Effects of unilateral, bilateral and combined resistance training on the speed and accuracy of the serve in youth tennis players

Expert Information	
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Title:	Effects of unilateral, bilateral and combined resistance training on the speed and accuracy of the serve in youth tennis players
Research Area:	Physical Education
Working Experience:	School assistant, coach

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Dear Professor,

My name is Ma Xudong, and I am a PhD student majoring in Physical education at Universiti Putra Malaysia (UPM). The aim of this study was to investigate the effects of single, bilateral and combined resistance training on the speed and accuracy of serving in Chinese amateur teenage tennis players.The subjects were young male tennis players aged 16-20 years from four universities in Gansu Province. The data obtained in this survey were used for academic research only. Therefore, I invited experts to evaluate and score the experimental design to help me better complete this experiment. Thank you very much.

The study was divided into control group (CG), experiment group 1 (EG1-unilateral group), experiment group 2 (EG2-bilateral group) and experiment group 3 (EG3-combined group). Used to compare the effects of different forms of resistance training on serve speed and accuracy. Previous studies have shown that unilateral and bilateral resistance training can effectively improve athletes' strength, explosive power, and speed (Speirs, et al., 2016; Davo, Jimenez, & Solana,., 2018), there is still controversy when comparing the advantages and disadvantages of two forms of resistance training (Ramirez-Campillo et al., 2015; Donathb & Wahl., 2022). In this study, unilateral resistance training, bilateral resistance training, and combined unilateral and bilateral resistance training were used as intervention modalities.

Based on the literature review, the training frequency of this experiment was arranged as 2 sessions/week, and the total training time was 6 weeks, with a fixed duration of each training session. Each training session lasted a maximum of 60 minutes. In this experiment, the interval between two

weekly training sessions was at least 24 h to prevent subjects from being in a fatigued state in the relevant muscle groups of the body and affecting the experimental level.

1. Pre-activation Prescription

week	Intensity of Pre-activation	Type of Warm-up	Type of Exercise	Intensity & Repetition	Sets	Recovery Time
1-6	CG	Routine Warm-up	Routine Warm-up	NO	NO	NO
	EG1	Dynamic Warm-up	Dynamic warm up (Table1)	NO	1	1min
	EG2	Dynamic Warm-up	Dynamic Warm-up (Table1)	NO		
	EG3	Dynamic Warm-up	Dynamic Warm-up (Table1)	NO		

Table1

EG1	EG2	EG3
Dynamic Warm-Up (Time)		
1. High-knee walk. While walking, lift knee towards chest, raise body on toes, and swing alternating arms. 2. Straight-leg march. While walking with both arms extended in front of body, lift one extended leg towards hands then return to starting position before repeating with other leg. 3. Hand walk. With hands and feet on the ground and limbs extended, walk feet towards hands while keeping legs extended then walk hands forward while keeping limbs extended. 4. Lunge walks. Lunge forward with alternating legs while keeping torso vertical. 5. Backward lunge. Move backwards by reaching each leg as far back as possible. 6. High-knee skip. While skipping, emphasize height, highknee lift, and arm action. 7. Lateral shufflfle. Move laterally quickly without crossing feet. 8. Back pedal. While keeping feet under hips, take small steps to move backwards rapidly. 9. Heel-ups. Rapidly kick heels towards buttocks while moving forward. 10. High-knee run. Emphasize knee lift and arm swing while moving forward quickly.		
This study recommends a warm-up with dynamic exercises and a cool-down using body stretching. Warm-up programmes have been shown to be effective in improving jumping performance and are recommended for young people as a standardised warm-up prior to RT (Faigenbaum et al., 2005).		

Expert score: your evaluation of measurements is (the full score is 10 points, 9-10 points are very applicable, 7.5-8.5 points are applicable, 6-7 points are less applicable, and 4.5-5.5 points are not applicable.)

Order	**Items**	**Score**
1	The Content of whole Training Program	
2	Intensity of Pre-activation	
3	Type of Warm-up	
4	Type of Exercise	
5	Intensity & Repetition	
6	Training Sets	
6	Recovery Time	
Modification Suggestions of Experts:		

2. Basic Training Program

<table>
<tr><th>EG1</th><th>EG2</th><th>EG3</th><th>CG</th></tr>
<tr><td colspan="3">Dynamic Warm-Up and Training (Time)</td><td>Routine Warm-Up and Training (Time)</td></tr>
<tr><td colspan="3">● High-knee walk- 1 time (1min)
● Straight-leg march -1 times (1min)
● Hand walk - 1sets- 1 time (1min)
● Lunge walks - 1 time (1min)
● Backward lunge - 1 time (1min)
● High-knee skip -1 time (1min)
● Lateral shufflfle- 1 time (1min)
● Back pedal -1 time (1min)
● Heel-ups -1 time (1min)
● High-knee run -1 time (1min)
● Unilateral, bilateral, combined resistance training (EG1, EG2, EG3) (50 min)
● Total time (60min)</td><td>● Jogging - 1 time (10 min)
● traditional training（50min）
● Total time (60min)</td></tr>
<tr><td colspan="4">Training Content</td></tr>
<tr><td colspan="4">(Training base phase (first two weeks): 65-75% of intensity, 2sets, 8raps)（NSCA，2009）</td></tr>
</table>

Specific Intervention Prescription

Unilateral resistance training programme

	Category	Free weight resistance training movements （NSCA，2009）	Intervals	Rapid Contraction resistance Training （Carter，2014）
Unilateral training（1h）	Upper limb	**Unilateral Bench Press Dumbbell** dominant limb: 50% 1RM, 4 × 8; Non-dominant limb: 50% 1RM, 4 × 8 **VIPR energy barrel for unilateral bench press** dominant limb: 50% 1RM, 4 × 8; Non-dominant limb: 50% 1RM, 4 × 8	2min	**One-handed push-ups on box** (dominant limb: 4 x 10; non-dominant limb: 4 x 10) **medicine ball forward throw** (dominant limb: 4 x 10; non-dominant limb: 4 x 10.) **Stretch band continuous tennis swing action** (dominant limb: 4 x 20; non-dominant limb:4 x 20.)
	lower limb	**Bulgarian Arrow Squat** dominant limb:50% 1RM, 4×8 Non-dominant limb :50% 1RM, 4×8 **Bulgarian unilateral heel lift** dominant limb :50% 1RM, 4 x 8 Non-dominant limb:50% 1RM, 4 x 8	2min	**Self-weighted cross lunge jump** (dominant limb: 4 x 10; non-dominant limb: 4 x 10) **Single foot hurdle vertical jump** 0.25cm (dominant limb: 4 x10; non-dominant limb: 4 x10)
(Training base phase (first two weeks): 65-75% of intensity, 2sets, 8raps)（NSCA，2009）				

Bilateral resistance training programme

	Category	Free weight resistance training movements （NSCA，2009）	Intervals	Rapid Contraction resistance Training （Carter，2014）
Bilateral training（1h）	Upper limb	**Bench Press for Dumbbell** (80-85%1RM 4×8） **VIPR energy barrel for bench press** (80-85%1RM 4×8）	2min	**High five with push-ups** (4×10) **Double-sided medicine ball forward throw** (4×10) **Stretch band continuous tennis swing action （Bilateral ）** (4×20)
	lower limb	**Bilateral Weight Squat** (80-85%1RM 4×8） **Bulgarian Heel Lift** (80-85%1RM 4×8）	2min	**Jump box** (3×10) **Hurdle Vertical Jump** 0.25cm，4×10
(Training base phase (first two weeks): 65-75% of intensity, 2sets, 8raps)（NSCA，2009）				

Combined（UL+BL） resistance training programme

	Category	Free weight resistance training movements （NSCA，2009）	Intervals	Rapid Contraction resistance Training （Carter，2014）
Combined（UL+BL）ltraining（1h）	Upper limb	**Unilateral Bench Press Dumbbell** dominant limb: 50% 1RM, 4 × 8; Non-dominant limb: 50% 1RM, 4 × 8 **VIPR energy barrel for bench press** (80-85%1RM 4×8）	2min	**One-handed push-ups on box** (dominant limb: 4 x 10; non-dominant limb: 4 x 10) **Double-sided medicine ball forward throw** (4×10) **Stretch band continuous tennis swing action（Bilateral and Unilateral）** (2×20/2×20)
	lower limb	**Bulgarian Arrow Squat** dominant limb:50% 1RM, 4×8 Non-dominant limb :50% 1RM,4×8 **Bulgarian Heel Lift** (80-85%1RM 4×8）	2min	**Self-weighted cross lunge jump** (dominant limb: 4x 10; non-dominant limb: 4 x 10) **Hurdle Vertical Jump** 0.25cm，4×10
(Training base phase (first two weeks): 65-75% of intensity, 2sets, 8raps)（NSCA，2009）				

Expert score: your evaluation of training program is (the full score is 10 points, 9-10 points are very applicable, 7.5-8.5 points are applicable, 6-7 points are less applicable, and 4.5-5.5 points are not applicable.)

Order	**Items**	**Score**
1	The Content of whole Training Program	
2	Warm-up	
3	Training Duration & Frequency	
4	Type of Exercise	
5	Training Intensity & Repetition	
6	Training Sets	
7	Recovery Time	
Modification Suggestions of Experts:		

3.Instruments

Sport performance tests（The contribution of the tennis serve）

TEST	5RM-BS	5RM-BP	CMJ	OMB	SJF	SRT	HEC
PURPOSE	Maximum strength of the upper limb	Maximum strength of the lower limb	Maximum power of the lower limb	Maximum power of the upper limb	Flexibility of upper limb joints	Flexibility of lower limb joints	body coordination
EQUIPAMENT	Barbell（kg）	Barbell（kg）	APP （cm）	Measuring tape （m）	Ruler with scale (cm)	Ruler with scale (cm)	Stop watch（times）
POSITION	Subjects were supine on a bench, which was parallel to the floor. The back of the subject should be close to the surface of the table, with the knees in the same direction as the toes	Subjects were instructed to stand behind the barbell with their feet shoulder-width apart and their knees facing in the same direction as their toes	The subject remains standing	The subject remains standing	Subjects remain standing	The subject remained in a seated position	The subject stood with a tennis ball in hand
ACTION	The subject held the dumbbell tightly. Subjects had to reach the specified depth with downward motion (90° at the elbow). In addition, the direction of the dumbbell should be consistent with the direction of the nipple throughout the movement	Move your toes outward 30°. The barbell was clenched and the hands rested on the scapula. The subject must reach the specified depth ((90° knee Angle)) when moving down.	The subjects kept their hands still and completed the jump during the squat	Subjects grabbed the medicine ball and threw it as far as they could over their heads	The upper limbs of the subjects were extended and rotated backward without tilting the trunk	Subjects had their legs straight and their upper limbs extended forward	The subject threw the tennis ball against the wall and repeated the action until the ball fell to the ground
MEASUREMENT	The maximum weight that can be pushed	The maximum weight that can be pushed	The vertical height of the jump	Horizontal distance	The distance between the hands	Horizontal distance	Number of times in 30 seconds

Tennis serve performance

TEST	SPEED TEST	ACCURACY TEST
PURPOSE	Measure the speed of a tennis serve	To measure the accuracy of a tennis serve
EQUIPAMENT	radar gun（Bushnell-10-1911）	Figure 1（score）
POSITION	The subject was prepared to complete the serve movement	The subject was prepared to complete the serve movement
ACTION	The subject completed the serve movement	The subject completed the serve movement
MEASUREMENT	Km/h	Score

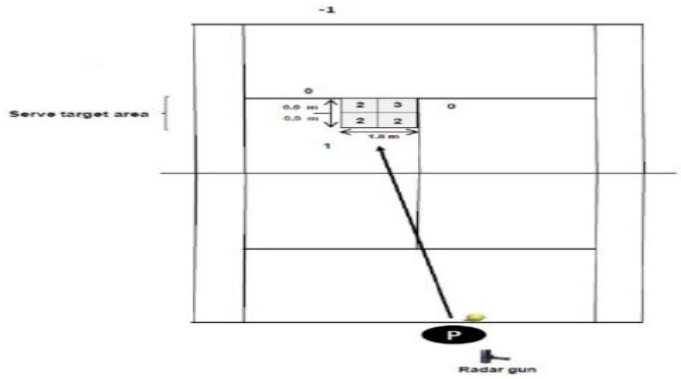


Figure 1-Tennis accuracy Tes

Expert score: your evaluation of measurements is (the full score is 10 points, 9-10 points are very applicable, 7.5-8.5 points are applicable, 6-7 points are less applicable, and 4.5-5.5 points are not applicable.)

Order	**Items**	**Score**
1	*5RM -Bench press*	
2	*5RM -Back squat*	
3	*Counter movement Jump*	
4	*Overhead medicine ball*	
5	*Shoulder Joint Flexibility Test*	
6	*Sit and reach Test*	
7	*Hand-Eye Coordination Test*	
8	*Tennis speed Test*	
9	*Tennis accuracy Test*	
Modification Suggestions of Experts:		

Dynamic warm-up content

(Athlete in Photo: One of the participants)

1. High-knee walk

While walking, lift knee towards chest, raise body on toes, and swing alternating arms.


2. Straight-leg march

Straight-leg march. While walking with both arms extended in front of body, lift one extended leg towards hands then return to starting position before repeating with other leg.


3. Hand walk

With hands and feet on the ground and limbs extended, walk feet towards hands while keeping legs extended then walk hands forward while keeping limbs extended.

4. Lunge walks.

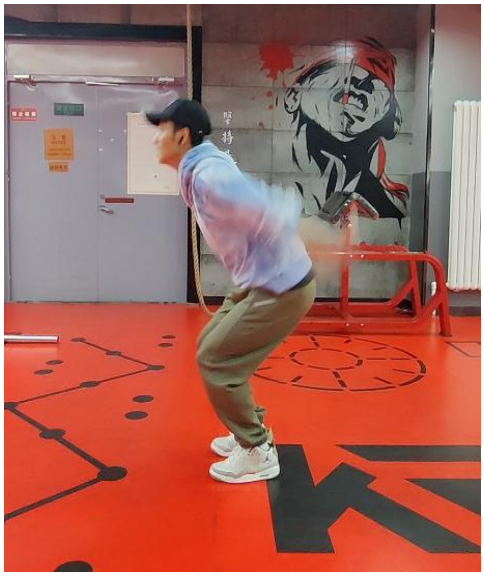
Lunge walks. Lunge forward with alternating legs while keeping torso vertical.

5. Backward lunge.

Move backwards by reaching each leg as far back as possible.

6. High-knee skip.

While skipping, emphasize height, highknee lift, and arm action.



7. Lateral shufflfle.

Move laterally quickly without crossing feet.

8. Back pedal.

While keeping feet under hips, take small steps to move backwards rapidly.

9. Heel-ups.

Rapidly kick heels towards buttocks while moving forward.

10. High-knee run.

Emphasize knee lift and arm swing while moving forward quickly.

Training content

(Athlete in Photo: One of the participants)

Unilateral resistance training content

Unilateral Bench Press Dumbbell

VIPR energy barrel for unilateral bench press

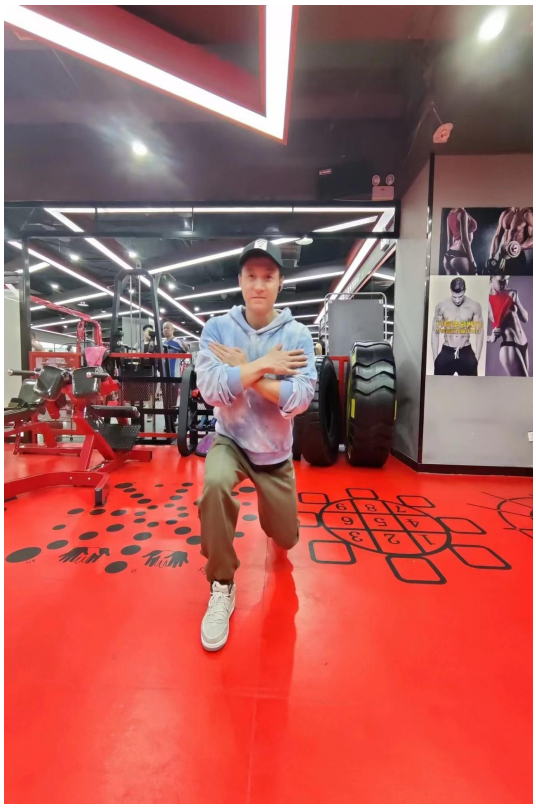
Bulgarian Arrow Squat


Bulgarian Heel Lift

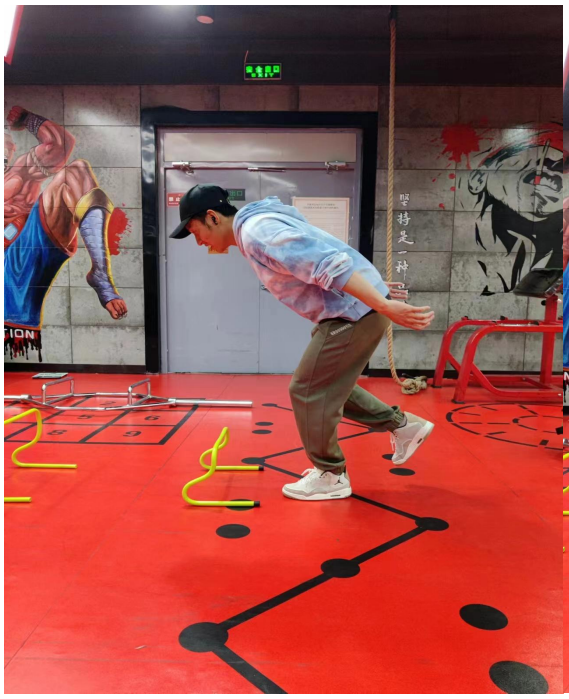
One-handed push-ups on box


medicine ball forward throw

Self-weighted cross lunge jump



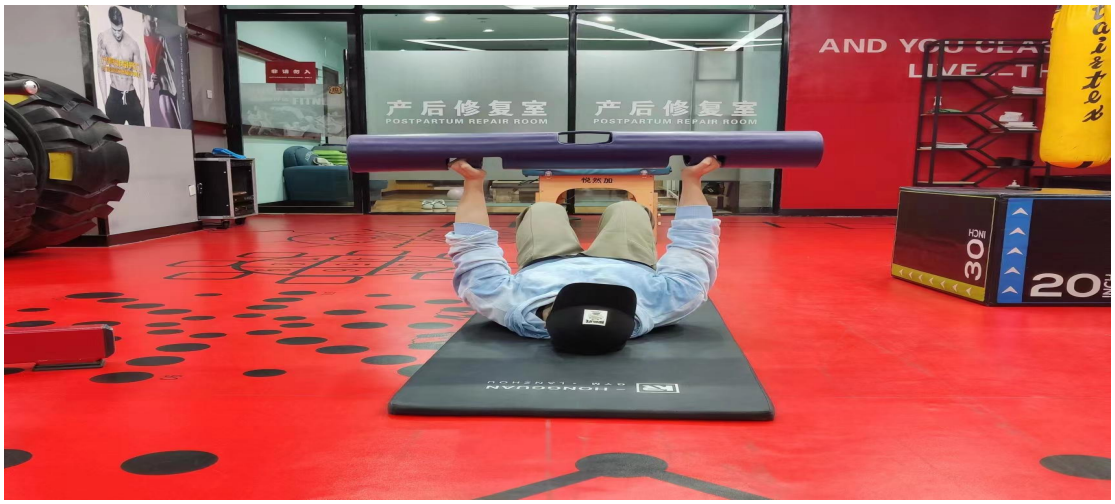

Single foot hurdle vertical jump




Unilateral resistance training content

Bench Press for Dumbbell

VIPR energy barrel for bench press

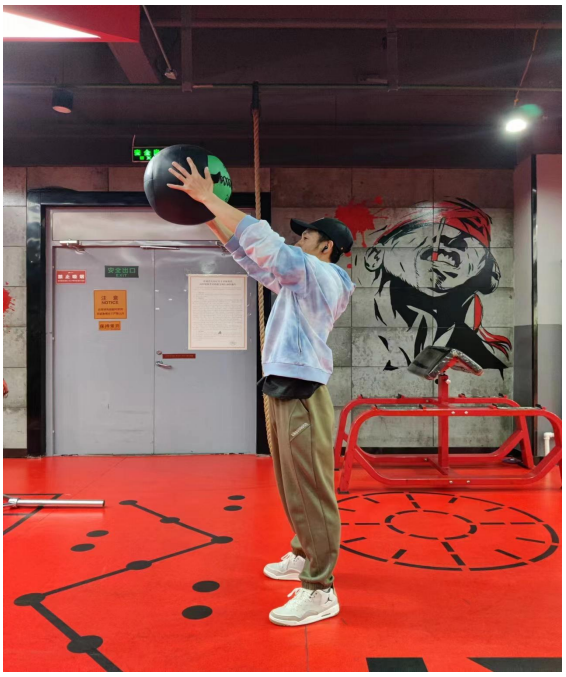


Bilateral Weight Squat

Bulgarian Heel Lift

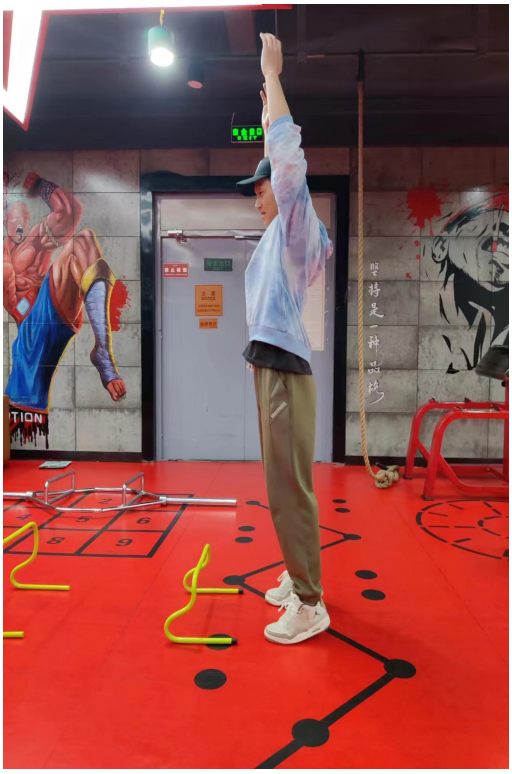
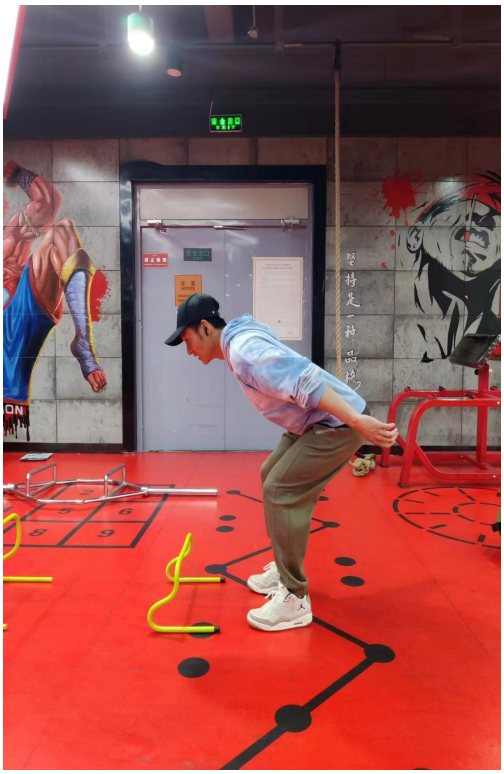
High five with push-ups


Double-sided medicine ball forward throw

Jump box


Hurdle Vertical Jump

Statistical Analysis Plan

Grouping of subjects	Intervention	Pre	Post-1	Post-2	Δ	Statistical Analysis	
						T-test/ANOVA	ANOVA
						Within group	between groups
Subject-1	X_U	X_UO_1	X_UO_2	X_UO_3	Post1-pre ($O_{\Delta1}$) Post2-pre ($O_{\Delta2}$) Post2-Post1($O_{\Delta3}$)	Post1 VS pre (T-test) Post2 VS pre (T-test) Post2 VS Post1 (T-test) $O_{\Delta1}$ VS $O_{\Delta2}$ VS $O_{\Delta3}$（ANOVA）	Post-1： $O_{\Delta1}$ VS $O_{\Delta4}$ VS $O_{\Delta7}$ VS $O_{\Delta10}$（ANOVA） Post-2： $O_{\Delta2}$ VS $O_{\Delta5}$ VS $O_{\Delta8}$ VS $O_{\Delta11}$（ANOVA）
Subject-2	X_B	X_BO_4	X_BO_5	X_BO_6	Post1-pre ($O_{\Delta4}$) Post2-pre ($O_{\Delta5}$） Post2-Post1($O_{\Delta6}$）	Post1 VS pre (T-test) Post2 VS pre (T-test) Post2 VS Post1 (T-test) $O_{\Delta4}$ VS $O_{\Delta5}$ VS $O_{\Delta6}$（ANOVA）	
Subject-3	X_C	X_CO_7	X_CO_8	X_CO_9	Post1-pre ($O_{\Delta7}$) Post2-pre ($O_{\Delta8}$) Post2-Post1($O_{\Delta9}$)	Post1 VS pre (T-test) Post2 VS pre (T-test) Post2 VS Post1 (T-test) $O_{\Delta7}$ VS $O_{\Delta8}$ VS $O_{\Delta9}$（ANOVA）	
CG	X	XO_{10}	XO_{11}	XO_{12}	Post1-pre ($O_{\Delta10}$) Post2-pre ($O_{\Delta11}$) Post2-Post1($O_{\Delta12}$)	Post1 VS pre (T-test) Post2 VS pre (T-test) Post2 VS Post1 (T-test) $O_{\Delta10}$ VS $O_{\Delta11}$ VS $O_{\Delta12}$（ANOVA）	
Dependent variables: strength, explosive power, flexibility, coordination, serve speed, accuracy							

Reference

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