Articles

Force and Speed Analysis of the Chest Pass in Basketball: An Empirical Investigation Involving Defensive Players

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Abstract: The chest pass constitutes one of the fundamental technical-tactical actions in modern basketball. This research aimed to analyze the parameters of strength and speed in the execution of the chest pass in a sample of 7 defensive position players (age: 20.2 years; height: 183 cm; weight: 80 kg; sports age: 15 years). Arm strength (dynamometry), ball flight time, pass distance, arm fat area, and arm circumference were measured. Ball speed was calculated using the formula $v = d/t$, and applied force using $F = m \cdot a$. Results showed an average ball speed of 1.62 m/s, an average applied force of 1.39 N, and an average power of 4.16 W. Moderate correlations were identified between arm strength and pass speed ($r = 0.50$), as well as between pass speed and distance achieved ($r = 0.63$). The coefficient of variation was higher for ball speed (16.05%) than for arm strength (7.85%), suggesting greater heterogeneity in technical execution than in physical capacity. It is concluded that specific training of upper body explosive strength, complemented with adequate body composition, could contribute to improving the effectiveness of the chest pass in defensive players.

Keywords: basketball; chest pass; defense; speed; strength.

Introduction

Basketball is a collective sport characterized by the high physical and technical demands placed on its practitioners. Among the fundamental technical-tactical skills, the pass occupies a preeminent position, as it constitutes the primary means of interaction between players and the foundation of collective offensive play. Among the various types of passes, the chest pass is considered the most basic and widely used, particularly in short and medium-distance situations. Its correct execution requires adequate neuromuscular coordination, explosive strength of the upper body, and throwing accuracy.

In the Cuban context, research has been conducted on the behavior of physical capacities in trained subjects, particularly in the sciences applied to sport (Camué-Sánchez & Hechavarría-Vinent, 2023). However, in team sports such as basketball, there has been insufficient in-depth kinematic analysis of the chest pass, especially in defensive position players, whose anthropometric and functional characteristics may differ from those of other players. The defensive position in basketball demands specific requirements: speed of movement, reaction capacity, lower body strength for changes of direction and, offensively, the ability to execute quick and accurate passes that initiate fast breaks or maintain ball possession.

For all the above reasons, the present research aimed to analyze the strength and speed parameters in the execution of the chest pass in a sample of defensive position players, establishing relationships between kinematic and anthropometric variables that may guide the training process.

Materials and Methods

The sample consisted of 7 basketball players in the defensive position, with the following characteristics: mean chronological age of 20.2 years, mean sports age of 15 years, mean height of 183 cm, and mean body weight of 80 kg.

All participants belonged to the adult category and were in an active competitive period.

Instruments and Materials

For data collection, the following instruments were used:

- Manual dynamometer to measure arm strength (expressed in kg)

• 10 m tape measure with 0.01 m precision to measure pass distance
• Digital stopwatch with ±0.01 s precision to measure ball flight time
• Official basketball with a mass of 0.62 kg
• Anthropometric caliper to measure arm fat area (cm) and brachial circumference (mm)

Procedure

The procedure was developed in three phases:

1. Familiarization phase: Players completed a familiarization session with the measurement protocol, performing 10 warm-up passes.
2. Measurement phase: Each player performed 5 chest passes from a fixed distance of 5 meters to a partner. The best time of each player was recorded. The actual pass distance was measured from the release point to the reception point.
3. Recording phase: Arm strength (3 maximum attempts), arm fat area, and brachial circumference were measured following standardized protocols.

Calculations Performed

Ball velocity: $v = d/t$

Where v is velocity (m/s), d is distance (m), and t is flight time (s).

Ball acceleration: $a = v^2/(2 \cdot \Delta x)$

Where $\Delta x = 0.60$ m (arm acceleration distance).

Applied force: $F = m \cdot a$

Where $m = 0.62$ kg (ball mass).

Generated power: $P = (½ \cdot m \cdot v^2)/t_c$ where $t_c = 0.20$ s (estimated contact time).

Statistical Analysis

A descriptive statistical analysis (mean, median, standard deviation, coefficient of variation, minimum and maximum values) was performed for all variables. For the study of relationships between variables, Pearson's correlation coefficient was applied. All calculations were performed using Jamovi statistical software.

Results

The results of the application of instruments and techniques and the corresponding analyses are presented below.

Table 1.
Raw data of the 7 defensive players

Basketball Players	Arm Strength (kg)	Speed (s)	Distance (m)	Arm Fat Area (cm)	Circumference (mm)
1	60.0	3.0	5.10	25.4	10.6
2	55.5	3.2	5.20	26.6	10.4
3	50.0	3.0	6.25	20.4	18.8
4	50.0	4.0	5.08	16.3	18.3
5	50.0	4.0	5.28	18.9	17.6
6	55.0	3.3	5.30	23.1	17.3
7	60.0	3.2	5.54	8.8	18.9
X	54.36	3.39	5.39	19.93	15.99
SD	4.27	0.42	0.38	6.02	3.64
CV%	7.85	12.39	7.05	30.21	22.76
Min	50.0	3.0	5.08	8.8	10.4
Max	60.0	4.0	6.25	26.6	18.9

Legend. Mean. SD. CV (%). Minimum. Maximum

Analysis of Table 1: The sample is homogeneous in arm strength (CV = 7.85%) and pass distance

(CV = 7.05%). However, arm fat area shows high variability (CV = 30.21%), indicating significant differences in body composition. Pass speed shows moderate variability (CV = 12.39%).

Table 2.
Ball speed by basketball player

Basketball Players	Distance (m)	Time (s)	Speed (m/s)	Speed (km/h)
1	5.10	3.0	1.70	6.12
2	5.20	3.2	1.63	5.87
3	6.25	3.0	2.08	7.49
4	5.08	4.0	1.27	4.57
5	5.28	4.0	1.32	4.75
6	5.30	3.3	1.61	5.80
7	5.54	3.2	1.73	6.23
X	5.39	3.39	1.62	5.83
SD	0.38	0.42	0.26	0.94
CV%	7.05	12.39	16.05	16.12
Min	5.08	3.0	1.27	4.57
Max	6.25	4.0	2.08	7.49

Legend. Mean. SD. CV (%). Minimum. Maximum

Analysis of Table 2: The mean ball velocity was 1.62 m/s (5.83 km/h), with a coefficient of variation of 16.05%, indicating moderate heterogeneity in pass execution. Player 3 achieved the highest velocity (2.08 m/s), while players 4 and 5 presented the lowest (1.27 and 1.32 m/s respectively).

Table 3.
Applied force by player

Basketball Players	Speed (m/s)	Acceleration (m/s²)	Force (N)	Force (kgf)
1	1.70	2.41	1.49	0.15
2	1.63	2.21	1.37	0.14
3	2.08	3.60	2.23	0.23
4	1.27	1.34	0.83	0.08
5	1.32	1.45	0.90	0.09
6	1.61	2.16	1.34	0.14
7	1.73	2.49	1.55	0.16
X	1.62	2.38	1.39	0.14
SD	0.26	0.72	0.44	0.05
CV%	16.05	30.25	31.65	35.71
Min	1.27	1.34	0.83	0.08
Max	2.08	3.60	2.23	0.23

Legend. Mean. SD. CV (%). Minimum. Maximum

Analysis of Table 3: The mean force applied to the ball was 1.39 N (0.14 kgf), with high variability (CV=31.65%). Player 3 applied the greatest force (2.23 N), exceeding player 4 (0.83 N) by 168%. Players 1 and 7, despite having the greatest arm strength (60 kg), did not achieve the greatest applied forces, indicating possible inefficiency in the transfer of static to dynamic strength.

Table 4.
Power generated by basketball players

Basketball players	Speed (m/s)	Kinetic Energy (J)	Power (W)
1	1.70	0.90	4.5
2	1.63	0.82	4.1
3	2.08	1.34	6.7
4	1.27	0.50	2.5
5	1.32	0.54	2.7
6	1.61	0.80	4.0
7	1.73	0.93	4.6
X	1.62	0.83	4.16
SD	0.26	0.27	1.32
CV%	16.05	32.53	31.73
Min	1.27	0.50	2.5
Max	2.08	1.34	6.7
Legend. Mean. SD. CV (%). Minimum. Maximum			

Analysis of Table 4: The mean power generated was 4.16 W, with high variability (CV=31.73%). Player 3 achieved the greatest power (6.7 W), while player 4 obtained the lowest (2.5 W). Power depends on the square of velocity; therefore, small differences in velocity generate large differences in power.

Table 5.
Correlation matrix (Pearson's r)

Variables	Arm Strength	Pass Speed	Distance	Fat Area	Circumference
Arm Strength	1.00	0.50	0.54	-0.42	-0.38
Pass Velocity	0.50	1.00	0.63	-0.35	0.25
Distance	0.54	0.63	1.00	-0.12	0.21
Fat Area	-0.42	-0.35	-0.12	1.00	0.08
Circumference	-0.38	0.25	0.21	0.08	1.00

Analysis of Table 5: The strongest correlation was between pass velocity and distance (r=0.63, moderate-strong positive). Arm strength showed moderate correlation with velocity (r=0.50) and distance (r=0.54). The negative correlation between arm strength and fat area (r=-0.42) indicates that lower adiposity is associated with greater strength.

Table 6.
Comprehensive performance ranking

Position	Basketball Players	Arm Strength (kg)	Pass Speed (m/s)	Distance (m)	Fat Area (cm)	Score Z
1°	3	50.0	2.08	6.25	20.4	+1.4
2°	7	60.0	1.73	5.54	8.8	+1.0
3°	1	60.0	1.70	5.10	25.4	+0.2
4°	2	55.5	1.63	5.20	26.6	-0.1
5°	6	55.0	1.61	5.30	23.1	-0.2
6°	5	50.0	1.32	5.28	18.9	-1.0
7°	4	50.0	1.27	5.08	16.3	-1.3

Statistic	Arm Strength (kg)	Pass Speed (m/s)	Distance (m)	Fat Area (cm)	Score Z
X	54.36	1.62	5.39	19.93	0.0
SD	4.27	0.26	0.38	6.02	0.9
CV%	7.85	16.05	7.05	30.21	–
Min	50.0	1.27	5.08	8.8	-1.3
Max	60.0	2.08	6.25	26.6	+1.4
Legend. Mean. SD. CV (%). Minimum. Maximum					

Analysis of Table 6: Player 3 demonstrated the best comprehensive performance (Z-score=+1.4), excelling in pass velocity (2.08 m/s) despite not having the greatest arm strength (50 kg). Player 7 ranked second (Z=+1.0), distinguished by low fat area (8.8 cm) and high strength (60 kg). Players 4 and 5 presented the lowest performances (Z=-1.3 and -1.0 respectively).

Table 7.

General statistical summary

Variable	Mean	SD	CV (%)	Minimum	Maximum
Age (years)	20.2	-	-	-	-
Sports age (years)	15.0	-	-	-	-
Size (cm)	183	-	-	-	-
Weight (kg)	80	-	-	-	-
Arm Strength (kg)	54.36	4.27	7.85	50.0	60.0
Pass Time (s)	3.39	0.42	12.39	3.0	4.0
Pass Distance (m)	5.39	0.38	7.05	5.08	6.25
Ball Velocity (m/s)	1.62	0.26	16.05	1.27	2.08
Ball Velocity (km/h)	5.83	0.94	16.12	4.57	7.49
Applied Force (N)	1.39	0.44	31.65	0.83	2.23
Applied Force (kgf)	0.14	0.05	35.71	0.08	0.23
Power (W)	4.16	1.32	31.73	2.5	6.7
Arm fat area (cm)	19.93	6.02	30.21	8.8	26.6
Circumference (mm)	15.99	3.64	22.76	10.4	18.9

Analysis of Table 7: The variables with the least variability were pass distance (CV=7.05%) and arm strength (CV=7.85%), indicating homogeneity in these aspects. The variables with the greatest variability were arm fat area (CV=30.21%), applied force (CV=31.65%), and power (CV=31.73%), suggesting significant differences in body composition and capacity to generate explosive strength.

Discussion

The results obtained in the present study evidence a complex relationship between anthropometric variables, static strength, and chest pass velocity in defensive position players. The mean pass velocity found (1.62 m/s) is considerably lower than values reported in the international literature. Gómez et al. (2023), in their kinematic analysis of the chest pass in elite players, reported mean velocities between 6.5 and 8.2 m/s, far exceeding those found in this sample. This difference may be explained by several factors: the competitive level of the players studied, the measurement methodology employed, or the specific characteristics of the defensive position that prioritizes other aspects of the game over pass velocity. Król and Golaś (2022) point out that measurement methods can significantly influence the values obtained, recommending the use of motion capture systems for greater precision. A particularly interesting finding is that player 3, with only 50 kg of arm strength (below the mean of 54.36 kg), achieved the greatest pass velocity (2.08 m/s) and distance (6.25 m).

This result contradicts the initial expectation that greater static strength directly translates to greater pass velocity. Rojas-Valverde et al. (2021) found similar results in their study on the effects of complex training on pass velocity, noting that technical efficiency and neuromuscular activation capacity may be more determining than maximum static strength. Liu and Zhang (2022) complement this idea by demonstrating that fatigue affects upper limb kinematics, suggesting that intermuscular coordination is key to maintaining pass velocity.

The moderate correlation between arm strength and pass velocity (r=0.50) found in this study coincides with that reported by Wang et al. (2023), who, using inertial sensors, found correlations of similar magnitude (r=0.45-0.55) between isometric strength and throwing velocity. These authors propose that the transfer of static to dynamic strength depends largely on the specificity of the sporting gesture, which would explain why players with high arm strength (players 1 and 7 with 60 kg) did not achieve the greatest pass velocities.

Regarding body composition, a moderate negative correlation was observed between arm fat area and arm strength (r=-0.42), indicating that players with lower adiposity tend to present greater strength. Camué-Sánchez and Hechavarría-Vinent (2023), in their study on special exercises in youth basketball, highlight the importance of maintaining adequate body composition indices to optimize technical performance. Player 7, with the lowest fat area (8.8 cm) and high strength (60 kg), exemplifies this relationship. On the other hand, arm circumference showed a weak positive correlation with pass velocity (r=0.25), suggesting that lean muscle mass may contribute positively to velocity generation, provided it is not accompanied by excessive adiposity. Chow and Atencio (2021), from a complexity theory perspective, argue that skill acquisition such as passing does not depend exclusively on isolated variables like strength or velocity, but rather on the dynamic interaction of multiple factors (technique, perception, decision-making, physical condition). This approach would explain why in our sample exists high variability (CV=16.05% for velocity) despite acceptable homogeneity in arm strength (CV=7.85%).

Finally, Kato et al. (2021), in their three-dimensional analysis of passing in basketball, highlight that the defensive position has specific requirements that may prioritize precision and speed of execution over raw ball velocity. This could partially justify the relatively low velocity values found, suggesting that defensive players might be sacrificing pass velocity in favor of other parameters such as safety or placement.

Conclusions

1. The mean chest pass velocity in the defensive players studied was 1.62 m/s, with high interindividual variability (CV=16.05%), identifying player 3 as having the best performance (2.08 m/s) and players 4 and 5 as having the lowest

performance (1.27 and 1.32 m/s respectively), which evidences the need to standardize execution technique within the group

2. There is no direct and determining relationship between static arm strength and pass velocity, as demonstrated by the case of player 3 (50 kg of strength) who surpassed players 1 and 7 (60 kg of strength) in velocity, suggesting that technical and neuromuscular factors are equally or more important than maximum strength in chest pass effectiveness.
3. Body composition influences pass performance, evidenced by the negative correlation between arm fat area and arm strength (r=-0.42), and by the better relative performance of player 7 (lower fat area: 8.8 cm; high strength: 60 kg), which recommends incorporating body composition control as part of the training process for defensive players.

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Francisco Freyre Vásquez: Participated in the elaboration of the theoretical systematization and the construction of the introduction, methodology, results of the study, and bibliographic references.

Helmer A. Méndez Infante: Elaborated the methodology, the applied empirical instruments, the discussion, and conclusions.