Effects of Blood Flow Restriction Training Combined with Abdominal draw-in Maneuver on Transverse Abdominis Strengthening

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I. Study Protocol:

Healthy adults (age ranged 18-34 years and BMI between 18.5~24.99) were randomly recruited in the study. For the intervention group, an inflatable cuff (14 cm in width * 84 cm in length) is warped around abdominal muscles below ribs which may cause to at least 60% restriction of blood flow detected by Power Doppler ultrasonography. All participants are instructed to perform ADIM both condition of BFR and BFR-free twice a week, for four weeks. Core muscle thickness will be measured at rest and at draw-in by 2D ultrasound. Abdominal core stability, strength and endurance test by double leg lowering test, dynamometer and abdominal static endurance test.

II. Statistical Analysis Plan

Two-way mixed design ANOVA test is used to measure the group difference, time difference and interaction. Using Bonferroni post hoc test to analyze the difference among timepoints within group and Independent t test for the difference between two groups.

III. Results

1. Muscle thickness measured by ultrasound

1.1 Transverse abdominis

Measured by two-way mixed design ANOVA, there is no main time effect, group effect and interaction of time and group of mean bilateral thickness of transverse abdominis (TrA) at rest. At draw-in, there is no main time effect but group effect and interaction of time and group of mean bilateral thickness of TrA. Of muscle thickness change between draw-in and resting, there are main time effect, group effect and interaction of time and group of mean bilateral thickness of TrA.

Before training, there is no significant difference between ADIM+BFR group and ADIM group of TrA thickness at rest, draw-in and thickness change($p>0.05$). After 3 weeks of training, there is no significant difference between ADIM+BFR group and ADIM group of TrA thickness at rest. ADIM+BFR group shows significant thicker muscle at draw-in and thickness change. After 4 weeks of training, there is no significant difference between ADIM+BFR group and ADIM group of TrA thickness at rest. ADIM+BFR group shows significant thicker muscle at draw-in and thickness change. One week after the end of training, there is no significant difference between ADIM+BFR group and ADIM group of TrA thickness at rest. ADIM+BFR group shows significant thicker muscle at draw-in and thickness change.

ADIM+BFR group shows no significant difference of TrA thickness among timepoints at rest. There is significant increase at week 4 and one week after the

end of training compared with baseline and at week 4 compared with week 3 at draw-in. There is significant thickness change at week 3, 4 and one week after the end of training compared with baseline. There is no significant difference at rest, at draw-in and thickness change among timepoints in ADIM group.

2. Abdominal functional test

2.1 Abdominal core stability

Measured by two-way mixed design ANOVA, there are main time effect, group effect and interaction of time and group.

Before training, there is no significant difference between ADIM+BFR group and ADIM group of double leg lowering test, so as after 3 weeks of training. However, ADIM+BFR group shows significant decrease in angle of double leg lowering test after 4 weeks of training and one week after the end of training, which shows better core stability.

ADIM+BFR group shows significant different among timepoints. Compared with baseline, it shows significant decrease after 3,4 weeks of training and one week after the end of training. Furthermore, after 4 weeks of training and one week after the end of training, it shows significant different compared with week 3 and week 4.

2.2 Abdominal strength test

Measured by two-way mixed design ANOVA, there is main time effect but no group effect and interaction of time and group.

Before training, there is no significant difference between ADIM+BFR group and ADIM group of abdominal strength test measured by dynamometer, so as after 3 weeks of training. However, ADIM+BFR group shows significant increase after 4 weeks of training and one week after the end of training, which shows better core strength.

ADIM+BFR group shows significant different among timepoints. Compared with baseline, it shows significant increase after 4 weeks of training and one week after the end of training. Furthermore, after 4 weeks of training and one week after the end training, it shows significant different compared with week 3. ADIM group shows significant different after 4 weeks of training compared with baseline.

2.3 Abdominal endurance test

Measured by two-way mixed design ANOVA, there are main time effect, group effect and interaction of time and group.

Before training, there is no significant difference between ADIM+BFR group

and ADIM group of abdominal endurance test, so as after 3 weeks of training. However, ADIM+BFR group shows significant increase after 4 weeks of training and one week after the end of training, which shows better core endurance.

ADIM+BFR group shows significant different among timepoints. Compared with baseline and 3 weeks of training, it shows significant increase after 4 weeks of training and one week after the end of training. Furthermore, one week after the end of training, it shows significant different compared with week 3. ADIM group shows significant different after 3,4 weeks of training and one week after the end of training compared with baseline.