EFFECT OF FATIGUE ON BASKETBALL THREE POINTS SHOT KINEMATICS

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The purpose of this study was to measure the effect of fatigue on basketball shooting kinematics. Young elite players (n=8) were included in the study. Maximal and minimal 3D joint angles, at maximum and minimum centre of mass height were measured with inertial sensors (Moven Biomech, Xsens). Each player performed four 3 points shot (3PS) in dynamic conditions before and after a submaximal exercise (70% of maximal exhausting). This exercise consisted in a repetition of 20-meters sprints with 5 jumps between each sprint. Results showed that fatigue decreased hip joint angle and increased shoulder joint angle when the center of mass was at its lowest point. These biomechanical modifications did not alter the precision of shooting. This study demonstrated that fatigue has small effect on kinematics and precision of the 3PS.

KEY WORDS: Team Sport, biomechanics, elite.

INTRODUCTION: Basketball is a game that requires qualities of speed, acceleration, change of direction and precision. Many actions are executed and repeated at high intensity, which induces fatigue of the player (Ben Abdelkrim et al., 2010). The modification of the rules in the year 2000, particularly the reduction the offensive time from 30 at 24 seconds, increases the physiological load on the athletes. Fatigue plays a central role in competition and can determine the outcome of a match (Lyons, Al-Nakeeb, & Neville, 2006). The recent studies of Padulo et al. (2014) confirmed these results by showing that at 80% of the maximum heart rate, the three points shot (3PS) accuracy decreased significantly by more than 20%. The 3PS has a particular importance because it represents 16 % of points marked during a match (Guo, Deng & Zhang, 2004). Fatigue could thus particularly decrease the efficiency of the players in the 3PS and modify the outcome of the game. Although fatigue is an important element in basketball games, few studies have analysed its effects on the degradation of biomechanical parameters of the 3PS (Erculj & Supej, 2009; Uygur, Goktepe, Ak, Karabörk, & Korkusuz, 2010). These studies used 3D video analysis and showed contradictory results. Erculj & Supej (2009) found significant effect of fatigue on maximal height of the centre of mass and on the shoulder and elbow joint angles whereas Uygur et al. (2010) did not find any effect. To complete these works, the purpose of the present study was to measure the impact of fatigue in basketball 3PS kinematics and precision.

METHODS: The population was composed of 8 young athletes (4 men and 4 women) belonging to the pole basketball of the National Institute of Sport and Expertise (age: 16.3 ± 1.2 years, mass: 76 ± 12.2 kg, height: 1.90 ± 0.13 m.). The protocol consisted in four steps : 1) On a first day, one exhausting exercise (ExEx) was performed. The player had to perform repetitions of 20 m sprints immediately followed by five consecutive vertical jumps between each sprints (Uygur et al. 2010). The participants were instructed to accelerate/decelerate as fast as possible during the sprints and to jump as high as possible until exhaustion. The time of exhaustion (T_{ExEx}) and the heart rate (HR_{EX}) where measured (Suunto T6). 2) On a second day, four 3PS in dynamic conditions were realised. The played ran a few step, received the ball and shot at a distance of 7.24 m. 3) Then, the player completed again the ExEx only until he reached 70% of T_{ExEx} ($T_{ExEx70\%}$). 4) Four 3PS in dynamic conditions were realised. The 3PS accuracy was measured (%3PS). Except during the ExEx, the players were equipped with 17 wearable inertial motion sensors (Biomech, Xsens, Enschede, The Nederland). First, the maximal and minimal position and velocity of the centre of mass (CM) were identified. Then, the flexion/extension angles of the ankle, knee, hip, shoulder, elbow and wrist joints on the side of the shooter (figure 1) were computed from the time when the

CM is at its lowest position to the time when the CM is at its highest position (figure 2). We used a student T test to compare pre and post fatigue states. Significance level was set at $p \leq 0.05$.

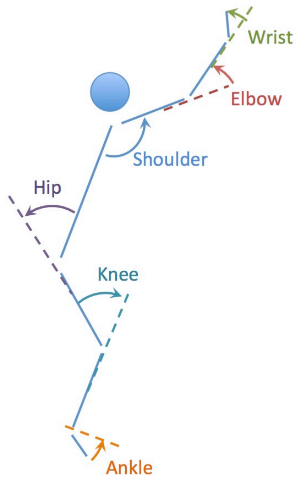

Figure 1: Joint angle orientation for the flexion/extension.

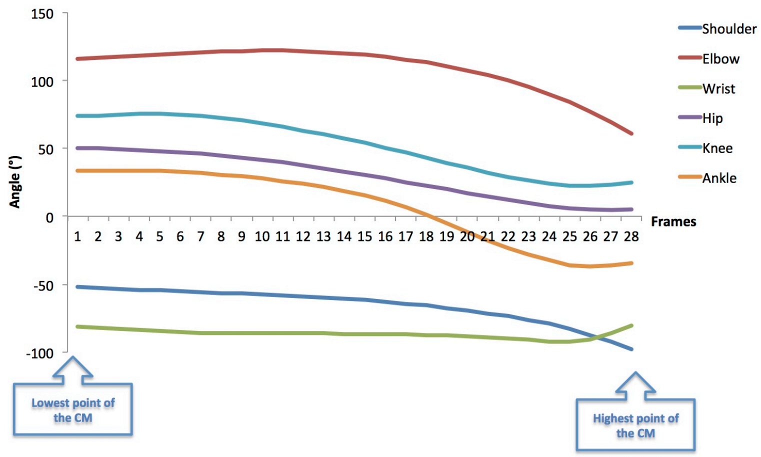

Figure 2: Typical example of the variation of the different joint angles measured between the lowest and highest point of the CM in non-fatigue conditions.

RESULTS: The average T_{ExEx} was 142.8 ± 62.6 s and HR_{EX} was 182.1 ± 9.4 bpm. The average $T_{ExEx70\%}$ was 99.7 ± 43.9 s, the HR was 179.1 ± 8.4 bpm and represented respectively 70% of T_{ExEx} and 98% of HR_{EX}. Results showed that fatigue has no effect on %3PS (43.7 ± 21.6 % vs 41.4 ± 18.9 %; p = 0.8). Fatigue has no effect on maximal position or velocity of the CM (0.147 ± 0.031 m vs 0.135 ± 0.026 m; p = 0.52 and 2.34 ± 0.30 $m.s^{-1}$ vs 2.56 ± 0.44 $m.s^{-1}$; p = 0.09). Effects of fatigue on the different joint angles are presented in table 1. Fatigue decreased hip joint angle and increased shoulder joint angles when the CM was at its lowest point.

Table 1 : Difference between pre and post exhausting exercise (PreExEx and PostEXEx) for the different maximal and minimal joint angles on the flex/ext axis (*Significantly different from PreExEx ; p ≤ 0.05)

	Pre ExEx (Max flex/ext) *Mean (±SD)*	Post ExEx (Max flex/ext) *Mean (±SD)*	Pre ExEx (Min flex/ext) *Mean (±SD)*	Post ExEx (Min flex/ext) *Mean (±SD)*
Ankle (°)	28.7 ± 9.2	31.7 ± 8.8	-15.3 ± 22.3	-17.6 ± 20.3
Knee (°)	84.4 ± 5.8	85.5 ± 9.2	39.2 ± 30.2	32.4 ± 21.2
Hip (°)	52.2 ± 12.0	50.0 ± 11.9*	13.6 ± 19.1	11.9 ± 14.8
Shoulder (°)	-43.7 ± 16.5	-39.3 ± 17.1*	-84.7 ± 26.8	-88.1 ± 27.2
Elbow (°)	114.2 ± 15.0	114.4 ± 13.4	76.9 ± 29.2	73.5 ± 30.7
Wrist (°)	-32.4 ± 17.2	-21.0 ± 31.8	-66.3 ± 13.3	-78.2 ± 27.1

DISCUSSION: The present results demonstrated that fatigue decreased hip joint angle and increased shoulder joint angle when the CM is at its lowest point. However the precision of the 3PS was not influenced by these biomechanical modifications. Erculj & Supej (2009) demonstrated a significant decrease in jump height, a decrease of the elbow joint angle and an increase of the shoulder joint angle with fatigue. In the present study, we only observed the same results for the increase of the shoulder joint angle. No modification of jump height or elbow angle was observed. Three main hypotheses can explain these differences. The first one concerned the time at which the different biomechanical parameters were recorded.

Erculj & Supej (2009) focused their analysis ±60 ms from the release point and Uygur et al. (2010) analyzed 3 different frames: the ball release point, and 83.3 ms (5 frames) before and after the ball release point. In the present study, the release point could not be precisely identified with the sole use of the wearable inertial motion sensors and we analyzed the highest and lowest position of the CM. Thus biomechanical analysis was not performed at the same time of the movement between different studies. The second hypothesis concerned the level of the fatigue of the players. We used a protocol of fatigue similar to Uygur et al. (2010). This protocol leaded the players to reach around 88% of their theoretical maximal HR (220-age). The protocol of fatigue used by Erculj & Supej (2009) (6 series of 8 x 10s sprint, change direction and shoots) allowed the player to reach 97% of his theoretical maximal HR. Thus, a more fatiguing protocol may lead to greater biomechanical modifications. However such protocol does not represent the real fatigue induced by a match. Finally the third hypothesis is the accuracy of the wearable inertial motion sensors. Indeed, to date, only two studies have explored the accuracy of the 17 inertial sensors provided by Xsens (Cloete & Scheffer, 2010; Dinu, Bidiugan, Natta, & Houel, 2012). Rather good repeatability, the transverse and frontal plane joint angles values were moderately accurate. More data need to be collected from wearable inertial motion sensors to examine the accuracy of such systems.

CONCLUSION: The present study demonstrated that fatigue modifies the kinematics of the three points shot. These modifications depend on the time at which the different biomechanical parameters were recorded and on the degree of fatigue of the player.

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