Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXII, ISSUE 2, 2022, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXII, ISSUE 2, 2022
June 2022, 22 (2): 113 - 118
Original article

The influence of a pre-competition training program with plyometric exercises on the training of performance handball players

CAZAN Florin[1], GEORGESCU Adrian[1], GIDU Diana Victoria[1], MUȘAT George[1], POPA Cristian[1]

Abstract

Aim. This study shows the opportunity to use plyometric workouts in the pre-competitive period to improve jumping, for men's handball players. The main purpose of this paper is to demonstrate the usefulness of a pre-competitive PT program. We will assume that if we use an 8-week PT program, we will get effective results in jumping performance tests.

Methods. There are 18 research subjects, members of Team Handball, with an average age of 22.64 (± 1.28 years), stature 192.41 (±3.22 cm), body mass 94.23 (±7.61 kg). The team is playing in the National Championship, Second League. The study was conducted during the precompetitive period. The subjects were tested twice, before and after applying the work program that was conducted for 8 weeks. The subjects completed the following in this order: squat jump, counter-movement jump with arm-swing, continuous 6 jumps with straight legs without arm-swing. Within eight weeks during the two tests, the team included in the training process, the new program designed to improve the jumping performance. The program provides three workouts per week, on Monday, Wednesday and Friday, 30 min each, included in the team's training session.

Results. After 8 weeks of training, the group made significant ($p \leq 0.05$) improvements in SJ (from 46.44 ± 1.54 to 50.50 ± 1.47 cm; 8.73%), CMJ (34.83 ± 1.54 to 37.44 ± 1.15 cm; 7.5%) and CJSL (from 29.78 ± 1.26 to 32.61 ± 1.33 cm; 9.51%) performance compared with the initial test.

Conclusions. The research hypothesis was confirmed, an 8-week pre-competitive PT program with three workouts per week, can get effective results in jumping performance tests.

Keywords: plyometrics, jumping, handball.

Introduction

Handball is played by approximately 20 million players distributed between 1,000 thousand teams across 209 member federations listed by the International Handball Federation (https://www.ihf.info). Team handball is a demanding sport, because numerous high-intensity displacements and actions occur throughout the game. The aerobic system is therefore highly taxed during the game. The time between each change of intensity and the number of intense actions and movements suggest a high anaerobic energy turnover during the critical periods of the game. Therefore, the training of elite handball players should comprise exercises targeting the ability to repeatedly perform high-intensity activities and to rapidly recover during less intense periods. In addition, because a high number of intense actions are required throughout the match, basic strength training (e.g., squat, leg extension) combined with specific power-related actions (e.g., jumps, sprints) following complex and contrast training principles is recommended (Póvoas et al., 2012, Gidu, 2016, Oltean, 2018, Georgescu et al., 2019, Mușat, and Petcu, 2019). The sport requires that handball players possess various technical skills (e.g. shooting and passing) and fitness components (e.g. jumping ability, speed, endurance) to reach the highest levels (Nikolaidis and Ingebrigtsen, 2013).

A fast handball player moves uniformly, explosively and effortless on the court. While speed is crucial, so is the moment when it is used, when the rhythm is broken, as a mean to give the opponents a hard time. Improving movement speed is not easy, but it is possible for a player to become more efficient and faster. This can be achieved by dividing the action in sequences and by performing each sequence separately (Mușat and Gidu, 2018). When the sequences will be unified, the action will be improved. By using each sequence of the movement, one can increase the strength and eliminate weaknesses. This improvement can be achieved through plyometric training (P.T.) (http://sportsmedicine.about.com/od/sampleworkouts/a/Plyometrics.ht).

Plyometric workouts emphasize lateral movements, and the change of direction and vertical jumps (Impellizzeri et.al.2008).

We can say that the best way to improve the strength of a handball player is to use plyometric exercises (Gabbett et al., 2008; Young et al., 2002).

PT is an effective training method for improvement vertical jump height (Slimani et al., 2016). PT takes advantage of rapid cyclical muscle action known as the 'stretch-shortening cycle'(SSC), whereby the muscle undergoes eccentric contraction, followed by a transitional period before to the

[1]Faculty of Physical Education, Ovidius University of Constanta, No.124 Mamaia Avenue, Romania
Email: cazan10florin@yahoo.com

concentric contraction. With the growing interest in PT, many researchers have attempted to identify the potency of this training modality for improving athletic performance. To date, PT improves the following physical qualities in both young and adult population: strength, speed, power, change of direction speed, balance, jumping, throwing, kicking (https://www.scienceforsport.com/plyometric-training/#toggle-id-1).

During the pre-season period, handball training emphasizes the development of physical fitness, whereas the in-season period is aimed at maintaining aerobic and anaerobic capacity and improvement of tactical and technical skills. As a result, one of the aims of pre-season training is to improve jumping ability, repeated sprint ability (RSA) and aerobic endurance (Mazurek et al., 2018).

Short-term PT (i.e. 2–3 sessions a week for 6–15 weeks) can change the stiffness properties of the muscle-tendon complex and improve lower-extremity strength, power and SSC muscle function in healthy individuals (Markovic and Mikulic, 2010).

The main purpose of this paper is to demonstrate the usefulness of a pre-competitive PT program. The research hypothesis- we will assume that if we use an 8-week PT program, we will get effective results in jumping performance tests.

Method

Participants

There are 18 research subjects, members of Team Handball C.S. Medgidia, with an average age of 22.64 ± 1.28 years, stature 192.41 (±3.22 cm), body mass 94.23(±7.61 kg). The team is playing in the National Championship, Second League. They were all adults and had at least 7 years of training experience. The athletes participated in 9 handball-specific training units per week with a duration of 90 min each.

The research was conducted on the team C.S. Medgidia and the tests occurred in the Sports Hall from Medgidia while the team was conducting official matches, on the sports arena approved by the Romanian Handball Federation and by the gym of the same hall as well. All participants were properly informed about all testing and training procedures, as well as potential benefits and harms related to the study. The study was approved by the club's manager and performed according to the principles expressed in the Declaration of Helsinki.

Measures

The study was conducted during the precompetitive period. The subjects were tested twice, before and after applying the program.

In the initial testing the subjects underwent anthropometric measurements, and then after warm-up for 20 min, which consisted of stretching, jogging, elements of school running and school jump (running with knees up, running pendulum leg back etc.), gymnastics, running faster, sprints, the subjects completed the following tests in this order: squat jump (SJ), Counter-movement jump with arm-swing (CMJ), Continuous 6 jumps with straight legs without arm-swing (CJSL).

The participants performed two trials for each jumping exercise and the best result was recorded (Aragon-Vargas, 2000). The height of each jump was estimated using the Opto-jump (Microgate Engineering, Bolzano, Italy), and was expressed in cm. The final testing followed the same protocol as the initial testing.

Design and Procedures

Within eight weeks during the two tests, the team included in the training process, the new program designed to improve the jumping performance.

The program provides three workouts per week, on Monday, Wednesday and Friday, 30 min each, included in the team's training session. The programs made of three sets with ten workouts each, using one set per training. The first set is performed every Monday for 8 weeks, the second set is performed every Wednesday and the third set is performed every Friday.

The first workout set:

1. From standing position, jump on both legs on 80 cm high prop - 10 jumps x3
2. From standing position, jump on a leg on 80 cm high prop - 10 jumps on each leg x3
3. From sitting position on a 30- 40 cm high, jump on the bench on both legs, at the sound signal – 10 jumps x3
4. From standing in semi-genuflection over a 30- 40 cm high, jump on the bench on both legs, at the sound or visual signal – 10 jumps x3
5. In pairs, an athlete standing in semi-genuflection, the other place his palms on the hips of the first athlete for 3 seconds, then allowing him to perform a high jump on both legs – 10 jumps x3
6. Standing on one leg on the gym bench, high jump landing on the bench - 10 jumps on each leg x3
7. The same as 6, but with a 1 kg medicinal ball in hand - 10 jumps on each leg x3
8. Standing on an 80 cm high box, jump landing on the floor on two legs plus 5 jumps in a row on two legs over five hurdles of 60 cm high-2-4X
9. Standing on a gym bench, jump landing on the floor on two legs plus 8 jumps in a row on two legs over five hurdles of 60 cm high and three gym benches of 30 cm high-2-4X
10. The same as 9, but the athlete will hold a 1 kg medicinal ball with both hands -2-4X

Second workoutset:

11. From standing position, with a handball in hand, with a two-step running jump, tap on one foot on a gym bench, placed longitudinally, jump with the gate throw simulation and landing on the bench - 10 jumps on each leg x3
12. From standing position, placing the palms on the hips, on a 40 cm high, jump from the box, landing on

the floor, jump on another 50 cm high box, return to 180º and repetition of jumps in the opposite direction - 10 jumps x3
13. The same as 12, but instead of boxes, two props 80 cm high will be used, and the athletes can also help themselves with their arms for running jump - 10 jumps x3
14. From standing position, two-step running jump, tap on one foot on a gym bench, placed longitudinally, high jump and landing on a gym mat - 10 jumps x3
15. From standing in semi-genuflection on a 50 cm high, jump from the box, landing on the floor in semi-genuflection, jump on another 50 cm high and landing in semi-genuflection, return to 180º and the repetition of jumps in the opposite direction - 10 jumps x3
16. Standing on a 20 cm high box, the athlete takes a step on the floor, then performs a jump on another 20 cm high box without flexing the legs from the knee and co-femural joint, return to 180º and the repetition of jumps in the opposite direction - 10 jumps x3
17. Standing on one leg on a 20 cm high box, side jump with landing on the floor on the same leg, followed by another jump on another box of 20 cm - 10 jumps x3
18.The athlete breaks into a trot on the floor at maximum speed for three seconds, then 5 successive jumps on two legs over 5 hurdles of 50 cm, and finally a trot run for three seconds -2-4X
19. Standing on a gym bench, jump with landing on the floor on two legs, plus 5 successive jumps over 5 hurdles of 30 cm, jump over the first hurdle on two legs and landing on one leg, followed by a jump with tap on one leg over the second hurdle and landing on two legs and so on until the end when a maximum high jump is performed with a tap on one leg -2-4X
20. Standing on a gym bench, jump with landing on the floor on one leg, plus 5 successive jumps on one leg over 5 hurdles of 30 cm, and finally a maximum high jump with a tap on one leg -2-4X
The third workout set:
21. Standing on a 50 cm high, the athlete takes a step and lands on the floor, then performs a jump with a tap on both legs and lands on a 60 cm prop, without flexing the legs from the knee and co-femural joint, after which he returns on the first box - 10 jumps x3
22. Facing a gym bench placed transversely, jump over the bench on two legs, with landing on both legs, followed by another jump on another gym bench - 10 jumps x3
23. Standing aside on a gym bench, successive jumps at maximum speed (without pause) from two legs, on both legs over a bench -6-10 jumps x3
24. Standing on a 40 cm high box, two-legged side jump with landing on the floor on both legs, followed by another side jump on another 40 cm high box, then the jumps are performed in the opposite direction - 10 jumps x3
25. The same as 24, but each jump on the floor and from the floor is performed with a return to 180º-10 jumps x3
26. Standing on a gym bench, jump with landing on the floor on two legs, plus 5 jumps in a row on two legs over five 30 cm high hurdles, and finally a maximum high jump with a tap on one leg - 2 - 4 X
27. Sprint on the distance of 5 m starting at the signal, speeding up over four 20 cm hurdles through jumps on one leg, and sprint again on a distance of 5 m -2-4X
28. Standing on a gym bench, jump landing on the floor on two legs, left side jump on two legs, forward jump on two legs over a 50 cm hurdle, right side jump, forward jump over the hurdle, and so on until 4 hurdles -2-4X
29. 8 skipped steps in a row with left and right movement -2-4X
30. Facing a gym bench placed longitudinally, 8 - 10 alternate jumps are performed from one leg to another over the bench -2-4 X.

Statistical Analysis

Statistical analyses were performed using MINITAB version 15.1 of MINITAB Inc Company. Data were expressed as mean and standard deviations of the mean (*SD*). The level of significance was set at α=0.05.

Results

No injuries occurred throughout the study period, and the testing and training procedures were well tolerated by the subjects. After 8 weeks of training, the group made significant ($p \leq 0.05$) improvements in SJ (from 46.44 ± 1.54 to 50.50 ± 1.47 cm; 8.73%), CMJ (34.83 ± 1.54 to 37.44 ± 1.15 cm; 7.5%) and CJSL (from 29.78 ± 1.26 to 32.61 ± 1.33 cm; 9.51%) performance compared with the initial test, results are presented in Fig. 1., 2., 3., while evaluations are reported in Table 1.

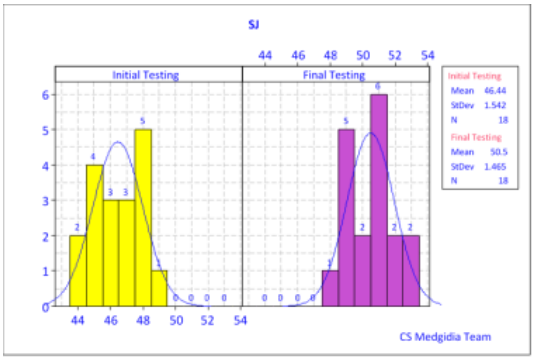

Fig.1. SJ initial and final testing results

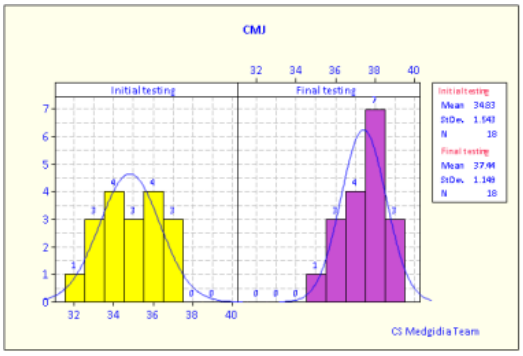

Fig.2. CMJ initial and final testing results (authors analysis/creation)

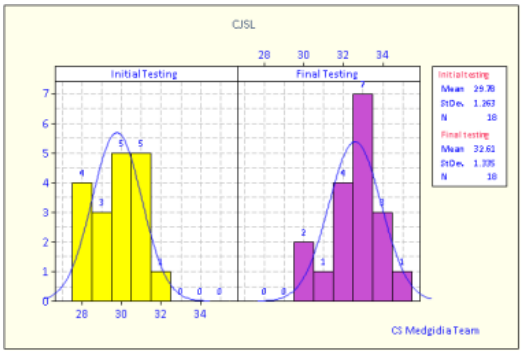

Fig.3. CJSL initial and final testing results (authors analysis/creation)

Table 1. Evaluations and comparison between initial and final testing (authors analysis/creation)

Nr.	Test	Testing	Mean	Difference F-I	±SD	Cv (%)	t	p≤
1	Squat jump (SJ) cm	I	46.44	8.73%	1.54	3.32%	21.44	0.05
		F	50.50		1.47	2.90%		
2	Countermovement jump with arm-swing (CMJ) cm	I	34.83	7.50%	1.54	4.43%	13.04	0.05
		F	37.44		1.15	3.07%		
3	Continuous 6 jumps with straight legs (CJSL) cm	I	29.78	9.51%	1.26	4.24%	19.44	0.05
		F	32.61		1.33	4.09%		

Discussion

It has been tested the effect, if any, of an 8 week long pre-season plyometric training on the jumping performance of handball players. The study revealed that, when a plyometric training program is introduced in the athlete training session, their performance in jumping tests improves. The subjects of this study experienced improvements in all three tests, SJ, CMJ, CJSL (8.73%, 7.5% respectiv 9.51%).

In one study, Mazurek et al., 2018 proved that a 5-week pre-season conditioning program supplemented with only 15 sessions of plyometric exercise did not induce any additional benefits, compared to a matched format of standard jump training, in terms of improving jump performance and maximal power in the RSA test. In addition, other studies have not shown any improvement in jump height after a six-week plyometric training program (Gottlieb et al., 2014) and a 9-week training program supplemented with plyometric exercises (Brito et al., 2014). Slimani et al., 2016 recommends a period of at least 10 weeks or more than 20 plyometric workouts to achieve significant improvements in the performance of athletes, we are using a program of 24 plyometric workouts (three per week). Other studies proved that an 8 week long training session with biweekly plyometric training improved jump performance during the season in elite male handball players (Hermassi et al., 2014, Chelly et al., 2013). The difference, between these studies and our study, is the period in which it was applied, the competitive period in their case, or the pre-competitive period in this study.

Numerous studies have discovered the effects of short-term PT on jumping performance in basketball (Matavulj et al., 2001, Asadi, 2013), soccer (Thomas et al., 2009, Sáez de Villarreal et al.,2015, Beato et al., 2018), volleyball (Milič et al., 2008, Gjinovci et al., 2017) and other team games. Based on a meta-analysis of the studies, Marković cited by Lehnert et al., 2013 concluded that PT provides statistically significant and relevant data in vertical jump height ranging from 4.7% to 8.7% depending on the jump type. Improving the jumping performance in our study from 7.5% to 9.51%, may also be because the study is conducted in the pre-competitive period, the athletes started training after a break, returning to training with a lower level of physical training. The pre-competitive period is a period when the coaches try improv the level of general and specific physical training, through different training methods and programs (to improve the strength of the lower or upper limbs, to improve the specific speed, endurance, agility, etc.), methods that may also influence improving the jumping performance.

Conclusions

The research hypothesis was confirmed, an 8-week pre-competitive PT program with three workouts per week, can get effective results in jumping performance tests. The result of this study, shows the opportunity to use plyometric workouts in the pre-competitive period to improve jumping, especially for men's handball players. It is recommended that, coaches design plyometrics in pre-competitive phase for athletes, because this type of training can be an effective method for improving performance.

References

Asadi A., 2013, Effects of in-season short-term plyometric training on jumping and agility performance of basketball players. *Sport Sci Health*. 9,133–137.

Aragon-Vargas L.F., 2000, Evaluation of four vertical jump tests: Methodology, reliability, validity, and accuracy. *Meas Phys Educ Exerc Sc.* 4, 215–228.

Beato M., Bianchi, M., Coratella, G., Merlini, M., Drust, B., 2018, Effects of Plyometric and Directional Training on Speed and Jump Performance in Elite Youth Soccer Players, *J Strength Cond Res*. 32(2), 289- 296.

Brito J., Vasconcellos, F., Oliveira, J., Krustrup, P., Rebelo, A., 2014, Short-term performance effects of three different low-volume strength-training programmes in college male soccer players. *J Hum Kinet*. 40, 121–128.

Chelly M.S., Hermassi, S., Aouadi, R., Shephard, R., 2014, Effects of 8-Week In-season Plyometric Training on Upper and Lower Limb Performance of Elite Adolescent Handball Players. *Journal of strength and conditioning research*. 28(5), 1401-1410.

Gabbett T.J., Kelly, J.N., Sheppard, J.M., 2008, Speed, change of direction speed, reactive agility of rugby league players. *J Strength Cond Res*. 22, 174–181.

Georgescu A., Varzaru, C., Rizescu, C., 2019, Improving Speed to Handball Players. *Revista Romaneasca Pentru Educatie Multidimensionala*, 11(1), 73-87. https://doi.org/10.18662/rrem/97

Gidu D.V., 2016, Influence of proprioceptive training on the strenght of the lower limb in women soccer players, *"Mircea cel Batran" Naval Academy Scientific Bulletin*, Volume XIX Issue 1, p 405-408.

Gjinovci B., Idrizovic, K., Uljevic, O., Sekulic, D., 2017, Plyometric Training Improves Sprinting, Jumping and Throwing Capacities of High Level Female Volleyball Players Better Than Skill-Based Conditioning. *J Sports Sci Med*. 16(4), 527-535.

Gottlieb R., Eliakim, A., Shalom, A., Dello-Iacono, A., Meckel, Y., 2014, Improving Anaerobic Fitness in Young Basketball Players: Plyometric vs. Specific Sprint Training. *J Athl Enhanc*. 3, 1–6.

Hermassi S., Gabbett, T., Ingebrigtsen, J., Tillaar, R., Chelly, M.S., Chamari, K., 2014, Effects of a Short-Term In-Season Plyometric Training Program on Repeated- Sprint Ability, Leg Power and Jump Performance of Elite Handball Players,

International Journal of Sports Science & Coaching. 9(5),1205. ·

Impellizzeri F.M., Rampinini, E., Castagna, C., Martino, F., Fiorini, S., Wisloff, U., 2008, Effect of plyometric training on sand versus grass on muscle soreness and jumping and sprinting ability in soccer players. *British Journal of Sports Medicine*. 42, 42-46.

Lehnert M., Hůlka, K., Malý, T., Fohler, J., Zahálka, F., 2013, The effects of a 6 week plyometric training programme on explosive strength and agility in professional basketball players, *Acta Univ. Palacki. Olomuc., Gymn*. vol. 43, no. 4, 7-15.

Markovic G., Mikulic, P., 2010, Neuro-Musculoskeletal and Performance Adaptations to Lower-Extremity *Plyometric Training. Sports Med*. 40, 859–895.

Matavulj D., Kukolj, M., Ugarkovic, D., Tihanyi, J., Jaric, S., 2001, Effects of plyometric training on jumping performance in junior basketball players. *J Sports Med Phys Fit.* 41, 159–164.

Mazurek K., Zmijewski, P., Makaruk, H., Mróz, A., Czajkowska, A., Witek, K., Bodasiński, S., Lipińska, P., 2018, Effects of Short-Term Plyometric Training on Physical Performance in Male Handball Players, *Journal of Human Kinetics.* 63(1), 137-148.

Milič V., Nejic, D., Kostic, R., 2008, The effect of plyometric training on the explosive strength of leg muscles of volleyball players on single foot and two-foot take-off jumps. *Physical Education & Sport.* 6,169–179.

Mușat G., Petcu, D., 2019, Development of resistance in soccer players by using specific methods, *Journal of Sport and Kinetic Movement*, 33(1), 26-29.

Mușat G.C., Gidu, D.V., 2018, Development of Technical Skills in Representative School Team of Female Soccer Players, *Proceedings of ICU The impact of sport and physical education science on today's society*, 193-195.

Nikolaidis P.,T. Ingebrigtsen, J., 2013, Physical and physiological characteristics of elite male handball players from teams with a different ranking, *Journal of Human Kinetics.* 38, 115–124.

Oltean A., Georgescu, A., 2018, Evolution of anthropometric indices in handball selection. *Proceeding of ICU The impact of sport and physical education science on today's society,* 99-102.

Póvoas S.C., Seabra, A.F., Ascensao, A.A., Magalhaes, J., Soares, J.M., Rebelo A.N., 2012, Physical and physiological demands of elite team handball. *J Strength Cond Res*. 26, 3365–3375.

Sáez de Villarreal, E., Suarez-Arrones, L., Requena, B., Haff, G.G., Ferrete, C., 2015, Effects of Plyometric and Sprint Training on Physical and Technical Skill Performance in Adolescent Soccer Players, *J Strength Cond Res*. 29(7), 1894-1903.

Slimani, M., Chamari, K., Miarka, B., Del Vecchio, F., Cheour, F., 2016, Effects of Plyometric Training on Physical Fitness in Team Sport Athletes: A Systematic Review, *Journal of Human Kinetics*. 53(1), 231-247.

Thomas K., French, D., Hayes, P.R., 2009, The effect of two plyometric training techniques on muscular power and agility in youth soccer play-ers. *Journal of Strength & Conditioning Research.* 23, 332–335.

Young W.B., James. R., Montgomery, I., 2002, Is muscle power related to running speed with changes of direction? *J Sports Med Phys Fitness*. 42, 282–288.

https://www.scienceforsport.com/plyometric-training/#toggle-id-1 accessed on 14.11.2020.

http://sportsmedicine.about.com/od/sampleworkouts/a/Plyometrics.ht accessed on 10.10.2020

https://www.ihf.info accessed on 1.10.202