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Back extensor strength as a new frailty marker: propensity score matching & machine learning approach

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Introduction

- Frailty is a geriatric condition defined as increased vulnerability.
- Previous studies have assessed Frailty with Fried's criteria, using grip strength as a factor of weakness.
- We showed relationship between back extensor strength and trunk muscle/fat compositions and developed prediction model for frailty using back extensor strength.

Purpose

- To show predictive power of back extensor strength for frailty with logistic regression and machine learning model.
- To show relationship between trunk muscle/fat compositions and back extensor strength, suggesting exercise program to prevent frailty.

Methods

- We recruited 560 farmers.
- Trunk muscle/fat compositions was evaluated from CT, mid L4.
- Back extensor strength was recorded with designed chair using a BTE PrimusRS system.
- Multivariate linear regression between back extensor strength, trunk muscle/fat compositions, and confounding such as age.
- Fried's frailty criteria from the lowest 20% back extensor strength group were compared with those from the higher back extensor strength group, using PS matching.
- Frailty prediction model
  - Multivariate logistic regression
  - Extreme gradient boosting (XGBoost)
- To show predictive power of models, 70% of participants were used for train, and the rest were used for test .

Result

- Of the 560 participants, 255 were male and 305 were female (shown in Table 1). The average age of the participants was 58.0±7.0 years, with an average of 58.5±7.0 years for men and 57.5±6.9 years for women.

- Table 1 shows the results of multivariate linear regression. After adjusting for age and sex, a clear trend was observed ($p<0.05$) in which higher back extensor strength was associated with increased AMM ($r=1.12$) and BMM ($r=0.89$). VIF was < 10, indicating no multicollinearity issue. Relative weight analysis showed that AMM was the most significant predictor.

- Table 2 shows results of two groups comparison with PS matching. After PS matching (with a match ratio of 1-to-3, a caliper of 0.01), 108 participants from the lowest 20% group and 279 participants from the higher group remained with an SMD < 0.1. Table 2 shows that grip strength, self-reported exhaustion, and walking speed were significantly different ($p<0.05$) between the lowest 20% back extensor strength group and the higher group, with the lowest 20% back extensor strength group showing greater frailty.

- Table 3 shows results of the multivariate logistic regression. showing that higher back extensor strength was significantly associated with a lower risk of frailty (OR, 0.990, 95%CI, 0.983–0.997; $p < 0.05$), whereas aging was associated with an increased risk of frailty (OR, 1.088, 95%CI, 1.025-1.160, $p < 0.05$).

- Figure 1 shows the feature importance of XGBoost model to predict frailty. The results of XGBoost for frailty prediction (frailty score ≥ 3 or not) showed that back extensor strength was the most important predictor of frailty (gain = 0.502±0.006), and was more important than age (gain = 0.325±0.005), BMI (gain = 0.145±0.005), and sex (gain = 0.026±0.002).

Table 1. Multivariate linear regression analysis for the predictor of back extensor strength

	Coefficient	Standard error	t	p-value	VIF	Relative Weight
Constant	209.661	42.076	4.983	8.39E-7		
AMM	1.122	0.398	2.819	0.005	3.571	0.089
PMM	0.121	0.878	0.139	0.890	3.812	0.077
BMM	0.887	0.419	2.113	0.035	2.485	0.077
VFM	0.010	0.088	0.120	0.905	1.688	0.013
SFM	0.062	0.056	1.103	0.270	1.486	-0.005
Age	-1.823	0.508	-3.583	<0.001	1.312	-0.017
Sex	72.901	12.417	5.871	7.48E-9	3.985	-0.118

Abbreviation: VIF, variance inflation factor; AMM, abdominal muscle mass; BMM, back muscle mass; PMM, psoas muscle mass; VFM, visceral fat mass; SFM, subcutaneous fat mass; sex, female.

Table 2. Propensity score matching for back extensor strength and Fried's frailty

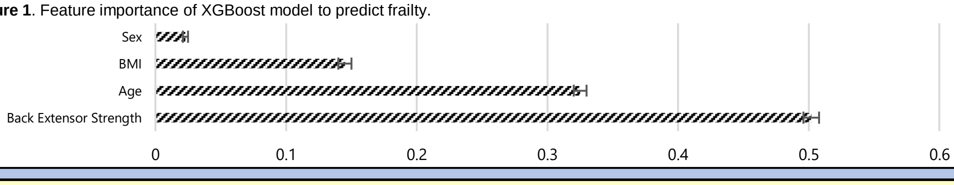
	Before propensity score matching				After propensity score matching			
	Low 20% back extensor strength (n=114)	The higher (n=444)	SMD	p-value	Low 20% back extensor strength (n=108)	The higher (n=279)	SMD	p-value
Age	60.6±6.2	57.3±7.0	0.532	<0.001	59.9±5.7	59.4±5.7	0.002	0.423
Female	54.4%	54.5%	-0.002	1.000	55.6%	55.9%	-0.019	1.000
Grip	25.4±10.2	29.6±10.0		<0.001	25.2±10.3	28.7±9.9		0.001
Wt. loss	13.2%	10.1%		0.447	13.0%	6.8%		0.082
Exhaust	15.8%	5.6%		0.001	16.7%	6.8%		0.006
Activity	5372±5051	5706±5811		0.708	5340±4998	5559±5520		0.800
Gait speed	1.0±0.2	1.1±0.2		<0.001	1.0±0.2	1.1±0.2		0.002

Table 3. Result of multivariate logistic regression analysis

Risk Factor	Coefficient	Standard error	Odds ratio (95% CI)	p-value
Back Extensor strength	-0.009	0.003	0.990 (0.983-0.997)	0.008
BMI	0.026	0.061	1.027 (0.907-1.156)	0.664
Age	0.084	0.031	1.088 (1.025-1.160)	0.007
Sex	-0.108	0.488	0.897 (0.350-2.413)	0.824
Constant	-6.325			

Abbreviation: BMI, body mass index; Sex, being female

Figure 1. Feature importance of XGBoost model to predict frailty.



Conclusion

- The significant linear relationship was demonstrated between back extensor strength and abdominal and back (multifidus, iliocostalis lumborum, longissimus, and quadratus lumborum) muscle volumes.
- Back extensor strength was associated with multiple Fried frailty parameters and is considered a significant indicator of Fried's frailty.
- Exercise programs targeting the abdominal and back muscles may help slow down the aging process, and the measurement of back extensor strength could be an important tool in frailty prediction.

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