Biomechanical, physiological and genetic predictors of lower limb musculoskeletal injury in military physical education students.

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Summary

This study investigated whether a combination of physical and cardiovascular capacity tests and genetic polymorphisms could predict the risk of injury during the first-year term of male military physical education students. Lower limb musculoskeletal injuries were monitored in 50 participants over 8 months. Biomechanical, physiological, and genetic variables were analyzed using logistic regression, with injury occurrence as the outcome. Greater flexibility, lower strength, reduced $\dot{V}O_2max$, and the rs12055409 genotype were associated with a higher injury risk, with a prediction accuracy of 0.80 (95% CI: 0.66–0.90).

Introduction

Musculoskeletal injuries (MSI) can limit physical activity, often requiring rehabilitation. Physical education students frequently engage in highly demanding exercises, often without proper preparation. While biomechanical and fitness assessments have been linked to injury history, the genetic contribution to MSI risk remains unclear. Genetic factors influence ~50% of traits related to physical performance [1], and single-nucleotide polymorphisms (SNPs) may affect injury susceptibility. Given MSI's multifactorial nature, the interaction between biomechanics, physiology, and genetics is poorly understood. This study examines whether vertical jump performance, muscle strength, flexibility, $\dot{V}O_2max$, and genetic polymorphisms predict MSI in first-year male military physical education students.

Methods

Lower limb MSIs were monitored in 50 male (26.8±1.5 years; 78.3±8.8 kg; 177.5±6.2 cm) military students over eight months. Biomechanical, physiological, and genetic variables were assessed at the start of the course over five days, with 48-hour intervals: Day 1: Flexibility (sit-and-reach test, Wells bench). Day 2: Countermovement jump (CMJ) height (force platform). Day 3: Lower limb strength (one-repetition maximum (1RM) squat test, Smith machine), normalized to body mass. Day 4: Estimated maximum oxygen uptake ($\dot{V}O_2max$) via a 12-minute running test. Day 5: DNA (oral swabs) (SNPs: rs1815739 – ACTN3, rs4341 – ACE, rs12055409 – MLN). A lower limb MSI questionnaire was administered every two months (four assessments total). After eight months, 34 participants sustained at least one injury, while 16 remained injury-free. The biomechanical, physiological and genetic variables were analyzed using logistic regression, with injury occurrence as the outcome. Relevant variables were selected by bidirectional stepwise method and validated through K-fold cross-validation.

Results and Discussion

Flexibility, relative 1RM, $\dot{V}O_2max$ and the rs12055409 were identified as injury predictors with an accuracy of 0.8 (95% CI = 0.66 – 0.90). Lower flexibility, higher strength and $\dot{V}O_2max$, as well as the rs12055409 GG and AG genotypes, were associated with a lower risk of MSI (Figure 1).

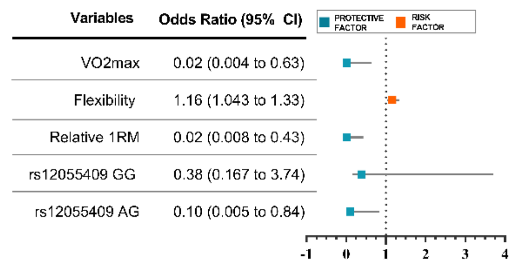

Figure 1: Odds Ratios for factors associated with MSI, with risk factors shown in orange and protective factors in blue.

These findings align with previous studies linking increased flexibility [2] and reduced strength [3] with MSI. Additionally, the influence of the rs12055409 G-allele on muscle function may help mitigate the risk of MSI as it is associated with increased muscle strength, mass, and fiber [4].

Conclusions

Flexibility, 1RM strength, cardiorespiratory capacity and rs12055409 alleles were injury predictors. These findings may help select preventive strategies for musculoskeletal injuries in this population.

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