

Skill-based conditioning Vs. plyometric training in team sports

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Plyometric training

- Popular form of physical conditioning of healthy individuals
- Aimed at improving conditioning capacities that require the fast development of muscular force
- Involves performing bodyweight jumping-type exercises and throwing medicine balls (and some derivations) using the so-called stretch-shortening cycle (SSC) muscle action
- The SSC enhances the ability of the neural and musculotendinous systems to produce maximal force in the shortest amount of time, prompting the use of plyometric exercise as a bridge between strength and speed
- Plyometric training has been extensively used for augmenting dynamic athletic performance (i.e. jumping, throwing, sprinting)

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### Effects of plyometric training (in brief)

- Earliest studies examined the effects on jumping performance (mostly vertical jumps)
- The focus later evolved and studies frequently investigate effects on throwing, kicking, sprinting, and agility performances
- Also, plyometric training has the potential
  - To improve biomechanical technique and neuromuscular control during high-impact activities like cutting and landing
  - To reduce the risk of lower-extremity injuries
  - To induce bone and musculo-tendinous adaptation

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### Skill-based conditioning

- Another popular training method in contemporary sports (mainly „sport/games“)
- Based on the postulate that the greatest improvement in performance occurs when the stimulus of training mimics real-game (ie, real-sport) metabolic and technical demands
- Aimed at the simultaneous improvement of fitness and skills, which is particularly important in young athletes
- Includes various sport-specific exercises performed in „sport-specific environment“

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### Effects of skill-based conditioning

1. When compared to „traditional exercises“ skill based conditioning resulted in
  - Similar improvement in aerobic endurance as traditional aerobic exercise
  - Similar improvement in 10-m speed, agility as traditional speed- agility- training
2. When „non-compared“ to traditional exercises
  - Significant improvement in 5 and 10-m sprint
  - Significant improvement in jumping, and agility performances

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### What is important

- Most team-sports (football, basketball, volleyball, handball, etc.) involve include upper and lower body activities that involve stretch-shortening cycles (volleyball: spiking and jumping).
- It is reasonable to expect that team-sport skill-skill conditioning could result in training effects similar to those seen as a result of plyometric conditioning
- **But, studies rarely examined the concurrent effects of Skill-based-conditioning vs. Plyometric conditioning in development of „important conditioning capacities“ (jumps, throws, sprints, etc.)**
  - This question is particularly important as it comes to differences between young and „older“ athletes

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### Herein

- We will present findings of two studies
- Both studies included female volleyball players
  - First one examined „18+“ players
  - Second one examined „<18“ players
- In both studies we compared effects of plyometric vs. Skill based conditioning
- In both studies experimental programs were applied as „an addition“ to standard volleyball training (5-7 sessions weekly)
  - Throughout 12 weeks (3 months)
  - Twice a week
  - 30-60 min each session (plyo or skill-based)
  - Done at the beginning of the season (after summerbreak)

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### Study 1: +18 players

Gjinovci, B., Idrizovic, K., Ujjevic, O., & Sekulic, D. (2017). Plyometric training improves sprinting, jumping and throwing capacities of high level female volleyball players better than skill-based conditioning. *Journal of sports science & medicine*, 16(4), 527.

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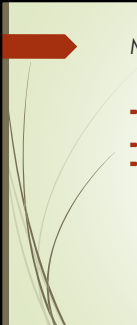
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### Methods (most important)

- 41 highly skilled female volleyball players (1st division), all older than 18 years
- Divided into plyometric group (n=20) and skill-based group (n=21)
- Plyometric- and skill-based conditioning were performed as an addition to the regular technical and tactical volleyball training

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### Measures

- Body height and body mass
- Sprinting 20 meters - S20M,
- Vertical countermovement jump - CMJ
- Standing broad jump - SBJ,
- Medicine ball toss - MBT

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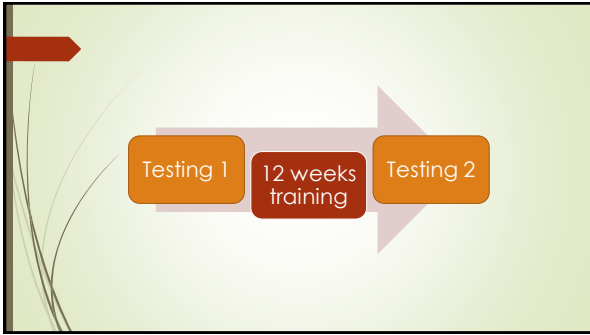
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**Table 1. Pliometric training program**

Week	Body part	Exercises	Intensity	Reps	Sets	Rest between sets
1	Lower body	Leg hops, back jumps, vertical jumps	Low	40	12	2-3 min
	Upper body	Explosive push-ups, jumping spider	Low	40	12	2-3 min
2	Lower body	Lateral diagonal and broad jumps	Low	40	12	2-3 min
	Upper body	Clapping push-ups, medicine ball passes, rotational throws	Low	40	12	2-3 min
3	Lower body	Vertical and obstacle jumps, box shuffles	Low	40	18	2-3 min
	Upper body	Clapping push-ups, medicine ball passes, chest passes	Low	50	21	2-3 min
4	Lower body	Lateral diagonal jumps, obstacle jumps, box shuffles	Medium	40	18	2-3 min
	Upper body	Clapping push-ups, rotational throws, chest passes	Medium	50	21	2-3 min
5	Lower body	Broad jumps, box jumps, box shuffles, drop jumps	Low	40	18	2-3 min
	Upper body	Medicine ball passes, rotational throws, overarm throws	Low	50	21	2-3 min
6	Lower body	Vertical jumps, obstacle jumps, box shuffles, drop jumps	Medium	40	18	2-3 min
	Upper body	Jumping spider, chest passes, overarm throws	Medium	52	21	2-3 min
7	Lower body	Lateral jumps, drop jumps (= vertical jumps), box jumps	Medium	40	18	2-3 min
	Upper body	Explosive push-ups, clapping push-ups, rotational throws, overarm throws	Medium	52	21	2-3 min
8	Lower body	Tuck jumps, box jumps, drop jumps, box shuffles, obstacle jumps	High	46	18	3-4 min
	Upper body	Jumping spider, chest passes, overarm throw	High	52	21	3-4 min
9	Lower body	Obstacle jumps, box shuffles, drop jumps, broad jumps, box jumps	Medium	48	18	3-4 min
	Upper body	Jumping spider, rotational throws, overarm throws	Medium	52	21	3-4 min
10	Lower body	Drop jumps, drop jumps + vertical jump, lateral diagonal jumps, obstacle jumps	High	46	18	3-4 min
	Upper body	Jumping spider, medicine ball throw, chest passes, overarm throws	High	56	24	3-4 min
11	Lower body	Tuck jumps, drop jumps, broad jumps, box jumps	High	48	20	3-4 min
	Upper body	Rotational throws, Chest passes, overarm throws	High	58	24	3-4 min
12	Lower body	Drop jumps, drop jumps + vertical jumps, lateral diagonal jumps, obstacle jumps	High	48	20	3-4 min
	Upper body	Chest passes, overarm throws	High	58	24	3-4 min

**Table 2. Skill based conditioning program**

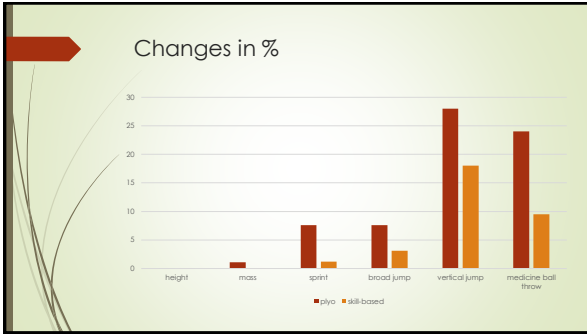
Week	Drills	Exercises	Intensity	Percentage of total for skill based conditioning
1	Volleyball drills	Performed as a single-element	Low	50%
	Small sided games	4 vs. 4 games	Low	25%
	Game drills	6 vs. 6 games	Low	25%
2	Volleyball drills	Performed as a single-element	Low	50%
	Small sided games	4 vs. 4 games	Low	25%
	Game drills	6 vs. 6 games	Low	25%
3	Volleyball drills	Performed as a single-element	Medium	40%
	Small sided games	4 vs. 4 games	Medium	30%
	Game drills	6 vs. 6 games	Medium	30%
4	Volleyball drills	Performed as a combined-element	Medium	40%
	Small sided games	4 vs. 4 games	Medium	30%
	Game drills	6 vs. 6 games	Low	30%
5	Volleyball drills	Performed as a combined-element	Medium	40%
	Small sided games	4 vs. 4 games; 3 vs. 3 games	Medium	30%
	Game drills	6 vs. 6 games	Medium	30%
6	Volleyball drills	Performed as a combined-element	Medium	40%
	Small sided games	3 vs. 3 games	Medium	30%
	Game drills	6 vs. 6 games	Medium	30%
7	Volleyball drills	Performed as a combined-element	Medium	40%
	Small sided games	3 vs. 3 games	High	40%
	Game drills	6 vs. 6 games	Medium	20%
8	Volleyball drills	Performed as a combined-element	Medium	40%
	Small sided games	3 vs. 3 games	Medium	40%
	Game drills	6 vs. 6 games	Medium	20%
9	Volleyball drills	Performed as a combined-element	Medium	25%
	Small sided games	3 vs. 3 games	High	40%
	Game drills	6 vs. 6 games	Medium	35%
10	Volleyball drills	Performed as a combined-element	Low	20%
	Small sided games	3 vs. 3 games	High	40%
	Game drills	6 vs. 6 games	High	40%
11	Volleyball drills	Performed as a combined-element	Low	20%
	Small sided games	3 vs. 3 games	High	40%
	Game drills	6 vs. 6 games	High	40%
12	Volleyball drills	Performed as a combined-element	Medium	20%
	Small sided games	3 vs. 3 games	High	40%
	Game drills	6 vs. 6 games	High	40%

## Results

**Table 3. Descriptive statistics (Mean ± Standard Deviation) for pre- and post-training results in each group; results of two-way analysis of the variance for main effects (Group and Time) and Interaction (Group x Time), and pre- to post-training differences in percentages (%).**

	Pliometric group (n = 21)			Skill-based group (n = 20)			Analysis of variance (F test)		
	Pre-	Post-	%	Pre-	Post-	%	Group	Time	Interaction
BH (cm)	177.9 ± 5.5	177.2 ± 5.1	<0.1	175.4 ± 7.0	176.0 ± 7.1	<0.1	0.9	0.1	1.1
BM (kg)	61.9 ± 5.2	61.2 ± 5.4 *	1.1	58.5 ± 7.5	58.5 ± 7.9	<0.1	0.7	0.1	1.3
S20m (s)	3.80 ± 0.32	3.53 ± 0.22 *	7.6	4.15 ± 0.27	4.10 ± 0.30	1.2	24.7 #	1.9 #	2.3 #
SBJ (cm)	190.7 ± 22.9	205.3 ± 17.3 *	7.6	167.3 ± 18.5	172.4 ± 18.7 *	3.1	11.8 #	96 #	16.3 #
CMJ (cm)	38.0 ± 6.5	48.5 ± 5.2 *	27.6	28.9 ± 7.2	34.1 ± 7.1 *	18.0	33.5 #	275.1 #	101.7 #
MBT (m)	6.1 ± 0.6	7.6 ± 0.7 *	24.5	5.3 ± 0.8	5.8 ± 0.8 *	9.4	2.8 #	156.3 #	40.2 #

BH – body height, BM – body mass, S20m – sprint over 20 meters distance, SBJ – standing broad jump, CMJ – countermeovement jump, MBT – medicine ball throw, # denotes F-test significance of p < 0.05, \* denotes pre- to post-measurement post-hoc significance of p < 0.05.




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### Most important finding

- Both training programs resulted in improvements in jumping and throwing capacities, but the changes induced by plyometric training were larger than those achieved by skill-based conditioning
- Is this expected, and why?**

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### Sprinting

- Plyometric training is known to be effective for sprint performance (rugby, tennis)
- But there are also reports that similar improvements in sprint can be achieved by skill based conditioning (soccer)
  - However, it seems that similar results of training modalities may be a result of difference in testing length (soccer study investigated 40 m sprint)
- CONCLUSION:** In +18 volleyball players **plyometric conditioning improves sprint** (but skill-based conditioning doesn't)

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### Jumping and throwing

- Improved in both groups
- When observed independently we may conclude
  - Plyometric training is effective
  - Skill-based training is effective
- When observed concurrently...

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### Jumping and throwing

- Improved in both groups
- When observed independently we may conclude
  - Plyometric training is effective
  - Skill-based training is effective
- When observed concurrently...

Changes in %

Metric	Plyometric Training (%)	Skill-based Training (%)
height	~1	~1
mass	~1	~1
speed	~10	~5
accuracy	~10	~5
vertical jump	~25	~15
medicine ball throw	~20	~10

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### Indeed

- Plyometric conditioning is known to be effective for jumping and throwing (even in similar participants such as female soccer and volleyball players)
- Skill based conditioning did not improve jumps and throws in volleyball (but these studies were shorter: 8 weeks vs. 12. weeks)

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Where to seek for a difference between plyometric and skill-based conditioning?

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Where to seek for a difference between plyometric and skill-based conditioning?

- There are some „physiological“ and „real-world“ explanations, but we will present it later
- For a moment the most important idea is (was) (copied-pasted from the article)
  - It is likely that the skill-based conditioning program did not result in changes of higher magnitude because of the players' familiarity with volleyball-related skills. Namely, in this study we included experienced senior players (+18 years of age), which could have resulted in a low impact of this skill-based conditioning and consequently did not result in adequate training stress. Therefore, in future studies, the influence of plyometric- and skill-based conditioning should be evaluated in younger and less experienced volleyball players.
- Also (non copied-pasted): What would happen if they have trained volleyball only (without additional exercise)?

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Study 2: <18 players

Idrizovic, K., Gilhovi, B., Sekulic, D., Ujevic, O., Jozic, P. V., Spasic, M., & Sattler, T. (2018). The Effects of 3-Month Skill-Based and Plyometric Conditioning on Fitness Parameters in Junior Female Volleyball Players. Pediatric exercise science, 30(3) 353.

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### Methods (most important)

- Participants were divided in 3 groups
  - Plyometric (n=13) ... but we will talk about it later
  - Skill-based conditioning (n = 17)
  - Control (n = 17)

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### Variables (measures)

- Body mass and height
- Calf girth
- Calf skinfold
- Corrected calf girth (calf girth „minus“ calf skinfold → indicator of musculature)
- Countermovement jump (CMJ).
- 20-m-sprint (SPRINT20M).
- Medicine ball toss from a laying position (MEDBALL)
- Sit-and-reach flexibility (SIT-AND-REACH)

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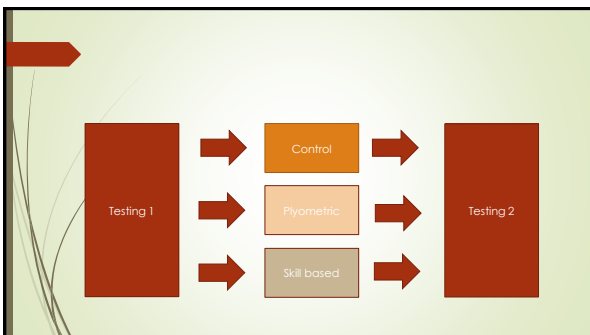
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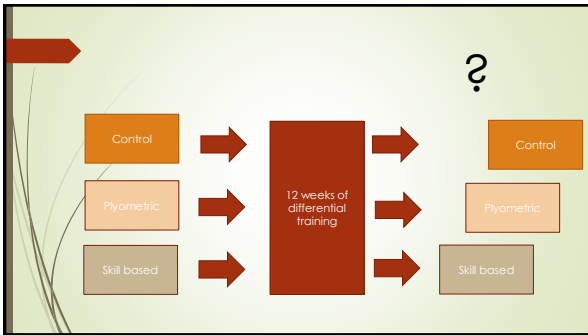
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### What was different?

- Control group
  - Volleyball training only (10 hours per week)
- Plyometric group
  - Volleyball training (10 hours per week) + 2 sessions weekly of plyo (30-60 min)
- Skill based group
  - Volleyball training (10 hours per week) + 2 session weekly of skill-based conditioning (30-60 min)

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### What was different?

- Control group
  - Volleyball training only (10 hours per week)
- Plyometric group
  - Volleyball training (10 hours per week) + 2 sessions weekly of plyo (30-60 min)
- Skill based group
  - Volleyball training (10 hours per week) + 2 session weekly of skill-based conditioning (30-60 min)
- Basically: Is more also the better?

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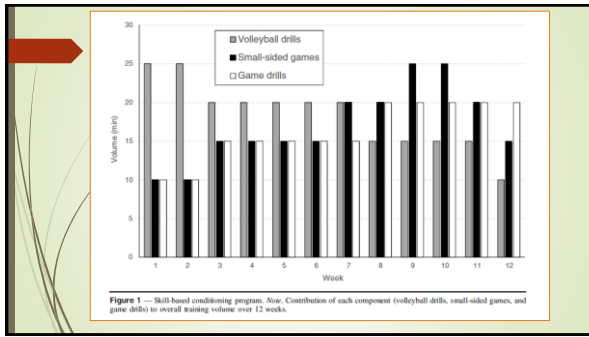
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	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
<b>Lower body plyometric exercises</b>												
side knee to knee (2 kg) <sup>1</sup>	5 x 1 [2]						5 x 3 [2]					
vertical vertical jump (2 kg) <sup>1</sup>	5 x 1 [2]	5 x 3 [2]					5 x 3 [2]					
vertical knee jump (2 kg) <sup>1</sup>	5 x 1 [2]							5 x 2 [2]			5 x 1 [2]	
vertical windmill jump (2 kg) <sup>1</sup>								4 x 4 [2]				
vertical knee jump (2 kg) <sup>1</sup>								5 x 3 [2]				
oblique jump (2 kg, 30 cm high) <sup>1</sup>								5 x 3 [3]			5 x 4 [3]	
box shuffle (30 cm high) <sup>1</sup>								4 x 4 [2]	5 x 2 [2]			
drop jump (2 kg, 40 cm high) <sup>1</sup>								5 x 4 [3]	5 x 3 [3]	5 x 2 [3]		
drop jump (2 kg, 40 cm high) <sup>1</sup>								5 x 2 [2]	5 x 2 [2]	5 x 1 [2]	5 x 4 [4]	
drop jump (2 kg, 40 cm high) <sup>1</sup>								5 x 2 [2]	5 x 1 [2]	5 x 2 [2]	5 x 3 [3]	
vertical jump (1 kg) <sup>1</sup>								5 x 1 [2]				5 x 3 [4]
vertical jump (1 kg) <sup>1</sup>								6 x 1 [2]	6 x 1 [2]	5 x 2 [2]		5 x 4 [4]
box jump (1 kg, 20 cm high) <sup>1</sup>								6 x 1 [2]	6 x 1 [2]	5 x 2 [2]		5 x 4 [4]
total lower body volume	1585	3096	1500	1500	2005	2000	1800	2108	2381	2090	2050	2015
<b>Upper body plyometric exercises</b>												
explosive push-up (10 cm knee) <sup>1</sup>	5 x 3 [2]							5 x 3 [2]				
jumping spider (10 cm knee) <sup>1</sup>	5 x 3 [2]							5 x 3 [2]	5 x 3 [2]	5 x 3 [2]		
clapping push-up (10 cm knee) <sup>1</sup>								5 x 3 [2]				
explosive medicine ball press (1 kg med ball) <sup>1</sup>	5 x 4	5 x 3 [2]						5 x 3 [2]				
clapping medicine ball press (1 kg med ball) <sup>1</sup>	5 x 4	5 x 3 [2]	5 x 4 [2]	5 x 4 [2]				5 x 4 [2]	5 x 4 [2]	5 x 2 [2]		
explosive chest pass (1 kg med ball) <sup>1</sup>								5 x 3 [2]	5 x 3 [2]	5 x 2 [2]	5 x 3 [2]	
explosive chest pass (1 kg med ball) <sup>1</sup>								5 x 3 [2]	5 x 2 [2]	5 x 2 [2]	5 x 3 [2]	
explosive medicine ball throw (1 handball, 1 kg med ball) <sup>1</sup>								5 x 3 [2]	5 x 2 [2]	5 x 2 [2]	5 x 3 [2]	
explosive medicine ball throw (2 handball, 1 kg med ball) <sup>1</sup>								5 x 3 [2]	5 x 2 [2]	5 x 2 [2]	5 x 3 [2]	
total upper body volume	3000	3312	1500	1500	1500	1500	2400	1500	1500	2400	2245	1607

<sup>1</sup>Rest time: 30 sec. (or specific number) (ie, with no rest interval between repetitions).

<sup>2</sup>Low-intensity exercises.

<sup>3</sup>Medium-intensity exercises.

<sup>4</sup>Rest time: 60 sec. (or specific number) (ie, with brief rest interval between repetitions).

<sup>5</sup>High-intensity exercises.

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## Results

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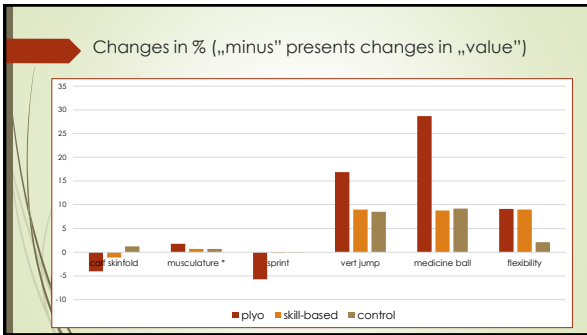
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Main findings

- Plyometric training resulted in positive anthropometric changes
- The changes in jumping and throwing were positive for all 3 groups but plyometric training induced most evident changes
- Additional skill based conditioning did not contribute to improvement of conditioning capacities (when compared to volleyball training alone)

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Plyometric training induced positive changes in body build

- Generally, plyometric training was rarely studied with regard to changes in anthropometrics
- Possible explanations:
  - Plyometric is applied for other purposes
  - Authors examined but did not find changes and therefore did not present it
- Our results indirectly confirmed positive changes in body composition (ie, decrease in skinfold and increase in corrected girth).
- Such changes, together with maintenance of body mass at the baseline level, indicate positive changes in body composition (ie, an increase in lean body mass and decrease of fat mass in **JUNIOR FEMALE VOLLEYBALL PLAYERS**)

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**Plyometric training improved sprinting, jumping and throwing capacities**

- Main physiological explanations:
  - elongation of the Achilles tendon and a consequent increase in the amount of stored elastic energy → jumping
  - stimulation of an increased number of muscle units and higher (neural) firing frequency → jumping, sprinting, throwing
  - Improved joint proprioception → sprinting
- Altogether resulted in „fast production of force“

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**Skill-based conditioning „did not contribute“ to improvement in conditioning capacities**

- Main explanation
  - lack of training intensity due to lack of control over training intensity
- In brief:
  - The proper adjustment of training intensity is crucial in achieving exercise goals
  - Adjustment is dependent on „controllability“ (you can not adjust if can not control)
    - monitoring the single-session intensity of skill-based conditioning is inaccurate
    - intensity during skill-based conditioning depends on the partner and/or opponent's performance, which is hardly controllable

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**Conclusion (of the 2nd study)**

- Plyometric training is effective for junior volleyball players
- Skill-based conditioning is not effective
- **Note that we did not observe changes in sport-specific skills!**

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Let's put it together

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In general

- 12-week plyometric training is „equally effective“ in „senior“ and „junior“ female volleyball players

PLYOMETRIC	% changes	
	SEN	JUN
Jumping	8-28%	17%
Throwing	25%	29%
Sprinting	8%	6%

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In general

- 12-week plyometric training is „equally“ for „senior“ and „junior“ female volleyball players
- Skill based conditioning is similarly effective for JUN and SEN**

SKILL BASED	% changes	
	SEN	JUN
Jumping	3-18%	9%
Throwing	9%	8%
Sprinting	1%	0%

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### In general

- 12-week plyometric training is „equally“ for „senior“ and „junior“ female volleyball athletes
- Skill based conditioning is similarly effective for JUN and SEN
- But, plyometric is more effective than skill-based for both groups**

PLYOMETRIC	% changes		SKILL BASED	% changes	
	SEN	JUN		SEN	JUN
Jumping	8-28%	17%	Jumping	3-18%	9%
Throwing	25%	29%	Throwing	9%	8%
Sprinting	8%	6%	Sprinting	1%	0%

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### In general

- 12-week plyometric training is „equally“ for „senior“ and „junior“ female volleyball athletes
- Skill based conditioning is similarly effective for JUN and SEN
- But, plyometric is more effective than skill-based for both groups
- And skill-based did not contribute to additional improvement when compared to „regular“ training (in studied capacities)**

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### But, there is BUT!

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But, there is BUT!

- Remember this?

Methods (most important)

- Participants were divided in 3 groups
  - Plyometric (n=13) ... but we will talk about it later
  - Skill-based conditioning (n = 17)
  - Control (n = 17)

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But, there is BUT!

- The original number of participants (starting) was
  - Plyo: 16; Control: 18; Skill-based: 18
- At the end of the study we observed only those who participated at >80% training sessions (PLYO: 13, SKILL-BASED: 17, CONTROL: 17 players), meaning that drop-out rates were:
  - 20% for plyometric
  - 6% for control and skill-based groups
- We did not study it specifically, girls did not report injuries, etc.
- But ... it is indicative, don't you think?

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In conclusion

- Plyometric training performed twice-a-week as an addition to regular volleyball training in 12-week period will improve „explosive capacities“
- There is no evidence that plyometric training is „differentially“ effective for different age-groups
  - When performed under „similar“ conditions (i.e. not „specifically tailored“)
- There is no evidence that additional skill-based conditioning performed twice-a-week is effective for development of jumping-, throwing-, and sprinting-capacities in female volleyball players
- But, caution is needed when it comes to „risks“
  - It is indicative that drop-out rates were much higher in plyo- than in skill-based conditioning (studied in juniors only)
- What happened with volleyball skills, still have to be evaluated

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