Adolescent Knee Strength and Endurance Profiles: Establishing Age- and Sex-Specific Normative Data for Return-to-Activity Assessments

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Summary

Adolescent, sex-specific knee strength characteristics are similar to adults, but there appear to be distinct differences in knee muscular endurance. An isokinetic endurance task may also highlight limb-symmetry characteristics that are not evident through only isometric testing.

We propose that sex-specific strength and endurance tasks should be incorporated into adolescent functional assessment, rehabilitation and return-to-activity test batteries following anterior cruciate ligament injury.

Introduction

The analysis of lower extremity strength has been widely used in knee rehabilitation to assess readiness for return to activity following injury, such as anterior cruciate ligament (ACL) ruptures, and subsequent surgery. Deficits in knee extensor muscle strength are known to accompany functional restrictions such as altered gait or landing patterns [1], while limb asymmetry is also frequently assessed [2]. However, effective rehabilitation programs rely on population- and sex-specific normative strength and limb-symmetry data, which are less well understood in adolescents. The effects of muscular endurance and limb dominance on return-toactivity criteria are also less clear.

The purpose of this study was therefore to examine sex-differences and limb-symmetry in isometric and dynamic knee strength and endurance among healthy adolescent males and females, and to establish baseline metrics to better inform knee rehabilitation protocols for this population.

Methods

Forty-six healthy adolescent males (14.1 ± 2.2 years) and 54 females (13.9 ± 2.0 years) participated in the study. Isometric and isokinetic torques were assessed using an isokinetic dynamometer (Biodex Medical Systems, NY, USA) sampling at 2000Hz. Subjects first performed three, five-second repetitions of maximal voluntary isometric knee extension and flexion with the participant's hip and knee joint held at 90° and 60°, respectively. A correction for resting limb weight was included.

Subjects then completed an endurance protocol involving 40 continuous maximal concentric-concentric knee extension and flexion contractions. Contractions were performed at an angular velocity of 90°/s within an 85° range of motion (100-15° knee flexion).

Outcome variables included peak isometric knee extensor and flexor torque (iPT), the ratio between the two (IHQSR), and torque deficit (calculated as the fatigue index (FI)) during the isokinetic endurance task, based on peak dynamic torque (dPT) at the start and end of the protocol. A mixed-methods ANOVA with leg dominance as the within-factor and sex as the between-factor was used to assess differences in each of the outcome variables.

Results and Discussion

Females displayed a higher knee flexion FI ($p = 0.007$) compared to males, which is contrary to research in adults, where females have shown greater resistance to fatigue [3] However, as expected, males showed higher dPT knee extension strength at the start ($p = 0.043$) and end of the endurance task ($p = 0.008$), as well as higher dPT knee flexion strength at the end ($p = 0.009$). Males also showed significantly higher iPT for knee extension and flexion ($p < 0.001$).

Regarding limb-symmetry, results were dependent on the task performed (isometric strength or isokinetic endurance). The dominant leg had higher knee flexion strength ($p = 0.036$) and higher IHQSR ($p = 0.049$) compared to the non-dominant leg, as well as higher dynamic extension strength at the start ($p < 0.001$) and end ($p < 0.001$) of the endurance task. However, the non-dominant leg had higher dynamic flexion strength at the start ($p < 0.001$) and end ($p < 0.001$) of the endurance task compared to the dominant leg.

Conclusions

Adolescent males and females exhibit distinct force generation abilities and should be considered separately when interpreting strength profiles. Higher fatigue among females suggest that sex-specific endurance characteristics identified in adults should not be extrapolated to adolescent populations. Finally, the inclusion of an endurance task may provide additional insight into limb-asymmetry that is not evident using only isometric strength testing.

References

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