

Variation of the jump shot accuracy in expert and junior basketball players consequently to different levels of induced fatigue (#20436)

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Justin Keogh / 2 Oct 2017

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Variation of the jump shot accuracy in expert and junior basketball players consequently to different levels of induced fatigue

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Background. In basketball conditioning and related fatigue affect performance. Moreover a maximum accuracy is required while shooting. Aim of the present study was to study the effect of three different levels of fatigue on jump shot accuracy in expert and junior basketball players. **Materials & Methods.** Eleven expert players (age 26 ± 6 yrs, weight 86 ± 11 kg, height 192 ± 8 cm) and ten junior players (age 18 ± 1 yrs, weight 75 ± 12 kg, height 184 ± 9 cm) completed three series of twenty jump shots at three different levels of exertion. Counter Movement Jump (CMJ) height was also measured after each series of jump shots. Increasing fatigue was induced manipulating basketball-specific drills. Heart rate was measured for the whole duration of the tests. **Results.** Heart rate and rating of perceived exertion (RPE) were statistically different in the three conditions for both expert and junior players. CMJ height remained almost unchanged in both groups. Jump shot accuracy decreased with increasing fatigue both in experts and junior players. Expert players showed higher accuracy than junior players for all the three levels of fatigue (83% vs 64%, $p < 0.001$; 75% vs 57%, $p < 0.05$; 76% vs 60%, $p < 0.01$). Moreover, for the most demanding level of fatigue, experts showed a higher accuracy in the last ten shots compared to the first ten shots (82% vs 70%, $p < 0.05$). **Discussion.** Experts coped better with different levels of exertion, thus maintaining a higher level of performance. The introduction of technical short bouts of high-intensity sport-specific exercises into skill sessions should be proposed to improve jump shot accuracy during matches.

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16 **Abstract**

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34 exercises into skill sessions should be proposed to improve jump shot accuracy during matches.

35 **Keywords:** sport performance; shot accuracy; level of exertion; technical drills

Introduction

Basketball is a common sport where conditioning and related fatigue affect performance (Erculj & Supej, 2009). Very severe physiological requirements are associated with this sport, with mean heart rate during live time of 169 ± 9 beats per minute and mean blood lactate concentration of 6.8 ± 2.8 mmol L⁻¹ (McInnes, Carlson, Jones, & McKenna, 1995). Together with a high level of fitness, a maximum accuracy is required while performing specific motor tasks such as shooting at a target (Erculj & Supej, 2009). Due to these specific characteristics several studies analyzed the effect of fatigue on several aspects of basketball. Ahmed (Ahmed, 2013) investigated the effect of upper extremity fatigue on grip strength and passing accuracy, showing a significant decrease of both these variables after a fatigue protocol. Similarly, it has been showed a detriment in the passing performance in novice and expert basketball players following a high intensity total body fatigue protocol (Lyons, Al-Nakeeb, & Nevill, 2006). The effect of fatigue on 3 points-shooting has been investigated from a biomechanical point of view analyzing the position of the release arm and shoulder girdle showing that all the measured angles decreased drastically as a consequence of the heavy level of fatigue (Erculj & Supej, 2009). Three points-shooting accuracy has also been investigated after two different resistance circuit training protocols showing a worsening only after the most intensive protocol (Freitas, Calleja-González, Alarcón, & Alcaraz Ramón, 2015). Conversely, free throw shooting analysis demonstrated that fatigue did not affect kinematics and that shooting technique was the same considering successful and unsuccessful shots (Uygur, Goktepe, Ak, Karabörk, & Korkusuz, 2010). Similarly repeated sprint test performance indices remained unchanged or even improved after half time and after the end of the game in comparison with the same indices performed after the warm up (Meckel, Gottlieb, & Eliakim, 2009). In the evaluation of fatigue on sport skill performance, it has been showed that a key point is the employment of sport-specific methods to induce fatigue (P. R. Davey, Thorpe, & Williams, 2002; P. Davey, Thorpe, & Williams, 2003;

Vergauwen, Spaepen, Lefevre, & Hespel, 1998). To the best of our knowledge, while in water polo (Royal et al., 2006), tennis (Lyons, Al-Nakeeb, Hankey, & Nevill, 2013) and soccer (Rampinini et al., 2008) accuracy was evaluated employing these sport-specific methods, in basketball the effect of fatigue on passing (Ahmed, 2013; Lyons et al., 2006) and shooting (Freitas et al., 2015) accuracy was quantified after standard strength training exercises. Therefore the purpose of the present study was to analyze the effect of three different levels of fatigue induced with sport-specific methods on the jump shot accuracy and jump height of expert and junior basketball players. Our hypothesis was that fatigue could induce in both groups a decrease of the accuracy and of the jump height as exertion increased. Moreover we expected expert players to better cope with fatigue with respect to junior players because of their higher level of expertise.

Materials & Methods

Participants

Twenty-one basketball players divided in two groups volunteered in the study. The first group included 11 expert players (age 26 ± 6 yrs, weight 86 ± 11 kg, height 192 ± 8 cm) and the second 10 junior players (age 18 ± 1 yrs, weight 75 ± 12 kg, height 184 ± 9 cm). Experts trained four times per week while junior players three times. Inclusion criteria included at least 10 years of competitive basketball experience for expert players and 5 years for junior players, regular participation to official matches and lack of any muscle and tendon pathologies to upper and lower limbs at the time of the study. A detailed description of the experimental procedures was given to each participant which provided an informed consent prior to testing. The study was approved by the ethical committee of the Department of Biomedical Sciences, University of Padova (HEC-DSB11/16).

84 *Experimental protocol*

85 Each participant was asked to perform three series of twenty jump shots at three different
86 levels of fatigue. A 15 minutes standardized warm up, consisting in 10 minutes of aerobic
87 conditioning and 5 minutes of free shots, took place before the three series of jump shots. In the
88 low intensity fatigue protocol (LIFP) the participant stayed with feet on the free throw line,
89 received the ball from a teammate positioned under the basket, and performed the jump shot. The
90 teammate proved to regain the ball to perform the successive pass. This procedure was repeated
91 until the twenty jump shots were completed. In the moderate intensity fatigue protocol (MIFP)
92 each participant started the series from the half-court line. Then he had to run slowly to one of the
93 two cones placed on the 3 point line, by the side of the extension of the long sides of the 3
94 seconds area. After reaching the cone he performed a side cutting maneuver towards the free
95 throw line where he received the ball from a teammate and performed the jump shot.
96 Subsequently the participant had to return to the half-court line walking and started again. This
97 course was repeated until the twenty jump shots were completed. Unlike the moderate intensity,
98 in the high intensity fatigue protocol (HIFP) participants had to sprint towards the cone and, after
99 the side cutting maneuver, towards the free throw line. The return to the half-court line was done
100 half walking and half slowly running. In both moderate and high intensity fatigue protocols each
101 participant had to choose one of the two cones and then perform the side cutting maneuver
102 always on that for all the trials. The rest among the three series was set to 4 minutes. Before the
103 beginning of the first series of jump shots and immediately after the moderate and high intensity
104 series three counter movement jumps (CMJ) were collected for each athlete by means of a Bosco
105 conductance mat (Globus Italia, Treviso, Italy) which estimates the height of the jump measuring
106 the fly time. For the whole duration of the tests participants wore a chest band which recorded the
107 heart rate at a sampling rate of 1 Hz (Garmin, Kansas City, USA). In order to calculate Karvonen
108 heart rate reserve (%HRR) (Karvonen, Kentala, & Mustala, 1957) at each level of fatigue, resting

heart rate was assessed by each participant when they woke up in the morning for the two days prior the tests. At the end of each set of shots the rating of perceived exertion (RPE) was recorded by means of a 6-20 Borg scale (Haile, Gallagher, & Robertson, 2015). A schematic of the experimental setup is reported in figure 1.

Statistical analysis

One way repeated measurements analysis of variance (ANOVA) was used to compare the three levels of fatigue. Significant level was set at $p < 0.05$. If the statistically level was reached, Tukey's multiple comparison test was employed. Unpaired t-test was used to compare expert and junior players at every level of induced fatigue. Data analysis was performed with the software package GraphPad Prism version 4.00 for Windows (GraphPad Software, San Diego California USA). Statistical effect size was calculated with the G*Power 3.1.5 software (Faul, Erdfelder, Lang, & Buchner, 2007).

Results

Significant differences among the level of fatigue reached during the three set of jump shots for the two groups of athletes were reported by the statistical analysis (Table 1). Among experts, heart rate values were lower in LIFP with respect to MIFP ($p < 0.01$, ES: 1.00) and HIFP ($p < 0.01$, ES: 3.06) and the rate of perceived exertion was lower in LIFP with respect to MIFP ($p < 0.01$, ES: 1.50) and HIFP ($p < 0.01$, ES: 4.00). Among junior players, heart rate values were lower in LIFP with respect to MIFP ($p < 0.01$, ES: 0.75) and HIFP ($p < 0.01$, ES: 2.19) and the rate of perceived exertion was lower in LIFP with respect to MIFP ($p < 0.05$, ES: 1.09) and HIFP ($p < 0.01$, ES: 3.56). Shot accuracy of expert players was 83% (LIFP), 75% (MIFP) and 76% (HIFP), while for the group of junior players it was 64% (LIFP), 57% (MIFP), 60% (HIFP). Conversely, jump height was very similar for junior players and expert players (Table 1). Moreover, a statistically significant increase of expert players' jump height after HIFP with

respect to warm up was found ($p < 0.01$; $ES = 0.58$). The analysis of jump shot accuracy between expert and junior players revealed a better proficiency among expert players at every level of induced fatigue (LIFP: $p < 0.001$, $ES: 1.74$; MIFP: $p < 0.05$, $ES: 1.03$; HIFP: $p < 0.01$, $ES: 1.37$), as reported in figure 2. A further analysis compared the effect of the induced fatigue protocols on jump shot accuracy of the first ten shots with the last ten shots. Expert players showed a decrease of accuracy only between LIFP and HIFP ($p < 0.05$, $ES: 1.03$) while junior players showed no statistically significant differences in the first ten shots. On the other hand, variation of the accuracy of the last ten shots was not statistically significant neither in expert nor in junior players. Moreover, expert players showed a higher accuracy comparing the second ten shots with the first ten shots only in the HIFP condition ($p < 0.05$, $ES: 0.73$). No statistically significant differences were detected among junior players. All the results relative to the first and to the last ten shots for both groups are reported in Table 2.

Discussion

To assess the effect of fatigue on sport-specific skills it is essential to employ sport-specific protocols for an ecological validity of the experimental results (Lyons et al., 2006; Royal et al., 2006). In the present study three different levels of fatigue (LIFP, MIFP and HIFP) were induced by means of basketball drills such as sprinting, cutting maneuvers and passes allowing to investigate jump shot accuracy in expert and junior players. A decrease in shot accuracy was detected for both groups according with previous investigations on technical skills deterioration as a consequence of fatigue (Freitas et al., 2015; Lyons et al., 2006; Rampinini et al., 2008). Conversely, the results of the present study showed no differences in jump height after the three fatigue protocols. Similar results were obtained investigating repeated sprint tests at different game stages (Meckel et al., 2009). Since a **contribute** to the proficiency of jump shot is the capacity of releasing the ball as high as possible (Struzik, Pietraszewski, & Zawadzki, 2014), our

results seem to suggest that sport specific fatigue protocols had a negligible effect on jump height while at the same time they negatively influenced shoulder and wrist height of the release arm (Erculj & Supej, 2009).

Our jump shot accuracy results supported the suggestion of training at level of exertion similar to those recorded during competitive games (Erculj & Supej, 2009; Freitas et al., 2015; Lyons et al., 2013, 2006) together with the recommendation to employ sport-specific drills to increase the level of fatigue (Lyons et al., 2006; Royal et al., 2006). The decrease in jump shot accuracy was indeed more marked for both groups comparing LIFP with HIFP rather than MIFP compared to HIFP. Thus, an increased number of high intensity skill sessions should aim to improve the shot accuracy at those levels of exertion representative of a match. However, during the introduction of these technical short bouts of high-intensity exercise into skill sessions the technique should be monitored to assure a correct execution (Lyons et al., 2013).

The comparison between expert and young players showed a higher accuracy in the expert group for each level of fatigue. Our results are in agreement with previous investigations on basketball (Lyons et al., 2006) and tennis (Lyons et al., 2013), showing how expert players can cope better with higher levels of exertion, thus maintaining a higher level of performance. This could be due to the fact that technical and motor patterns are strongly formed in experts and that they can adjust motor coordination strategies as a reaction to induced fatigue better than young players (Aune, Ingvaldsen, & Ettema, 2008). Therefore it is clear again how with young players the introduction of technical short bouts of high-intensity exercise into skill sessions should be carefully **proposed** to avoid technique alterations as much as possible (Lyons et al., 2013).

An additional interesting point relative to HIFP is the higher shot accuracy recorded by experts players in the last ten shots with respect to that recorded in the first ten shots. Since athletes begin the HIFP bout after a 4-minute recovery (see figure 1), only in the second part of

the bout heart rate values were similar to those recorded in a real match (Erculj & Supej, 2009). In fact expert player mean heart rate was 143 ± 9 beats·min⁻¹ during the first ten shots and 165 ± 9 beats·min⁻¹ in the last ten shots. This condition, together with the employment of basketball-specific tasks to regulate fatigue, could have created sensory states similar to those experienced in contest inducing participants to use the same processes responsible for their expertise in match-play (Royal et al., 2006). For the same reason junior players could have maintained their shot accuracy in the last ten shots in comparison with that recorded in the first ten shots. In fact their mean heart rate was 153 ± 10 beats·min⁻¹ and 176 ± 8 beats·min⁻¹ during the first and the last ten shots respectively. To this extent, we can hypothesize that in the last ten shots of HIFP the decrease of shot proficiency due to their lower ability in coping with high level of fatigue was counterbalanced by the sensory states typical of a match-play they experienced.

On this point an additional aspect deserves consideration. Previous literature (Meckel et al., 2009) reported that an intensive warm up is needed to increase repeated sprint performance at the initial phases of the match. Our findings on the accuracy during HIFP, comparing the first ten shots with the second ten shots, are in agreement with this theory. When heart rate was stabilized at a high value, accuracy increased in experts and stayed constant in junior players. Therefore, an intensive warm-up could be useful to activate a game-specific arousal since the initial phases of the match. Moreover short intensive exercises could be proposed for the cases in which a player comes off the bench to reactivate this game-specific arousal entering in the court.

Conclusions

Our study showed how expert basketball players coped better with different levels of exertion with respect to junior players, thus maintaining a higher level of jump shot proficiency. Moreover, experts players showed at HIFP the best shot accuracy when heart rate was high in the last ten shots. This high level of fatigue together with the employment of sport specific drills

could have induced participants to activate during training the same processes responsible for their expertise in real match-play. Therefore our findings could be of practical interest for coaches to improve the efficacy of technical skill sessions during training and warm up before matches. However the introduction of these high-intensity technical exercises into skill sessions should be carefully monitored since it is fundamental to avoid technique alterations. Thus, further studies are required to investigate different fatigue sport-specific protocols and their effectiveness in activate game-specific arousal on athletes with distinct level of expertise without altering the technical execution of the jump shot.

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271 **Figure captions**

272 **Figure 1.** Schematic representation of the experimental protocol.

273 **Figure 2.** Baskets scored: comparison between experts and young players for the three different
 274 levels of fatigue (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

Figure 1

Experimental protocol

Schematic representation of the experimental protocol

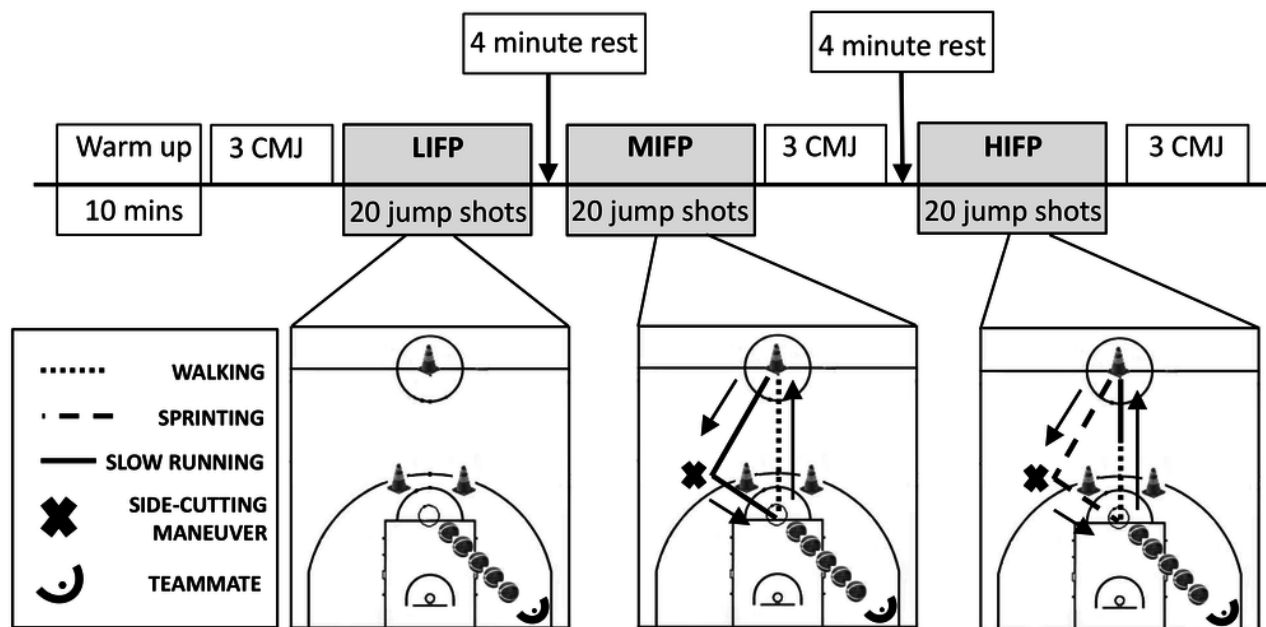


Figure 2

Jump shoot accuracy score

Baskets scored: comparison between experts and young players for the three different levels of fatigue (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

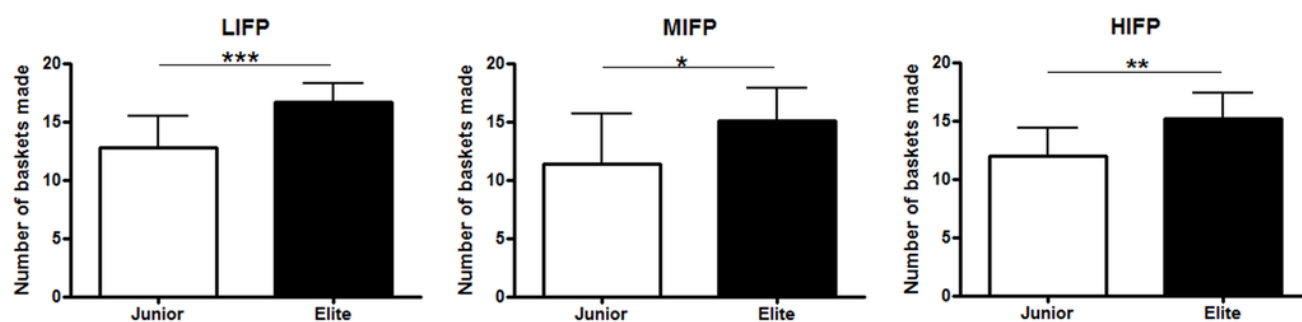


Table 1(on next page)

Heart rate, rate of perceived exertion (RPE), jump shot accuracy and jump height data.

Heart rate, rate of perceived exertion (RPE), jump shot accuracy and jump height recorded immediately after each fatigue protocol. Data are presented as mean $\pm$ s. For both groups: * different from low intensity fatigue protocol (LIFP); § different from moderate intensity fatigue protocol (MIFP).

	Fatigue protocol		
	LIFP	MIFP	HIFP
Heart Rate (beats · min⁻¹)			
Expert players	116 ± 14	129 ± 11*	154 ± 9*§
Junior players	134 ± 16	145 ± 11*	165 ± 9*§
Karvonen Heart Rate reserve (%)			
Expert players	47 ± 9	57 ± 7*	75 ± 5*§
Junior players	57 ± 12	65 ± 9*	79 ± 7*§
Rating of Percived Exertion (6-20)			
Expert players	8 ± 1.5	10.2 ± 1.3*	13.5 ± 1.1*§
Junior players	9.8 ± 1.3	11.2 ± 1.2*	14.4 ± 1.3*§
Jump shot accuracy (baskets made)			
Expert players	16.6 ± 1.6	15.1 ± 2.8	15.2 ± 2.2
Junior players	12.8 ± 2.7	11.4 ± 4.2	12 ± 2.4
Jump height (cm)			
Expert players	49.1 ± 3.4	49.8 ± 3.5	50.9 ± 2.8*
Junior players	46.1 ± 2.1	47.7 ± 3.8	46.9 ± 3.4

Table 2 (on next page)

Expert and Junior shoot performance

Baskets scored for each level of induced fatigue. Experts: * Different from 1-10 series

Series of shot	LIFP		MIFP		HIFP	
	1-10	11-20	1-10	11-20	1-10	11-20
Groups						
Expert players	8.5 ± 1	8.1 ± 1.1	7.6 ± 1.7	7.5 ± 1.7	7 ± 1.8	$8.2 \pm 0.6^*$
Junior players	6.3 ± 2	6.5 ± 1.6	5.5 ± 2.4	5.9 ± 2.2	5.9 ± 1.3	6.1 ± 1.5