

Effect of Low-Intensity Interval Training on Physical Performance and Blood Parameters Among Junior Handball Players

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ABSTRACT

The purpose of this study is to investigate the effect of low-intensity interval training program (LIIT) on physical fitness and blood parameters among junior

handball players. Thirty young players participated in this study and were divided into two groups: an experimental group (n=15) which underwent a low-intensity interval training program, and a control group (n=15) which underwent a traditional training program. Blood parameters (hemoglobin (g/dl), mean corpuscular hemoglobin MCH (pg), and hematocrit (%)) and physical capacities (flexibility, speed, endurance, agility, upper body muscle strength, and power) were evaluated before and after eight weeks of training in the two groups. At the beginning and end of the eight-week program, significant differences between the groups were observed. The experimental group exhibited better development compared to the control group in the following parameters: endurance (2.77%, $p=0.03$), speed (6.8%, $p=0.001$), power (17.09%, $p=0.02$), agility (4.22%, $p=0.01$), flexibility (29.25%, $p=0.01$), and upper body strength capacity (8.82%, $p=0.02$). The MCH was significantly higher in the experimental group ($p=0.01$). However, no significant differences were observed for hemoglobin and hematocrit ($p>0.05$). Our findings demonstrate that the low-intensity interval training intervention was more effective than the traditional program in improving physical parameters and mean corpuscular hemoglobin. The suggested low-intensity interval training program could serve as a viable fitness strategy for aerobic sports.

Keywords: LIIT, physical capacity, blood parameters, team sport.

INTRODUCTION

Handball is a high-contact team sport that requires technical, tactical, and physical abilities [1, 2]. This sport involves high-intensity intermittent exercises, including running, jumping, sprinting, and directional changes (e.g., 10- to 12-meter sprints lasting 2.3 seconds each; 50 turns per game) [3, 4]. Handball demands a combination of aerobic and anaerobic abilities to support numerous repetitions of short-duration, high-intensity tasks combined with brief recovery periods (i.e., 825 short-duration [2-6 seconds] high-intensity actions with 6-second rests) [3, 5].

Both physical and technical handball-specific training are essential for handball players to enhance intermittent aerobic efforts, speed, agility, strength, power, and ball throwing in both offensive and defensive phases of the game.[3, 4] Furthermore, recent research emphasizes the significance of physical strength for young male players at all training stages and the need for a balance between strength and speed, which is a functional characteristic of the muscular and other physiological systems [6].

On the other hand, low-volume, high-intensity interval training (LIIT) appears to be an effective and practical method for improving physical fitness [7]. The fundamental principle of interval training involves alternating periods of moderately intense exercise with periods of lower intensity or complete rest for recovery. Low-volume interval training refers to sessions with a limited amount of activity [8]. LIIT represents the minimum exercise intensity threshold for developing aerobic capacity, typically at 40 - 45% of the maximum oxygen uptake (VO_{2max}) [9]. While handball coaches and players seem to prioritize the development and enhancement of specific physical performance, the effects of LIIT on various physical capacities such as flexibility, speed, endurance, agility, upper body muscle strength, and power have not been previously studied among young handball players.

Additionally, it has been revealed that regular blood sample-based monitoring of professional team sports players is recommended at precise times, such as during match exposure and training sessions, in order to adjust the workload during the season and avoid preventable injuries, overreach, and overtraining [10]. Moreover, it is known that excessive physical activity disrupts the body's balance and weakens immune function in blood variables, potentially leading to a state of overwhelm that ultimately affects physical performance. Therefore, any physical training administered to players must be closely associated with physiological variables [11].

During training periods, and to mitigate the risk of injury, blood samples can be taken to monitor changes in blood parameters such as hemoglobin (g/dl), hematocrit (%), and mean hemoglobin concentration (%) [11]. Collectively, these findings underscore the importance of evaluating blood parameters for the same handball players within the same group who experience the same physical training load. Given these considerations and limitations, the objective of this study was to investigate the impact of a low-intensity interval training program on various physical variables and blood parameters among junior handball players.

METHODS

Participants

Thirty young male handball players from (Blinded for peer review) were recruited for the study and were randomly divided into two groups. The experimental group (LIIT) consisted of 15 participants (age: 14.53 ± 0.51 years old, body mass: 54.8 ± 10.8 kg, height: 1.64 ± 0.09 m) who underwent a low-intensity interval program. The control group (TTP), consisting of 15 participants (age: 14.47 ± 0.52 years old, body mass: 51.8 ± 11.7 kg, height: 1.63 ± 0.08 m), underwent a traditional training program approved by the club (Table 1).

None of the participants reported neuromuscular disorders or specific musculoskeletal injuries. They were instructed to refrain from engaging in any form of physical exercise other than what was provided in the study and to maintain standard times for eating and sleeping habits (breakfast between 6:30 and 7:30 AM, lunch between 12 and 1 PM, dinner between 8 and 9 PM, sleep between 8 and 9 PM, and wake between 6 and 7 AM). Prior to providing their written informed consent, participants and their parents were fully informed about the study's objectives, associated risks, and benefits. All study procedures were approved by the national ethics committee.

Table 1: Participant's characteristics (means $\pm$ SD) (n=30).

Variables	LIIT (n=15)	TTP (n=15)
Age (year)	14.53 ± 0.51	14.47 ± 0.52
Height (m)	1.64 ± 0.09	1.63 ± 0.08
Body mass (kg)	54.8 ± 10.8	51.8 ± 11.7
BMI (kg/m^2)	21.6 ± 1.9	21.3 ± 1.2

Experimental Procedures

The study took place during the period of 2021-2022 in (Blinded for peer review) over an 8-week training duration, consisting of two test sessions (pre- and post-training tests). Pre-exercise tests (T1) were conducted 4 days before the commencement of training, incorporating

both laboratory and field assessments (December 2021). The post-training test (T2) occurred 2 to 3 days after the conclusion of the training program phase (February 2022).

$$\text{Target heart rate} = (\%60 \text{ or } \%70 + (((220 - \text{age}) - \text{Resting heart rate})) + \text{Resting heart rate}$$

Both groups underwent 8 weeks of distinct training programs, each comprising 3 sessions per week (Saturday, Monday, and Wednesday), with each session lasting 90 minutes. The exercise protocol consisted of a 10-minute general warm-up (including walking, stretching, and movement exercises), 75 minutes of aerobic training such as running and Swedish exercises at an intensity of 50-65 percent of maximum heart rate reserve (MHRR), followed by a 5-minute cool-down involving stretching and activities like jogging to return the body to its normal state. The LIIT program involved intermittent interval training with 4 sets of 18 repetitions and a 3-minute rest between sets. On the other hand, the traditional program consisted of continuous exercise at 65% of heart rate reserve, with matched total work.

Both programs were supervised by specialists in the field of training and physiology to ensure the intensity of exercise based on Karvonen equation using a heart rate monitor [12].

Both pre-and post-training tests were evaluated at the same time of day and under the same experimental conditions through three days that were separated by 24h: i) one session for anthropometrical measurements and blood collection in the fasted state ii) a second session for the speed test (30-m), the vertical jump test and the strength test with medicine ball, and iii) the third session for the Cooper test, agility and flexibility test. Players were asked to standardize and follow the same nutritional plan 24 hours before each testing session to minimize diet-related changes in performance.

Blood Samples and Testing

Endurance: Cooper Test:

The cooper test was used to assess player endurance performances and their ability to cover as much distance as they can in 12 minutes. The test was preceded with 10 min of warm up, set intervals around the track were marked to aid in measuring the completed distance. Participants run for 12 minutes; they were informed of the time remaining at the end of each round of (400) m. Distance covered was recorded for the last (15) meters.

Speed: 30 m Speed Test:

The sprint tests began with 10 min warm-up. A straight section (30) meters long was defined by the examiner using paired photocells (Microgate, Bolzano, Italy). Players then ran for 30-m from a standing position at the starting photocell beam. Three trials were separated by 6-8 min of recovery periods for each sprint test and the examiner chooses the fastest time to assess the performance of the athlete's speed [13].

Power: Vertical Jump Test:

Participants warms up for (10) minutes, each player stands side on to a wall keeps feet on floor, stretches as high as possible with one hand and touches the wall with fingertips M1. This is called the standing reach height. The athlete then stands away from the wall and jumps vertically to a fixed position as high as possible using both arms and legs to assist in projecting the body upwards and puts a marker on the wall M2. The difference in distance between the

standing reach height and the jump height is the score M1/M2. The athlete repeats the test (3) times and the best of three attempts is recorded [14].

Strength: Medicine Ball Test:

A straight section was defined by the examiner for taking the test on the starting line, then the player throws the medicine ball with both arms as far as possible from the sitting position, after which we measure the distance of the medicine ball while falling. The athlete repeats the test (3) times and the best of three attempts is recorded [14].

Flexibility: Sit and Reach Test:

The test preceded with a 10 min warm-up with some gentle stretches, player then removes shoes and places his feet against the box with the legs fully extended. Athletes then reach forward as far as possible keeping their knees touching the floor for two seconds and the assistant records the distance the player has moved with his fingertips. Commonly the athlete will repeat this procedure three times. This will enable coaches to calculate the average score for the athlete [14].

Agility: Illinois Agility Test:

To perform the test, participants warm up for (10) minutes, then each player starts in a laying position face down on the floor. When assistant gives the command (GO) they must then stand up as fast as possible and sprint forwards 10 m to a cone, complete a 180° turn and then sprint back 10 m to another cone and complete another 180° turn. They must then weave in and out of 4 cones over a 10 m distance, complete a 180° turn at the 4th cone and finally, the athlete will complete a 180° turn, sprint forwards 10 m to a cone, complete another 180° turn and sprint 10 m to the finish line. The assistant stops the timer and records the time the player passes from one cone to the finish step [15].

Blood Sampling and Analysis

Blood samples were collected from antecubital vein at 2-time points after an overnight fast, and on the same day of the week (Monday at 8:00 AM): 1) before the start of the training programs (baseline measurement), and 2) at the end of the investigation period in order to examine the blood variables (hemoglobin (g/dl), hematocrit (%), mean corpuscular hemoglobin concentration (MCHC) (%)). The samples were collected in a sterile tube for vacuum blood collection containing anticoagulant (EDTA) and analyzed for a complete blood count using an automated cell counter.

Statistical Analyses

Data were expressed as mean values and standard deviations (SD). All statistical tests were processed using SPSS version 26.0 software (SPSS Inc., Chicago, United States). The normality of data distribution was confirmed using the Kolmogorov-Smirnov test. A Two-way ANOVA test was used to compare all parameters measured before and after the period of pre-season training (T1 vs. T2) and between the two groups. A statistical significance for all analyses was set at $p < 0.05$. The 95% confidence intervals (CI) and effects sizes (ES) were calculated to compare differences in mean values for all analyzed parameters before and after the eight weeks of the preparatory phase for the season. The percentage of variation (%) of all variables was also calculated to establish changes between pre-and post-tests using the following formula:

$$\left(\frac{\text{final value} - \text{initial value}}{\text{initial value}} \right) \times 100$$

RESULTS

All participants completed the study with 100% adherence to the procedures. No injuries were observed or reported during the experimental period. The data for blood collection and physical capacity tests are presented in Table 1 and 2 for both groups at T1 and T2.

A significant difference was reported between the two groups for all physical capacity tests ($p < 0.05$), with the percentage of improvement being higher among the LIIT group compared to the TTP group. For endurance (2.77%, $p=0.03$), speed (6.8%, $p=0.001$), power (17.09%, $p=0.02$), agility (4.22%, $p=0.01$), flexibility (29.25%, $p=0.01$), and upper body strength capacity (8.82%, $p=0.02$). No significant differences between groups were found for hemoglobin concentration and hematocrit ($p = 0.84$ and $p = 0.59$, respectively). However, a significant difference was observed for MCHC ($p = 0.01$). Specifically, an increase in MCHC was noted among the LIIT group, with a percentage variation of 2.05 ($p < 0.001$).

Table 2: Changes in physical performances and blood components before and after the 8 weeks program training among the two groups (n=30).

Variables	LIIT (n=15)			TTP (n=15)			Time	Group	Group vs time
	T1 mean $\pm$ SD	T2 mean $\pm$ SD	(%) variation	T1 mean $\pm$ SD	T2 mean $\pm$ SD	(%) variation			
Test cooper (Endurance) (m)	2550.67 $\pm$ 6.2	2621.4 $\pm$ 56.3***	2.77	2544.5 $\pm$ 93.7	2562.6 $\pm$ 84.91*	0.71	0.000*** (0.56)	0.378 (0.028)	0.002** (0.3)
30m test (Speed) (s)	5 $\pm$ 0.2	4.66 $\pm$ 0.3***	-6.8	5.09 $\pm$ 0.2	5.02 $\pm$ 0.17**	-1.38	0.000*** (0.679)	0.008* (0.223)	0.000*** (0.482)
Vertical jump test (Power) (cm)	34.27 $\pm$ 3.2	40.13 $\pm$ 4.4***	17.09	35.07 $\pm$ 5.1	36 $\pm$ 4.8**	2.65	0.000*** (0.607)	0.0086* (0.101)	0.000*** (0.426)
Medicine ball test (strength) (m)	2.72 $\pm$ 0.3	2.96 $\pm$ 0.2***	8.82	2.65 $\pm$ 0.2	2.72 $\pm$ 0.3*	2.64	0.000*** (0.561)	0.303 (0.038)	0.005** (0.25)
Sit and reach test (Flexibility) (cm)	5.47 $\pm$ 1.2	7.07 $\pm$ 1.4***	29.25	5.53 $\pm$ 1.5	5.6 $\pm$ 1.4	1.26	0.000*** (0.553)	0.094 (0.097)	0.000*** (0.505)
Illinois agility test (agility) (s)	18.94 $\pm$ 1.3	18.14 $\pm$ 1.1**	-4.22	19.30 $\pm$ 1.1	19.19 $\pm$ 1.1***	-0.56	0.001** (0.351)	0.169 (0.067)	0.007** (0.231)
Hemoglobin (g/dl)	13.37 $\pm$ 1.2	13.41 $\pm$ 1.2	0.92	13.27 $\pm$ 1.1	13.33 $\pm$ 1.1	0.45	0.032* (0.155)	0.803 (0.002)	0.705 (0.005)
Hematocrit (%)	41.53 $\pm$ 3.8	41.57 $\pm$ 3.8	0.1	40.81 $\pm$ 3.6	40.84 $\pm$ 3.6	0.07	0.008** (0.255)	0.966 (0.000)	0.692 (0.006)
MCHC (%)	33.6 $\pm$ 1.1	34.39 $\pm$ 1.1***	2.05	33.33 $\pm$ 0.7	33.35 $\pm$ 0.76	0.06	0.000*** (0.458)	0.182 (0.063)	0.000*** (0.415)

MCHC: Mean corpuscular hemoglobin concentration; LIIT: low-intensity interval training group; PPT: traditional training program group; *: $p < 0.05$ (pre-post test); **: $p < 0.01$ (pre-post test); ***: $p < 0.001$ (pre-post test).

DISCUSSION

The purpose of this study is to investigate the effects of a low-intensity interval training program (LIIT) on various physical performance variables and blood parameters among junior handball players. Our findings indicate that the LIIT intervention was more effective than the

traditional continuous training regime in improving physical parameters such as endurance, speed, agility, power, and certain blood parameters, including mean corpuscular hemoglobin.

It is evident from the results presented in Table 1 that there were statistically significant improvements in all the tested physical characteristics of the handball juniors from pre to post measurements in the LIIT group compared to the control group. The percentage changes in physical characteristics were as follows: transitional speed (-6.80%) seconds, agility (-4.22%) seconds, muscular strength of the legs (17.09%) centimeters, muscular strength of the arms (8.82%) meters, flexibility (29.25%) meters, and endurance (2.77%) meters. The improvements observed in the experimental group in this study can be attributed to the nature and characteristics of the LIIT program administered to the handball players. Low-Intensity Interval Training has emerged as a distinct exercise approach, characterized by alternating between periods of low to moderate intensity exercise and rest or active recovery [16]. Unlike High-Intensity Interval Training (HIIT), which pushes the body to its maximum capacity, LIIT maintains a lower overall intensity, making it more accessible to individuals with varying fitness levels and physical conditions [17]. Our findings align with recent studies demonstrating the efficacy of LIIT in enhancing the physical performance in trained and untrained participants [3, 16, 18]. These benefits are attributed to the emphasis on longer intervals of lower intensity exercise, which aids in building a robust aerobic foundation. This enhanced aerobic capacity is crucial for sustaining high-intensity efforts and facilitating quick recovery during intense bursts of activity in handball matches. Additionally, LIIT promotes active recovery during lower intensity phases, contributing to reduced muscle soreness and fatigue [16, 17]. Moreover, LIIT has demonstrated effects on brain function, coronary vascular function, preservation of Ca^{2+} -sensitive K^{+} , and offers cardiopulmonary and metabolic advantages [19]. Given the demanding schedules of handball players, integrating LIIT can expedite recovery between training sessions and matches, ensuring consistent performance levels. Moreover, we speculated that LIIT gradually enhances muscular endurance through prolonged low-intensity exercise. This improved endurance translates to better performance during extended handball matches, enabling players to sustain energy levels and skill execution throughout the game.

In this study, we observed that Mean Corpuscular Hemoglobin (MCH) was significantly higher after LIIT, with non-significant effects on hemoglobin and hematocrit. It is hypothesized that LIIT could have notable effects on various blood parameters, including hemoglobin levels, mean corpuscular hemoglobin, and hematocrit, particularly in sports like handball. The enhancement in MCH may be attributed to the improvement in oxygen utilization [20]. It has been reported that LIIT is a potent stimulant that increases mitochondrial capacity of the skeletal muscle and improves exercise performance, and this encourages better oxygen utilization, potentially influencing red blood cell production and size, which in turn affects MCH levels [20]. We speculated that LIIT can lead to aerobic adaptations, including increased capillarization (formation of new capillaries) and improved oxygen-carrying capacity of the blood. These adaptations may impact MCH levels by influencing red blood cell production and characteristics.

It's important to note that the effects of LIIT on blood parameters can vary based on factors such as training duration, frequency, intensity, and an individual's baseline fitness level. For accurate and comprehensive information, future research should focus on examining the effects of these variables on blood parameters within handball players.

A larger and more diverse sample could enhance the generalizability of the findings and provide a more robust understanding of the potential impact of LIIT on a broader population of junior handball players. Future research could explore the long-term effects of LIIT, investigating whether the observed improvements in physical parameters are sustained over an extended period. Including a broader range of physiological markers and performance metrics could offer a more comprehensive assessment of the overall impact of LIIT on the participants' health and athletic performance. Considering the specificity of the study to junior handball players, future research may explore the applicability and effectiveness of LIIT across different age groups, skill levels, and sports disciplines.

CONCLUSION

In conclusion, our study showed that low-Intensity Interval Training (LIIT) emerges as an efficient and effective method for enhancing the physical fitness of handball players, surpassing traditional training approaches. Its unique characteristics make it a well-suited option, particularly for junior handball players seeking to improve their performance. Notably, LIIT offers advantages over traditional training by accommodating varying fitness levels, promoting sustained endurance, and reducing the risk of overuse injuries. While the effects of LIIT on various blood parameters in handball players are not fully elucidated and remains uncertain, future study in this topic are warranted. Until then, based on the available knowledge, LIIT emerges as a promising avenue for junior handball players striving for optimal physical development and performance.

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