Structural Equation Modeling of the Contributing Factors to Landing Performance: Implications for Injury Prevention Programs

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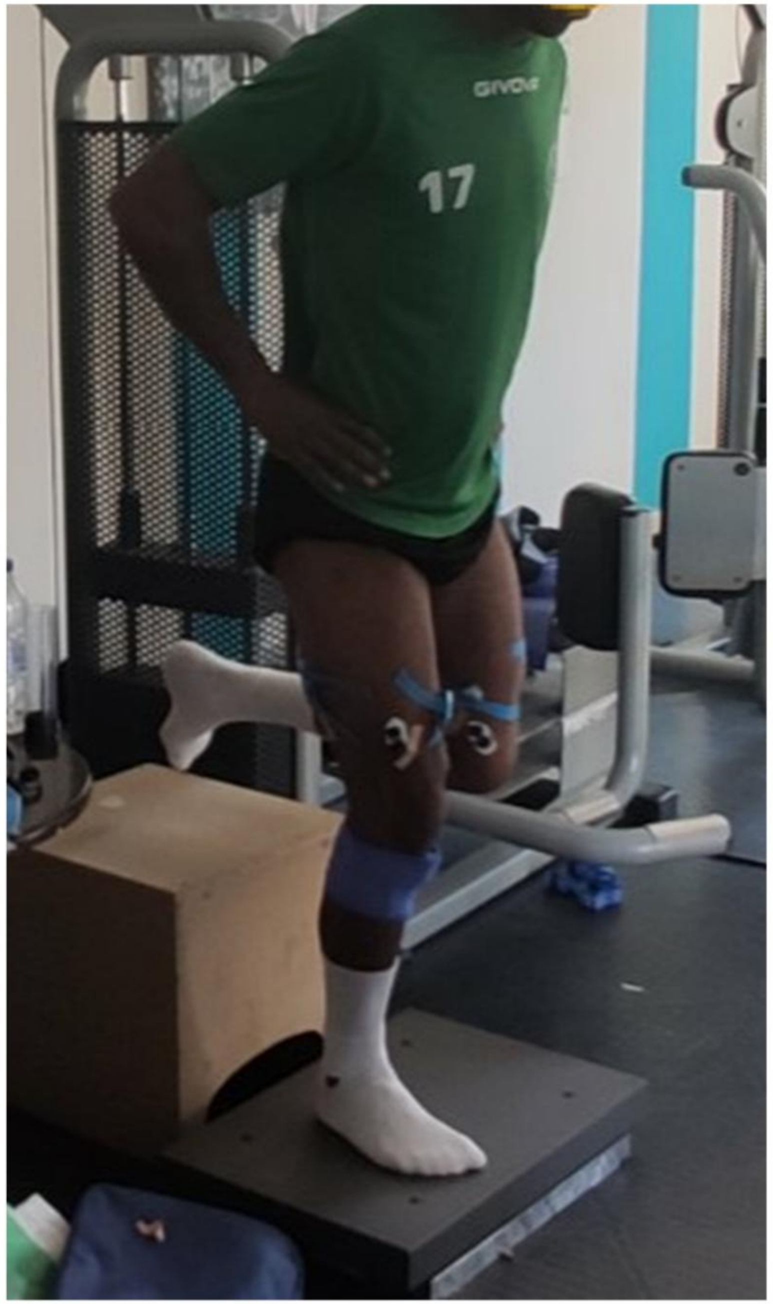
Introduction

- Poor performance on single-leg drop-jump landing has been identified as a potential contributing factor to ligament injuries in the lower limb.
- This study aimed to explore the factors affecting landing performance using exploratory factor analysis (EFA) and structural equation modeling (SEM).



Materials and Methods

The Experiment:

- During field-based preseason screening (N=62)

Test:

- Drop-jump landing with the dominant leg from a 30cm box

Data:

- Kinetic using a 40 × 60 cm force plate (Bertec)
- EMG (Noraxon)

	Mean ± SD
Age	21,32±4,54
Weight	74,64±8,03
Height	178,75±6,42
BMI	23,33±1,83
Football starting age	7,40±2,66
Years in Professional Level	3,27±3,49

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Materials and Methods

<u>Outcome measures</u>

- *Force Platform*

Ground reaction forces peak vertical ground reaction force (VGRF), center of pressure (COP) standard deviation, and total COP length for 2,5 seconds after landing.

- *EMG*

Hamstring-to-quadriceps activation ratio recorded between 25-ms pre- and 70-ms post-landing

Materials and Methods

Trunk Muscle Assessment

- Abdominal Muscles Endurance (AME): prone and side bridge tests
- Back Muscles Endurance (BME): Biering-Sørensen test

Thigh Muscle Assessment using a handheld dynamometer (MicroFET 2; Hoggan Scientific)

- Isometric and brake tests of the hamstring muscles at 30 degrees flexion
- Isometric tests for the quadriceps muscles at 90 degrees flexion

Functional Performance Assessment

- Single-leg hop for distance

A B C

A. Prone bridge test, B. Side Bridge test, C. Biering-Sorensen test

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Materials and Methods

Statistical Analysis (SPSS v. 28 and SmartPLS version 4.1.0.6)

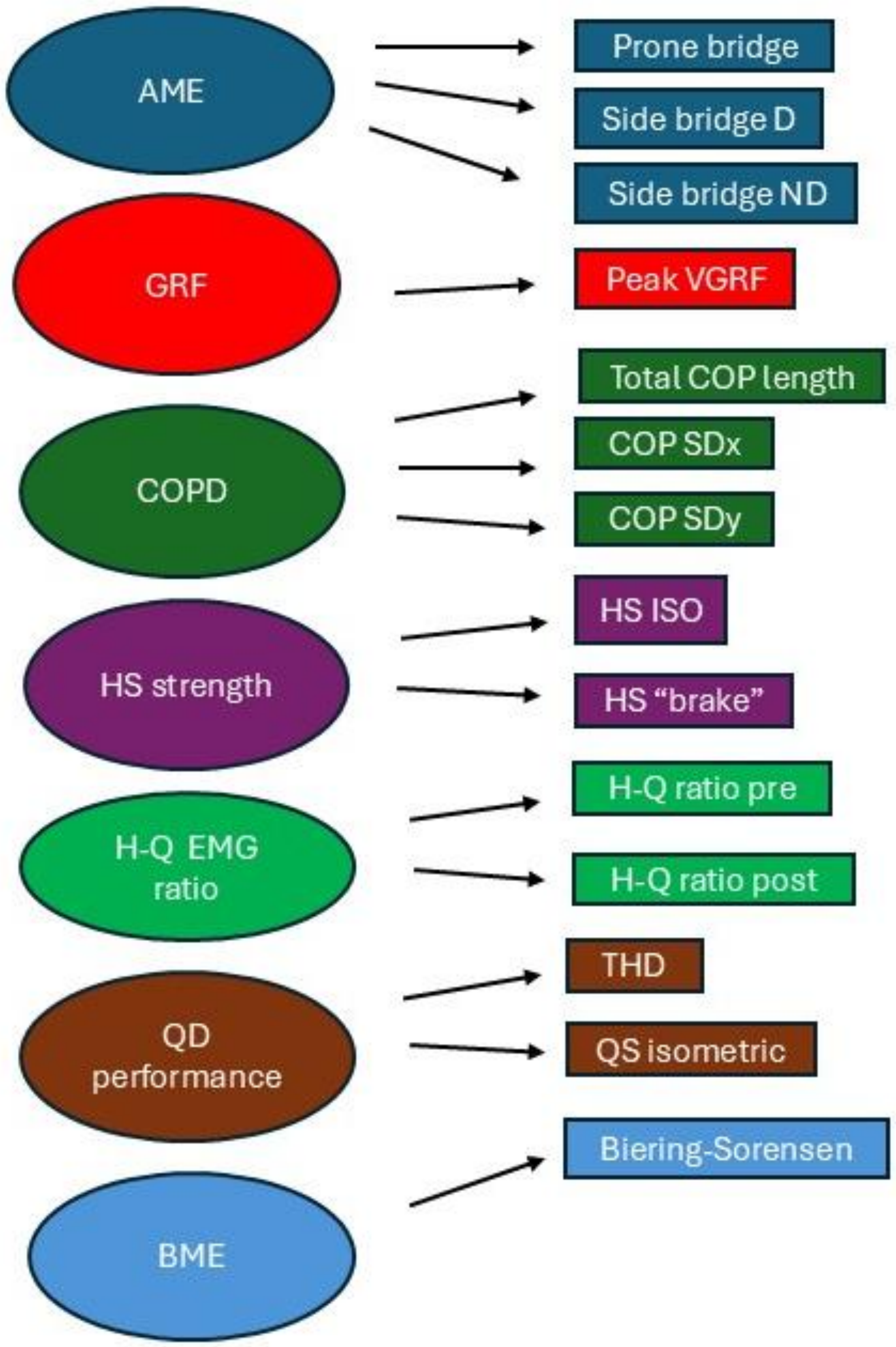
- Exploratory Factor Analysis (EFA) was employed to identify the underlying grouping of the measured variables,
- Partial Least Squares SEM was used to examine the interrelationships among the factors.

Results of Exploratory Factor Analysis

Seven latent factors were validated with 14 associated items:

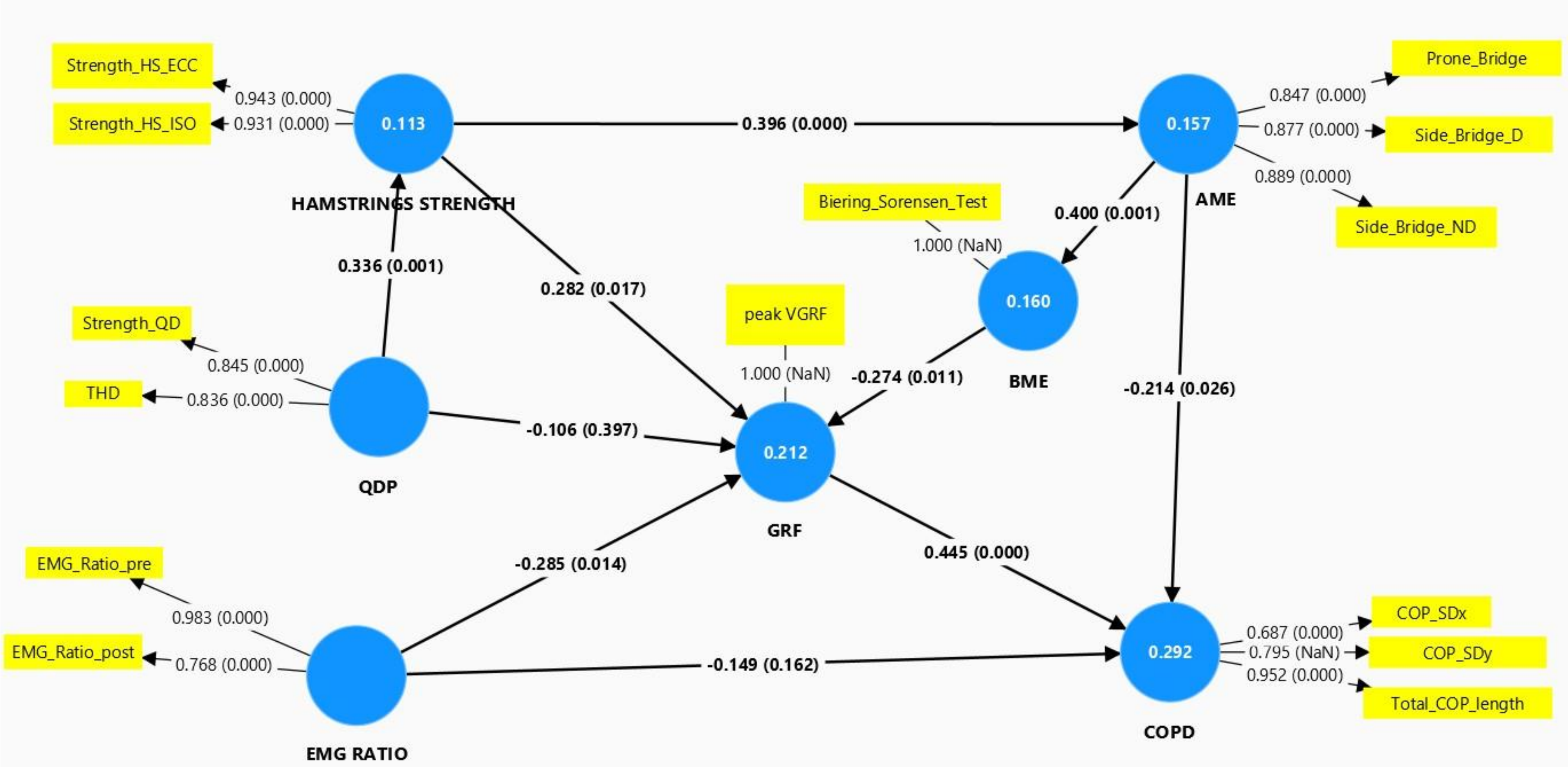
- VGRF, COP displacement (COPD), back muscle endurance (BME), abdominal muscle endurance (AME), quadriceps performance (QP), Hamstrings to Quadriceps activation ratio (H-Q), and isometric hamstring strength (HS).

✓ The measurement items had adequate loadings for each latent factor (>0.7), resulting in appropriate reliability and validity of the latent constructs (Average variance extracted >0.50, Cronbach's alpha >0.6).



Results of the Structural Model

- H-Q ratio exhibited an inverse relationship with VGRF *path coefficient (PC) -0.285, p=0.014*
- HS had a positive influence on VGRF *PC 0.282, p= 0.017*
- VGRF had the strongest direct effect on COPD *PC 0.491, p=0.000*



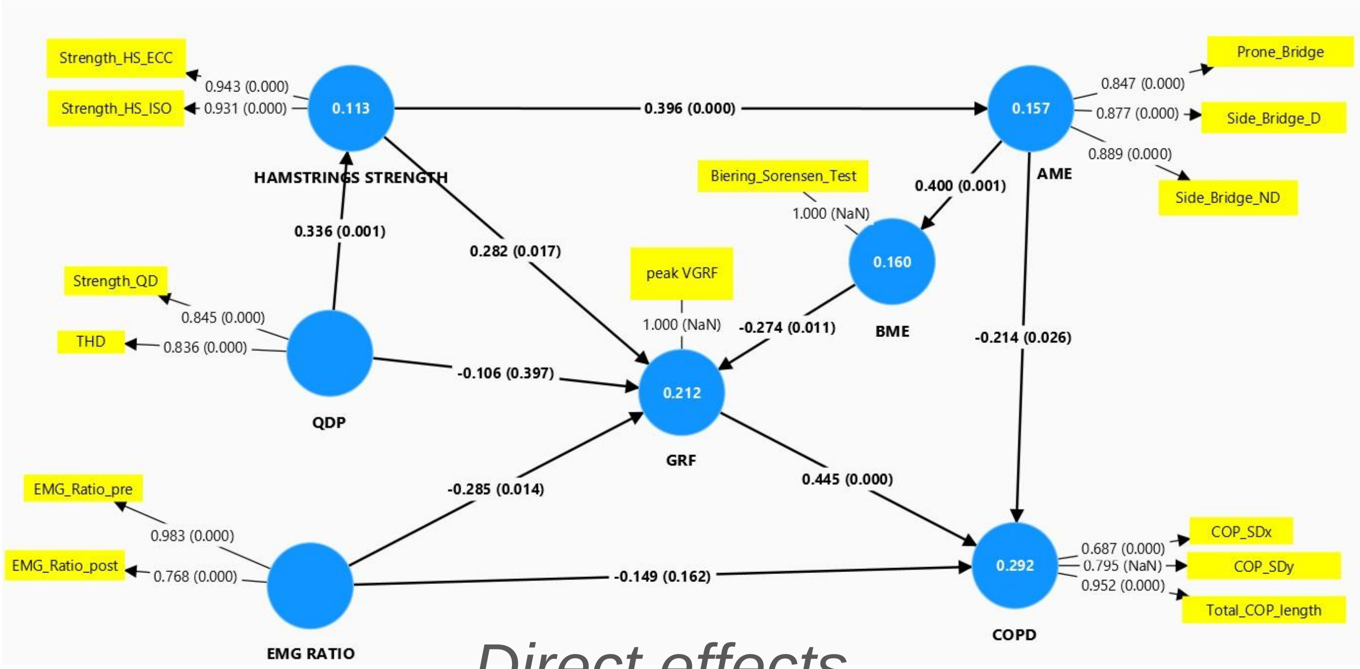
Results of the Structural model

BME and AME had significant negative effects on

- VGRF <u>*BME->VGRF PC -0.274, p=0.011, AME->VGRF PC -0.110, p=0.044*</u>
- COPD <u>*BME->COPD PC -0,135, p=0,017, AME->COPD PC -0.259, p=0.006*</u>

- QP and HS were interrelated <u>*PC 0.336, p=0.001*</u>
- Both QP and HS had a strong positive relationship with AME

  <u>*QP->AME PC 0.133, p=0.007*</u>, <u>*HS->AME PC 0.396, p=0.000*</u>
- Only HS positively influenced <u>*BME PC 0.158, p= 0.021*</u>



Direct effects

	Path coefficients	T values	P values
HAMSTRINGS STRENGTH -> BME	0.158	2.309	0.021
QDP -> AME	0.133	2.678	0.007
QDP -> GRF	0.080	1.620	0.105
QDP -> BME	0.053	1.924	0.054
HAMSTRINGS STRENGTH -> COPD	0.022	0.271	0.786
QDP -> COPD	-0.040	0.674	0.500
HAMSTRINGS STRENGTH -> GRF	-0.043	1.667	0.096
AME-> COPD	-0.049	1.846	0.065
AME-> GRF	-0.110	2.005	0.045
BME -> COPD	-0.122	2.275	0.023
EMG RATIO -> COPD	-0.127	2.013	0.044

Indirect effects

Discussion

- The **endurance of the core muscles** and the **thigh muscles co-activation ratio** plays a crucial role in the mechanics of landing
- Muscle strength may not be a sufficient indicator of function during dynamic activities
- However, strength factors are interrelated and influence core muscle endurance

Conclusions

- Performance on landing reflects multiple components of neuromuscular control.
- The incorporation of exercises that improve **thigh muscle strength**, **thigh muscle co-activation**, and **core muscle endurance** may exert a significant impact on landing performance and, by extension, on the risk of ligament injuries.

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