

Abstract

BACKGROUND: Low-load resistance training at 20-50% of the one repetition maximum (1RM) combined with blood flow restriction (BFR) has been shown to be an effective method to improve muscular strength. Within program design, many variables can be manipulated including tempo and the use of open (OKC) and closed kinetic chain exercises (CKC). In traditional resistance training, tempo is commonly varied, however, in BFR training the standard 1:0:1 is common. Furthermore, both open and closed kinetic chain exercises have been used in BFR training but have not been directly compared. **PURPOSE:** To evaluate the effect of manipulating exercise tempo and kinetic chain with BFR training of the lower body. **METHODS:** 40 resistance trained college-aged males participated in the study. The subjects were randomized into one of four groups: knee extension normal tempo (KENOR), knee extension time under tension (KETUT), back squat normal tempo (BSNOR), and back squat time under tension (BSTUT). The normal tempo group completed reps at 1:0:1 tempo, meaning 1 second eccentric, 0 second during the transition, and 1 second concentric. The TUT group completed reps at 1:3:1 tempo. Volume was manipulated to equate total time under tension between groups. Cuff occlusion pressure was set at 130% of systolic blood pressure taken in the supine position. All groups completed 18 progressive resistance training sessions over 6 weeks. 1RM measurements were taken pre and post training. Participants started at 20% of 1RM and progressed to 30% of 1RM after 9 sessions. The primary outcome measures were absolute and relative changes in maximal strength. A one-way ANOVA was used to compare differences between each of the intervention groups with a Bonferroni post hoc analysis. Statistical significance was set at $p \leq 0.05$. **RESULTS:** All groups experienced a significant increase in maximal strength pre to post ($p=0.006$). KENOR experienced larger changes in strength when compared to BSNOR (+16.8kg; $p=0.003$) and BSTUT (+15.2kg; $p=0.008$). KETUT experienced larger changes in strength when compared to BSNOR (+15.5kg; $p=0.007$) and BSTUT (+13.9kg; $p=0.019$). KENOR experienced greater relative changes in strength when compared to BSNOR (+14%; $p=0.004$) and BSTUT (+13.3%; $p=0.006$). **CONCLUSION:** There was no difference between normal tempo and time under tension groups. Gains in absolute strength were larger in the KE groups compared to the BS groups. Relative strength gains were only larger in KENOR compared to BS groups. **PRACTICAL APPLICATIONS:** Both OKC and CKC exercises are effective in improving lower body strength, confirming previous research. Manipulating tempo had a neutral effect on strength gains, possibly allowing coaches and clinicians to deviate away from the standard 1:0:1 tempo when prescribing BFR training.

Introduction

Blood flow restriction (BFR) training involves the use of pressurized cuffs placed at the proximal end of the limb to restrict arterial blood flow and occlude venous return. This creates an artificially hypoxic environment in the working tissues, simulating high intensity exercise. Tempo refers to the speed at which an exercise is completed. For example, 1:3:1 indicates 1 second lowering (eccentric), 3 second pause in bottom position, and 1 second raising (concentric). Exercises can differ in numerous ways, including kinetic chain. A closed kinetic chain exercise involves the most distal portion of the limb remaining fixed while the body moves around it (i.e. back squat). Conversely, an open kinetic chain exercise involves the most distal portion of the limb moving freely while the body remains fixed (i.e. knee extension).

Methods

All participants filled out a health history questionnaire (HHQ), a physical activity readiness questionnaire (PAR-Q), and an informed consent to determine eligibility. After clearance, baseline measurements of height, weight, resting heart rate, as well as blood pressure were taken. Blood pressure was measured in the supine position and determined each participant's unique occlusion pressure for the intervention, 130% of systolic blood pressure. 1 Repetition Maximum (1RM) was tested on the modality each subject was assigned to for the duration of the intervention. Progress was measured by calculating change as a percentage of

Methods

Each subject completed a standardized lower body dynamic warm-up designed by the researchers in order to prepare the participant for the exercise protocol. After the warm-up, the occlusion cuff was applied at the proximal end of the lower extremities at a pre-determined pressure based on each subject's supine, resting blood pressure reading. The cuff remained on and pressurized for the entire duration of the working sets and was removed immediately following the last set. BS groups squatted using a traditional 45 lb barbell in a power rack. KE groups completed sessions on a Cybex knee extension machine. The working sets varied based on the randomized group, (BS_{NOR}, BS_{TUT}, KE_{NOR}, KE_{TUT}) however, the total time under tension was the same between all groups. For example, normal tempo groups (1s eccentric, 0s isometric, 1s concentric) completed the first set of 30 reps for a total of 1 minute of time under tension. Sets 2-4 were 20 reps for a total of 40 seconds time under tension. Time under tension groups completed 12 reps for the first set (1s eccentric, 3s isometric, 1s concentric) for a total of 1 minute of time under tension. Sets 2-4 consisted of 8 reps following the same tempo scheme as the first set, for a total of 40 seconds time under tension. Rest between each set was 45s for all groups.

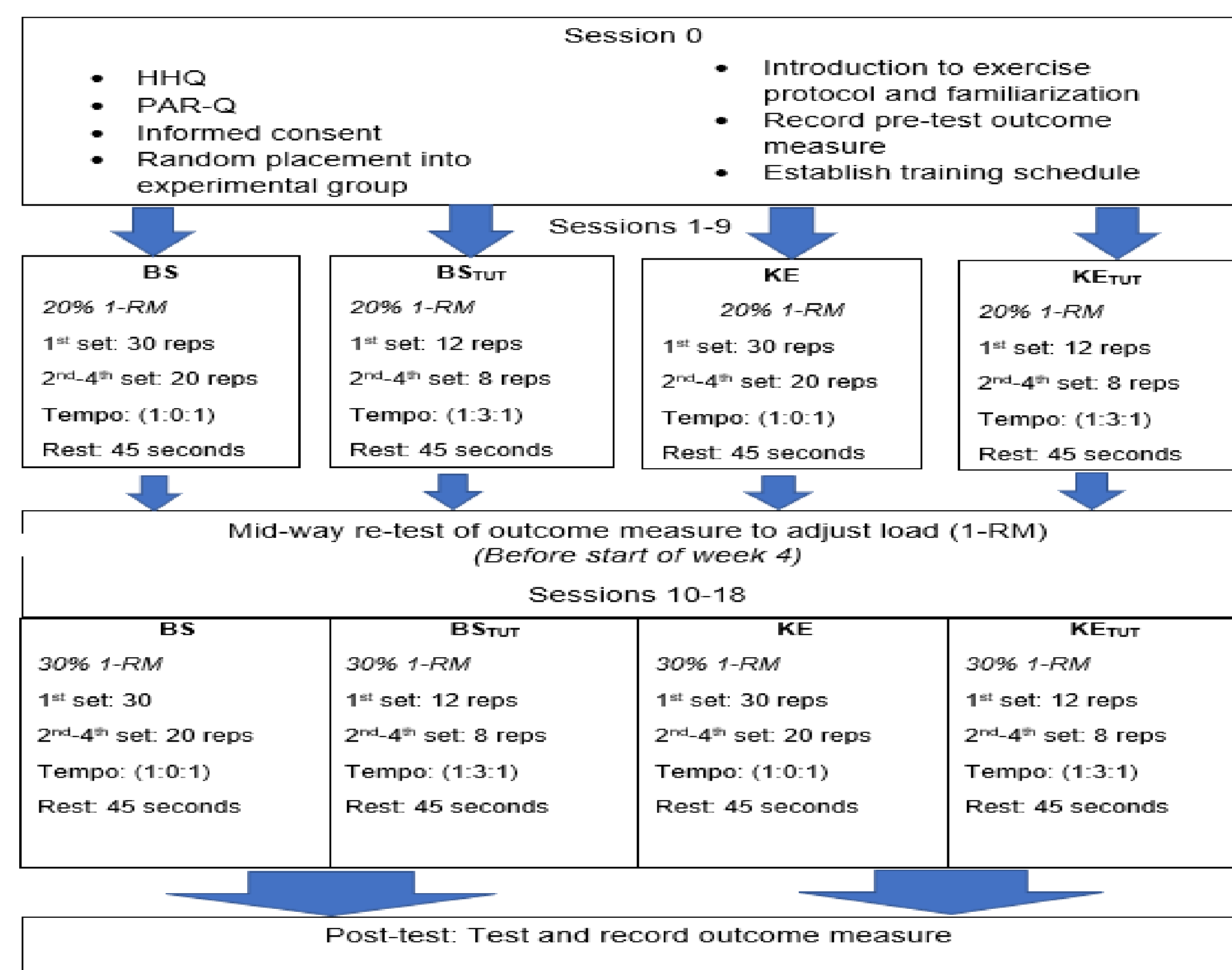
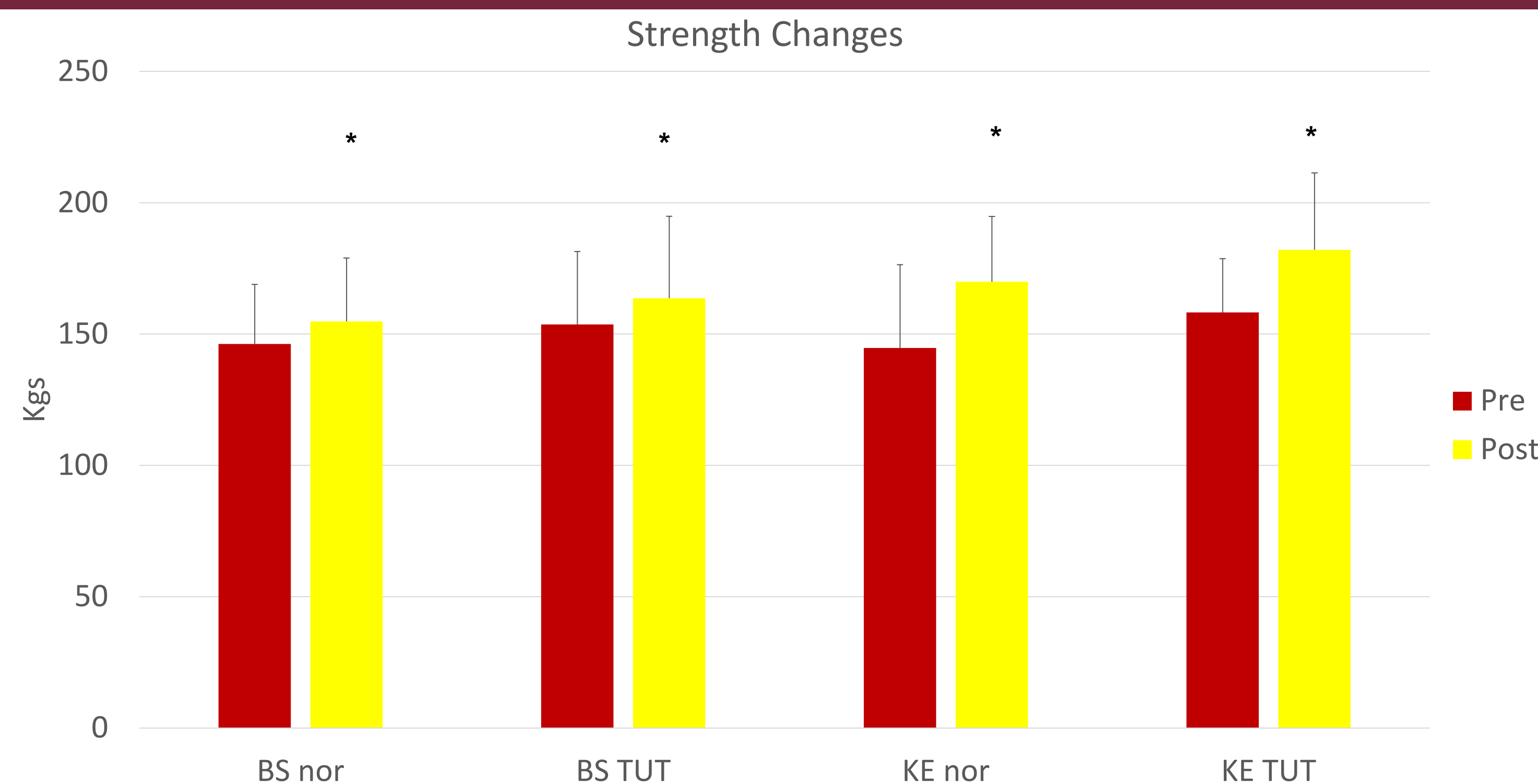


Figure 1. Flowchart displaying timeline of events for the duration of the study.

Results



Results

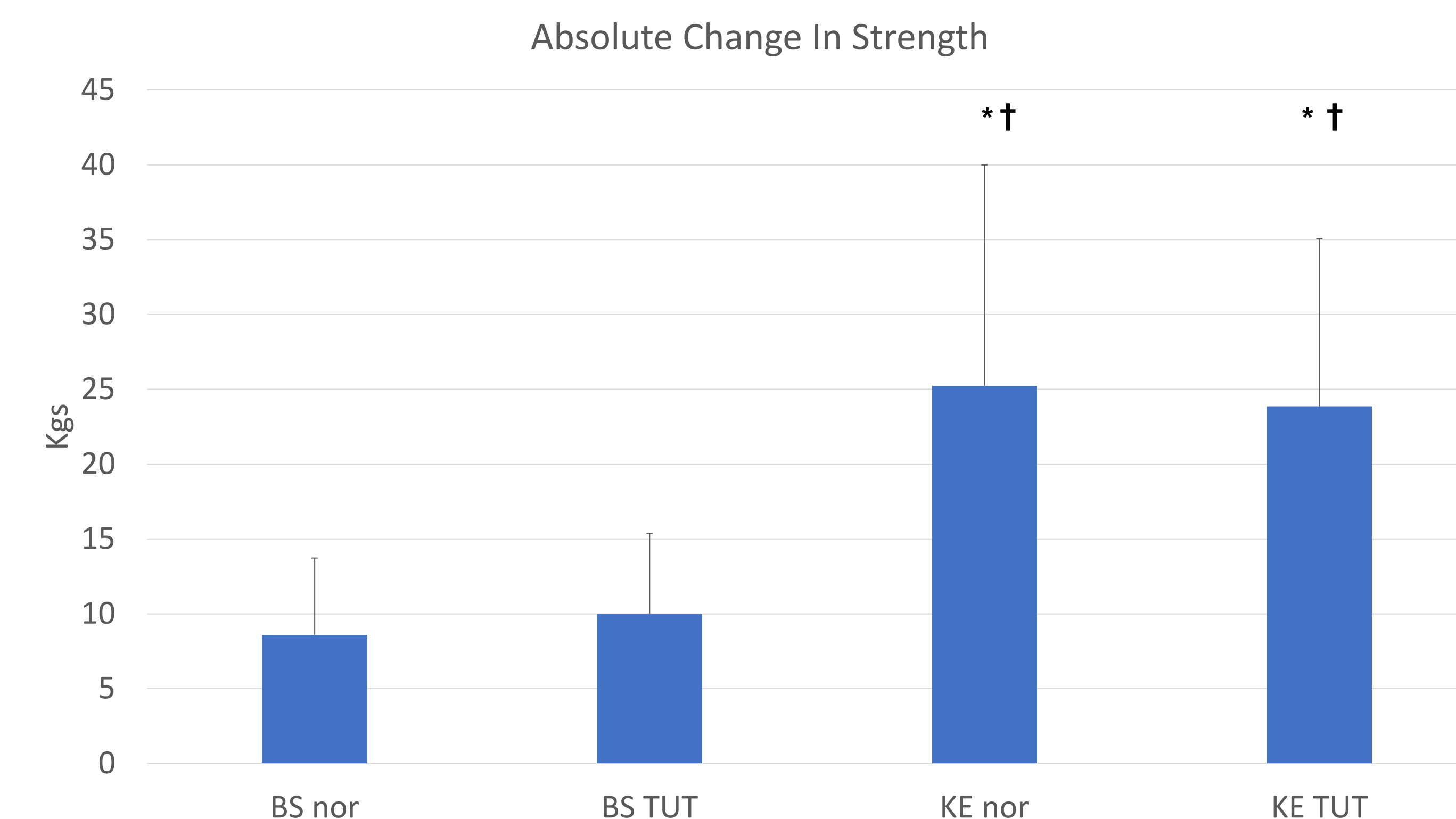


Figure 4. Average absolute change in strength over 6-weeks (18 sessions) of training
 * Denotes significant difference from BS NOR ($p=0.019$; $p=0.047$)
 † Denotes significant difference from BS TUT ($p=0.003$; $p=0.009$)

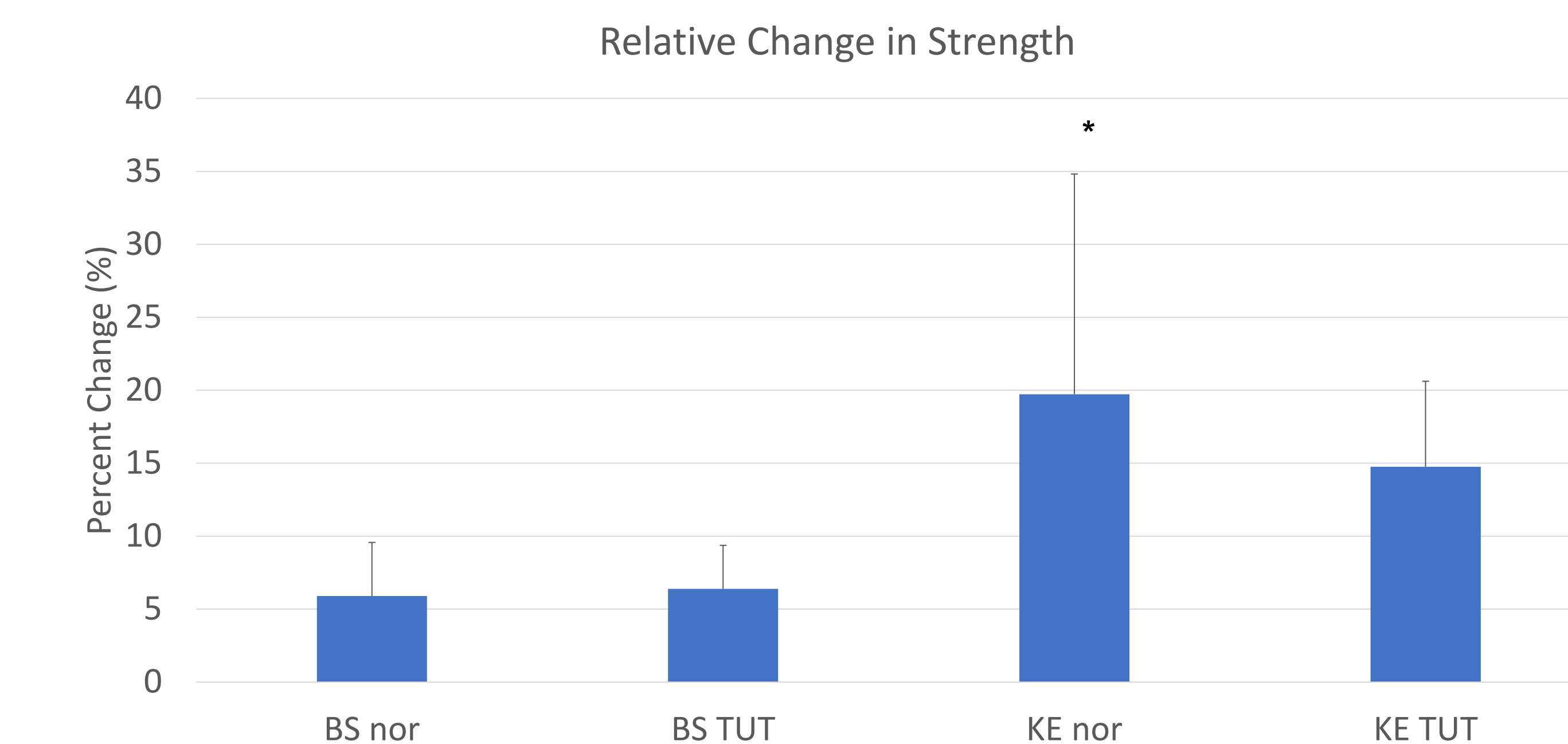


Figure 5. Average relative change in strength over 6-weeks (18 sessions) of training
 * Denotes significant difference from BS NOR ($p=0.028$)

Discussion

All groups showed significant increases in strength following the 6-week training program, which is consistent with previous findings. Absolute changes were higher in the knee extension group compared to the back squat group and relative changes in the knee extension normal group were higher than the back squat normal group. The back squat is a complex compound movement that has a high skill level and recruits core and accessory muscles. The knee extension is an isolated single joint movement focusing on one muscle group. This isolation may have led to the higher absolute and relative changes.