



# SEX AND LOAD BASED NEUROMUSCULAR LOADING DURING SUBMAXIMAL BACK SQUATS

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## Abstract

**INTRO:** Despite its frequent prescription across both sexes, males and females perform loaded back squats differently[1]. Males exhibit smaller hip flexion and greater knee flexion angles during squats compared to females, indicating different movement strategies possibly due to altered muscle activation[2]. In addition to neuromuscular assessments like quadricep to hamstring ratios (which are pertinent across many dynamic tasks), multifaceted variables like joint work, which represents the summative load placed on the joints to perform a task, could shed light on neuromechanical differences between males and females, and provide foundation for improving programming[3]. **PURPOSE:** The purpose of this study is to investigate sex differences in hip and knee joint work and integrated muscle activation (EMG) across two submaximal loads. **METHODS:** 17 healthy adults (8 females) with at least six months of experience squatting with appropriate technique completed this two-day study. One repetition max (1RM) was tested on day one and used to calculate the submaximal loads on day two. Five squats were performed to full (120-degree knee flexion) depth at 50% 1RM, and 80% 1RM. Lower body kinematics (Vicon Vantage System; 200Hz), kinetics (Bertec forceplates; 2000Hz), and EMG (Delsys Trigno; 2000Hz) were recorded for all squats. Joint work (Joules/system mass) was calculated for the downward (beginning of descent to full depth) and upward (full depth to standing upright) phases separately. Integrated quadricep to hamstring activation ratio (semitendinosus, biceps femoris, vastus lateralis and vastus medialis) was determined across the full squat. Two-way mixed model analyses of variance were used to determine sex by load interactions and main effects. **RESULTS:** No significant interactions were found for any variable ( $p > 0.05$ ; Table 1). No sex main effects were found in knee joint work ( $p > 0.05$ ). However, there was a sex main effect in hip joint work for both the eccentric (partial  $\eta^2$  effect size:  $\eta^2 = 0.343$ ) and the concentric ( $\eta^2 = 0.277$ ) phases, with women displaying greater work than men. There were significant load main effects, with 80% 1RM loads invoking larger work than 50% 1RM loads for both hip and knee eccentric ( $\eta^2 = 0.264$  &  $\eta^2 = 0.481$ , respectively) and concentric ( $\eta^2 = 0.277$  &  $\eta^2 = 0.653$ , respectively) phases. **CONCLUSION:** The significant increase in hip joint work for females compared to males and across loads provides evidence to include more full depth back squat movements for female athletes to improve hip strength and decrease the knee dominance currently found in female athletes during dynamic eccentric tasks like landing. Future research should aim to expand on this work by, assessing different depths (e.g., parallel), stance width, bar position, and shoe type. **PRACTICAL APPLICATION:** Strength and conditioning coaches should consider implementing more full depth squat to enhance hip loading in female athletes

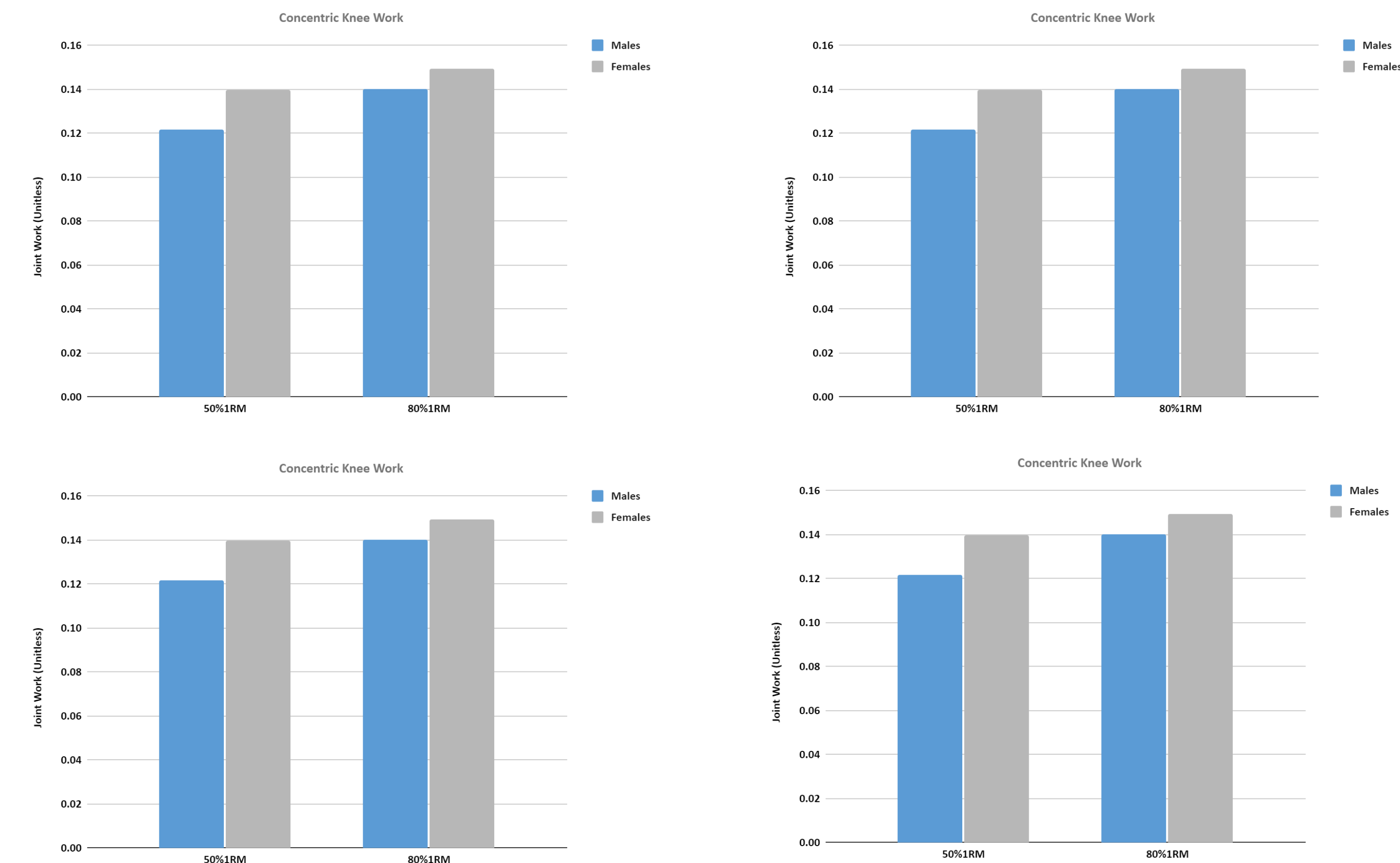
## Purpose

- The purpose of this study is to investigate sex differences in hip and knee joint work and iEMG across two submaximal loads during the back squat

## Methods

- 17 (10 males, 7 females) healthy, recreationally active participants with At least 6 months of squatting experience, active 30 minutes three times a week
- Day One: 1-Repetition Maximum (1RM) testing
- Loads were increase 5 – 20 pounds each set with 2 – 4 minutes of rest until 1RM was achieved
- Day two: Full body motion capture (see fig below) and EMG were recorded during back squats with submaximal loads (50% and 80% of 1RM) performed to 120-degree depth
- Electrodes were placed on the semitendinosus, biceps femoris, vastus lateralis, and vastus medialis
- Two-way mixed model analyses of variance (ANOVA) were used to analyze sex 'x' load effects for integrated EMG along with hip/knee joint work during eccentric (lowering) and concentric (raising) portions of the squat.

## Results



## Conclusion

- Female participants exhibited significantly ( $p < 0.05$ ) larger hip joint work moments during both the eccentric and concentric portions of the back squat
- No sex main effects were found at the knee joint ( $p > 0.05$ )
- Significant load main effects were seen in both knee and hip joint work with 80% of 1RM invoking larger work moments compared to 50% of 1RM

## Practical Application

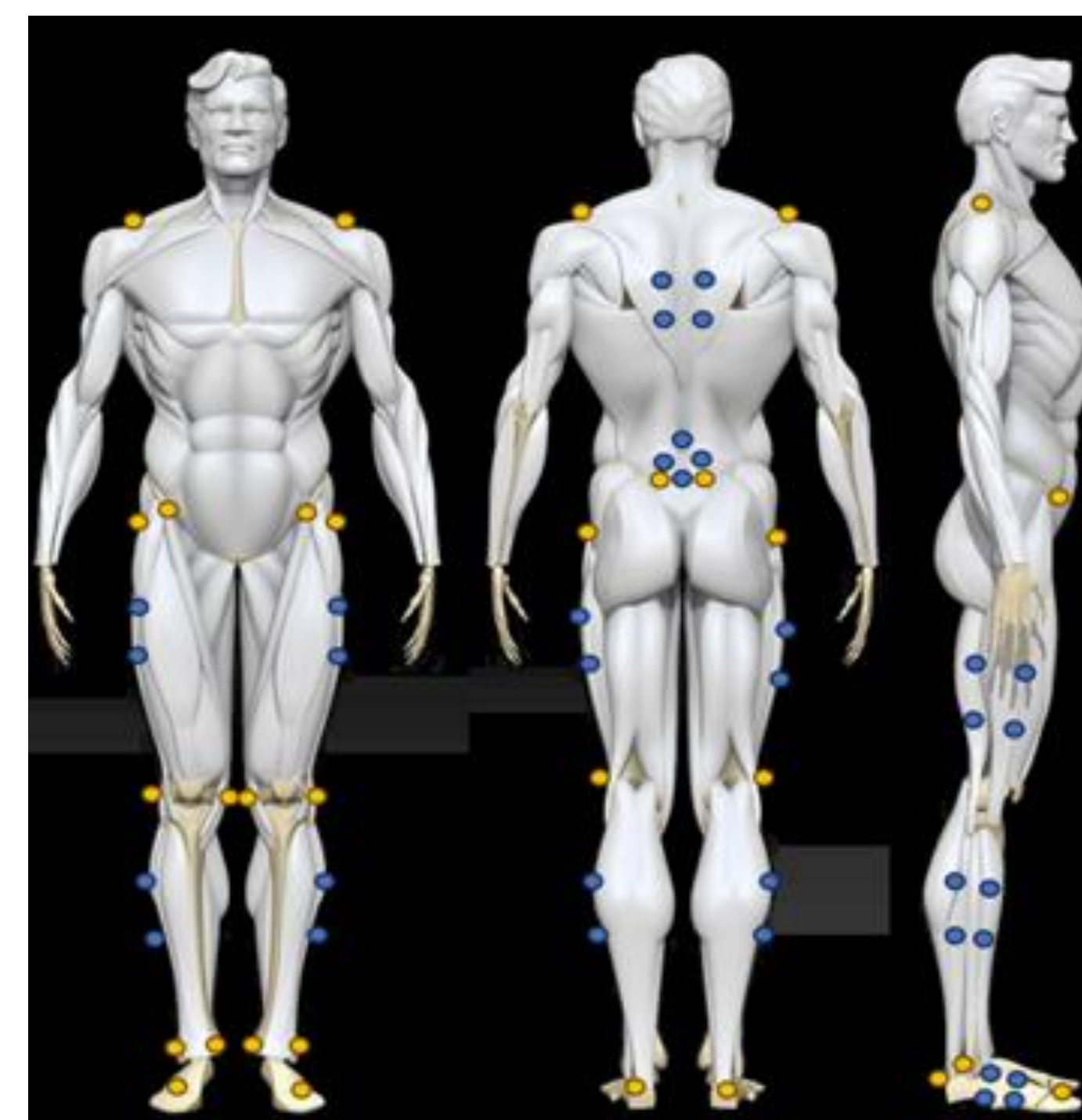
- Implement full depth squat protocols for female athletes at submaximal loads

## References

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## Introduction

- Sex differences exist biomechanically during loaded back squat movements
- Males exhibit smaller hip flexion angles and greater knee flexion angles, which are indicative of different movement strategies between males and females
- A better understanding of neuromuscular (e.g., electromyography (EMG)) and mechanical aspects of the squat can influence future training programs and assessments



Marker placement for data collections

- Blue circles: Tracking markers
- Red circles: Static markers
- Tracking clusters were used for the thigh and shank