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Interrelationships Among Clinical Risk Factors and their Effects on Hamstring Injury Occurrence: A Mediation Moderation Analysis Based on Partial Least Square Structural Equation Modeling

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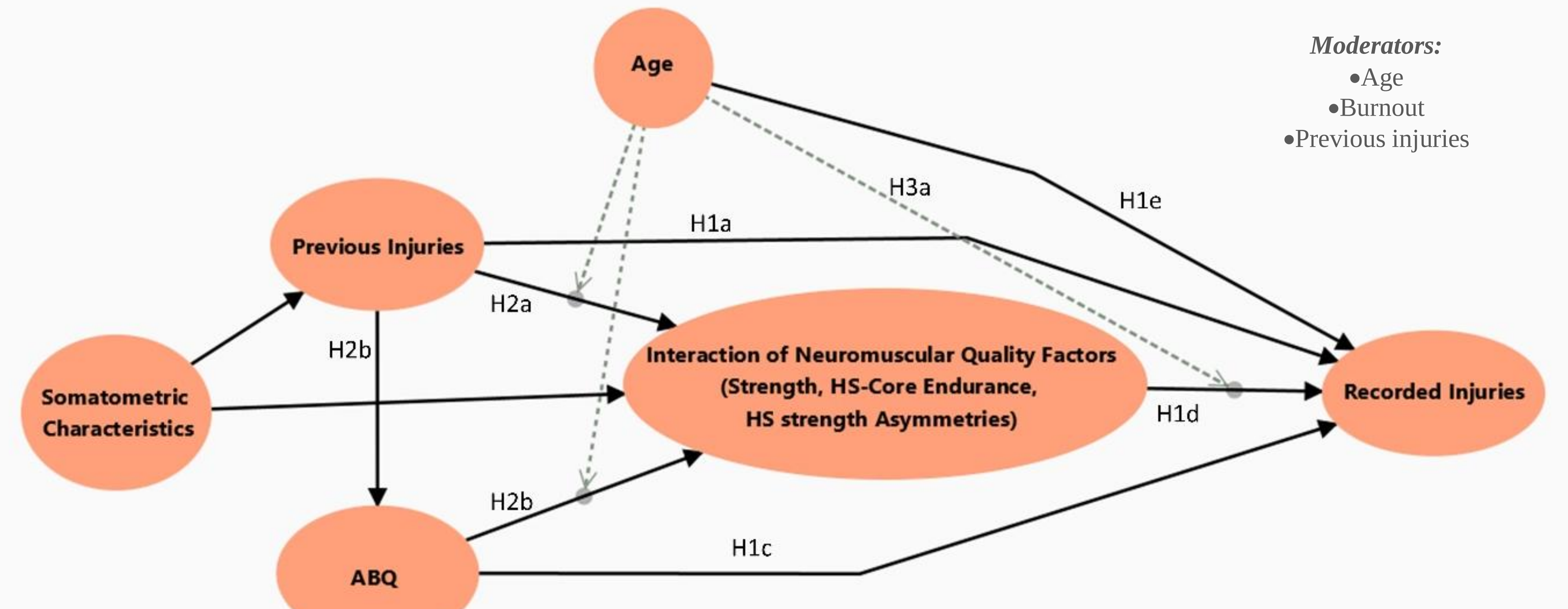
Introduction

- Hamstring injury (HI) poses a significant challenge in field-based team sports. Research identifies Increased athlete age and prior injuries as major risk factors, though results are inconsistent with other commonly measured factors.
- Recent studies highlight the necessity of investigating the intricate relationships among risk factors contributing to hamstring injuries (HIs).

➢ This study aimed to prospectively assess the interrelationships among clinical risk factors that result in direct and indirect effects on HI.



Structural hypothesis for testing of risk factors interrelationships.

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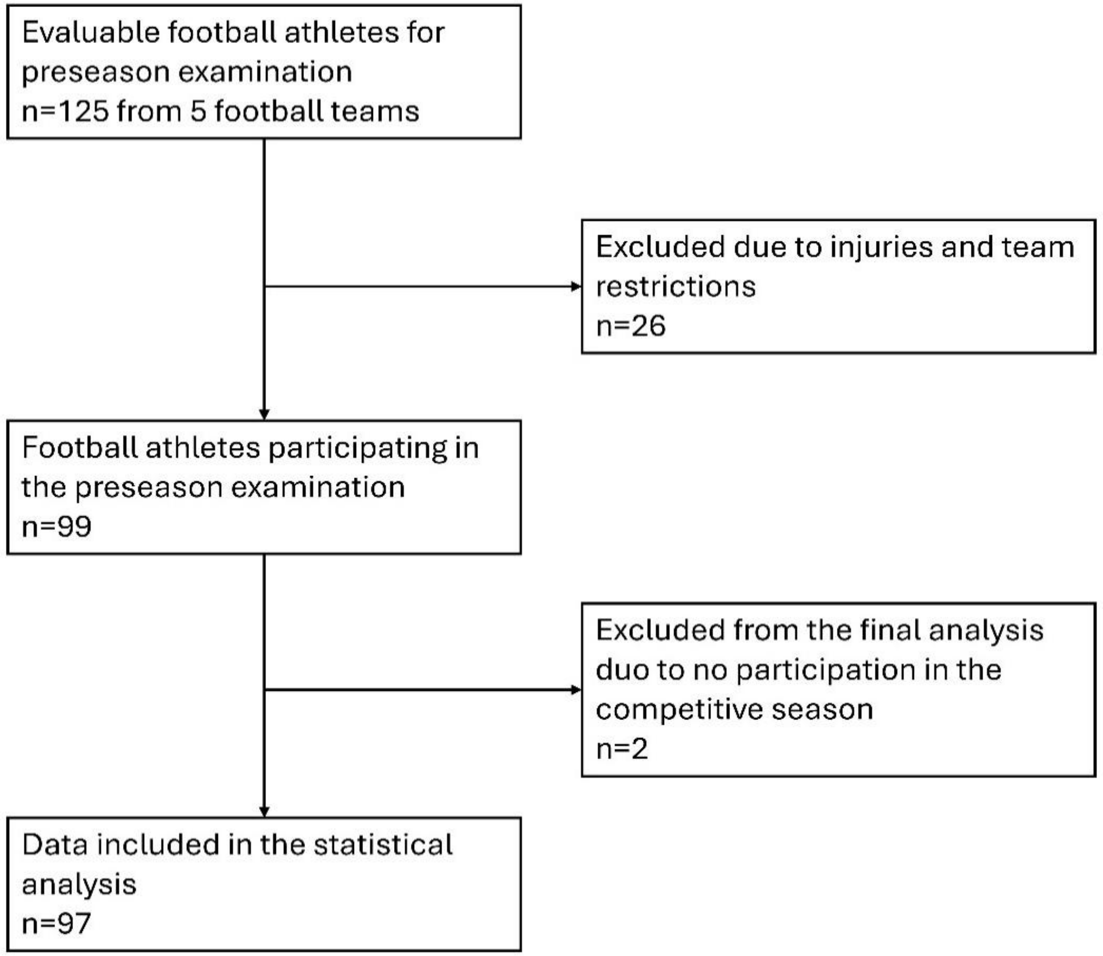
Materials and Methods

- The data were collected through field-based preseason screening involving ninety-nine professional and semi-professional football athletes from five teams participating in the second and third Greek divisions.
- Throughout the following season, new HIs were recorded.

Sample characteristics	Mean ± SD
Age	22,16 ± 5,03
Weight (kg)	74,44 ± 7,71
Height (cm)	178,82 ± 6,27
BMI	23,25 ± 1,76
Football Start Age	7,75 ± 2,94
Years Playing in Professional Level	3,79 ± 4,06
Games Participation Previous Year	19,26 ± 9,48
Hours Training per day previous year	2,33 ± 0,64
Days Training per Week Previous Year	5,53 ± 0,60



Materials and Methods

Preseason measurements protocol

1. Athletes completed a structured questionnaire regarding demographic and previous injury characteristics as well as the Athlete Burnout Questionnaire (ABQ).
2. Measurements:
   - Anthropometric characteristics
   - Isometric hamstring (HS) and quadriceps strength with the use of a handheld dynamometer
   - HS endurance (single-leg HS bridge)
   - Core endurance (prone bridge, side bridge, Biering-Sorensen test)
   - Single leg triple hop test

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Materials and Methods

Statistical analysis

- Exploratory factor analysis was used to identify the grouping of measured parameters into latent factors based on parameters' associations
- Partial least squares structural equation modeling was used to examine the direct, indirect, and mediated effects of the factors.
- Data were analyzed using SPSS version 28 and SmartPLS version 4.1.0.6.

Results

- Thirteen athletes sustained sixteen HIs during the season.

Type of injury	Frequency of Injuries (injuries and re-injuries)	Re-injuries	Percent (%)	Time Loss (Mean ± SD)	Injuries per 1000 athlete-hours exposure
Sports hernia/abdominal tendinopathy	4	0	5,3	48,00 ± 30,53	0,10
Other lumbar/hip injury	5	0	6,7	8,00 ± 5,29	0,13
Groin strain	13	2	17,3	6,62 ± 6,25	0,34
Hamstring strain	**16**	**3**	**21,3**	**13,31 ± 9,80**	**0,42**
Quadriceps strain	12	1	16	13,00 ± 12,66	0,31
Unspecified thigh muscle strain	1	0	1,3	20,00 ± 0,00	0,03
Meniscus	1	0	1,3	60,00 ± 0,00	0,03
Other knee injury	5	0	6,7	15,00 ± 19,64	0,13
Lower leg injury	6	0	8	6,33 ± 4,85	0,16
Ankle injury	11	2	14,7	16,00 ± 20,99	0,29
foot injuries	1	0	1,3	22,00 ± 0,00	0,03
Total	75	0	100		1,97

Results

- Exploratory factor analysis confirmed eight latent factors with their associated 20 measured items.
- The measured items appropriately loaded onto each latent factor (>0.60), resulting in an adequate level of factor validity and reliability.

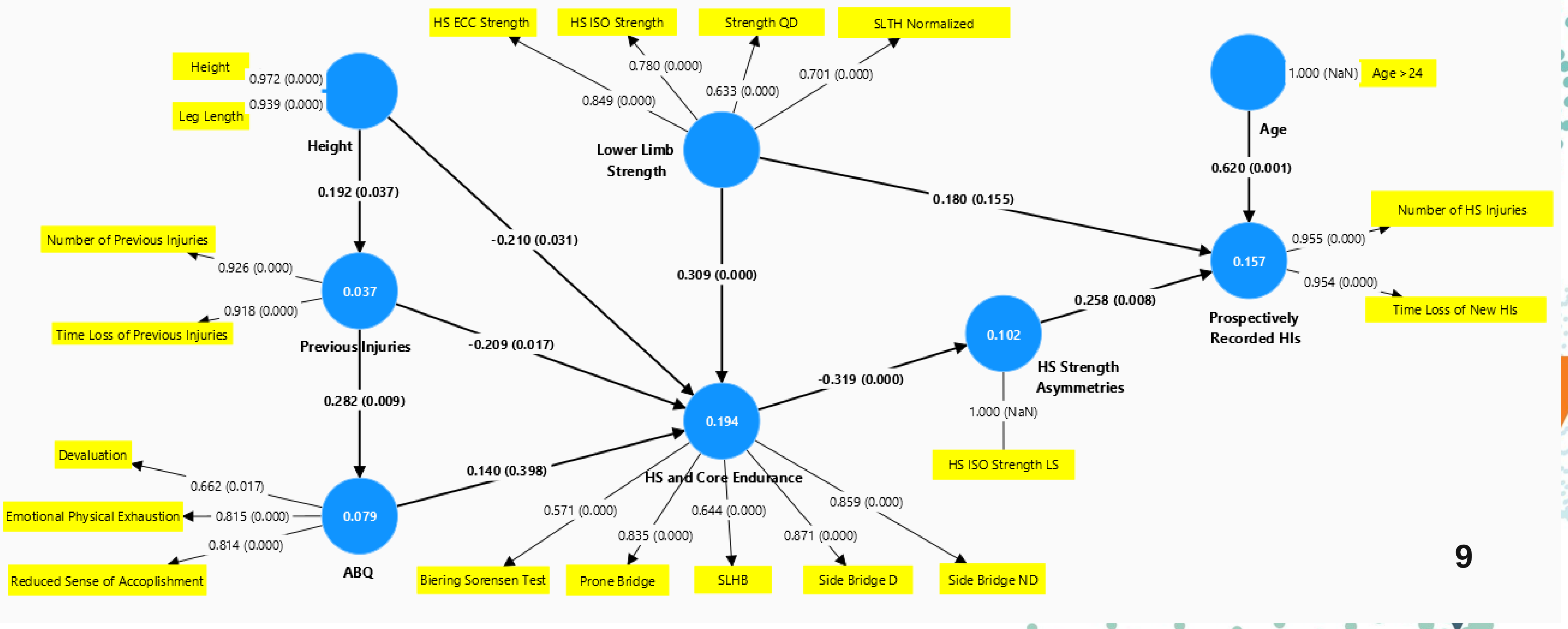
Latent Variable	Indicators	Convergent Validity		Internal Consistency Reliability			Discriminant Validity
		Loading	AVE	Cronbach's Alpha	Reliability pA	Composite Reliability pc	HTMT
		>0.70	>0.50	0.60–0.90	0.60–0.90	0.60–0.90	Significantly lower than 0.85
ABQ	Devaluation	**0.662**	0.588	0.658	0.691	0.809	YES
	Emotional Physical Exhaustion	0.815					
	Reduced Sense of Accoplishment	0.814					
Lower Limb Strength	HS ECC Strength	0.849	0.555	0.729	0.744	0.831	YES
	HS ISO Strength	0.780					
	Strength Quad D	**0.633**					
	Triple Hop D Normalized	0.701					
Heigth	Heigth	0.972	0.913	0.908	1.011	0.955	YES
	Leg Length	0.939					
Previous Injuries	Number of Previous Injuries	0.926	0.849	0.823	0.824	0.919	YES
	Time Loss	0.918					
HS-Core Endurance	Biering Sorensen Test	**0.571**	0.587	0.819	0.864	0.874	YES
	Prone Bridge	0.835					
	SLHB	**0.644**					
	Side Bridge D	0.871					
	Side Bridge ND	0.859					
Age	Age >24	1.000					
HS Strenth Asymmetries	HS ISO Strength LSI	1.000					
New HIs	Number of HS Injuries	0.955	0.912	0.903	0.903	0.954	YES
	Time Loss of New HIs	0.954					

Results

Main structural model results:

- Age had the greatest direct influence on new HIs (path coefficient (PC) 0.620, p=0.001).
- Furthermore, HS strength asymmetries had a significant direct positive influence on the propensity for new HIs (PC 0.258, p=0.008).
- HS and core endurance were found to indirectly reduce HIs (PC -0,082, p=0,046) and had a negative direct association with HS strength asymmetries (PC -0.319, p=<0.001).

- Lower limb strength, previous injuries, and height significantly affect the HS and core endurance



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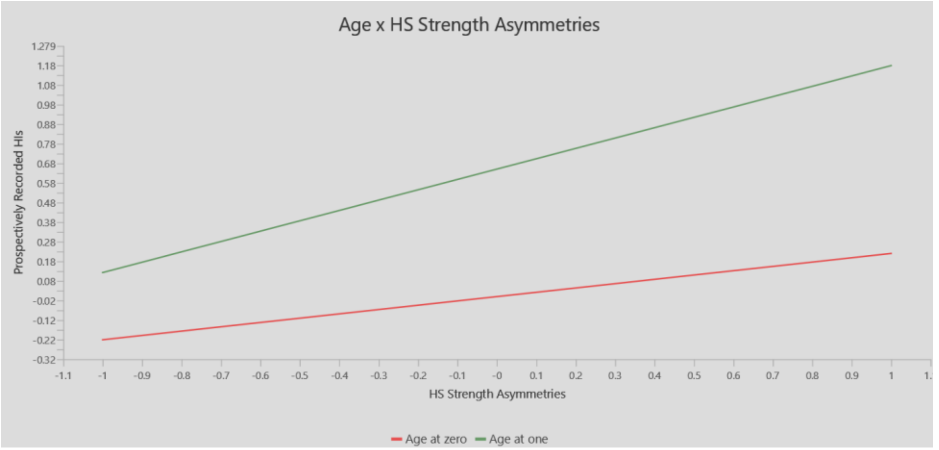
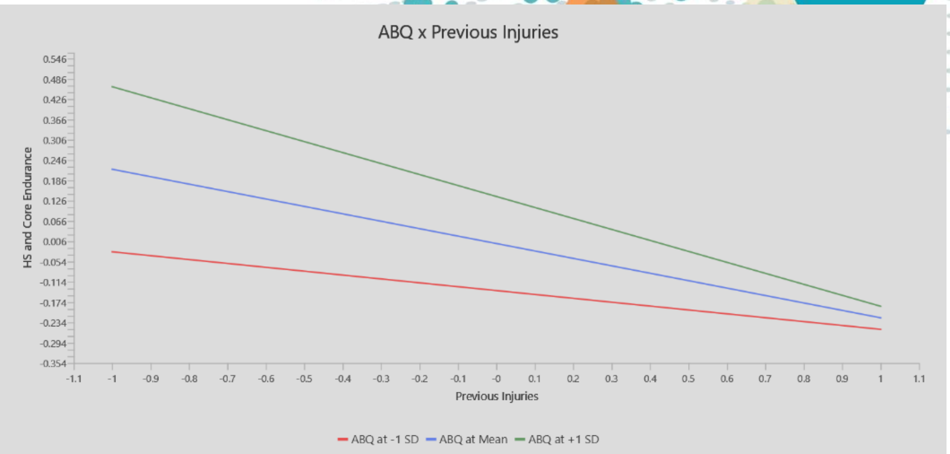
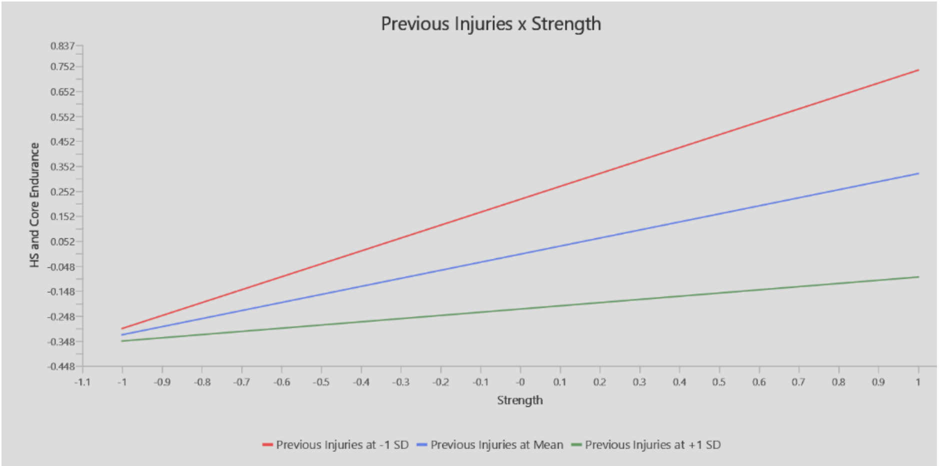
Results

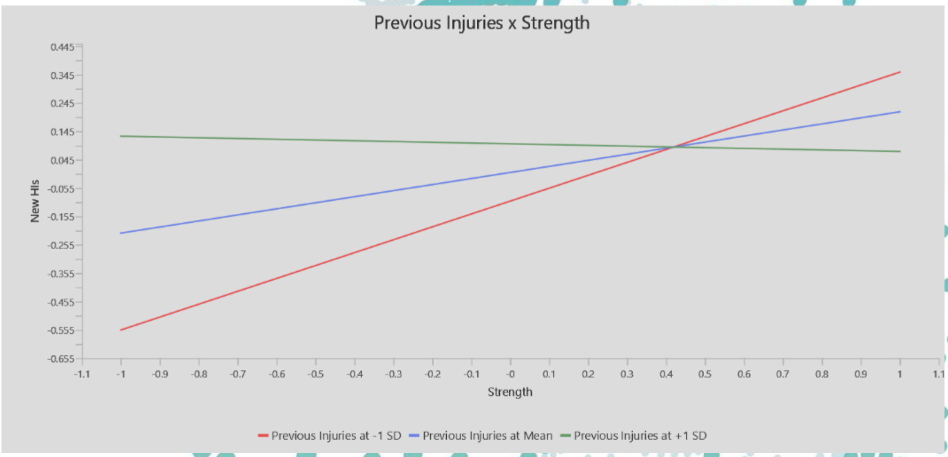
Moderating analysis (simple slop plot analysis)

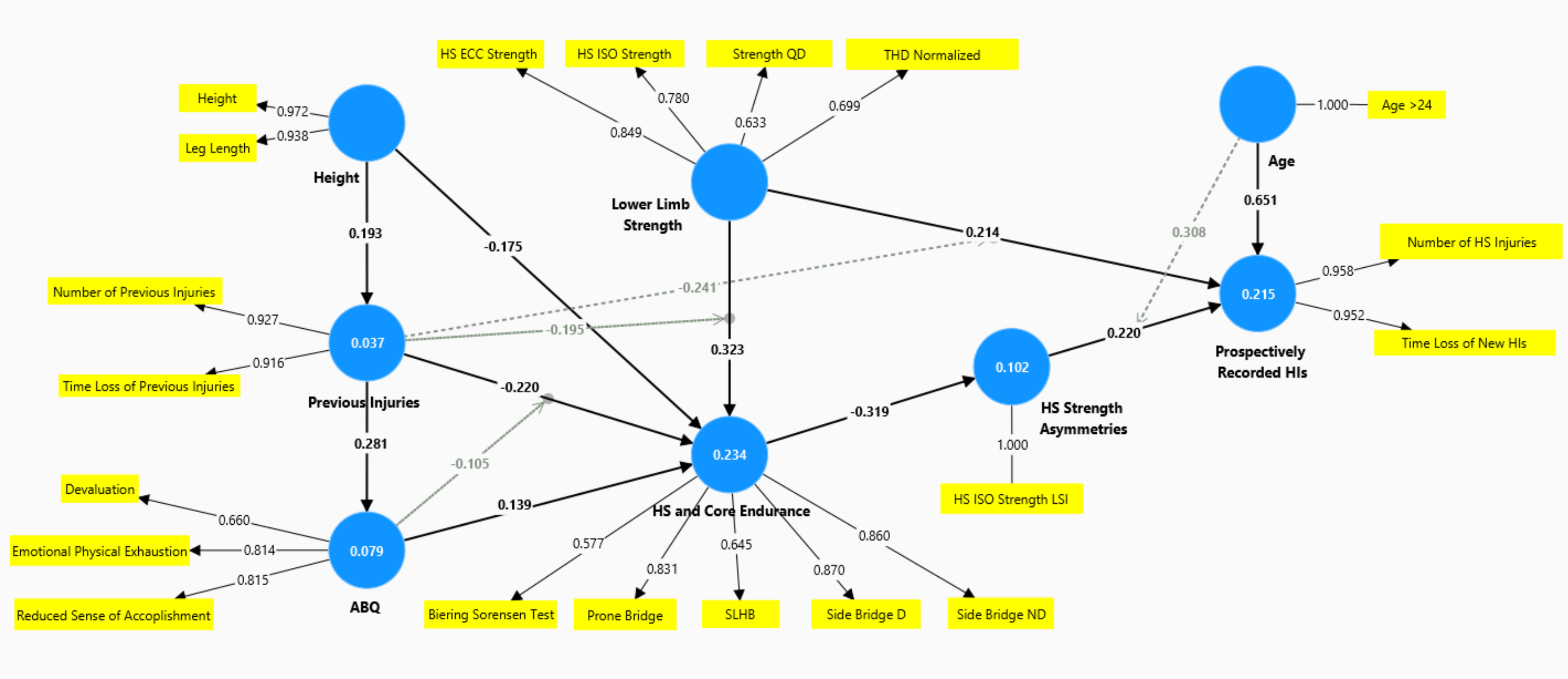
- Increasing age strengthens the positive effect of HS strength asymmetries on new HIs
- Higher values of ABQ strengthen the negative effect of previous injuries on HS and core endurance
- The existence of previous injuries impacts the relationships between HS and core endurance with strength and strength with new HIs.











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Discussion and Conclusions

- Based on the SEMs' results, injury prevention strategies should emphasize:
  - Improvements of athlete's HS and core endurance
  - Decreases of strength asymmetries, particularly in higher-age athletes
  - Individualized management of higher-age athletes and those with a history of previous injuries

- These findings contribute to a more comprehensive understanding of the interrelationships of critical intrinsic factors influencing HIs and facilitate improved planning for injury prevention strategies.

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