- for height_SJ, the average value for the experiment group is higher by 2.41 and for the control group by 0.05. The difference in progress between the two groups is 2.36 cm in favor of the experimental group.
- for the specific energy_CMJ, the average value for the experiment group is higher by 0.72, and for the control group it is higher by 0.05. The difference in progress between the two groups is 0.66 J / kg in favor of the experimental group.
- for height_CMJ, the average value for the experiment group is higher by 3.25 and for the control group by 0.12. The difference in progress between the two groups is 3.13 cm in favor of the experimental group
- for the endurance test there were significant differences for all indicators only in the experimental group
- The average value for the total distance to the experimental group is higher by 668.75 at the final test, and for the control group higher by 45. The difference in progress between the two groups is 623.75 m in favor of the experimental group.
- In the case of VO_2max, the average value for the experiment group is higher by 5.34 at the final test, while for the control group it is higher by only 0.34. The difference in progress between the two groups is 5 ml / kg / min in favor of the experimental group.
- for the Yo-Yo test level, the average value for the experiment group is higher by 1.88, and for the control group by 0.14. The difference in progress between the two groups is 1.74 in favor of the experimental group.

The goal of improving the physical training of junior handball players has been achieved. The main research has verified that through the modern means and methods of training applied, substantial contributions are made to the increase of sports performance through a specific strength training..

Synthesis of chapter 7. Determination of regression equations based on the results of tests for measuring body composition, dynamometric, strength and endurance

To date, research has intensified in the development of a linear regression model for predicting muscle strength based on vertical jump height and body weight. Sayers et al. (1999) determined the maximum power based on the height of the vertical jump (cm) and body weight (kg) in the study performed on 108 participants of different sex by applying the SJ and CMJ jumps. As a result, they reported that the SJ jump data provided a better prediction equation than the CMJ jump. Top power (W) = 60.7 x (jump height cm]) + 45.3 (body mass [kg]) - 2055. (R2 = 0.88). In another study, Kochanowicz et al. (2016) developed the regression model [W] = 73.81 x VJH [cm] + 34.666 X body mass [kg] - 1617 (R2 = 0.75).

Another group of researchers (Lara et al., 2006) developed the power equation to more accurately assess muscle strength in the special population. They argued as a power prediction equation: [Power = (62.5 x jump height (cm)) + (50.3 X body weight (kg) - 218.4.7], and that it could be used in a way valid among sports students Tufano et al (2011) developed the power estimation equation using body weight and jump height as independent variables with 3 variables (height, body weight and power): Power = 666.3 + 14 , 74 x [weight (kg)] +1925.72 [Height (m)] [R2 = 0.69, P <0.05] and found a significant correlation between power generation and jump height. In another study, Lara Sanchez et al. (2011) presented two specific predictions of equations that measure vertical jump power on male participants ([61.8 x jump height (cm)] + [37.1 x body weight (kg)] 1941.6) and female ([31 x vertical jump (CM))] + [45 x body mass (kg) - 1.045.4].

From the data obtained in the personal research, a linear regression model regarding the specific power was analyzed. The variable dependence was chosen specific power, and as influencing factors were chosen BF, BMI and jump height. The multiple linear regression equation has the form: Specific power_VJ15s = -1.135 x BMI + 0.248 x BF + 0.637 x Height_VJ15s + 40.88.

Another regression equation was generated taking as variable dependence the specific power SJ, and as influencing factors BF, BMI and jump height, Specific power_SJ = 1,462 x BMI - 0.362 x BF + 1,212 x Height_SJ - 44,822.

A linear regression model on VO_2max was analyzed. Variable dependence was chosen VO_2max, and the total distance, BF, BMI and squats were chosen as influencing factors. The equation has the form: VO_2max = 0.306 x BMI - 0.098 x BF - 0.034 x squats + 0.012 x total distance + 26.117.

A regression equation was also established in which the variable dependence was chosen for the specific energy of CMJ, and BF, BMI, deadlifts and squats were chosen as influencing factors. The regression equation has the form: Specific energy_CMJ = -0.273 x BMI + 0.01 x BF - 0.02 x squats + 0.012 x deadlifts + 10.882.

Synthesis of chapter 8. General conclusions and methodological recommendations

In handball, the time for physical training is limited, because more emphasis is placed on the technical-tactical and mental aspects. The introduction of specific physical training is crucial in increasing sports performance. Any training program for a player should be based on analysis of requirements during the game, to determine what motor skills are important for good performance. An analysis of the ability of individual players must be carried out so that their strengths and weaknesses can be identified. This will allow the coach to assess what aspects the training should contain in particular, and realistic goals can be set based on the analysis. Even if handball is a team sport, players must be trained individually, as there is no training program that is optimal for all players. Studies carried out (Hermassi et al., 2011) on physical training twice a week for eight weeks have been reported for performance handball players. An increase in muscle strength and endurance was observed for both upper and lower limbs, without interfering with endurance or speed. The specific physical training proved to be practical and easy to integrate in the regime of the technical-tactical training program. The performance improvements obtained following the specific training of the handball game by capitalizing on running, jumping, throwing in the tactical actions of attack and defense, contribute to the increase of sports performance.

Coaches have worked, largely through attempts, to identify appropriate short-term training techniques to achieve the most effective improvements in athletic performance. Lately, the physical training has increased a lot, and if the technical level of the athlete is not doubled by an adequate physical training, he will not be able to cope during the whole match. Physical training must be part of the management of each professional club.

Preliminary research aimed at certifying the tests that were later used in personal research, by designing an effective testing protocol to assess body composition and muscle characteristics of performance handball players and compare anthropometric characteristics and strength, specific strength of upper and lower limbs between handball players at senior and junior level. Such profiling studies are used in a variety of sports in an attempt to develop baseline data and to standardize testing procedures.

The senior group scored better compared to the junior group in all assessments. The hypothesis was confirmed by the results that show us that the parameters obtained by juniors are below the level of seniors, the difference of technical-tactical training being an impediment to be able to cope in senior competitions. Following the analysis of the obtained data, the objective was established to optimize the physical training of the senior performance handball players through a complementary strength training.

The main research was carried out over a period of 12 months, during which time the means of training were applied. The personal research began in June 2020 and ended in retesting in June 2021. The subjects who participated in the research were from two groups: the control group consisting of 16 junior I athletes aged 16-18, from the handball club CSM Reșița, and the experimental group consisting of 16 junior I athletes aged 16-18, from the handball club SCM Politehnica Timișoara. On the experimental group, it was applied in addition to the normal training

program a complementary training program to increase strength and endurance. The number of workouts planned during a week was 6 / week with a day off. The main aim of the main research was to determine the effect of training on the physical training of a group of junior I handball players. The main research tests aimed at evaluating the following parameters: body composition, strength of lower and upper limbs, specific strength, specific energy or aerobic fitness.

The main research has validated that through modern means and methods of training applied, important contributions are made to increase sports performance, by substantially improving physical training.

In the third study, the following linear regression equations were developed from the test results:

- regression equation between the specific power in the vertical jump, jump height VJ, BF and BMI;
- regression equations between specific power in SJ jump, SJ jump height, BF and BMI.
- regression equations between VO_2max, total distance traveled in the beep test, BF, BMI and 1RM squats
- regression equations between the specific energy of the CMJ jump, 1RM deadlifts with the Olympic bar, BF, BMI and 1RM squats.

The linear regression equations developed in this research, have the role of providing coaches an easy, practical and valid method for estimating the muscle strength of an athlete by a simple vertical jump.

In conclusion, the applied strength training program contributes significantly to improving the sports performance of elite junior handball players. The aim of the study was achieved through a modern approach of introducing a specific physical training, in addition to technical-tactical training. Following the physical evaluation of the parameters, the training of elite handball players can be customized. The training of elite handball players must include exercises aimed at the ability to perform specific high-intensity actions throughout the game and to recover as quickly as possible during less intense periods.

The practical implications of this study consist in the tactical approach of the matches, considering a very good physical preparation. In case of a very good physical training, can approach a modern game in which the game speed is extremely high, without downtime and without breaks.

The theoretical implications of the study consist in the fact that the study highlights a phenomenon often encountered in Romania in general, and in handball in particular, when the specific physical training is not in accordance with the requirements of the game at international level.

Following the study, the following recommendations can be made:

– the realization of the training programs to be personalized and individualized with the needs of each athlete.
– the evaluation must precede, accompany and complete the training process.

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