KINEMATICS IN BASKETBALL SHOOTING: THE INFLUENCE OF BASKET HEIGHT AND BALL SIZE & WEIGHT

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INTRODUCTION

Satern et al. (1989) studied the influence of basket height and ball size on the mechanics of shooting, with thirteen-year-old basketball players. After selecting a group of six kinematics parameters at the instant ball release of analyzing the displacement of the center of gravity and the shooters body slant, the obtained results were compared for every imposed contextual condition. No significant distinctions were found among the mechanical characteristics of shooting when compared to the two ball sizes involved in this study. Satern et al. (1989) suggested that basketheight can cause some biomechanical alterations on technical characteristics of the motion in youngsters of this age. Ferreira and Barata (1996), by focusing on analyzing shooting results as a function of the basket height, confirmed thefindings of Satern et al. (1989).

Inspired by the experimental paradigm proposed by Satern et al. (1989), Ferreira, Fernandes, and Abrantes (1996) searched to conduct a kinematic analysis on shooting as a function of ball sizelweight. Six kinematic parameters were selected at ball realease time and three stability parameters related to the position of the center of gravity and the performer's support surface. Although slight differences were found in every parameter studied, the possibility of verifying less efficiency on energy transfer to the biggest and heaviest ball is suggested. When using a regular ball, a tendency for a greater horizontal center of gravity displacement was found.

As the starting point, a model of a technical shooting in basketball was used. The goal of the study was to analyse the kinematics of performing the skill, restricted to two independant condtions: basket height and ball sizelweight.

METHODS

Ten young, right-handed basketball players were the subjects in this study, all representing the district team from Sehibal belonging to the Sehibal Basketball Association. All subjects were born in 1982, representing 14 year old players and played in the beginners team during the 95/96 season. The average height of the subjects was 162.1 cm (+/- 10.9) and an average weight of 52.4 Kg (+/- 10.9). Each subject performed a series of 20 free throws in each contextual condition created.

Two basket heights were considered: the designated regular height (BKRH) at 3.05 metres and an adapted height (BKAH) only measuring 2.80 metres. Two ball sizes were used: the regular size ball (BLRS), a NBA *Spalding Official* with 613 gr. and 76.5 cm; and an adapted-size ball (BLAS) referenced as a Mikasa *Official 1110*, with a weight of 608 gr. and perimeter of 74 cm. Video images were obtained for all the free throws performed by each subject. A total of 113 free throws were digitalized. The digitalizing process was done with a 2D analysis system named BIOSIST, designed by Femandes, Anes & Abrantes (1996).

In function of the time intervals that each parameter were taken, we define two distinct type of parameters: the designated instantaneous kinematic parametres (IKP), which time interval have the tendency to be null; the behaviour kinematic parametres (BKP), which have a well defined time interval limit in which they occur. The selected IKP, obtained at the time of ball realease, were the following: linear shooting-hand velocity (LSHV), shooting-hand height (SHH), angle formed between the shooting hand and the horizontal plane that passes through the centre of gravity (ANG HS), hand/forearm angle (ANG H/F), forearm/upper arm angle (ANG F/U), upper arm/trunk angle (ANG U/T), trunk/thigh angle (ANG T/T), thigh/lower leg angle (ANG T/L), angle formed between the trunk and the transversal plane (ANG T/H). The BKP variables were selected consistantly on the analysis of the behaviour of the centre of gravity (CG) of the participant in each of its planes: horizontal plane (CGX) and the vertical plane (CGY). For comparative analysis, IKP results were submitted to the parametric statisical comparison technique of Anova - One Way.

RESULTS

Table 1.

Values of average. standard deviation and probability of error associated with Anova - One Way for each IKP.

	BKAH		BKRH		P	BLAS		BLRS		P
LSHV (ms^{-1})	2.77	(+/-0.27)	3.08	(+/-0 35)	0.024 **S**	2.91	(+/-0.33)	2.94	(+/-0.29)	0.839 **NS**
ANG HS (°)	43.54	(+/-2.44)	43 33	(+/-2.27)	0 833 **NS**	43.97	(+/-2.50)	42.91	(+/-2.21)	0.296 **NS**
SHH (m)	1.78	(+/-0.15)	1.64	(+/-0.13)	0.025 **S**	1.71	(+/-0 13)	1.70	(+/-0.14)	0.857 **NS**
ANG HIF (°)	115.85	(+/-9.17)	118.53	(+/-8.84)	0.497 **NS**	117 03	(+/-8.27)	117.35	(+/-9.74)	0.932 **NS**
ANG FIU (°)	119.68	(+/-8.31)	117.21	(+/-8.42)	0.472 **NS**	119.79	(+/-6.90)	117.10	(+/-9.83)	0.404 **NS**
ANG U/T (°)	97.32	(+/-8.33)	96.55	(+/-9.14)	0.835 **NS**	98.66	(+/-8.69)	95.22	(+/-[illegible] 78)	0.368 **NS**
ANG T/T (°)	169.69	(+/-7 79)	170.96	(+/-5.26)	0.648 **NS**	170.62	(+/-[illegible] 84)	170.03	(+/-6.21)	0 806 **NS**
ANG T/L (°)	154.67	(+/-9.14)	157 43	(+/-7.37)	0.422 **NS**	156.73	(+/-7.53)	155 37	(+/-8.98)	0.678 **NS**
ANG T/H (°)	84.74	(+/-3.82)	86.21	(+/-3 13)	0.334 **NS**	85.25	(+/-3.68)	85.69	(+/-3.27)	0.761 **NS**

The most evident aspects demonstrated in Table 1 are the results obtained by the comparison between both basket heights. While in BKAH, the shooting hand reaches, on the average,a linear speed of 2.77(0.27) m/s at ball release, in BKRH values, the velocity reached about 3.08 m/s. The opposite happens with SHH, that'determines the position of the working point, in terms of its height at ball release instant. A difference of 0.14 m is observed in every dimension of the variable. The parameter ANG HS has an identical result, either in BKAH or in BKRH. The differences registered in LSHV and SHH appear, in fact, in a significant manner. The f- values obtained were 5.991 and 5.972, both associated with an error probability of 0.02 ($p \leq 0.02$). This fact allows us to suggest that the adaptation of the basket height can establish a condition for the young subjects to shoot, placing the ball at a higher point and promoting a degraded linear speed to the shooting hand at ball release.

Relative to the ball size/weight, the results revealed the nonexistance of significant differences in all parameters related to the shooting hand. In fact, the values obtained for LSHV, ANG HS and SHH, appear very similar.

The results found for ANG U/T, ANG F/U and ANG H/F, suggest that in BKAH, each segment of the shooting member intervened in a greater angular amplitude, during the execution of the shot. Although small, these slight differences should have implications on quality and quantity of intersegmented energy transfered to the ball, reflecting on the characteristics of its trajectory. In this way, perhaps this is one of the reasons that justifies a greater SHH and lower LSHV registered for the shooting hand in BKAH.

The parameters that relate the trunk with the lower members at ball release, point to the fact that in BKAH the trunk was in a more vertical position, being however, slightly flexed over the lower member. The values of ANG **T/H** and of ANG **T/T** for each of the basket heights, are examples of this fact. This may indicate that in BKAH the trunk rolls in the process of intersegment transfer, can be more reduced than in BKRH. With this last basket height the trunk must increase its participation, due to the exisence of the required ball trajectory to move to a target that is found at a higher position.

From the analysis of the group of intersegment angles determined at ball release, we observed that the performance of the shot does not differ significantly relative to the ball **sizes/weights.** The values associated to the angles **ANG F/U** and ANG **U/T** reveal the largest differences. These values suggest that the size of BLAS allows a greater extention and elevation of the shooting hand at the instant of this analysis. Conversely, shooting with the heavier and diametrically greater ball does not allow the task to be facilitated. As in ANG **F/U,** the angle ANG **T/L** reveals the same tendency. In fact, the execution of BLAS allows a greater aperture of the thigh relatively to the lower leg, that might indicate that the intervention of the lower members could be more effective.

Figures 1 and 2 reveal the character of behaviour of the CG in both horizontal and vertical planes, respectively, analysed relative to the basket height.

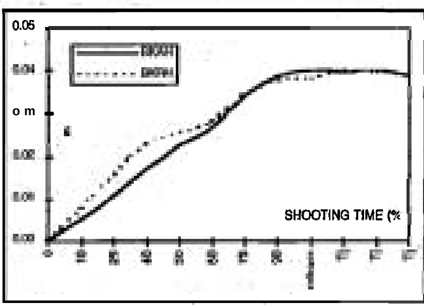

Figure 1

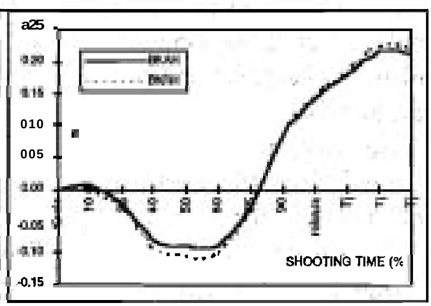

Figure 2

In the horizontal plane (Figure 1), the displacement of the CG relatively to its initial position increases progressively in the positive direction (forward), from the prepation phase until the instant of ball release. From this, a tendency is noticed for the maintenance of this position until the end of shot. From the comparison of the curves a slight irregularity was noticed in the course of BKAH, not only in the preparing phase, but also immediately before release of the ball. After an initial period of advance of the CG, a slight withdrawal was noticed at about 40% from the beginning of the execution, also occurring at the same time as the final phase of propulsion. In the vertical plane the behaviour of the CG was characterized by the definite lowering in the preparing phase, so that in the propulsive phase it registered a progressive elevation up to the time when the ball is released, extending itself to the final phase of the execution. The analysis of Figure 2 revealed a similar courseof the displacement of the CG of the particpant for both basket heights. However, in the BKRH condition, participants displayed a lower CG. On average, the minimum values obtained in BKAM and BKRH are, respectively, -0.10 (0.07) and -0.12 (0.07) m. This means that the BKAH doesn't cause such a large lowering of the CG of the shooter, to obtain the same values of elevation at the time of ball release. At around 70% from the beginning of the shot, we notice the intersection of both curves.

The figures below (3 and 4) demonstrate the horizontal and vertical behavior of the CG relative to sizes and weights of the balls.

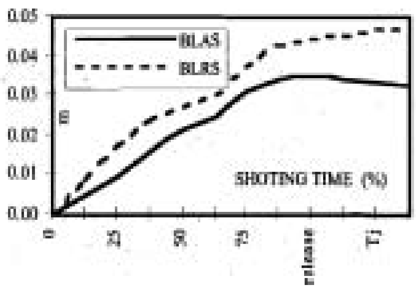

Figure 3

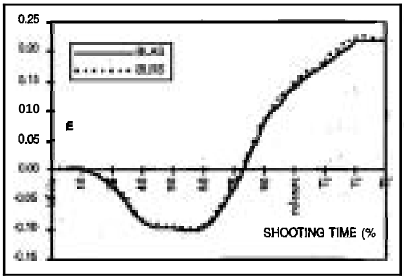

Figure 4

The characteristics of the ball size/weight seemed to introduce slight differences in how the CG of the participant behaved in the horizontal plane. In fact, the observation of Figure 3, allows us to state that the BLRS promotes a greater mobility of the CGX, relative to its initial position during the execution. When we previuosly searched to verify the influence of basket height, we concluded that the horizontal displacement of the CG presented a slight distinction in the preparation phase of the shot. The propulsive phase and initial phase seemed to present a similar pattern of behavior. Conversely, the influence of ball sizelweight seems to prolong the execution time, The analysis of the behavior of CGX, in this case, demonstrates that the differences that BLRS and BLAS promote increase as the execution reaches its terminus. Contrary to the horizontal plane, the vertical displacement of CG does not seem to be influenced by the ball sizelweight. We can observe from Figure 4, that during the execution, the distance that the CG of the participant, holds steady relative to its initial position and is unaffected by the ball's characeristics.

CONCLUSIONS

As a result of this study, it is possible to make the following conclusions:

- the characteristics of the shot towards a regular basket height, independent from the ball sizelweight, imposes the necessity of theparticipants to increase the speed of their shooting hand and to release the ball at a lower height.

- the relative positions between the diverse body segments, measured at ball release, suggest the tendency for the participants, when confronted with the adapted conditions of basket height or ball sizelweight, to produce a gesture more compatible to the basic principles of execution.

- any contextual combination of basket height or ball sizelweightprovided the participants stable conditions more closely related to the desired conditions in from the reference models of the execution of the shot.

- in a general form, more than the adaption to the ball sizelweight, the adaption to the height of the basket could generate, in the participants of this age, the production of a pattern of shooting more closely related to the models of technical reference appointed by the majority of the coaches.

REFERENCES

Fernandes O.; Anes, E.; Abrantes, J. (1996); BIOSIST - Two Dimensional Kinematics Performance Analysis; in, Proceeding of 14th International Symposium on Biomechanics in Sports, 189-192. Ed. By João M.C.S. Abrantes; Ediqdes F.M.H., Tecnical University of Lisbon.

Ferreira, A.P.; Barata, R.(1996); A Influência da Altura do Cesto no Lanqamento - Análise da Prestação de um Grupo de Jovens do Escalão Infantis; Rev. Horizonte, XII (71); 177-179.

Ferreira, A.P.; Fernandes, O.; Abrantes, J. (1996); Kinematic Analysis of Basketball Shooting. Preliminar Results; in, Proceeding of 14th International Symposium on Biomechanics in Sports, 189-192. Ed. By João M.C.S. Abrantes; Ediqdes F.M.H., Tecnical University of Lisbon. 471-474.

Ferreira, A.P. (1997); Alterações Cinemhticas do Lancamento em Basquetebol. A Influência da Altura do Cesto e da Dimensão/Peso da Bola; Dissertação de Mestrado; Faculdade de Motricidade Humana; Lisboa.

Satern, M.; Messier, S.; Keller-McNulty, S. (1989); The Effect of Ball Size and Basket Height on Mechanics of Free Throw; Journal of Movement Studies, 16(3); 123-137.