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Training effects on physical fitness and vertical jumps of junior handball players

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Abstract

Introduction: In handball, the time for physical training is limited, because the focus is placed on the technical-tactical and mental aspects. The introduction of specific physical training is crucial in increasing the sports performance. Even though handball is a team sport, match analysis has shown that physical training in modern handball should be pointed towards the specific playing position and individual physical ability of the players. *Materials and methods*: The subjects who participated in this are from two groups: the control group consisting of 16 junior I athletes aged 16-18 years, from the CSM Resita handball club, and the experimental group represented by 16 junior I athletes aged between 16-18 years old, from the handball club SCM Politehnica Timişoara. On the experimental group, it was applied in addition to the specific training program, an additional strength training program to increase strength and endurance. The tests aimed to evaluate the following parameters: specific power and specific energy of lower and upper limbs or aerobic fitness. *Results and discussions*: For both dynamometric and endurance tests, statistically significant differences for all parameters have been registered only for the experimental group. The results showed an important improvement in the variables of the experimental group after training. *Conclusions*: The objective to improve the physical training of junior handball players by applying a complementary training program was achieved.

***Key words**: junior handball players, vertical jumps, training, endurance, Yo-Yo test*

Rezumat

Introducere: În handbal, timpul pentru antrenamentul fizic este limitat, deoarece se pune mai mult accent pe aspectele tehnico-tactice și mental. Introducerea unui antrenament fizic specific este crucială în creșterea performanței sportive. Chiar dacă handbalul este un sport de echipă, analizele meciurilor au arătat că pregătirea fizică în handbalul modern ar trebui să fie direcționată către poziția de joc specifică și capacitatea fizică individuală a jucătorilor. *Materiale și metode*: Subiecții care au participat la acest studiu provin din două grupe: grupa de control formată din 16 sportivi juniori I cu vârsta cuprinsă între 16-18 ani, de la clubul de handbal CSM Reșița, și grupa experimental reprezentată de 16 sportivi juniori I cu vârsta cuprinsă între 16 -18 ani, de la clubul de handbal SCM Politehnica Timișoara. La grupul experimental s-a aplicat pe lângă programul de antrenament specific, un program suplimentar de antrenament de forță pentru creșterea forței și a rezistenței. Testele au vizat evaluarea următorilor parametri: puterea specifică și energia specifică a membrelor inferioare și superioare și fitnessul aerob. *Rezultate și discuții*: Atât la testele dinamometrice, cât și la cele de rezistență în regim de viteză, s-au înregistrat diferențe semnificativ din punct de vedere statistic pentru toți parametrii doar la grupa experimentală. Rezultatele obținute au arătat o îmbunătățire semnificativă a parametrilor pentru grupul experimental după antrenament. *Concluzii*: Analizând datele obținute se poate concluziona că s-a atins obiectivul de a îmbunătăți pregătirea fizică a jucătorilor de handbal juniori prin aplicarea unui program de pregătire fizică complementar.

***Cuvinte cheie**: jucători de handbal juniori, salt vertical, antrenament, rezistență, testul Yo-Yo*

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Introduction

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. Handball is a multidimensional and dynamic sport, which incorporates speed, agility, balance, endurance, strength, as well as repeated sprinting skills and it is essential that handball coaches choose exercises that approach real game situations (Billat 2001, Gorostiaga et. al. 2006, Hermassi et. al., 2017, Povoas et.al. 2012, Wagner et.al. 2014).

In handball, the time for physical training is limited, because the focus is placed on the technical-tactical and mental aspects. The introduction of specific physical training is crucial in increasing sports performance (Bosco & Viitasalo 1982, Cardoso & Gonzalez 2006, Iacono et.al. 2018). Even though handball is a team sport, match analysis has shown that physical training in modern handball should be pointed towards the specific playing position and individual physical ability of the players. Any training program for a player should be based on in-game requirements analysis 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 coaches 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 so far have reported that physical training twice a week for eight weeks is improving the performance of handball players. An increase in muscle strength and endurance was observed for both upper and lower limbs, without interfering with endurance or speed (Hermassi et.al., 2017). The specific physical training proved to be practical and easy to integrate into the regime of the technical-tactical training program.

Improvements obtained in the performance after the specific physical training in the handball game by capitalizing on running, jumping, and throwing, in the technical - tactical actions during attack and defense, contribute to the increase of sports performance (Dugan et.al. 2004, Franz et.al. 2017, Gomez-Bruton et.al. 2019).

The aim of this study is to apply an additional strength training program besides the specific handball training program that will lead to improving the physical characteristics of junior handball players.

Materials and methods

The subjects who participated in this are from two groups: the control group consisting of 16 junior I athletes aged 16-18 years, from the CSM Resita handball club, and the experimental group represented by 16 junior I athletes aged between 16-18 years old, from the handball club SCM Politehnica Timişoara. On the experimental group, it was applied in addition to the specific training program, an additional strength training program to increase strength and endurance. The number of workouts planned during a week was 6 per week with a day off. The additional training program is presented in table I.

Table I. Training program

Day	Training
Day 1	Arms and chest 1 70% Intensity
Day 2	Lower limbs 1 70% Intensity
Day 3	Back and shoulders 1 70% Intensity
Day 4	Arms and chest 2 65% Intensity
Day 5	Lower limbs 2 65% Intensity
Day 6	Back and shoulders 2 65% Intensity
Day 7	rest

The main purpose of the study was to determine the effect of training on the physical performance of a group of junior handball players. The tests aimed to evaluate the following parameters: specific power and specific energy of lower and upper limbs or the aerobic fitness.

In the dynamometric tests for establishing the muscle profile, the specific energy, the height during the jump, and the specific power were determined following the 15s vertical jumps VJ, CMJ counter-movement jumps, and SJ squat jumps.

In the Yo-Yo endurance test, the total distance covered during the test, the maximum amount of VO_{2max} oxygen, and the level obtained were determined.

The effect of the training was reached with the Wilcoxon statistical test which determines the magnitude of the differences between the results obtained by a group of subjects on test and retest.

Results

A comparison of VJ parameters following the initial and final testing of both groups is listed in Table II.

Table II. Comparison of pre-test and post-test changes in VJ parameters of groups

Variable	Group	Pre-test	Post-test	Progress
Specific Energy VJ (J/kg)	EG	54.24±3.89	59.23±4.11	4.99
	CG	54.94±1.78	55.04±1.78	0.1
Specific Power VJ (W/kg)	EG	32.2±3.38	35.2±3.25	2.71
	CG	31.7±2.95	31.8±2.88	0.02
Height VJ (cm)	EG	29.6±3.38	32.1±3.6	2.48
	CG	28.8±2.88	28.9±2.9	0.04

Statistical processing of VJ parameters highlighted the following:

- specific energy VJ- In EG the lowest value at the initial test is 45.54 J/kg, and the highest value is 60.86 J/kg, the amplitude being 15.32 J/kg. The final test shows an increase of up to 4.6 J/kg. The initial mean is 54.24 J/kg, and the final mean is 59.23 J/kg. The standard deviation is 3.89 J/kg at the initial test, respectively 4.11 J/kg at the final one. The difference between the values obtained before and after training is statistically significant as z = -2.921, p = 0.003< 0.05. The size effect r = 0.73 >0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 50.12 J/kg, and the highest value is 59.62 J/kg, the amplitude being of 9.5 J/kg. The final test shows an increase of up to 0.2 J/kg. The initial mean is 54.94 J/kg, and the final mean is 59.82 J/kg. The standard deviation is 1.78 J/kg at the initial test, respectively 1.77 J/kg at the final test. The difference between the values obtained in both tests is not statistically significant as z = -0.226, p = 0.821> 0.05. The size effect r = 0.05 <0.1 shows a very small difference between the two tests.

- specific power VJ - In EG the lowest value at the initial test is 30.2 W/kg and the highest value is 36.2 W/kg, the amplitude being of 6 W/kg. The final test shows an increase up to 3.8 W/kg. The initial mean is 32.2 W/kg, and the final mean is 35.2 W/kg. The standard deviation is 3.38 W/kg at the initial test, respectively 3.25 W/kg at the final test. The difference between the values obtained before and after training is statistically significant as z = -2.035, p = 0.042< 0.05. The size effect r = 0.51 >0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 26.78 W/kg, and the highest value is 36.78 W/kg, the amplitude being of 10 W/kg. The final test shows a slight increase up to 0.3 W/kg. The initial mean is 31.72 W/kg, and the final mean is 31.75 W/kg. The standard deviation is 3.01 W/kg at the initial test, respectively 2.95 W/kg at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.151, p = 0.88> 0.05. The size effect r = 0.03 <0.1 shows a very small difference between the two tests.

- height VJ - In EG the lowest value at the initial test is 24.9 cm and the highest value is 34.2 cm, the amplitude being of 9.3 cm. The final test shows an increase up to 2.9 cm. The initial mean is 29.6 cm, and the final mean is 32.1 cm. The standard deviation is 3.38 cm, at the initial test, respectively 3.6 cm at the final test. The difference between the values obtained before and after training is statistically significant as z = -1.905, p = 0.057< 0.05. The size effect r = 0.47 <0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 24.1 cm, and the highest value is 34.2 cm, the amplitude being of 10.1. cm. The final test shows a slight increase up to 0.1 cm. The initial mean is 28.89 cm and the final mean is 28.93 cm. The standard deviation is 2.88 cm, at the initial test, respectively 2.9 cm at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.150, p = 0.88> 0.05. The size effect r = 0.03 <0.1 shows a very small difference between the two tests.

The training progress between groups for VJ parameters is presented in Figure 1.

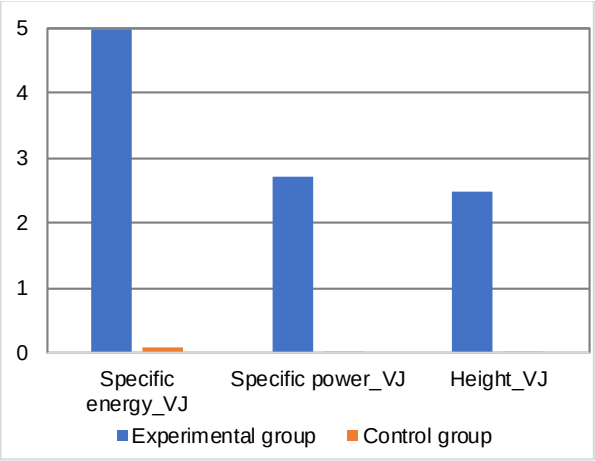

Figure 1. Progress differences in VJ parameters between the two groups

For specific energy VJ, the mean value of the experimental 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 mean value for the experimental group is 2.71 higher at the final test, while for the control group it is only 0.02 higher. The difference in progress between the two groups is 2.68 W/kg in favor of the experimental group.

For height VJ, the mean value for the experimental 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.

The comparison of SJ parameters following the initial and final testing of both groups is listed in Table III.

Table III. Comparison of pre-test and post-test changes in SJ parameters of groups

Variable	Group	Pre-test	Post-test	Progress
Specific Energy SJ (J/kg)	EG	12.4±2.06	13.2±2.12	0.89
	CG	12.3±1.78	12.4±1.78	0.02
Specific Power SJ (W/kg)	EG	20.7±4.16	23.2±4.51	2.48
	CG	21.7±2.72	21.8±2.71	0.07
Height SJ(cm)	EG	28.9±4.7	31.3±4.86	2.41
	CG	30±3.72	30±3.66	0.015

Statistical processing of SJ parameters highlighted the following:

- specific energy SJ- In EG the lowest value at the initial test is 11.2 J/kg, and the highest value is 14.2 J/kg, the amplitude being 3 J/kg. The final test shows an increase of up to 1.5 J/kg. The initial mean is 12.4 J/kg, and the final mean is 13.2 J/kg. The standard deviation is 2.06 J/kg at the initial test, respectively 2.12 J/kg at the final one. The difference between the values obtained before and after training is not statistically significant as z = -1.225, p = 0.221> 0.05. The size effect r = 0.3 <0.5 shows a medium difference between the two tests.

In CG the lowest value at the initial test is 9.65 J/kg, and the highest value is 14.89 J/kg, the amplitude being of 5.24 J/kg. The final test shows an increase of up to 0.04 J/kg. The initial mean is 12.39 J/kg, and the final mean is 12.41 J/kg. The standard deviation is 1.78 J/kg at the initial test, respectively 1.77 J/kg at the final test. The difference between the values obtained in both tests is not statistically significant as z = -0.094, p = 0.925> 0.05. The size effect r = 0.02 <0.1 shows a very small difference between the two tests.

- specific power SJ - In EG the lowest value at the initial test is 12.3 W/kg and the highest value is 14.8 W/kg, the amplitude being 2.5 W/kg. The final test shows an increase of up to 3.1 W/kg. The initial mean is 20.7 W/kg, and the final mean is 23.2 W/kg. The standard deviation is 4.16 W/kg at the initial test, respectively 4.51 W/kg at the final test. The difference between the values obtained before and after training is not statistically significant as z = -1.489, p = 0.136> 0.05. The size effect r = 0.37 <0.5 shows a medium difference between the two tests.

In CG the lowest value at the initial test is 16.68 W/kg, and the highest value is 25.38 W/kg, the amplitude being of 8.7 W/kg. The final test shows a slight increase up to 0.04 W/kg. The initial mean is 21.76 W/kg, and the final mean is 21.83 W/kg. The standard deviation is 2.72 W/kg at the initial test, respectively 2.71 W/kg at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.151, p = 0.88> 0.05. The size effect r = 0.03 <0.1 shows a very small difference between the two tests.

- height SJ - In EG the lowest value at the initial test is 18.6 cm and the highest value is 33.8 cm, the amplitude being 15.2 cm. The final test shows an

increase of up to 2.9 cm. The initial mean is 28.9 cm, and the final mean is 31.3 cm. The standard deviation is 4.7 cm, at the initial test, respectively 4.86 cm at the final test. The difference between the values obtained before and after training is not statistically significant as z = -1.659, p = 0.097> 0.05. The size effect r = 0.41 <0.5 shows an important difference between the two tests.

In CG the lowest value at the initial test is 21.6 cm, and the highest value is 34.5 cm, the amplitude being of 12.9 cm. The final test shows a slight increase up to 0.1 cm. The initial mean is 30.02 cm and the final mean is 30.03 cm. The standard deviation is 3.72 cm, at the initial test, respectively 3.66 cm at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.01, p = 0.98> 0.05. The size effect r = 0.002 <0.1 shows a very small difference between the two tests.

The training progress between groups for SJ parameters is presented in Figure 2.

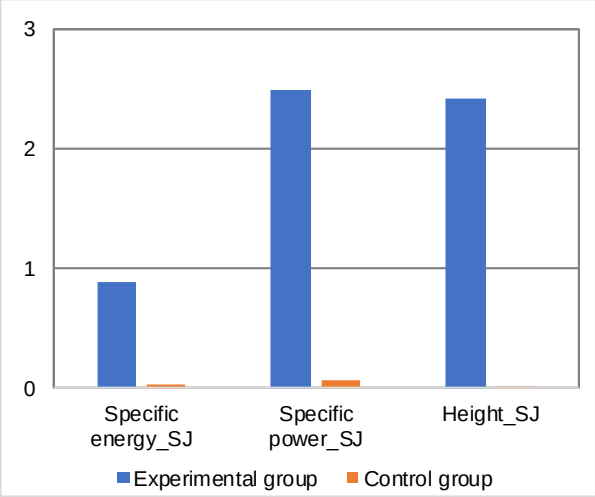

Figure 2. Progress differences in SJ parameters between the two groups

For the specific energy SJ, the mean value of the experimental 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 mean value for the experimental group is 2.48 higher on the final test, while for the control group it is only 0.07 higher. The difference in progress between the two groups is 2.41 W/kg in favor of the experimental group.

For SJ height, the mean value of the experimental group is 2.41 higher and for the control group 0.05 higher. The difference in progress between the two groups is 2.36 cm in favor of the experimental group. The comparison of CMJ parameters following the initial and final testing of both groups is listed in Table IV.

Table IV. Comparison of pre-test and post-test changes in CMJ parameters of groups

Variable	Group	Pre-test	Post-test	Progress
Specific Energy CMJ (J/kg)	EG	2.7±0.4	3.5±0.68	0.72
	CG	2.7±0.3	2.8±0.4	0.057
Height CMJ (cm)	EG	29.1±4.41	32.3±4.87	3.25
	CG	29.5±3.44	29.7±3.3	0.12

Statistical processing of CMJ parameters highlighted the following:

- specific energy CMJ- In EG the lowest value at the initial test is 2 J/kg, and the highest value is 3.2 J/kg, the amplitude being 1.2 J/kg. The final test shows an increase of up to 1.67 J/kg. The initial mean is 2.7 J/kg, and the final mean is 3.5 J/kg. The standard deviation is 0.4 J/kg at the initial test, respectively 0.68 J/kg at the final one. The difference between the values obtained before and after training is statistically significant as z = -2.903, p = 0.004< 0.05. The size effect r = 0.72 >0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 2.1 J/kg, and the highest value is 3.3 J/kg, the amplitude being 1.2 J/kg. The final test shows an increase of up to 0.1 J/kg. The initial mean is 2.76 J/kg, and the final mean is 2.81 J/kg. The standard deviation is 0.35 J/kg at the initial test, respectively 0.4 J/kg at the final test. The difference between the values obtained in both tests is not statistically significant as z = -0.473, p = 0.637> 0.05. The size effect r = 0.11 <0.3 shows a small difference between the two tests.

- height CMJ - In EG the lowest value at the initial test is 20.5 cm and the highest value is 34.2 cm, the amplitude being 13.7 cm. The final test shows an increase of up to 3.3 cm. The initial mean is 29.1 cm, and the final mean is 32.3 cm. The standard deviation is 4.41 cm, at the initial test, respectively 4.87 cm at

the final test. The difference between the values obtained before and after training is statistically significant as z = -2.187, p = 0.029< 0.05. The size effect r = 0.47 <0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 22.1 cm, and the highest value is 34.6 cm, the amplitude being 12.5 cm. The final test shows a slight increase up to 0.2 cm. The initial mean is 29.58 cm and the final mean is 29.7 cm. The standard deviation is 3.44 cm, at the initial test, respectively 3.3 cm at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.057, p = 0.95> 0.05. The size effect r = 0.01 <0.1 shows a very small difference between the two tests.

The training progress between groups for CMJ parameters is presented in Figure 3.

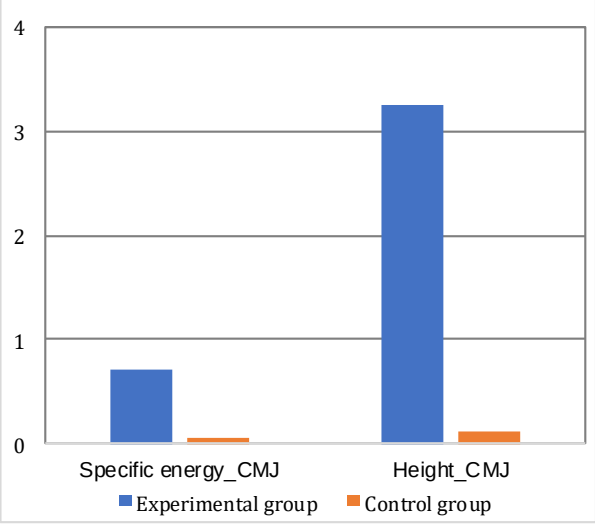

Figure 3. Progress differences in CMJ parameters between the two groups

For the specific energy CMJ, the mean value of the experimental 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 mean value for the experimental 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.

The comparison of endurance test parameters following the initial and final testing of both groups is listed in Table V.

Table V. Comparison of pre-test and post-test changes in Yo-Yo test parameters of groups

Variable	Group	Pre-test	Post-test	Progress
Total distance (m)	EG	1785± 602.3	2453.7± 687.6	668.75
	CG	1792.5 ±487.9	1837.5± 481.08	45
VO_2max (ml/kg/ min)	EG	51.27± 4.89	56.61± 5.31	5.34
	CG	51.47± 4.1	51.81± 4.07	0.34
Level	EG	18.12± 1.84	20± 1.91	1.88
	CG	18.14± 1.51	18.28± 1.48	0.14

Statistical processing of endurance test results highlighted the following:

- total distance - In EG the lowest value at the initial test is 840 m, and the highest value is 2880 m, the amplitude being 2040 m. The final test shows an increase of up to 720 m. The initial mean is 1785 m, and the final mean is 2453.7 m. The standard deviation is 602.37 m at the initial test, respectively 687.63 m at the final test. The difference between the values obtained before and after training is statistically significant as z = -2.490, p = 0.013<0.05. The size effect r = 0.62>0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 1080 m, and the highest value is 2560 m, the amplitude being 1480 m. The initial mean is 1792.5 m and the final mean is 1837.5 m. The standard deviation is 487.98 m at the initial test, respectively 481.08 m at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.568, p = 0.570> 0.05. The size effect r = 0.14 <0.3 shows a small difference between the two tests.

- VO_2max - In EG the lowest value at the initial test is 43.6 ml/kg/min, and the highest value is 59.2 ml/kg/min, the amplitude being 15.6 ml/kg/min. The initial mean is 51.27 ml/kg/min, and the final mean is 56.61 ml/kg/min. The standard deviation is 4.89 ml/kg/min at the initial test, respectively 5.31 ml/kg/min at the final test. The difference between the values obtained before and after training is statistically significant as z = -2.565, p = 0.01<0.05. The size effect r = 0.64>0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 45.5 ml/kg/min, and the highest value is 58 ml/kg/min, the amplitude being 12.5 ml/kg/min. The initial mean is 51.47 ml/kg/min and the final mean is 51.81 ml/kg/min. The standard deviation is 4.1 ml/kg/min at the initial test, respectively 4.07 ml/kg/min at the final test. The difference between the values obtained in tests is not statistically significant as z = -0.510, p = 0.610> 0.05. The size effect r = 0.12 <0.5 shows a small difference between the two tests.

- level - In EG the lowest value at the initial test is 15.2, and the highest value is 21.3, the amplitude being 6.1. The final test shows an increase of up to 1.88. The initial mean is 18.12, and the final mean is 20. The standard deviation is 1.84 on the initial test, respectively 1.91 on the final test. The difference between the values obtained before and after training is statistically significant as z = -2.471, p = 0.013<0.05. The size effect r = 0.61>0.5 shows a big difference between the two tests.

In CG the lowest value at the initial test is 15.8, and the highest value is 20.5, the amplitude being 4.7 kg. The initial mean is 18.14 and the final mean is 18.28. The standard deviation is 1.51 on the initial test, respectively 1.48 on the final test. The difference between the values obtained in tests is not statistically significant as z = -0.568, p = 0.590> 0.05. The size effect r = 0.14 <0.5 shows a small difference between the two tests.

The training progress between groups for strength is presented in Figure 4.

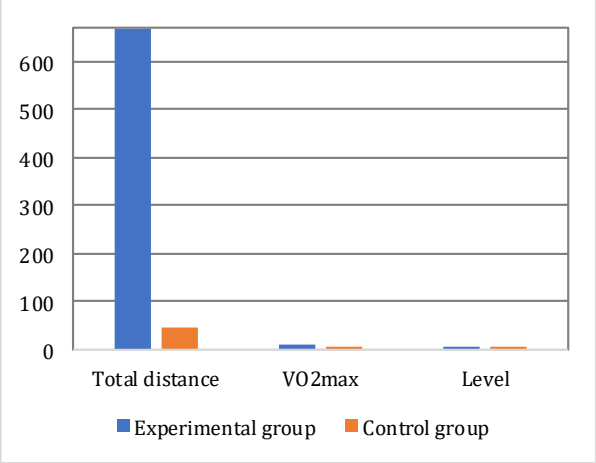

Figure 4. Progress differences in Yo-Yo test parameters between the two groups

The mean value for the total distance of the experimental group is higher by 668.75 m at the final test, and for the control group higher only by 45m. 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 mean value for the experimental group is 5.34 higher on the final test, while for the control group it is only 0.34 higher. The difference in progress between the two groups is 5 ml / kg / min in favor of the experimental group.

For the level of the Yo-Yo test, the mean value for the experimental 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.

Discussions

In handball, the time for physical training is limited, the technical-tactical and mental aspects are considered to be more important. The introduction of specific strength training is crucial in increasing sports performance. Any training program for a player should be based on analyzes of in-game demands to determine which motor qualities are important for good performance. An analysis of the ability of individual players should be carried out so that their strengths and weaknesses can be identified.

Studies have been reported (Hermassi et al., 2011) that after strength training for handball players, twice a week for eight weeks, was observed an increase in muscular strength and endurance for both upper and lower limbs without interfering with endurance or speed.

This specific physical training proved to be practical and easy to integrate into the technical-tactical training program. The performance improvements obtained from the specific training on running, jumping, and throwing in the tactical actions of attack and defense, contribute to the increase in sports performance.

The findings of the present study showed that the training applied to the experimental group led to significant increases in strength and aerobic fitness. The training of 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 the study

consist in how to approach matches tactically, given a very good physical condition. In the case of a very good physical condition, one can approach a modern game in which the speed of the game is extremely high, without dead times and breaks.

Conclusions

The study aimed to analyze the effectiveness of the specific strength training applied and highlight the changes in the selected physical abilities and physiological variables of junior I handball players. The selected tests were used to evaluate the following parameters: lower and upper limb strength, specific power, specific energy, or aerobic fitness.

For both dynamometric and endurance tests, statistically significant differences for all parameters have been registered only for the experimental group. The results showed an important improvement in the variables of the experimental group after training. Therefore, the objective to improve the physical training of junior handball players by applying a complementary training program was achieved.

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