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Physiological profile after a combined high-intensity interval training and Fartlek training program in amateur basketball players: A pilot study

Raul Josue Najera-Longoria [1], Omar Ricardo Ortiz Gomez [1*], Ramón Alfonso González-Rivas [1], Željko Rajković [2], Yunuen Socorro Rangel-Ledezma [1], Miguel Conchas-Ramirez [1], Lucia Consepción Palma Gardea [1]

[1] University Autonomous of Chihuahua, Chihuahua, MEXICO
[2] University of Belgrade, Belgrade, SERBIA
***Corresponding Author:** Oortiz@uach.mx

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ABSTRACT

The aim of this study was to determine changes in aerobic and anaerobic capacities after an eight-week combined high-intensity interval training (HIIT) and Fartlek training program in amateur basketball players. Eight male players were evaluated. Estimated VO_2max was assessed using the 20-m multistage fitness test (20mMFT) and the Yo-Yo intermittent recovery test-1. Heart rate deflection point (HRdp) was measured during the 20mMFT. A continuous countermovement vertical jump (four sets of 15 s) was performed before and after the program. No changes in estimated VO_2max were detected ($p > 0.05$). HRdp was identifiable in some but not all participants. Lower limb jump height was affected by the number of sets completed, with differences between final and initial attempts. These changes were more noticeable before training, suggesting the program may have influenced the ability to maintain jump height. Training program may preserve aerobic fitness in amateur basketball players, while also indicating potential benefits for lower limb performance warranting further investigation.

Keywords: sport physiology, basketball, training, HIIT

INTRODUCTION

Basketball is an explosive, intermittent, and high-intensity sport that requires both anaerobic and aerobic capabilities (Tsunawake et al., 2003) . Effect in physical training in basketball performance has been widely studied during competition (Montgomery et al., 2010). Some studies demonstrated that training increases velocity, strength, oxygen uptake (Hoffman et al., 1991; Laplaud et al., 2004) and specifically in basketball skills (Balčiūnas et al., 2006). However, this seems to be relative to different factors like game position (Vučković et al., 2010), personal fitness (Hoffman et al., 1999) or physiological functions such pulmonary system, maximum cardiac output, oxygen carrying capacity, peripheral diffusion gradients, mitochondrial enzyme levels and capillary density (Bassett & Howley, 2000). Nevertheless, no changes have been reported in squat jump and speed in basketball players after four months of either intermittent or continuous exercise (Balčiūnas et al., 2006). Soccer players showed that maximal oxygen consumption (VO_2max) is less sensitive to detect changes with training than lactate or ventilatory threshold (Edwards et al., 2003) and this shows lack of information regarding design of training regimen and thus the potential increasing levels in physiological variables.

A recent systematic review pointed out that changes in performance after training, seems to be specifically to regimen involved, thus 6-8 reps of 20-s all out with 2 min passive recovery lead changes in repeated sprint ability and high intermittent interval exercise; while same stimuli with 40 s passive recovery, produces muscles ability to maximize fatigue tolerance in two different samples of soccer players (Iaia et al., 2015). On this basis, training programs should include some specific abilities such changes of directions (Sanchez-Sanchez et al., 2018) and monitoring of either internal or external load determination to ensure the correct load distribution (Paulson et al., 2015). The aim of this study was to determine changes in aerobic and anaerobic capacities after an eight-week combined high-intensity interval training (HIIT) and Fartlek training program in amateur basketball players.

METHOD

Approach to the Problem

This was an uncontrolled pre-post pilot intervention study with a single group. The aim was to assess the feasibility of an eight-week combined HIIT/Fartlek training protocol in amateur basketball players during the pre-competitive season. The design is therefore exploratory and descriptive; no control group was included

Participants

Initially, twelve male basketball players from the faculty of physical culture sciences at the Autonomous University of Chihuahua, Mexico, volunteered. All were healthy, had no musculoskeletal injuries in the previous three months. No participants reported taking any regular medication, but this was not systematically verified. The final sample comprised eight players (mean [M] ± standard deviation [SD]: age 21.1 ± 1.5 years, height 179.6 ± 5.6 cm, body mass 77.2 ± 11.7 kg). Four participants were excluded: one due to injury, two because they did not complete the post-intervention evaluations, and one for failing to attend at least 80% of the training sessions. The study complied with the Declaration of Helsinki and was approved by the institutional ethics committee with approval number CIE-A-128/15. All participants gave written informed consent.

Experimental Approach

The eight participants completed an eight-week training program, three days per week. Each session consisted of 10-15 minutes of HIIT or Fartlek training followed by 90-100 minutes of basketball-specific drills (passing, dribbling, rebounding, shooting, and footwork). During the HIIT/Fartlek portion, participants wore a telemetric heart rate (HR) monitor (Polar, Finland).

Weekly Progression

The HIIT/Fartlek component was kept constant across weeks (10-15 min per session, 3 sets of 12-15 reps for HIIT; 2:1 work:rest ratio for Fartlek). HR was monitored in real time to ensure effort, but data were not stored for analysis. Attendance was high (> 90% based on coach records). On days with a tournament game, the HIIT/Fartlek part was omitted.

Aerobic Fitness Determination

20-m multistage fitness test (20mMFT) and Yo-Yo intermittent recovery test-1 (YoYo IRT-1) were used to estimate aerobic capacity. 20mMFT requires running back and forth on a 20 m path, with an initial speed of 8.5 km h^{-1} and increments of 0.5 km h^{-1} each minute, mediated for a signal sound in a prerecorded tape. Lineal regression equation proposed for Léger et al. (1988) was used to estimate VO_2max. The YoYo IRT-1 consists of repeated 2 × 20 m runs back and forth. Subjects had 10 s active rest period in 5 m additional to the running course between each running bouts (Krustrup et al., 2003). We used the equation proposed for the authors to estimate VO_2max (Bangsbo et al., 2008).

Heart rate deflection point (HRdp) was not systematically assessed for all participants. As an exploratory illustration, HRdp was determined visually for two participants (subject 4 and subject 7) from the HR data recorded during the 20mMFT. Individual HR values were plotted against running speed, and the HRdp was identified as the speed at which the HR-speed relationship deviated from linearity (Vachon et al., 1999).

Lower Limbs Jump Height Determination

Participants performed four sets of 15 s of continuous countermovement vertical jumps with 10 s passive recovery between set (Markovic et al., 2004). They were instructed to use a self-selected knee flexion, keep the trunk vertically, and avoid knee flexion during the flight phase (Hespanhol et al., 2006). Measurement details (Kinovea v0.9.5): A camera (Sony FDR AX100) was placed 3.5 m from the participant, 1.2 m high, perpendicular to the sagittal plane, recording at 240 fps. A 1 m reference marker was filmed in the same plane before each session for calibration. Jump height (in cm) was calculated using the time of flight method for the first and last jump of each set (El-Raheem et al., 2015).

Training Protocol

Training protocol consisted of 10-15 minutes of warm-up exercises (jogging and stretching), followed by alternating Fartlek (moderate to high-intensity running followed by low intensity 1:2 ratio) or HIIT (burpees, jumping jacks, lounges, side to side hops, and bodyweight squats 2-3 series 12-15 reps) for 10-15 minutes, and 90-100 min of basketball specific training (shooting, dribbling, rebounding, footwork, and defensive and offensive drills). During the Fartlek/HIIT training part, HR was monitored to measure relative intensity of the effort.

Procedure

Each player was instructed and verbally encouraged to give and maintain a maximal effort during all tests. After warming up, the participants executed the 20mMFT, YoYo IRT-1 and the four sets of 15 s of vertical jump with 48 hours between testing, besides all players were asked to refrain from strenuous exercise. All the tests were conducted in a full-size FIBA regulation court.

After the preliminary evaluation was applied, the 8-week HIIT/Fartlek training protocol was administrated to the players three times a week, except when basketball games were rolled in a local tournament.

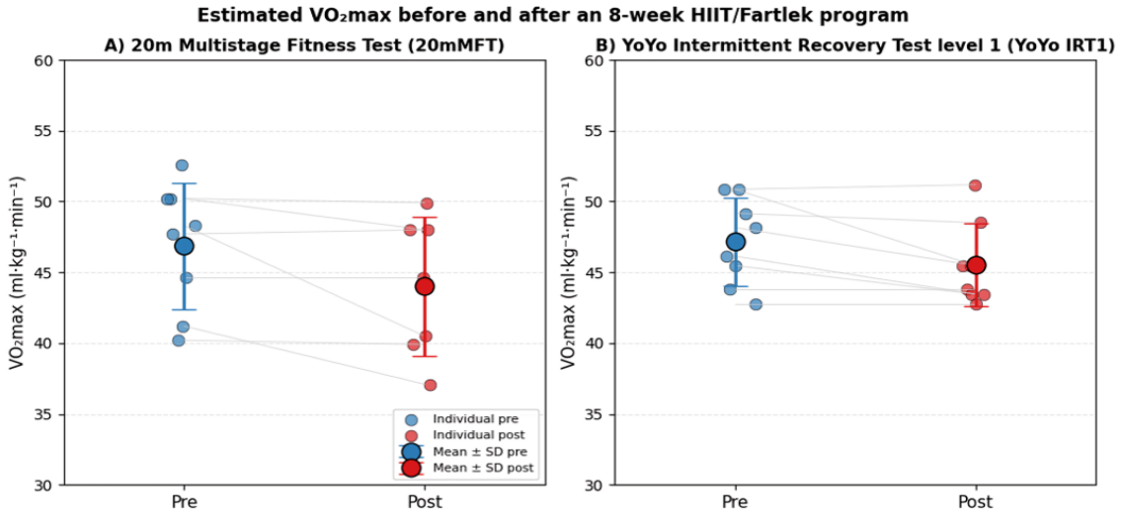

Figure 1. Estimated VO_2max (ml·kg^{-1}·min^{-1}) before (pre-) and after (post-) training program (part A shows values derived from the 20mMFT; part B shows values derived from the YoYo IRT1; individual participant data are shown as grey lines connecting pre- and post-values; large colored circles represent group means; error bars represent SDs; pre-intervention values are shown in blue; post-intervention values in red; no statistically significant differences were detected [paired t-tests, $p > 0.05$ for both tests]) (the authors' own elaboration)

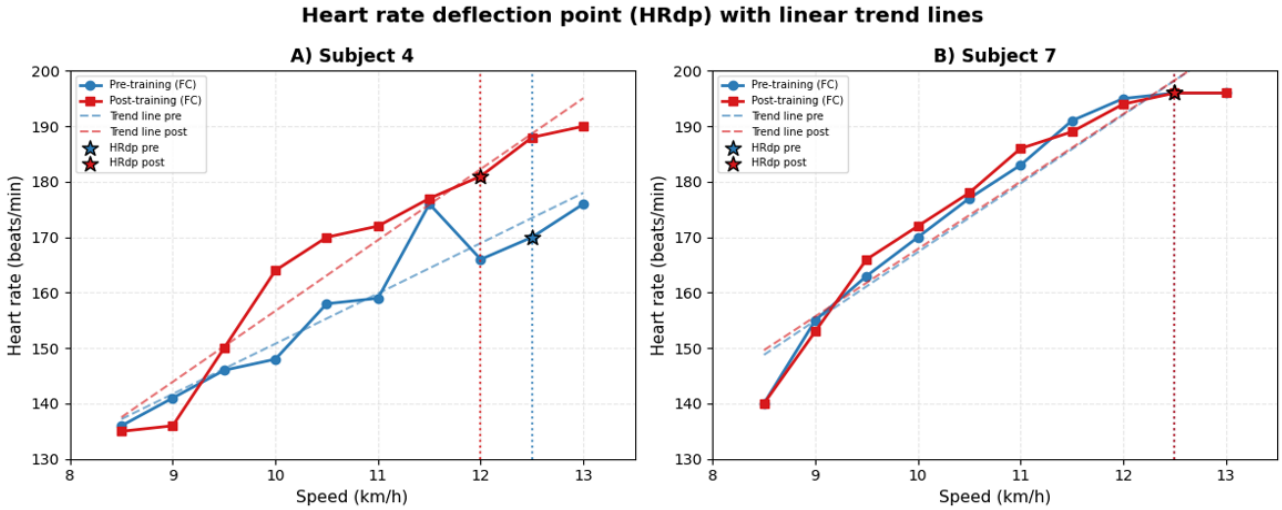

Figure 2. Individual HRdp for prior training (top arrow) and after training program (bottom arrow) for subject 4 (part A) and subject 7 (part B) (the authors' own elaboration)

Statistical Analysis

After normality inspection of the data, these were expressed as M ± SD. Comparison between VO_2max prior and after training was performed using dependent samples t-test. Coefficient correlation Pearson used to assess relation of physical fitness between 20mMFT and YoYo IRT1. Repeated measures analysis used to assess jump heigh comparison between series at initial and final attempt, respectively with Bonferroni post hoc adjustment. t-student with related samples allows comparing initial vs. final attempt in each series.

RESULTS

Figure 1 summarizes estimated VO_2max values before and after training using the 20mMFT (part A) and the YoYo IRT1 (part B). No statistical differences were detected between pre- and post-intervention values for either test (20mMFT: 46.8 ± 4.4 vs. 44.0 ± 4.8 ml·kg^{-1}·min^{-1}, mean difference = -2.8, $p > 0.05$; YoYo IRT1: 47.15 ± 3.14 vs. 45.51 ± 3.02 ml·kg^{-1}·min^{-1}, mean difference = -1.64, $p > 0.05$).

HRdp was examined in two participants as an exploratory illustration (**Figure 2**). For participant 4 (part A), the HRdp occurred at a higher running speed after training compared to pre training. For participant 7 (part B), no clear change was observed. HRdp was not determined for the remaining six participants due to the exploratory pilot design. No group level conclusions can be drawn from these data.

Table 1. Comparison of initial vs. final countermovement jump height (cm) within each of four sets, before (pre-) and after (post-) training

Time	Set	Initial jump (M ± SD)	Final jump (M ± SD)	Mean difference	95% confidence interval of difference	t	df	p
Pre	1	42.95 ± 8.40	39.19 ± 7.33	3.76	-2.20 to 9.71	1.622	5	0.17
	2	45.91 ± 9.51	36.77 ± 6.15	9.14	3.45 to 14.82	4.132		0.01
	3	44.47 ± 6.52	34.64 ± 5.46	9.82	3.45 to 16.20	3.962		0.01
	4	41.48 ± 5.34	33.55 ± 6.75	7.93	1.95 to 13.91	3.410		0.02
Post	1	42.14 ± 5.65	41.14 ± 7.57	1.01	-3.72 to 5.73	0.521	6	0.62
	2	43.31 ± 5.48	36.61 ± 7.12	6.70	3.03 to 10.37	4.470		0.00
	3	42.69 ± 4.61	37.30 ± 7.72	5.38	-0.38 to 11.14	2.286		0.06
	4	42.18 ± 4.88	34.44 ± 5.52	7.74	3.77 to 11.71	4.772		0.00

Repeated countermovement jump height data are presented in **Table 1**. Paired t-tests compared initial and final jump height within each of the four sets, separately for pre- and post-intervention.

Before the training program, significant differences between initial and final jump height were observed in sets 2, 3, and 4 ($p = 0.009$, $p = 0.011$, and $p = 0.019$, respectively), but not in set 1 ($p = 0.166$). After the training program, significant differences were observed in set 2 and set 4 ($p = 0.004$ and $p = 0.003$, respectively), while set 3 showed a marginal difference ($p = 0.062$) and set 1 showed no difference ($p = 0.621$).

DISCUSSION

The main finding of this study was that eight weeks of HIIT/Fartlek training program was enough to maintain the estimated aerobic capacity in amateur basketball players. The obtained VO_2max value was similar to reported by professional basketball players with same protocol used (Köklü et al., 2011), at this point, aerobic capacity tend to be higher as level goes up, however this may not be observable because in minor ages some studies show values of 56.7 $ml \cdot kg^{-1} \cdot min^{-1}$ in inter high school competition (Tsunawake et al., 2003). Nevertheless 8 weeks of training was insufficient to produce aerobic changes in this group, there are two explanations for this phenomena:

(1) the training load 3 times a week, this was conducted in a regular basis before the experiment, without the specificity of HIIT/Fartlek, in this case basketball players have reported to training 5-6 days a week in some studies (Manzi et al., 2010) and 20 weeks engaged in basketball training protocol (Anderson et al., 2003), this marks a quite different in comparison to this project and

(2) 20mMFT protocol to estimate VO_2max could not be a specialized tool for this purpose instead underestimates this parameter or not provide a valid predictions of it (Coo(the authors' own elaboration)per et al., 2005).

Near 50 % of the expected change in VO_2max in response to training due to genetic; this may explain why in response to the same training intervention, some people adapt significantly, others slightly, and some not at all. More recent studies suggest that reduction in training frequency and or duration can produce situations in which there is no change in VO_2max (Neufer, 1989).

Furthermore, physiological status change could be observed by anaerobic threshold modification with the HRdp, which can be used as a valid and noninvasive tool (Nájera-Longoria et al., 2017), in track field (Simões et al., 2005), recreational trained runners (Peserico et al., 2016) and water cycling (Pinto et al., 2016). Some author reports different ways to assessment the HRdp, ranging from algebraic computerized methods to visual determination by experts thus, with high correlation with physiological instances such anaerobic threshold (Pinto et al., 2016). However, due to different circumstances, HRdp could not be present in all subjects (Francis et al., 1989) as it occurs in this study where the principals factors may be players individuals physical fitness. Moreover, controversial reports lead to the dismiss the use of HRdp as an accurate predictor of lactate threshold (Jones & Doust, 1995; Vachon et al., 1999). According to a recent study, authors report moderate correlation of HRdp with anaerobic threshold thus mechanical condition assumed by myocardial function (Buchheit et al., 2007).

The YoYo IRT1 was initially elaborated to soccer players' populations, however the authors suggest it could be used in any sports that uses spontaneous changes of directions, and repeated sprint ability such basketball (Krustrup et al., 2003) . In this case we found similar physical behavior respect to both aerobic test and there is an association reported with aerobic fitness (Castagna et al., 2008). Additionally, this relationship has reported moderate ($r = 0.70$) and could not be sufficient to demonstrate predictive validity, principally due to fitness status and role position within a team (Castagna et al., 2008).

This study showed that lower limp performance is affected by the previous series completed and there is a change in power between the final attempts in each series vs. the initial jump. However, this was most markedly prior training and thus lead to proposition that the training program changed their ability to develop power output, besides it has been suggested that elite basketball players are able to cope with physical fatigue while performing coordinated movements (Slawinski et al., 2018).

CONCLUSION

In this exploratory pilot study with eight amateur basketball players and no control group, the eight-week combined HIIT/Fartlek program (three sessions per week, 10-15 min per session) was associated with maintenance of estimated aerobic fitness, as no significant pre-to-post differences were observed in either the 20mMFT or YoYo IRT1. Within-player observations of

repeated countermovement jump performance revealed a decline in jump height from the first to the last attempt within most sets, both before and after training; however, the small sample size precludes strong conclusions about changes in fatigue resistance. These findings should be interpreted as preliminary and hypothesis-generating. Future controlled studies with larger samples are needed to determine whether this training protocol improves lower-limb performance or attenuates fatigue in basketball players

Limitation of the Study

This study has two main limitations. First, the absence of a control group means that the observed pre to post changes cannot be unequivocally attributed to the training intervention. Second, the final sample size (n = 8) is small, which limits statistical power and precludes robust interaction analyses.

Author contributions: RJN-L: conceptualization, data curation, formal analysis, writing – original draft; writing – review & editing; **OROG:** conceptualization, data curation, formal analysis, writing – review & editing; **RAG-R:** conceptualization, writing – review & editing; **ŽR:** conceptualization, writing – review & editing; **YSR-L:** conceptualization, writing – review & editing; **MCR:** conceptualization, writing – review & editing; **LCPG:** conceptualization, writing – review & editing. All authors have agreed with the results and conclusions.

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Ethical statement: This study was approved by the Ethics and Research Committee of the State Central Hospital of Chihuahua and the Faculty of Medicine of the Autonomous, University of Chihuahua on 21 March 2025 with approval number CIE-A-128/15. All participants provided informed consent, and the study was conducted in accordance with the Declaration of Helsinki.

AI statement: AI was used for language refinement only. All creative, intellectual, and cognitive work was carried out by the authors.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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