KINEMATIC ANALYSIS OF HANDBALL THROWING

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Kinematic analysis of handball throwing is not well documented. If we know that the studies on the other throwing activities can give us important data, we have to develop the study of handball throwing in order to understand this special motion better. It appears that handball throwing is similar to football passing except for the special upper arm external rotation. Indeed, the maximal upper arm external rotation is minor to those noted in baseball pitching or football passing. Moreover, the upper arm is internally rotated at the ball release. If the common ball weight can explain the resemblance between football passing and handball throwing, the specific humeral rotation can result from some technical lacks of our players or from a specific adaptation to avoid a great external humeral rotation recognized as traumatizing for the arm.

KEY WORDS : handball, overarm throwing.

INTRODUCTION: The overarm throwing is performed in a lot of activities as baseball, football, javelin or handball. A lot of studies analysed baseball pitching. This gives us a lot of data for this kind of throwing (Feltner, & Dapena, 1986; Fleisig, Barrentine, Escamilla, & Andrews, 1996a; Fleisig, Escamilla, Andrews, Matsuo, Satterwhite & Barrentine, 1996b; Sherwood, Hinrichs, & Yamaguchi, 1997; Matsuo, Escamilla, Fleisig, Barrentine, & Andrews, 2001; Stodden, Fleisig, Mc Lean, Lyman, & Andrews, 2001). We can conclude that baseball pitching is well known and that the discriminated parameters of the performance are ever demonstrated (Sherwood, Hinrichs, & Yamaguchi, 1997; Matsuo, Escamilla, Fleisig, Barrentine, & Andrews, 2001; Stodden, Fleisig, Mc Lean, Lyman, & Andrews, 2001). On the contrary, kinematic analysis of handball throwing is not well documented. Nevertheless, as attested by Atwater (1979), if there are some common points between the different kinds of overarm throwing, each of them certain peculiarities. Moreover, the few studies interested by handball throwing focused on a particularity of the throw but did not give its global view as it was done for baseball pitching. For example Chagneau, Delamarche, & Levasseur (1992) focused on the shoulder rotation, Jöris, Edwards van Muyen, van Ingen Schenau, & Kemper (1986) on the energy transmission and Wit & Eliasz (1998) on the momentum analysis. Therefore, we do not have a study about the global description of handball throwing. So, the aim of our study was to analyse handball throwing to evaluate the particularities of this throw compared to the throws performed in other activities using the rotations.

METHODS: Twelve male handball players took part in this study. Six of them play in the second French league (25 years old in mean) whereas the other six who are the youngest (16 years old in mean) play at the best level of their age category. Their mean height was 1.84 ± 0.06 m and their mean mass 78.3 ± 7.5 kg. After warming up and stretching, each subject thrown at maximal velocity in a target (0.4 per 0.4 meter) placed in the middle of the handball goal. After a pass receipt, the player performed their throws with cross over steps in the 9-meter zone. For each throw, three-dimensional kinematic data was obtained at 60 Hz using an automatic optoelectronic tracking system (Vicon, Oxford Metrics, England). The seven cameras were located around the throwing zone. Thirteen reflective markers were placed over standardized anatomical landmarks in order to identify body segments. In particular, we placed markers at the lateral superior tip of the acromions, at the both lateral humeral epicondyle, at the ulnar styloid process and at the radial styloid process of the throwing arm to define a plan with the previous marker. We also placed four markers to measure the hip orientation (two at the iliac anterosuperior, two at the iliac anteroposterior) and one marker on the ball to determine the instant of ball release. The data were independently filtered using a Butterworth second order low-pass filter with a 10 Hz cut-off frequency. The ball velocities were measured with a Stalker Pro Radar Gun.

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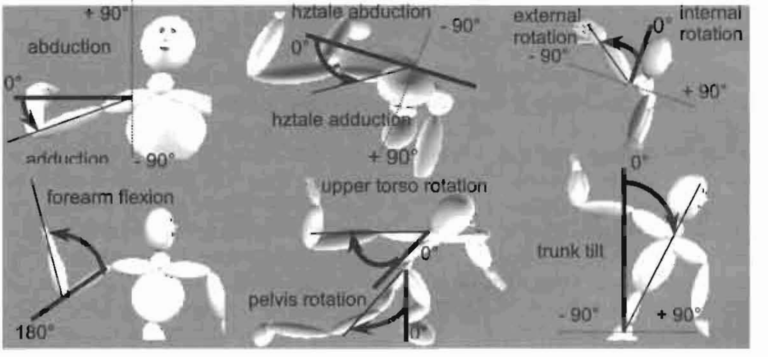

Figure 1. Definition of kinematic quantities: I) upper arm abduction, II) horizontal adduction, III) external rotation, IV) forearm flexion, V) upper torso and pelvis rotation, VI) trunk tilt.

For a better comparison with the previous studies, we calculated the arm angles (abduction / adduction, horizontal abduction / adduction, humeral rotation of the upper arm, forearm flexion) as depicted by Feltner & Dapena (1986). The method used for the trunk rotation (trunk tilt and pelvis rotation) was similar to that of Stodden, Fleisig, Mc Lean, Lyman, & Andrews (2001). For the upper torso was a little different because it was calculated in relation to the pelvis rotation and not in relation to the ball direction after release (cf Figure 1). We focused on the part of throw designed at the instant where the shoulder began its forward movement. The arm cocking presents in fact a lot of variabilities due to the quality of the ball receipt, the quality of the pass, the kind of arm cocking chosen (with the arm passing in front of or behind the body).

RESULTS AND DISCUSSION: The kinematic measurements are listed in Table 1. As expected, handball throwing presents some particularities. First, we can note that the forearm was not very extended at ball release, as attested by the 117 degrees obtained. Indeed, in baseball pitching authors noted a forearm extension of 160 degrees (Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine, 1996b). Nevertheless, our result is near the angle measured by Rash & Shapiro (1995), 121 degrees in their study on football passing and near the angle of 123 degrees measured by Mero & Komi (1994) for javelin throwing. If the upper arm horizontal adduction was the same than in other throwing activities, the humeral rotation was really different. The maximal external humeral rotation was indeed -43 degrees whereas baseball pitching and football passing demonstrated greater external humeral rotation, from –74 degrees for football passing to – 85 degrees for baseball pitching (Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine, 1996b). Moreover, at ball release, the upper arm was slightly internally rotated from 21 degrees. The other results given by the previous studies provided upper arm externally rotated at ball release from –23 degrees for football passing to –46 degrees for baseball pitching (Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine, 1996b; Feltner, & Dapena; 1986). Now, regarding the temporal parameters of the arm rotations, once again, football passing and handball throwing were close. Thus, the time of maximal humeral external rotation and the time of maximal forearm flexion was later for baseball pitching (respectively -0.027s and -0.068 s before ball release according to Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine (1996b)) than those of handball throwing and football passing respectively of -0.057 and -0.06 s for maximal external humeral rotation, -0.080 and -0.097 s for the maximal forearm flexion according to Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine (1996b). Nevertheless, the time of maximal horizontal adduction was nearer of ball release for handball throwing compared with the other results (-0.045 s according to our results opposite to – 0.074 s and – 0.093 s before ball release for baseball pitching and football passing). To conclude, the main difference between handball throwings and other throwing was the upper arm external rotation.

Table 1. Kinematics of upper extremity and trunk.

Quantity	Min (deg)	Time (seconds before ball release)	Instant of ball release
Upper arm horizontal adduction	14 ± 7	-0.045 ± 0.014	8 ± 6
Upper arm adduction	-23 ± 18	-0.057 ± 0.033	-18 ± 16
Humeral rotation	-43 ± 18	-0.061 ± 0.026	21 ± 4
Forearm flexion	72 ± 13	-0.080 ± 0.027	117 ± 12
Pelvis rotation	-55 ± 19	-0.269 ± 0.059	17 ± 15
Upper torso rotation	-27 ± 12	-0.167 ± 0.086	8 ± 12
Forward trunk tilt	-12 ± 5	-0.133 ± 0.019	42 ± 6

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On the other hand, the trunk movements during handball throwing were similar to those of other throwing activities as attested by the few studies focused on the trunk movement. Indeed, the trunk flexion at ball release, measured at 42 degrees, was between 31 and 65 degrees found by Stodden, Fleisig, Mc Lean, Lyman, & Andrews (2001) for baseball pitching and by Rash & Shapiro (1995) for football passing. So it was for the pelvis and the upper torso rotation (measured at 17 degrees and 8 and found at 1 and 20 degrees by Stodden, Fleisig, Mc Lean, Lyman, & Andrews (2001) for baseball pitching). If we look at these results we can note that the quarterbacks and the handball throwers displayed a similar throwing motion. Moreover, the two common points between these two activities are the presence of direct opponents during the throw and the fact that the football and the handball have more mass than the baseball. Indeed, the football is 0.43 kg weight, the handball is 0.45 kg weight and the baseball is 0.14kg weight. As Fleisig, Escamilla, Andrews, Matsuo, Satterwhite, & Barrentine (1996b) maybe we can incriminate the weight of the ball to explain a more flexed elbow during the last phase of the throw. The latter authors suggested that the quarterbacks compensate the heavier ball thanks to the elbow. The quarterback would increase upper arm horizontal adduction and forearm flexion at the expense of the contribution from the trunk and legs. Therefore, the quarterbacks would balance by achieving maximal external rotation before in order to have more time to accelerate the arm (Fleisig, Barrentine, Escamilla, & Andrews, 1996a). So in regards with our results on the arm and the trunk rotations, we could say that the handball throwers have the same adaptations because the ball is beavier than the quarterbacks. However, we can emphasize a great difference concerning the humeral rotation. Now, the humeral external rotation is considered as one of the most important factors to assure a good ball velocity (Fleisig, Barrentine, Escamilla, & Andrews, 1996a; Sherwood, Hinrichs, & Yamaguchi, 1997). As a consequence, the best pitchers have the greatest humeral external rotation (Sherwood, Hinrichs, & Yamaguchi, 1997, Matsuo, Escamilla, Fleisig, Barrentine, & Andrews, 2001). Indeed, a great magnitude of final humeral internal rotation gives more time to produce velocity (Fleisig, Barrentine, Escamilla, & Andrews, 1996a). However, if they present a less humeral external rotation, the handball throwers had comparable ball velocities at release (22.9 $m \times s^{-1}$ for our players and 21 $m \times s^{-1}$ for the Fleisig's quarterbacks). Furthermore, they released the ball with the upper arm internally rotated. So, these players seem to compensate a less humeral external rotation thanks to this shoulder internal rotation at ball release. In fact, the magnitude of the humeral rotation between the maximal humeral external rotation to the upper arm rotation at ball release is superior for handball throwing in comparison to the other throwing activities. Indeed, we have a magnitude of 64 degrees according to our results against 32 degrees and 57 degrees for the quarterbacks and the pitchers (Rash & Shapiro, 1995; Feltner & Dapena, 1986). Moreover, the final horizontal adduction, later for our handball throwers could be employed for the increasing of forward arm velocity. So we cannot conclude that the handball players' skill was worse than that of the quarterback. In fact the handball players have adapted their gesture to allow them to develop good ball velocities despite of a weightier ball.

Nevertheless, this does not explain why the humeral rotation was so different between handball throwing and football passing. However, while the combination of a great upper arm external rotation and of a less forearm extension is considered by Feltner & Dapena (1986) as a natural adaptation to avoid elbow injury at full extension, the great upper arm external rotation is also at the origin of traumatisms for the shoulder and the elbow (Fleisig, Barrentine, Escamilla, & Andrews, 1996a). Now, during these last ten years, the attitude of handball trainers was to let the players find themselves the best way to throw. This lack of specific formation for throwing can be an explanation of the existence of different throwing technique. The handball players without specific coaching may choose a less efficient but also a less traumatizing movement for the arm. However, we can always guess the level of our players who are not the best in this sport. To invalidate this hypothesis, we need to study the best players as the international ones.

CONCLUSION: This study allows us to point out the differences between handball throwing and the other throwing activities. It seems that handball throwing is very similar to football passing except for the final humeral rotation. We know that a great external upper arm rotation is difficult to realize and it is quite traumatizing for the arm. So, as we can observe a lack of specific training by the handball coaches, the handball players may choose a different way to throw which would be slightly less traumatizing for the arm but enough efficient. The study of the best handball players as the international ones will allow us to know if they present also this particularity. It will also allow to refute refuting the hypothesis of our players having a lower level.

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