CLINICAL STUDY DOCUMENT

# Study Protocol

Integrated Neuromuscular Training for Repeated Jumping Performance in Collegiate Volleyball Players

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| **Official title** | The Effects of Integrated Neuromuscular Training on Repeated Jumping Performance in Collegiate Volleyball Players |
| **Brief title** | Integrated Neuromuscular Training for Repeated Jumping Performance in Collegiate Volleyball Players |
| **Unique protocol ID** | CUSPE-INT-RJP-001 |
| **ClinicalTrials.gov identifier** | Not yet assigned |
| **Sponsor** | Capital University of Physical Education and Sports, China |
| **Principal investigator** | Zhikai Qin, PhD, Capital University of Physical Education and Sports |
| **Ethics approval** | Ethics Committee of the Capital University of Physical Education and Sports; Approval No. 2024A112 |
| **Protocol version** | 1.0 |
| **Document date** | 22 September 2026 |

*This document describes the study design, participant criteria, intervention, assessments, and statistical analysis for the registered protocol. It does not report study results.*

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## Document scope

This protocol is limited to the study identified by CUSPE-INT-RJP-001. The intervention and assessment descriptions below are aligned with the ClinicalTrials.gov record and the supplied study manuscript.

# 1 Protocol synopsis

| Item | Description |
|---|---|
| **Study type** | Interventional, randomized, parallel-group controlled study |
| **Population** | Collegiate volleyball players aged 18 to 25 years |
| **Planned enrollment** | 34 participants, allocated to an INT group or a control group; 17 participants per group |
| **Intervention** | Integrated neuromuscular training delivered in addition to conventional volleyball instruction twice per week for 9 weeks |
| **Comparator** | Conventional volleyball instruction consisting of warm-up, technical training, and tactical drills |
| **Assessment schedule** | Baseline, immediately after the 9-week intervention, and a 3-week follow-up |
| **Primary outcomes** | Jump height and peak force during repeated jumping |
| **Secondary variables** | Mean force and fatigue index during repeated jumping |
| **Ethics** | Ethics Committee approval No. 2024A112; written informed consent required |

## Protocol summary

This randomized controlled study evaluates whether adding a structured, multi-component integrated neuromuscular training program to regular volleyball instruction improves repeated-jumping performance in collegiate volleyball players. The design compares changes across two groups and three assessment time points, including a short-term follow-up after the intervention period.

# 2 Background and rationale

Volleyball requires repeated explosive actions during training and competition. Players must repeatedly jump while moving between attacking and defensive tasks, so performance depends not only on maximal output but also on the ability to sustain force production under fatigue.

Integrated neuromuscular training combines several training components, including plyometric exercise, strength training, core stabilization, balance, and speed-agility work. The present study operationalizes INT as a structured program of plyometric training, strength training, core stabilization, and speed-agility drills delivered alongside the standard volleyball curriculum.

Routine volleyball instruction and a structured INT program may produce different adaptations in repeated jumping. The present study uses repeated-jump tests of different durations to examine short-burst performance, performance during sustained jumping, and fatigue-related changes. The 3-week follow-up assesses whether observed changes are maintained after the formal training period.

The study addresses a practical question for collegiate volleyball training: whether a feasible, progressive INT program adds measurable benefit beyond conventional volleyball instruction.

# 3 Objectives and hypotheses

## 3.1 Primary objective

To determine whether 9 weeks of integrated neuromuscular training added to conventional volleyball instruction improves repeated-jumping performance compared with conventional volleyball instruction alone.

### 3.2 Secondary objectives

- To compare changes in jump height and peak force across the 5-jump, 15-second, and 30-second continuous jumping protocols.
- To compare changes in mean force and fatigue index between groups.
- To examine whether intervention-related changes are maintained at the 3-week follow-up.

### 3.3 Hypothesis

Compared with conventional volleyball instruction alone, integrated neuromuscular training will produce greater improvements in repeated-jumping performance, including jump height, peak force, mean force, and fatigue-related performance, and these improvements will be largely maintained at follow-up.

## 4 Study design

This is a randomized, parallel-group, controlled interventional study. Participants are assigned to an integrated neuromuscular training group or a control group. Both groups receive the same conventional volleyball instruction. The INT group also receives the structured INT program twice weekly for 9 weeks. Assessments occur at baseline, immediately after the intervention, and at a 3-week follow-up.

The study includes a one-week pilot period before the formal intervention. The formal study period consists of 9 weeks of intervention followed by a 3-week follow-up period.

The study is conducted at the Capital University of Physical Education and Sports, China. The study population is collegiate volleyball players enrolled through the sponsoring institution.

### 4.1 Sample size

The sample size was estimated using G*Power version 3.1 for a repeated-measures two-factor analysis of variance with group and time factors. Assuming a moderate effect size of f = 0.25, a two-sided alpha level of 0.05, and 80% power, at least 28 participants were required. The study enrolled 34 participants to provide 17 participants per group.

## 5 Participants

### 5.1 Eligibility criteria

Participants must meet all inclusion criteria and none of the exclusion criteria.

### Inclusion criteria

- Collegiate volleyball players.
- Healthy at the time of enrollment.
- No lower-limb injury within the preceding six months.
- Functional Movement Screen score greater than 16.
- Provided informed consent to participate in the study.

### Exclusion criteria

- Lower-limb injury within the preceding six months.
- Functional Movement Screen score of 16 or lower.
- Acute medical history that could affect safe participation in testing or training procedures.

### 5.2 Screening and baseline assessment

At screening, participants provide demographic information and undergo the Functional Movement Screen. Baseline age, height, weight, training experience, and jumping ability are recorded before randomization. Participants are instructed to avoid strenuous activity for 48 hours before testing.

The Functional Movement Screen includes the deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, push-up, and rotary stability. Each movement is performed three times and scored according to established criteria.

## 6 Randomization and allocation

Eligible participants are randomly assigned to the experimental INT group or the control group in a 1:1 allocation. The record specifies two parallel arms with 17 participants per group. The allocation sequence and assignment are documented by the study team.

Both groups receive the same conventional volleyball instruction throughout the 9-week intervention. The experimental group receives the additional INT program. The control group does not receive the additional INT program during the intervention period.

## 7 Interventions

### 7.1 Conventional volleyball instruction

Conventional volleyball instruction includes a 5- to 10-minute dynamic stretching and low-intensity aerobic warm-up, followed by volleyball technical training and tactical drills. The same conventional instruction is provided to both study groups throughout the 9-week intervention.

### 7.2 Integrated neuromuscular training

The INT group receives integrated neuromuscular training twice per week for 9 weeks in addition to conventional volleyball instruction. The program consists of four components: plyometric training, strength training, core stabilization, and speed-agility training. Training is progressively structured across an initial phase, an improvement phase, and a reinforcement phase.

The INT sessions are designed to complement, rather than replace, conventional volleyball instruction. Plyometric and strength exercises are combined in one session, while core stabilization and sport-specific speed training are emphasized in a separate session. Exercise selection and progression follow the study training plan.

### 7.3 Control of training exposure

Training exposure is monitored using class heart-rate measurements and the Borg CR-10 rating of perceived exertion. Participants complete the perceived-exertion rating after conventional instruction. Testing conditions and equipment are standardized across assessment time points.

## 8 Outcomes and assessments

### 8.1 Repeated-jumping assessment

Repeated jumping is assessed using the Continuous Countermovement Semi-Squat Jump test on an ELIGA-T132 force plate. Participants stand on the force plate with feet shoulder-width apart and hands on the hips. They repeatedly descend to approximately 90 degrees of knee flexion and immediately perform a maximal vertical jump. After landing, they return to the target squat position and continue without a prolonged pause.

Three protocols are administered: five consecutive maximal jumps, continuous maximal jumping for 15 seconds, and continuous maximal jumping for 30 seconds. Participants maintain the prescribed posture and rhythm throughout each protocol.

### 8.2 Primary outcomes

| Outcome | Operational definition | Assessment time points |
|---|---|---|
| **Jump height** | Vertical jump height recorded during the repeated-jump protocols. | Baseline; immediately after 9 weeks; 3-week follow-up |
| **Peak force** | Maximum force generated during the repeated-jump task, expressed in newtons. | Baseline; immediately after 9 weeks; 3-week follow-up |

### 8.3 Secondary variables

| Variable | Operational definition |
|---|---|
| **Mean force** | Mean force generated during each repeated-jump protocol, expressed in newtons. |
| **Fatigue index** | The relative decline in force calculated as (highest peak force - lowest peak force) / highest peak force x 100 percent. |

### 8.4 Standardization of testing

Testing is performed at the same location and under the same equipment, personnel, and procedural conditions at each time point. The force plate is calibrated according to the manufacturer's procedures. Participants are asked to follow the same pre-test restrictions at baseline, post-test, and follow-up.

## 9 Schedule of assessments

| Assessment or activity | Baseline | Weeks 1-9 | Post-test | Week 12 follow-up |
|---|---|---|---|---|
| **Informed consent and eligibility screening** | X | | | |
| **Demographics and baseline characteristics** | X | | | |
| **Conventional volleyball instruction** | | X | | |
| **Integrated neuromuscular training or control condition** | | X | | |
| **CCSJ repeated-jump testing** | X | | X | X |
| **Heart-rate and Borg CR-10 monitoring** | | X | | |

*CCSJ = Continuous Countermovement Semi-Squat Jump. Post-test occurs immediately after the 9-week intervention. Follow-up occurs 3 weeks after the intervention ends.*

# 10 Data analysis

Analyses are conducted using R version 4.5.1. Descriptive statistics are presented as mean and standard deviation. The primary analysis for each outcome uses a 2 by 3 mixed-design repeated-measures analysis of variance, with group as the between-participant factor and time as the within-participant factor. The Group x Time interaction is the primary test of the intervention effect.

If an interaction is statistically significant, post hoc pairwise comparisons of estimated marginal means are conducted with a Bonferroni adjustment. If the interaction is not significant, any pairwise comparisons are considered exploratory and are not used as the basis for the main intervention conclusion.

Effect sizes are reported using partial eta-squared for analysis-of-variance effects. Standardized mean differences using Hedges' g may also be reported for key post hoc contrasts. The fatigue index is calculated as (highest peak force - lowest peak force) / highest peak force x 100 percent.

The analysis set includes participants with available repeated-jump data at the relevant assessment time points. Missing observations and deviations from the planned assessment schedule are documented and considered when interpreting the analysis.

# 11 Ethics and dissemination

## 11.1 Ethical approval and consent

The study is conducted in accordance with the principles of the Declaration of Helsinki. The protocol received approval from the Ethics Committee of the Capital University of Physical Education and Sports under Approval No. 2024A112. Written informed consent is obtained from each participant before study participation.

## 11.2 Confidentiality and participant protection

Study data are handled by the study team for research purposes. Participant information is reported in aggregate form wherever possible. The study team maintains study records in accordance with applicable institutional requirements.

## 11.3 Dissemination

Study findings may be disseminated through scientific publication and presentation. Any dissemination uses the approved study data and follows applicable ethical and privacy requirements.

## 11.4 Data sharing

De-identified individual participant data underlying reported results may be made available to qualified researchers upon reasonable request to the corresponding author, subject to scientific purpose, ethical review, and privacy requirements.

# 12 References

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*End of protocol*