DETERMINANTS OF THE THROWING VELOCITY IN HANDBALL - - A STATISTICAL MODEL

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INTRODUCTION

Ball velocity is one of the most important factors which has a decisive affect on scoring in team games, like handball, baseball, cricket, water polo, volleyball, soccer etc. (Atwater 1980, Jöris et al.1985, Eliasz et al.1990, Marczinka 1993). Basically scientists are in agreement that the main determinants of the ball's velocity can be divided into three groups: technique of motion, somatic features and motor ability (Pauwels 1978, Muijen et al.1991). However, the technique of motion and the fitness level can be improved by the training process, morphological factors are, in the main part, genetically determined. Thus, the information about the degree of influence of each factor on the ball velocity appears substantial, in order to answer the question: proper selection or proper training has a better effect on ball velocity measured during throwing. Among experienced players it is particularly difficult to make progress in this area without special approach to exercises and training methods. The first step leading to this task is to specify the most important characteristics which effect ball velocity and develop them during training.

The aim of the research was to find the influence of the basic anthropometrical and motor ability parameters on ball velocity during throws in handball where the throwing technique remains consistent. These relationships seem to be very important for coaches, in order to improve the selection quality and the efficiency of training methods.

METHODS

Twelve high-performance handball field players took part in the experiment. The average values of basic parameters of physical characteristics of the subjects were: 89.0±7.8 kg body mass, 1.88±0.05 m body height and 23.3±2.5 years of age.

Anthropometric measurements were carried out according to Martin's method. The following somatic indices were used: length (body height, upper and lower extremity, arm, forearm, palm and fingers of the predominant hand), skeleton width (shoulder, pelvis, palm), musculature (arm and forearm circumference) and adiposity (three skin folds). For each player we used 26 somatic characteristics. In order to assess the **overarm throwing performance**, a standard handball was used (mass 480 g, circumference 58 cm). The subjects were instructed to throw the ball as fast as possible at a target (50 x 50 cm) placed at a distance of about 6 meters. The average linear ball velocity was measured over a 2 meter distance using a special photocells system (Eliasz et al.1990). The muscle strength was evaluated on the basis of **torques developed by main muscle groups under static conditions** The isometric muscle torque stand (locally made) was used to make the measurements, which enabled the direct measuring of torques for flexors and extensors of elbow, shoulder, knee and hip joints and flexors and extensors of trunk (Jaszczuk et al.1987).

The **measurement of the muscle torque under dynamic conditions** were carried out on the CES ARIEL modified in its mechanical part. Subjects performed simulated throws in the sitting position, propelling the bar of the Arm-Leg Station. Each subject executed 3 kinds of tests: maximal speed diagnostic (MSD), isokinetic exercises (IKE) at angular velocities 100, 300 and 500 deg/s, isotonic exercises (ITE) at external torques 10, 30 and 50 N×m. During the **vertical counter-movement jump** performed on a force platform maximal height of the jump and maximal mechanical power of the lower extremity and trunk were measured. The signal (force) was processed on-line using IBM PC.

Statistical methods

The mean value, standard deviation and coefficient of variance were calculated for each parameter. A normality of distributions were examined using the Shapiro-Wilk test. At the next stage the Pearson's correlation matrix and multiple regression analysis were used ($\alpha=0.05$). The row data were recalculated to values in T-scale and according to the Doolittle method the contribution to throwing velocity was calculated for each factor: motor (M) and anthropometric (A). The best regression subset was assigned using Fisher's discriminating method. The regression hyperplane parameters were estimated, which divided players according to throwing velocity criterion.

RESULTS

Multiple regression analysis has shown that the most important throwing velocity determinants are: range of fingers, shoulder width and length of hand - among anthropometrical factors and isometric muscle strength of trunk flexors, maximal angular velocity of the bar measured in MSD and average mechanical power developed in CMJ - among motor abilities. Expected value of the ball velocity (Y) is stated the following equation:

$$\mathbf{Y = 0.018\,X_1 + 0.733\,X_2 + 0.039\,X_3 - 0.332\,X_4 + 0.006\,X_5 - 2.854}$$

where: X_1 - maximal angular velocity (MSD), X_2 - range of fingers, X_3 - average power (CMJ), X_4 - shoulder width, X_5 - isometric muscle strength of trunk flexors
For these five parameters the multiple correlation coefficient is: $R=0.982$ ($R^2=0.963$).
The proportional contribution of these factors in expected value of the ball velocity is:
$X_1 = 36\%$; $X_2 = 41\%$; $X_3 = 3\%$; $X_4 = 6\%$; $X_5 = 11\%$.
After recalculation to T-values the final equation contains two main factors: anthropometrc (A) and motor (M):

$$\mathbf{Y = 0.017\,A + 0.072\,M}$$

$R=0.857$, $R^2=0.735$
The proportional contribution of these factors in expected value of ball velocity is 11.9% and 61.4%, respectively.

Using Fisher's discrimination method, according to ball velocity criterion, the subjects were divided into two groups, consisting of nine (mean velocity) and three people (high velocity). It is shown on figure 1. The hyperplane parameters are as follows:

$$\mathbf{0.149\,M + 0.051\,A - 23.821 = 0}$$

DISCRIMINANT ANALYSIS

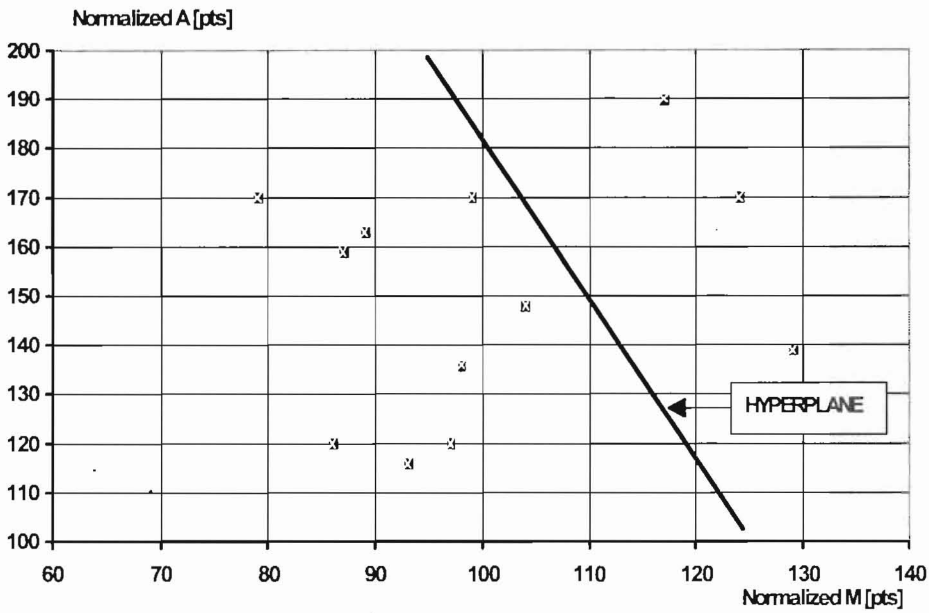

Fig.1. The hyperplane obtained in discriminant analysis separates handball players into two groups of different throwing velocity. The points placed on the right side of hyperplane represent the results of the subjects who throw the ball with high velocity.

The results suggest that motor abilities (especially muscle strength) have a great influence on throwing velocity in handball. Many researchers who have investigated an overarm throw, have indicated that muscle strength is a very important factor influencing throwing velocity (Pauwels 1978, Bartlett et al.1989, Pawlowski and Perrin 1989, Wooden et al.1992, Eliasz 1993). In this work statistical analysis has shown that the muscle strength of trunk flexors (abdominal muscles: abdominal rectus, external and internal obliques) and the maximal arm speed are the most significant velocity determinants. Abdominal muscles are involved in forward bending and trunk rotation (caused by one-side shortening action of external and internal obliques) - the type of motions observed during throwing before release (Atwater 1980, Jöris et al.1985, Eliasz 1993, Marczinka 1993). From a practical point of view there are two main possibilities to improve throwing velocity in handball: (1) development of abdominal muscles strength and (2) by improving the speed of external and internal rotation at the shoulder joint.

Among the anthropometrical features, only the range of fingers and hand length are correlated significantly with the ball velocity in measured throws. All these factors determine the grip quality, which allows the ball to be caught, held and manipulated easily. The influence of these factors on throwing velocity are significantly less than motor abilities. The basic somatic features (body hight, body mass) seem to be more important to the selection of players to specific positions in the game than to general selection for the sport, although it statement still needs verification (Maia et al.1991).

CONCLUSIONS

These results suggest that:

1. The most important throwing velocity determinant is the motor abilities level (if the technique of motion is not taken into the consideration).
2. Among analyzed motor parameters the strength of trunk flexors (abdominal muscles) and maximal arm (shoulder joint) angular velocity have a decisive effect on ball velocity in handball.

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