A COMPARISON OF STRUCTURAL EQUATION DERIVED PATH MODELS FOR MEN AND WOMEN BASED ON THE RELATIONSHIP BETWEEN ISOKINETIC TORQUE, VERTICAL JUMP POWER AND 10M SPRINT PERFORMANCE

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SUMMARY
Structural equation modeling (SEM) is analogous to multiple regressions but is a more powerful statistical method as it can evaluate the modeling of more complex interactions. SEM was applied to generate path diagrams to evaluate the direct and indirect effects of complex relationships that exist between strength, power and sprint acceleration, and to evaluate if any gender differences exist using path analysis of these constructs. Participants were measured for isokinetic torque, vertical jump power and 10m sprint. The results indicated different path coefficients and significant direct and indirect effects for the influence of 60°s⁻¹ peak torque leg extension and vertical jump height on 10m sprint and these effects were more important in male athletes. These finding indicate how strength, power and acceleration interact within the different genders and provide some guidelines for training strength and power development to enhance acceleration in sport.

INTRODUCTION
Structural equation modeling (SEM) is analogous to multiple regression but is a more powerful statistical method as it can evaluate the modeling of more complex interactions, nonlinearities, correlated independent variables, measurement error, correlated and uncorrelated error terms and multiple latent independents or factors, each measured by multiple indicators [1]. SEM may be used as a more powerful alternative to multiple regression, path analysis, factor analysis, time series analysis, and analysis of covariance. Research has established some of the relationships between strength, power and sprint acceleration [2,3,4] and usually the measures of muscular power being more predictive of sprint acceleration and sprint speed. Some multivariate research utilising the multivariate statistical technique of factor analysis has indicated that peak torque-strength and power constructs share some common variance but a significant amount of the variance is unique to each construct or factor [5]. Assessment texts on differences between the genders in terms of strength, power and speed in terms of norm referenced assessments are readily available, as well as IAAF World Athletic Rankings for the genders competing in identical athletic events.

However, research that has examined the relationship of strength-torque and power with sprint acceleration and sprint speed have relied on statistical correlation and regression, which are predominantly univariate measures of analysis and regression analysis is based on direct effect statistical model and does not consider mediating variables that can be analyzed by quantifying indirect statistical effects using structural equation modelling and more complex path analysis.

The two predominant research aims were to evaluate, 1. using structural equation modelling and path analysis the more complex relationships between the constructs of strength-torque, power and sprint acceleration in individual genders, and 2. evaluating if there are differences between males and females by comparing the derived path analyses using identical conceptual path diagrams for strength-torque, power and sprint acceleration.

METHODS
Research ethics’ approval was granted for undertaking research for humans by the institutional Research Ethics’ Committee. A screening process was applied to include only physically fit and active participants, as the participants were expected to perform all tests at maximal effort. The final sample was composed of sixty healthy, physically fit, active males (n=32; age=23.87yrs, s.d.=+/8.00; height=181.65cm, s.d.=8.04; weight=79.62kg, s.d.=+/10.27) and females (n=28; age=21.10yrs, s.d.=+/6.35; height=167.82cm, s.d.=+/4.99; weight=58.93kg, s.d.=+/6.41) who participated in the study. The exogenous variables in the model were isokinetic peak torque (N.m) at isokinetic speeds of 60°s⁻¹ (5 reps), 180°s⁻¹ (15 reps) and 300°s⁻¹ (15 reps) using leg extension/flexion. The endogenous variables were vertical jump performance as measured by flight time(s), peak vertical height (m) and jump contact time (s) and 10m (s) acceleration sprint performance. Peak torque was measured using a CYBEX 340 isokinetic muscle evaluation system with HUMAC NORM software.

All participants were instructed to perform the tests to the best of their ability (maximal effort). Leg power using the indices of contact time, flight time and height from were assessed with Speed Light Sports Timing System in jump mode and the participants were instructed to perform maximal effort vertical jumps. Sprint acceleration was tested by a 10m sprint time using the Speed Light Sports Timing System to the nearest 0.01s. Once again, participants were instructed to perform the sprint test with maximum effort. The analysis focused on the relationship between isokinetic leg extension torque at 60°s⁻¹, 180°s⁻¹ and 300°s⁻¹, vertical jump height and 10m sprint as indicants of strength, power and acceleration. Statistical analysis utilised AMOS 18 software to solve the structural equations and to generate the path coefficients for path diagrams. Initially, individual path diagrams were generated...
for each gender to evaluate the path coefficients between the
strength, power and acceleration constructs, then simultaneous
structural equation analysis using both groups was applied to
assess how well the models fitted across both genders.

RESULTS AND DISCUSSION
The path solutions for both genders were significantly
different as indicated in figure 1 and figure 2, the path
diagrams for males and females respectively.

Figure 1: Path diagram for males indicating path coefficients
for torque, vertical jump height and 10m sprint. The terms esp
and eht are error variance terms in the model.

Figure 2: Path diagram for females indicating path
coefficients for torque, vertical jump height and 10m sprint.
The terms esp and eht are error variance terms in the model.

The goodness-of-fit indicated both male and female models fit
the data resulting in non significant chi-squares. The negative
path coefficients indicate an inverse relationship. For example,
where the path coefficient is -.82 for the direct effect of jump
height on sprint time indicates greater jump height is
associated with reduced 10m sprint time. Comparing genders
using the path diagrams, it can be observed that the strength of
the relationship for jump height to sprint time is significantly
more important for males (coefficient = -.82) than for females
(coefficient= -.47). The path coefficients from peak torque are
different and more significant for males at 60°s⁻¹, however
peak torque at 180°s⁻¹ and 300°s⁻¹ are similar for both genders.
The important finer detail differences are identified in
the analysis of standardized coefficients for the indirect effects
displayed in tables 1 and 2. Tables 1 and 2 indicate clearly
that differences in indirect effect are gender related for 60°s⁻¹,
180°s⁻¹ and 300°s⁻¹ leg extension influencing 10m sprint time.

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<thead>
<tr>
<th>Table 1: Male standardized indirect effects.</th>
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<td>Height</td>
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<th>Table 2: Female standardized indirect effects.</th>
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The most significant indirect effect is the peak torque leg
extension for 60°s⁻¹ on 10m sprint performance mediated via
the vertical jump for males, whereas in females this mediation
effect is not significant. The simultaneous analysis assessing
the congruence between the two path models indicated a very
significant difference between genders in terms of the path
coefficients (Chi-square = 137.842, df = 20, p < .000). This
may be attributed to the significant direct effect between
vertical jump height and 10m sprint in males when compared
to females and the gender difference for the indirect effect of
peak torque leg extension for 60°s⁻¹ on 10m sprint
performance.

The results of this confirmatory analysis indicate the more
direct path between power and acceleration ability. In terms of
path models for males and females different interactions
between the constructs of strength-torque, power and
acceleration ability were evident. The significant indirect path
of isokinetic peak torque for leg extension for 60°s⁻¹
influencing 10m acceleration ability via vertical jump or
power ability in males, whereas this path in females was not
significant has implications for training different genders. For
examples males should gain improvement from both high
resisted strength training coupled with specific jump power
training to enhance acceleration where females would gain
more by training with sprint acceleration activities.

CONCLUSIONS
These findings may point to some important gender
differences in terms of interactions between strength, power
and sprint acceleration, for training different genders, however
larger sample sizes with varied athletes are required to verify
or refute these findings.

REFERENCES
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