Evaluating the Effects of Physiological and Kinematic Factors on Basketball Shooting Accuracy

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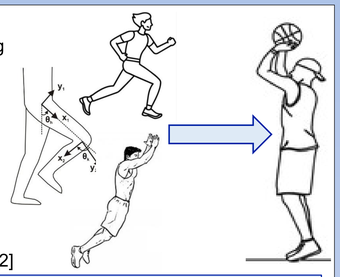
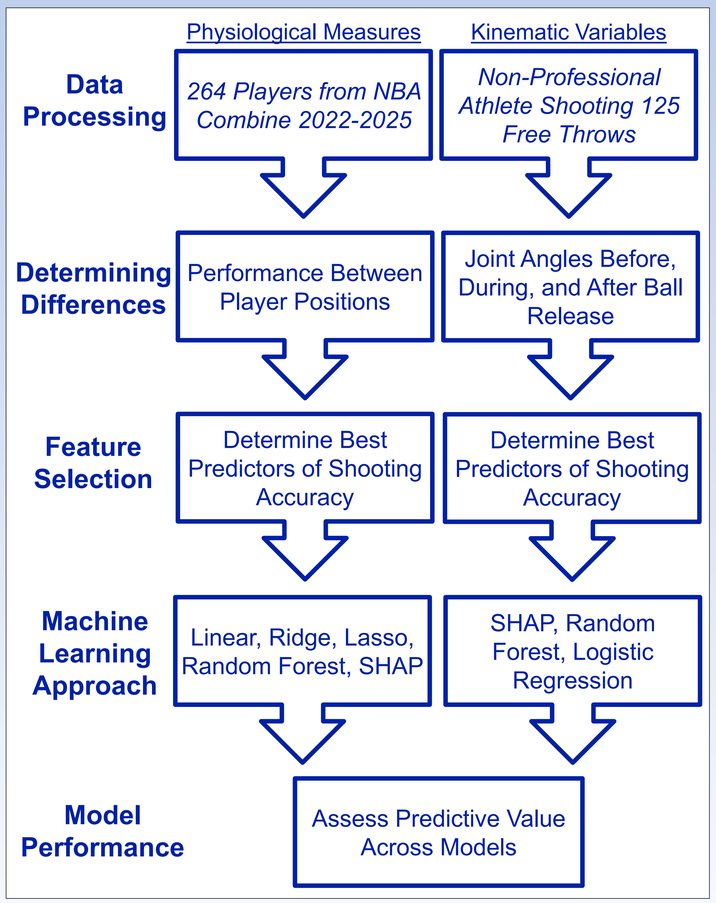
BACKGROUND

- Basketball's high economic stakes drive teams to invest in identifying and improving factors that influence player performance
- **Physiological Measures:** NBA Draft Combine data holds predictive value as a predictor of professional performance, but not specifically how it relates to shooting accuracy [1]
- **Kinematic Variables:** Adjustments during shooting play a key role in shooting outcome, so kinematic variables may provide valuable insight into performance [2]



Objective: *Compare the influence of physiological measures with kinematic variables to determine which set has a stronger association with shooting accuracy*

METHODOLOGY



Study 1: Physiological Measures

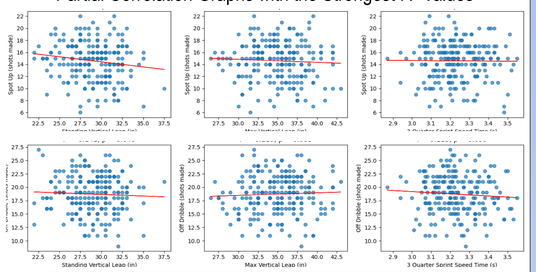
Differences in Performance Metrics Across Player Positions

Metric	C-PF	C-PG	C-SF	C-SG	PF-PG	PF-SF	PF-SG	PG-SG	PG-SG	SF-SG
Lane Agility	***	***	***	***	-	-	-	-	-	-
Three-Quarter Sprint Speed	-	***	***	***	***	**	*	*	-	-
Standing Vertical Leap	-	-	-	-	-	-	-	-	-	-
Maximum Vertical Leap	-	***	*	***	*	-	*	-	-	-
Off-Dribble	-	***	**	***	***	*	***	-	-	-
Spot-Up	-	***	***	***	*	-	-	-	-	-
Three-Point Star	-	***	-	**	*	-	-	*	-	-

Note. Asterisks indicate significance level: * = $p < .05$, ** = $p < .01$, *** = $p < .001$, - = $p > 0$

Centers exhibit greatest differences in agility due to larger size and role near the basket, whereas limited differences among other positions reflect high baseline athleticism [3].

Partial Correlation Graphs with the Strongest R^2 Values



All R^2 values were below 0.2 across the correlation analyses and the linear, ridge, and lasso models, indicating limited predictive capability

Random Forest Model Performance and SHAP Feature Importance for Shooting Metrics

	Random Forest Results				Importance					
	Train		Test							
	R^2	RMSE	R^2	RMSE	H	LA	3QSS	SVL	MVL	SR
Off Dribble	0.9	1.07	0.22	3.53	1.02	0.2	0.16	0.33	0.31	0.46
Spot Up	0.87	1.09	0.27	2.55	0.53	0.24	0.23	0.61	0.19	0.59
Three-Point Star	0.88	0.93	0.3	2.5	0.75	0.17	0.41	0.11	0.22	0.52
Free Throw	0.86	0.51	0.04	1.19	0.23	0.07	0.08	0.18	0.18	00.7

The random forest model remained weak overall, but height, shuttle run time, and standing vertical leap were identified as the most influential physiological measures for shooting performance.

Study 2: Kinematic Variables

Comparison of Average Joint Angles Before, During, and After Basketball Release from Hand

Joint	Before			During			After		
	$\overline{\theta_{made}}$ (°)	$\overline{\theta_{miss}}$ (°)	p	$\overline{\theta_{made}}$ (°)	$\overline{\theta_{miss}}$ (°)	p	$\overline{\theta_{made}}$ (°)	$\overline{\theta_{miss}}$ (°)	p
R. Knee	168.02	169.83	0.001	157.37	161.94	0.099	152.46	151.72	0.048
R. Shoulder	57.59	65.6	0.001	24.33	24.54	0.891	42.91	41.86	0.025
R. Elbow	138.34	136.86	0.464	126.65	124.74	0.444	104.52	104.18	0.656
L. Knee	171.13	172.63	0.001	165.6	165.65	0.971	157.43	157.04	0.182
L. Shoulder	24.63	26.38	0.048	22.41	22.38	0.979	37.68	37.29	0.228
L. Elbow	144.63	141.45	0.114	123.61	124.58	0.779	102.14	103.31	0.133

There were no significant differences at ball release, but smaller pre-release knee and shoulder angles as well as larger post-release right shoulder and knee angles were associated with made shots.

SHAP Feature Importance for Predicting Shot Outcome

Feature	Importance
Shooting Velocity	0.158
R. Knee at Release	0.111
R. Knee Before Release	0.11
R. Knee Extension	0.11
R. Shoulder Extension	0.109

Shooting velocity and knee kinematics are the most influential variables in predicting shooting accuracy.

Performance of Random Forest and Logistic Regression Models in Predicting Shots

	Random Forest				Logistic Regression			
	Unbalanced		Balanced		Unbalanced		Balanced	
	Train	Test	Train	Test	Train	Test	Train	Test
R^2	1	0.72	1	0.68	0.7	0.72	0.56	0.44
RMSE	0	0.529	0	0.566	0.548	0.529	0.663	0.748
	Random Forest				Logistic Regression			
	Unbalanced		Balanced		Unbalanced		Balanced	
	P. Miss	P. Make	P. Miss	P. Make	P. Miss	P. Make	P. Miss	P. Make
A. Miss	3	4	2	5	0	7	3	4
A. Make	3	15	3	15	0	18	10	9

The unbalanced models achieved higher R^2 values but exhibited clear signs of overfitting. Using balanced models reduced this issue, though it resulted in lower but still moderately strong R^2 values.

DISCUSSION

- Height, speed, and vertical leap were the most influential physiological measures
- Shooting velocity, right knee angles, and knee/shoulder extension were most influential kinematic factors
- Successful shots require coordinated lower/upper body movement and controlled release mechanics

Kinematic variables demonstrated greater relevance in distinguishing between made and missed shots than physiological measures

LIMITATIONS

- **Study 1**: The Combine dataset is limited to controlled drills over a single day rather than game situations
- **Study 2:** The dataset was dominated by made shots and collected from a single non-professional athlete
- Non-representative datasets limit generalizability

FUTURE WORK

- **Study 1:** Incorporate game-based and longitudinal datasets to better capture real performance
- **Study 2:** Expand datasets to include multiple players across a range of skill levels to reduce overfitting
- Overall: Integrate both physiological and kinematic variables within a single dataset

REFERENCES

[1] Teramoto et al. (2018). *Journal of Strength and Conditioning Research*, 32(2), 396–408.
[2] Cabarkapa et al. (2022). *Biomechanics*, 2(3), 352–360.
[3] Under Armour (n.d.). *The ultimate guide to the center position in basketball*.

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