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RESEARCH ARTICLE

The Effect of Simulation-based Training on Athletic Performances among Female Basketball Players

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Abstract:

Background:

The effectiveness of simulation-based training has been examined in various sports. However, considering the effect of gender and sport on training, it would be interesting to evaluate simulation-based training in female basketball.

Objective:

The purpose of the study was to examine the effect of simulation-based training on physical fitness and performance indices in female basketball players.

Methods:

Sixteen female semi-professional basketball players were randomly assigned to experimental (n=8; age, 25±2 years; weight, 62±9 kg; height, 167±8 cm) or control (n=8; age, 24±1 years; weight, 57±9 kg; height, 170±8 cm) groups. The experimental group participated in a six week basketball simulation training program including running with different speeds (jogging to sprinting), agility, jumping, and shuffling. Both groups performed the Cooper 12 min run, line drill, an adjusted T-test, 20 ms print, the Sargent vertical jump and basketball exercise simulation test before and after six weeks of the study period. Control and experimental groups performed typical basketball training, three times weekly. The overall training volume was similar for both groups.

Results:

The perceived exertion was higher in the simulation-based training than control ($p<0.05$) group. The findings of this study indicated a significant increase in VO_2 max ($p=0.001$), anaerobic power ($p=0.009$), explosive leg strength ($p=0.036$), and total distance covered in basketball exercise simulation test ($p=0.001$) and decrease of the meantime of one round of basketball exercise simulation test ($p=0.001$) in the simulation training compared to the control group.

Conclusion:

Generally incorporation of the simulation-based training in conditioning programs is recommended for improving aerobic, anaerobic and leg explosive strength of basketball players.

Keywords: Basketball, Female athletes, Simulation training, Physical fitness, Performance, Players.

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1. INTRODUCTION

Basketball is a team sport characterized by intermittent combinations of various intensity activities which involve different metabolic pathways [1, 2]. Success in this sport is associated with all dimensions of physical fitness including aerobic capacity, anaerobic power (vertical jump), agility, speed and muscular strength [2 - 4].

Intermittent and repeated sprint training has been suggested as an effective strategy to be included in basketball-specific training schedules [5]. Intermittent (*e.g.*, shuttle runs)

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training protocol is one of the common training programs which enhance oxidative capacity and reduce lactate accumulation in young basketball players [6]. Various factors including change of direction in running may intermittent training outcomes, *e.g*., Hader *et al*. [7] found that the change of direction is an effective practice considering the physiological load and neuromuscular adaptation. Even angle of change of direction may affect performance, physiological and perceptual response during repeated sprints [8]. Also, the intensity and mode of intermittent exercise can be effective on long-term adaptations to intermittent exercises [9].

In conditioning programs, besides considering all physical fitness and metabolic components, emphasizing exercise intensity or change of direction similar to the requirements of a basketball match might be important. It might be assumed that fitness and performance can be improved significantly when conditioning simulates physiological and technical demands of the sport. Although game based training can provide a specific training stimulus which is similar to the overall demands of team-sport competition, it has been suggested that it may not always satisfy the high-intensity, repeated-sprint demands of a team sport [10, 11].

The Basket Ball Simulation Test (BEST), developed by Scanlan, *et al*. [12], could be an appropriate model for designing a conditioning program. BEST is associated with aerobic and anaerobic fitness [13], which relies mainly on aerobic energy and anaerobic utilization of high-energy phosphates [14]. It consisted of 24 circuits on a basketball half-court with every circuit starting with a six meters sprint, followed by basketball-specific movements such as shuffling, jumping, sprinting, and repetitive changes in direction and speed [14, 15]. Although BEST was designed as a test, given that this test focused on important aspects of physical fitness of basketball players, it was hypothesized that exercise simulation based on this test could be a complete program to improve physical fitness. So, the purpose of the present study was to evaluate the effect of replacing a part of the usual six weeks basketball conditioning regimen with simulation-based training on some physical fitness components including aerobic and anaerobic power, agility, speed, explosive leg strength as well as BEST measurements among female professional basketball players.

2. METHODS

2.1. Participants

Participants of the study included 16 semiprofessional female basketball players who played basketball regularly at least three times a week for at least five years and were selected members of the state team (not national team) (age, 25.0±2.1 years; weight, 62.0±9.3 kg; height, 166.5±8.5 cm) volunteered to participate in the study with the permission of their coach. They played guard (n=4), forward (n=4) and center (n=8) positions. Regarding their playing positions, they were divided into two matched groups of training (n=8) and control (n=8). Exclusion criteria were the absence in 20% or more of training sessions or experiencing any kind of injury. All participants were present in 90% or more of the study sessions and did not experience any kind of injury six months before or during the study.

The study procedure was conformed to the latest version of the Declaration of Helsinki and was confirmed by the ethics and graduate committee of the university. Participants were informed about study procedures and its possible benefits and risks, and they signed the written informed consent.

2.2. Training Procedures

All participants were taking part in their regular pre-competitive season basketball- specific training consisting of 3 sessions of 2 hours per week. Participants did not consume any kind of supplements or ergogenics. They were instructed to have their usual food and enough sleep during the experiment. Simulation-based training was included as a part of their regular pre-competition season training program. All the participants in training and control groups were allocated the same time for training. Every session consisted of 10 minutes of general warm-up, 10 minutes of specific warm-up with the ball, 10 minutes of playing specific basketball techniques and about one-hour of basketball recreational competition or ordinary conditioning. BEST replaced their ordinary conditioning program. Although the duration of exercise was similar for both groups, according to the Borg scale, perceived exertion of the training group from the third session was significantly higher than the control group. The experimental group participated in a six weeks training program, three sessions per week which have been presented in detail in Table **1**. All training sessions were performed at a similar time of day (4-6 pm). In the control group, the simulation-based training was replaced by conditioning exercises including running with different speeds (jogging to sprinting), agility, jumping, shuffling with almost the same percentage of devoted time to each factor as simulation-based training but not in the same order or intensity or plan.

The mode of training was planned using the BEST designed by Scanlan *et al*. [12]. Each simulation-based circuit included 30 seconds of different activities. Participants were asked to perform the very circuit as follows:

(a) Walking at normal speed, (b) Jogging/running at a moderate intensity or a situation between walking and running (~50% of the maximal velocity), (c) Running at an intensity above moderate but less than maximal effort (~75% of maximal velocity), (d) Sprinting or running at maximal effort or intensity, (e) Low shuffling: activity characterized by shuffling action of the feet within a defensive stance position, performed without urgency, (f) High shuffling activity of the feet within a defensive stance position, performed at maximal effort, (g) Jumping as counter movement: maximal effort jump taking off with both legs.

Participants were introduced to the BEST test and activities before performance according to the following activity categories, similar to previous descriptions [13]. Walking activity at an intensity of usual walking pace. Jogging: moderate-intensity or higher than walking pace but without urgency (~50% of maximal velocity). Running: higher than moderate intensity, but still lower than maximal exertion (~75% of maximal velocity). Sprinting: an all-out effort at the maximal intensity.

Before performing every simulation-based circuit, the participants stood in a stationary position at the starting point and the time of every circuit was recorded from this point. The participants performed each BEST circuit in 22-27 seconds, so they could have rest for 3-8 seconds before the next circuit [12]. The number of circuits, set, rest intervals, and sessions have been presented in Table **1**.

Table 1. Description of the six week BEST training program.

-	Sessions	Circuits *Sets	The Interval between Sets (min)
Week 1	1st	4*4	3
	2nd	4*4	2
	3rd	7*4	3
Week 2	1st	7*4	2
	2nd	10*4	3
	3rd	10*4	2
Week 3	1st	13*4	3
	2nd ±	13*4	2
	3rd	16*4	3
Week 4	1st	16*4	2
	2nd	19*4	3 min(sets 1-2 and 3-4), 15 min(set 2-3)
	3rd	19*4	2 min(sets 1-2 and 3-4), 15 min(set 2-3)
Week 5	1st	21*4	3 min(sets 1-2 and 3-4), 15 min(set 2-3)
	2nd	21*4	2 min(sets 1-2 and 3-4), 15 min(set 2-3)
	3rd	24*4	3 min(sets 1-2 and 3-4), 15 min(set 2-3)
Week 6	1st	24*4	2 min(sets 1-2 and 3-4), 15 min(set 2-3)
	2nd	24*4	2min(sets 1-2 and 3-4), 15 min(set 2-3)
	3rd	24*4	2min(sets 1-2 and 3-4), 15 min(set 2-3)

2.3. Measures

All tests were performed at a similar time of day (4-6 pm) during one week before and one week after the training program (at least 48 hours following the last session of training). All participants were assessed out of severe bleeding or painful days of menstruation. Participants were asked to eat a similar light lunch of 6-8 oz. of lean protein (grilled chicken, meat, or fish), 1.5 cups of rice/pasta, and about 2 cups of vegetables, which was consumed at least 3 hours before testing sessions. They were asked to avoid drinking coffee or beverages containing coffee 8 hours before testing. They wore similar clothes and shoes during all testing sessions. Two weeks before initial testing, participants were familiarized with all tests and procedures during four sessions. Before each testing session, participants performed a general warm-up, including 8 min of running and stretching activities followed by 3 min specific warm-up similar to specific tests to be performed. All measurements were taken within at least 48 hours intervals. All tests were performed in a state free of fatigue or pain. An experienced coach supervised all tests and training.

Participants performed the Cooper 12 minute run test around the basketball court to measure aerobic capacity. VO_2 max was calculated using the following formula:

VO_2 max (ml /kg -1/ min-1) = (22.351 x distance covered in kilometers) - 11.288 [15]. Repeatability of the Cooper 12 minute run test with modified equation (r=0.95) has been documented previously [16].

The line drill test, which has been shown reliable (r=0.91) [17], was used for measuring anaerobic performance. Players ran several sprints (totally 140 m) with changes of direction. The line drill was performed on a basketball court. The players ran four consecutive sprints (5.8 m, 14.3 m, 22.9 m and 28.7 m) initiated from the baseline and returned to the same baseline. They started from the baseline of basketball court and ran at maximal speed to the nearest free-throw line (5.8 m), half-court line (14 m), opposite free-throw line (22.2 m), and opposite baseline (28.7 m). The time was recorded by one assistant researcher (coach) using a chronometer. The line drill was performed two times and the best time was considered for further analysis.

The modified T-test was used to determine the agility of the players. It was performed on a basketball court and players covered a total distance of 20 m. Players started with both feet behind the starting line A. Regarding the preference of players, they ran toward cone B and touched it with the right hand. Then, immediately they ran to the left to cone C and touched it with their left hand. Participants then ran to the right to cone D and touched it with the right hand. They ran back to the left to cone B and touched it. Two trials were taken and the best time was considered the score. The reliability of the Modified T-test for women (r=0.79) and men (r=0.75) has been examined in previous studies [18].

For the 20 m sprint test, cones were placed at 0 m, 5 m, 10 m, and 20 m. The players stood behind the start line for 2-3 seconds and ran 20 m as fast as possible in a straight line. The time was recorded by a stopwatch. When the first part of the body of players crossed the 5 m, 10 m, and 20 m, the time was recorded. The test reliability (repeated measurement correlation) has been documented (r=0.85) [19].

Sargent vertical jump height was performed according to the protocol of Harman *et al*. [20]. The Sargent Jump Test is a valid (r=0.99) and reproducible method (r=0.99) for measuring the explosive strength [21]. The vertical vertical jump was initiated with participants standing in an upright position next to the wall and the vertical jump board and using white chalk on the fingertips of the dominant hand. Participants began in a standing position and reached up with their dominant hand and touched the wall as high as possible to leave a mark on the wall, while their feet contacted the floor. The height of the mark from the floor was measured. Then, they stood beside the wall and bent their knees, swung their arms, and jumped straight as high as possible. The height of the highest mark by their extended right hand against the board was recorded. Three trials with at least 1 min interval time were performed and the best jump was recorded. The distance between the low (standing) mark and the highest jumping mark was considered vertical jump height.

The validated BEST test (r=0.81) was performed according to recommended procedures by Scanlan *et al* [12]. Meantime of one round of BEST and total distance covered in a BEST test was recorded. Decline in sprint performance was measured as the percent decrement in sprint times using the mean values across each of the two sprint efforts as (((total time/ideal time) × 100) – 100).

2.4. Statistical Analysis

SPSS software (version 20) was used for data analysis. Mean ± SD was used to describe variables. Normality and homogeneity of variance were assessed by the Kolmogorov Smirnov test and Levene's test respectively. All variables presented a normal distribution. So, a statistical analysis of covariance was used for comparing variables in experimental and control groups by considering their related pretest variables as covariate. Effect sizes were computed using the eta squared test.

3. RESULTS

Demographic characteristics of participants in the two groups of experiment and control have been presented in Table **2**.

Table 2. Anthropometric characteristics of experimental (n=6) and control (n=8) groups.

Group	Variable	Mean	SD
Experimental	Age(year)	25.9	2.1
	Weight(kg)	61.5	9.3
	Height(cm)	167.0	8.5
Control	Age(year)	24.4	1.4
	Weight(kg)	57.4	8.8
	Height(cm)	169.5	8.3

According to ANCOVA analysis, the findings of the study indicated that BEST training induced 71% improvement in aerobic power ($F_{(1,13)}$=35.83, p=0.001), 47% improvement in anaerobic power or line drill test ($F_{(1,13)}$=13.35, p=0.003), 35% improvement in the Sargent vertical jump height ($F_{(1,13)}$=7.05, p=0.020), 88% improvement in mean time of one round of BEST ($F_{(1,13)}$=77.157, p=0.001), 93% improvement in total distance of BEST ($F_{(1,13)}$=41.131, p=0.001), 26% improvement in the agility ($F_{(1,13)}$=4.58, p=0.05). BEST training improved but non-significantly the 20 meter sprint test ($F_{(1,13)}$= 2.593, p=0.313) (16%), and declined sprint performance of BEST ($F_{(1,13)}$=2.352, p=0.135) (20%) (Table **3**).

4. DISCUSSION

This study examined the effect of replacing a part of a basketball conditioning program with simulation-based training during six weeks for aerobic and anaerobic power, Sargent vertical jump, sprint, and BEST performance indices among female basketball players. The main findings of the study indicated that simulation training enhanced aerobic power, anaerobic power or line drill test, Sargent vertical jump, meantime of one round of BEST, total distance of BEST, and agility. In addition, simulation-based training improved – statistically non-significantly–the 20 m sprint test and attenuated the decline in sprint performance of BEST. As previously mentioned, basketball performance is associated with physical fitness dimensions including aerobic capacity, anaerobic power, agility, speed and muscular strength [2 - 4]. Previous studies have indicated the effect of explosive strength training on vertical jumps [20, 22]. In other words, all indices including in the conditioning program, similar to a basketball match, could be considered in the example of simulation-based training. In the present study, during the same training time, simulation-based training could enhance multiple physical fitness dimensions compared to the usual training.

Aerobic capacity is an important fitness component required in basketball performance to run approximately 7.5 km at an intensity of about ~90% of peak heart rate per match [3]. Findings of the study indicated that simulation-based training improved aerobic capacity of female basketball players, which was assessed through the Cooper test. No study was found related to the effect of simulation-based training on aerobic performance. But regarding the effect of circuit training which may be similar to BEST in part, Akilan [23] and Mayorga-Vega *et al*. [24] indicated that circuit training improved aerobic capacity. Simulation-based training can be regarded as game-based training. Gamble [25] found a significant improvement in aerobic fitness following a 9-week game-based training in rugby union players. However, Impellizzeri *et al*. [26] reported no significant difference in maximum oxygen consumption following game-based training

Table 3. Effect of assimilation -based training on physical fitness indices and performance in female basketball players

-	Experimental group			Control group			ANCOVA	
	Pre	Post		Pre	Post		P Value (eta square)	
	M±SD	M±SD	Δ%	M±SD	M±SD	Δ%	Pre	Group
Aerobic power (ml/kg/min)	35.02±3.04	44.15±2.59	26	33.61±1.97	36.99±2.37	10.05	0.011(0.456)	0.001(0.717)
Anaerobic power (sec)	36.20±1.35	34.64±1.28	-4.3	36.23±1.67	35.83±1.45	-1.1	0.01(0.381)	0.009(0.475)
Agility (sec)	8.16±0.55	7.40±0.38	-9.31	7.80±0.35	7.66±0.43	-1.79	0.166(0.167)	0.131(0.195)
Sargent test (cm)	30.00±3.11	32.75±2.37	19.17	32.87±5.86	32.50±5.47	-1.12	0.010(0.418)	0.036(0.342)
Sprint time (sec)	4.12±0.34	3.97±028	-3.64	4.10±0.32	3.97±0.20	-3.17	0.041(0.326)	0.143(0.184)
Mean time of one round of BEST (sec)	26.05±1.05	23.85±1.21	-8.37	27.49±0.87	27.65±0.51	0.58	0.0.28(0.369)	0.001(0.875)
Total distance of BEST (m)	1501.7±54.32	1727.5±0.3200	15.03	1424.8±89.09	1494.4±44.3	4.88	0.56(0.294)	0.001(0.928)
Decline in sprint performance (%)	14.62±5.27	11.75±5.37	-19.63	14.63±2.57	15.711±2.90	7.39	0.831(0.004)	0.124(0.201)

Notes: M: Mean; SD: Standard Deviation; Δ%: % improvement.

and aerobic interval training among junior soccer players. However, Gabbett [27] found similar improvement in aerobic power following game-based training and traditional conditioning among rugby league players. Simulation-based training involves aerobic pathways significantly and its positive effect on aerobic capacity which was found in the present study, was predictable according to the reported relationship between BEST and aerobic fitness [13, 14]. The improvement of aerobic capacity can be attributed to many adaptations in cardiovascular and respiratory systems as well as in muscles which can be clarified in future studies.

The present study showed a significant improvement in the anaerobic performance of female basketball players as a result of simulation-based training. Various studies have evaluated the effect of different training programs on anaerobic performance. However, regarding the similarity of training programs with game-based, circuit, and interval training, the present findings are in line with the findings of Dellal *et al*. (2012) who reported that six weeks of aerobic interval training and game-based training similarly improve the anaerobic capacity in soccer players. Monks *et al*. [28] also reported that 11 sessions of high intensity interval training over four weeks improved anaerobic capacity in Taekwondo athletes. Latzel *et al*. [14] reported that in a basketball exercise simulation, blood lactate increased to ~10mmol· L^{-1}, which is indicative of anaerobic energy system involvement. Thus, simulation-based training could be performed under the condition of a high level of blood lactic acid accumulation and has improved anaerobic performance.

In the present study, simulation-based training improved leg explosive strength which was in agreement with Aschendorf *et al*. [29], who indicated that high-intensity interval training did not improve jumping performance. Also, Howard and Stavrianeas [30] indicated that high intensity interval training improved vertical jump performance in soccer players. Tønnessen *et al*. [31] found that repeated sprints gave a moderate but not statistically marked improvement in counter movement jump. BEST training included jumping and running which might enhance the Sargent jump ability as a result of neuromuscular and physiological improvement [32].

Simulation-based training improved BEST test indices, including the meantime of one round of BEST and total distance covered in BEST for the experimental compared to the control group, but did not significantly affect the decline in sprint performance, which was measured as the percent decrement in sprint times using the mean values across each sprint effort as ((total time/ideal time) 100) – 100).

Regarding the non-significant effect of simulation-based training on the percent of decrement, which is the most reliable and valid method to assess fatigue during repeat-sprint tests [33], it is possible that the duration of training (six weeks) was not sufficient to produce a significant effect. Besides, simulation-based training was not significantly effective on the agility and sprint performance which were measured by the T-test and 20 m sprint test respectively. Agility was not practiced in simulation-based training, which can justify our findings. Simulation training included 6 m sprints, while we measured 20m sprint tests, which may involve different physiological systems. Female basketball players' training background might be an effective factor, and the duration of simulation-based training may also be insufficient to induce a significant effect. However, a recent study indicated that six weeks of unilateral/bilateral polymeric exercise in conjunction with a substantial number of agility exercises could improve agility performance [34]; the contradiction with present findings may be related to the mode of training.

One of the limitations of the study was the small number of participants. Another limitation of the study was the lower level of fitness and anthropometric indices of female professional basketball players compared to international players, which could be the result of limited participation in internal competitions. Thus, the generalization of our findings should be applied with caution to other samples of basketball players. In summary, short duration (six weeks') substitution is a part of traditional conditioning program with simulation-based training, although physically demanding (according to the increasing rate of perceived exertion), improved aerobic, anaerobic capacity, leg explosive strength, and basketball performance test (BEST test indices), but was not effective on agility, sprints or the percent decrement in sprint times.

CONCLUSION

In conclusion, six weeks of simulation-based training could be a conditioning program that enhanced aerobic and anaerobic capacity and leg explosive power, while it was not effective on agility, sprint and fatigue indices. This may emphasize the inclusion of such components besides simulation-based training in conditioning programs or performing simulation-based training for a longer duration.

Regarding the novelty of simulation-based training, further studies would be required to analyze the effect of combining simulation-based training with ball on the performance of basketball-specific skills as well as physical fitness indices. Regarding the increase of perceived exertion in training sessions, future studies would be needed to assess the effect of simulation-based training by reducing the overall volume of conditioning exercises.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Ethical Committee of the Department of Sport Sciences, Shiraz University, Iran.

HUMAN AND ANIMAL RIGHTS

No animals were used in this study. Reported experiments on humans were in accordance with the ethical standards of the committee responsible for human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

CONSENT FOR PUBLICATION

Participants were informed about study procedures and its possible benefits and risks and signed written informed consent.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available by the corresponding author (PN) upon reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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