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The effect of different strength training protocols on the jumping ability of amateur female volleyball players

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Abstract

Purpose: The purpose of the study was to examine the effect of different strength training protocols on the jumping ability of amateur female volleyball players.
Methods: 48 female volleyball athletes aged 18-32 years (M±SD=24.5±4.2 years) were divided into 2 groups, 2 experimental and one control group (N=16). The athletes of the experimental groups participated in one strength training protocol for 8 weeks as follows: GROUP 1: TRX-training combined with plyometric exercises, GROUP 2: resistance training and TRX-training combined with plyometrics. The Control Group was executing only field volleyball training. At the end of 8 weeks, the 2 experimental groups participated in a common training protocol with plyometric exercises for 8 weeks, followed by a 4-week detraining period. At baseline, after 8 weeks, 16 weeks and 20 weeks, measurements were performed in 6 jumping tests: squat jump, countermovement jump, countermovement jump with arm swing, drop jump, block jump and attack jump.
Results: After 8 weeks of intervention, significant improvements in performance were found in all jumping test for the 2 experimental groups ($p < 0.001$), but not for the control group. After the plyometric training, the players improved their jumping performance further. Although the test values did not differ significantly from the previous measurement, they remained significantly higher compared to the beginning of the survey ($p < .001$). The jumping performance of the experimental groups showed a small decrease (0.5% -1%) after 4 weeks of detraining, compared to the previous measurement, but it remained significantly higher in comparison to the initial values. The performance of the control group did not differ significantly among the measurements.
Conclusion: In conclusion, TRX-training, combined with plyometric exercises and/or resistance training, could provoke significant adaptation to the jumping ability of amateur female volleyball players. Therefore, TRX-exercises can be integrated into the training process, in the context of differentiation and variety of the training stimuli. In addition, the implementation of plyometric exercises in form of circuit training could bring further positive adaptations to the players' jumping ability. Finally, the majority of the training adaptations can be maintained during the detraining period, as long as a maintenance training program with jumping exercises is executed.

Keywords: Circuit training; Jumping ability; Plyometrics; Resistance training; TRX-training vertical jump.

1 Introduction

In many individual and team sports, the power production from the lower extremities for the execution of speed-power movements constitutes a crucial factor for the athletic performance (Newton & Kraemer, 1994). The power training is very important for the athletes and contributes to the improvement of the muscular strength (American College of Sports Medicine [ACSM], 2009; Kraemer & Ratamess, 2004) and the jumping ability

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(Adams, O'Shea, O'Shea, & Climstein, 1992). The training with low speed execution and ~80% of 1 RM or more relative intensity improves the maximum power notably (Hakkinen, Allen, & Komi, 1985). However, resistance training with less relative intensity (30%-60%) so as the speed of the movement would be faster is necessary for the development of speed power (Cronin, McNair, & Marshall, 2002). The most common method of power development is complex training which combines high intensity resistance training and plyometric exercises at the same training unit (Ebben & Watts, 1998; Jones & Lees, 2003). The term "complex" training was first used by Verkoschansky and Tatyan (1973) as a method based on the principle that every reactive movement is better developed when there is high activation of the central nervous system before. We also encounter the term difference method in the international bibliography (Duthie, Young, & Aitken, 2002), which is used when resistance and explosive exercises are used in the same set. In general, complex training combines resistance and explosive exercises such as plyometrics, at the same unit (Duthie et al., 2002; Ebben& Watts, 1998; Harris, Stone, O' Bryant, Proulx, & Johnson, 2000).

In recent years, TRX-training which is a kind of functional training that improves the strength (Danelly et al., 2011; Prokopy et al., 2008), coordination and balance (Pedersen, Kirkesola, Magnussen, & Seiler, 2006) has been instilled. The training bands are a simple construction but, at the same time, a multi-sided exercise machine with a wide variety of multi-level functional exercises which are executed with the use of body weight only. Due to the unstable training setting, the strength of the body and especially of the abdominal muscles is increased while the solidity of the joints is boosted without stressing them. However, a limited number of scientific researches has dealt with power training on an unstable setting, mostly studying the normal central mechanisms of stability (Anderson & Behm, 2005). Very few studies have examined the adaptation of strength and power after training in unstable conditions or the benefits that strengthening programmes which combine both stable and unstable workout conditions in jumping ability may have (Cowley, Swensen, & Sforzo, 2007; Sparkes & Behm, 2010). The main conclusion of the researches until now is that the loads which are applied on unstable conditions may not constitute a stimulus which is able to bring adaptation and strength (Anderson & Behm, 2004) or power (Drinkwater, Pritchett, & Behm, 2007; Kornecki & Zschorlich, 1994) gain. This can probably be explained because of the fact that the muscles around the joints tend to place emphasis on stability rather than energy production (Anderson & Behm, 2004). Thus, some researchers highlight the need for further investigation of the short-term and long-term adaptations of the muscle strengthening programmes in unstable conditions (Anderson & Behm, 2005).

The purpose of this study was to investigate the effect of: a) different protocols of complex muscle strengthening training of 8-week duration, b) a common protocol of plyometric exercises with 8-week duration following the complex training as well as c) a detraining period in relation to the different muscle strengthening programmes that had preceded on the jumping ability of amateur female volleyball athletes.

2 Method

2.1 Participants

The study involved 64 amateur volleyball female athletes aged 18-32 years, who were classified into three age categories: 18-22 years (n = 22), 23-27 years (n = 21) and 28-32 years (n = 21).). Then, four equal groups (n = 16) of athletes from all three age groups were randomly selected to participate in different training protocols, as follows:

- Group 1: resistance training (weights)
- Group 2: TRX Belt Training
- Group 3: TRX resistors and straps
- Group 4: Volleyball Training (CG = Control Group).

The initial values for age and anthropometric characteristics of the athletes included in the study are presented in Table 1. Based on the MANOVA results and the Pillai's trace criterion, no statistically significant main effect of group factor was found on none of the above variables (Pillai's trace = 0.127, F (15.174) = 0.51, p> .05).

Table 1. Age and anthropometric characteristics of the athletes who participated in the study.

Female athletes	Group 1 (RT, n=16)	Group 2 (TRX, n=16)	Group 3 (RT-TRX, n=16)	Group 4 (CT, n=16)	Total (n=64)
Age (years)	24.54±4.18	24.95±4.54	23.84±4.45	24.71±3.89	24.51±4.19
Weight (kg)	62.65±7.55	62.11±7.72	62.49±6.10	65.83±4.47	63.27±6.61
Height (cm)	172.14±8.87	168.57±7.83	172.12±9.44	173.88±10.14	171.68±9.10
BMI (kg/m2)	21.27±3.11	21.96±3.21	21.21±2.71	21.95±2.76	21.60±2.90

RT=resistance training TRX=Belt Training, RT-TRX=resistors and straps, CT=control group, BMI = body mass index

2.2 Measurement Instruments

Anthropometric indicators. The female athletes were dressed lightly and without shoes. Body weight was measured with a precision digital weighing scale (Electronic Weight Scale HD-351, Tanita, Illinois, USA) with a accuracy of 0.1 kg and height was measured with a height meter (Seca Stadiometer, Leicester, UK) and a ± 0.5 cm approx. with a metal rod on the wall. Each athlete stood barefoot, with soles together and hands hanging freely on the sides. The soles, head, shoulders and buttocks were resting on the metal rod. Each measurement was repeated twice. From these data the BMI was calculated as: BMI = body mass (kg) / height2 (m2).

- Jumping level: For the evaluation of jumping level the following tests were used:
- Semi jumping with hands in the middle (SJ): the athlete started from the position of squat with her hands in the intermediate position and jumped from that position.
- Countermovement jumping with hands in the middle (CJ): the athlete started upright with her hands in the middle. In order to perform the jump, she moved to squat position and then she did the vertical jump. The rate of movement was rapid / explosive.
- CJH Jump Counter: The execution technique was the same as CJ, with the difference being that the hands were free and the athlete could use them to give greater push.

- Deep jump from box (40cm): the athlete started on a 40cm box upright with her hands in the middle. From this position she let her body slide forward and down and as soon as she touched the floor, she made a vertical jump.
- Block jump: the athlete started from block position on the net and made a block jump simulation.
- Jump Attack: The athlete started by approaching the net and made the jump in a virtual effort.
- (For the test jumps we used Opto-jump Microgate Engineering, Bolzano, Italy).

2.3 Procedure

Two days before the study began, the female athletes came to the laboratory to get to know the measurement tests. One day before the intervention, the anthropometric characteristics and the jumping ability of the athletes were evaluated in the laboratory. Repeated measurements were performed two days after completion of the 8-week intervention. Subsequently, the 3 experimental groups participated in a common multimeter training program for a further 8 weeks, after which repetitive laboratory measurements were completed. An active 4-week respite (exclusively field training) followed and the research was completed with the final laboratory measurements.

The measurements took place as follows:

Table 2. Measurements tests.

Tests	Time
Anthropometric characteristics (height, weight)	3 min.
Warm-up with running	6 min.
Stretching	5 min.
SJ, CJ, CJH, DJ, block jump, jump attack	6x4 min., (3 efforts for each test with 1 min. rest) = 24 min.
Cool down with stretching	5 min.
Total measurement time	43 min.

2.4 Content of the muscles strengthening training protocols

The training frequency was 3 times / week. During the 8 weeks each experimental group performed a four-exercise program, while the CG simply performed field training without participating in any training program.

All athletes started running at a moderate pace (5 minutes), stretched, and then had a 3-minute rest. Follow-up exercises with straps and / or straps were followed by a 4-minute break and the groups completed their program with multimeter exercises. The main part of the program of Groups 1 and 2 is showed in Table 3. Group 3 performed alternate strength training programs with weights and strap and finished with two plyometric exercises, as Experimental Groups 1 and 2.

Table 3. Exercise List of Experimental Groups 1 and 2 (Muscle Strength with Resistors and TRX Straps).

Group 1 (strength training)	Group 2 (TRX training)
Leg press with machine	Deep sit

Squat with bar Leg extension with chair Leg curl with machine	Half seat with leg change Adverse protrusion with half seat and back leg in hanging Skater (slipping with back leg crossing and side jumping)
Intensity: 50% of 1RM Repetitions: 10, Lines: 3, Rest: 1 min between sets, 2 min. between exercises	Intensity: 50% of speed execution Repetitions: 10, Lines: 3, Rest: 1 min. between sets, 2 min. between exercises
4 min rest	
3x10 vertical jumps 3x10 width jumps from box 40cm	
Rate execution: fast/explosive Rest:1 min. between sets, 2 min. between exercises	

The content and characteristics of the 8-week joint weight training program are summarized in Table 4, while Table 5 shows the program followed during active rest (4 weeks).

Table 4. Exercise test of plyometric training with eight stops of circle training

Deep jump from box (40 cm), jumping over obstacle (50 cm) and attack jump (10 sec)
Throwing medical ball (2 kg.), upwards with bounce and catch of the ball (10 sec)
Two obstacle jumps from zone 4 followed by attack steps to the net (10 sec)
Continually side to side jumps over a 40 cm cone
Block jumps from help block position, doing a small block and after two side to side movements, the highest block jump, holding a 2 kg medicine ball (10 sec)
Continually jumps of ten stairs (50 cm / 10 sec)
Continually cross jumps with change of foot on a 40 cm high box (10 sec)
Rope skipping with simple bounce and stretched legs (10sec)
Frequency: **3 times/week,** Positions: **8,** Circles: **2,** Duration of practice at each position: **10 sec** Rest: **30 sec between the positions and 5 min between the circles.**

Table 5. Training content of the field training during active break.

Training schedule on the court during non-game period
5 min running - Stretching
10 min running exercises – stability exercises - training jumping on the net
Technique exercises with ball in pairs (15 min)
Combination team exercises of technique with and without the net (15 min)
Competitive exercises with attack and defence on the net (15 min)
Team games with rules (15 min)
3 min running - Stretching
Cooling down

2.5 Statistical analysis

Firstly, descriptive statistics methods, that is the calculation of the average and standard deviation, were applied and inferential statistics methods followed. The Analysis of Variables ANOVA with repeated measurements was used to determine the influence of the training on the athletes jumping ability. Mauchly's Test of Sphericity was used to

check the sphericity. Bonferroni Post-Hoc Test was used to determine the significance of several averages between time and groups. SPSS 19 was used for the analyses. All the test were two-sided. The differences among the variables were checked on significance level p<05.

3 Results

In order to investigate the effect of the different muscle strengthening protocols on the improvement of jumping ability, there was a repeated measurement analysis was employed. The factor “group” was defined as the independent variable, while the 6 evaluation tests of jumping ability, were defined as the dependent variable (see Unit Description of Testings). The Mauchly's Test of Sphericity indicated that the differences among each pair of values were significantly different (p<0005), therefore the Greenhouse-Geisser criterion was chosen for the testing of the main effect.

The athletes' performance on the jumping ability tests for the total of the measurements (first measurement, 8 weeks, 16 weeks and 20 weeks), is presented on section 3 of the Table 6. According to the results, the variable “group” had a statistically significant main effect on all jumping ability tests (p<.0001). There was a further analysis in order to check the exact levels on which statistically significant differences were noticed (Bonferroni's multiple comparison test). All the tests proved that there was significant improvement of the performances, from the first to the second measurement, for the two experimental groups but not for the control group. The improvement of the two experimental groups was similar in all tests (p<.073). Additionally, after 8 weeks of training, the performance of the control group on the “attack jump” test was significantly lower than that of the muscle strengthening group (p<.035), while in comparison with the TRX group, the differences in this testing approach is the level of statistical significance (p<.073). The adjustment regarding the athletes' age did not change the results.

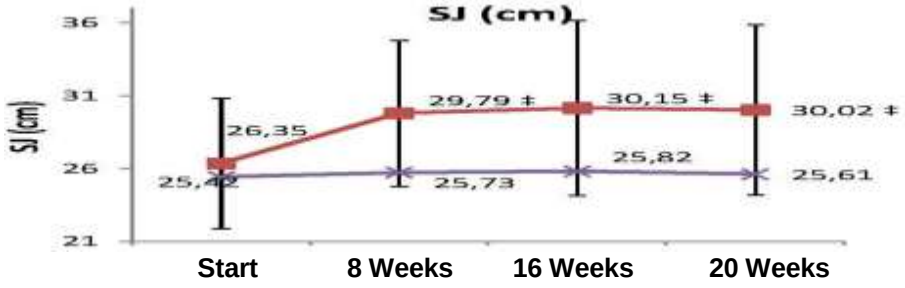
Table 6. Measurement results (Averages κ Standard Deviations) for the tests of elastic ability in the four groups that participated in the study.

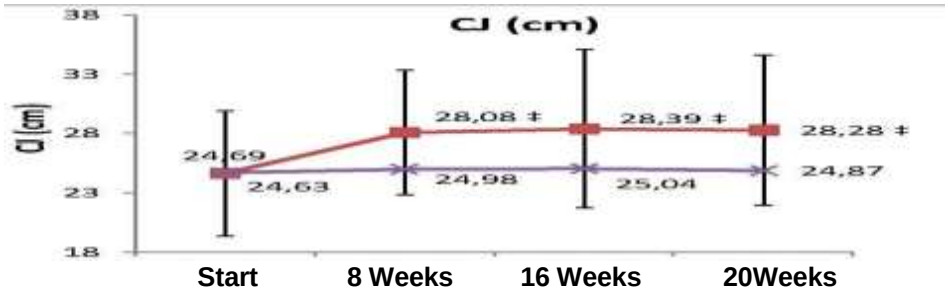
	1st Measurement	2nd Measurement	3rd Measurement	Last Measurement
		Squat jump (SJ)		
RT	25.23±3.39	28.47±4.33‡	28.75±4.45‡	28.56±3.94‡
TRX	26.35±4.47	29.79±5.01‡	30.15±6.02‡	30.02±5.85‡
RT-TRX	25.77±6.14	27.80±6.76‡	28.19±6.99‡	27.93±6.97‡
CG	25.42±4.56	25.73±4.67	25.82±4.67	25.61±4.62
	$F_{(9, 180)}$=5.47, p<.0001			
		Countermovement jump (CJ)		
RT	26.10±4.99	29.45±6.36‡	29.72±6.48‡	29.55±6.85‡
TRX	24.83±5.27	28.08±5.24‡	28.39±6.68‡	28.28±6.34‡
RT-TRX	26.47±5.94	28.56±6.26‡	28.96±6.56‡	28.71±5.62‡
CG	24.69±7.27	24.98±7.37	25.04±7.36	24.87±7.28
	$F_{(9, 180)}$=4.62, p<.0001			
		Countermovement jump with arm swing (CJH)		
RT	29.33±5.91	33.08±7.09‡	33.40±7.14‡	33.19±6.85‡
TRX	28.16±5.92	31.86±7.01‡	32.21±7.23‡	32.06±8.33‡
RT-TRX	27.31±5.00	29.47±5.33‡	29.87±5.80‡	29.61±4.57‡

CG	27.53±6.34	27.75±6.39	27.79±6.37	27.70±6.34
	$F_{(9, 180)}$=5.15, p<.0001			
	Deep jump from box (40cm) (DJ)			
RT	23.51±2.25	26.52±3.38‡	26.78±3.03‡	26.61±3.26‡
TRX	23.61±4.71	26.71±5.17‡	27.01±5.61‡	26.90±6.37‡
RT-TRX	25.37±4.09	27.38±4.87‡	27.75±5.12‡	27.50±5.20‡
CG	23.86±3.96	24.12±3.91	24.20±4.03	24.03±3.98
	$F_{(9, 180)}$=4.89, p<.0001			
	Block Jump			
RT	26.99±5.11	30.44±5.27‡	30.74±6.58‡	30.55±6.04‡
TRX	28.67±6.85	32.44±7.99‡	32.80±7.30‡	32.64±7.66‡
RT-TRX	27.24±6.18	29.40±6.94‡	29.79±6.75‡	29.53±7.54‡
CG	28.24±7.39	28.46±7.51	28.58±7.52	28.39±7.38
	$F_{(9, 180)}$=6.24, p<.0001			
	Attack Jump			
RT	36.23±5.97	40.87±8.04‡*	41.28±7.95‡*	41.00±7.17‡*
TRX	35.32±5.10	39.95±8.32‡	40.42±7.19‡*	40.23±7.09‡*
RT-TRX	33.75±5.88	36.72±7.02‡	36.97±6.65‡	36.34±6.31
CG	34.69±7.58	34.95±7.61	35.10±7.74	34.96±7.63
	$F_{(9, 180)}$=6.24, p<.0001			

*Statistically important differences ‡ in comparison with the initial measurement on level p < .001, *in comparison with the measurement of CGon level p<.05. abbreviationsαçin table 1*

As a result of the multivariate training (16 weeks), the performance of the three experimental groups in the tests showed little improvement compared to the second measurement, but was statistically higher than the beginning (p<.001). There were no statistically significant differences between measurements in the Control Group (Figure 1).





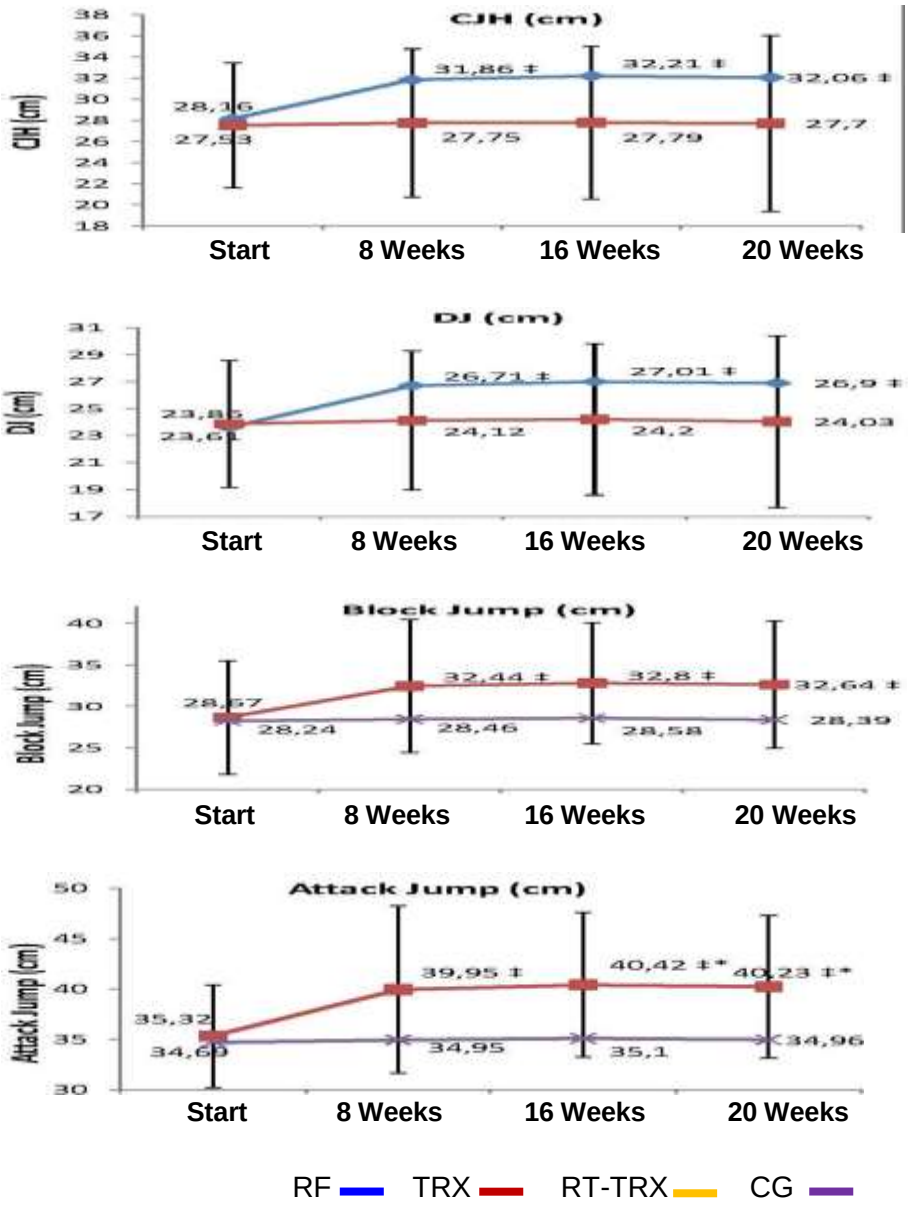
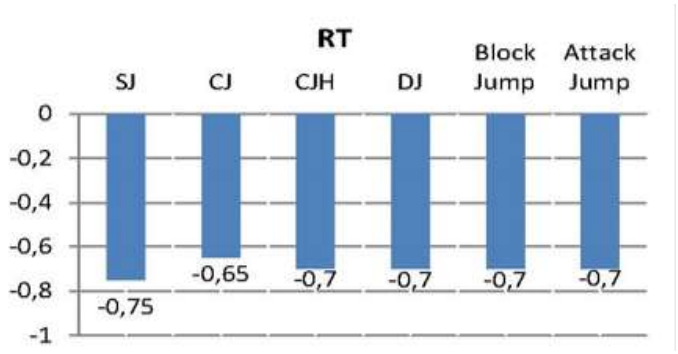
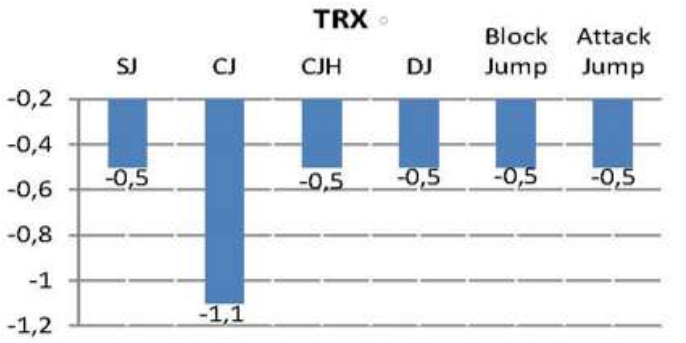


Figure 1. Differences between female athletes (MT ± TA) in the jump tests after 8 and 16 weeks of intervention. Statistically significant differences: ‡ relative to initiative measurement ($p < .001$), * relative to CG measurement ($p < .05$). Abbreviations as before.

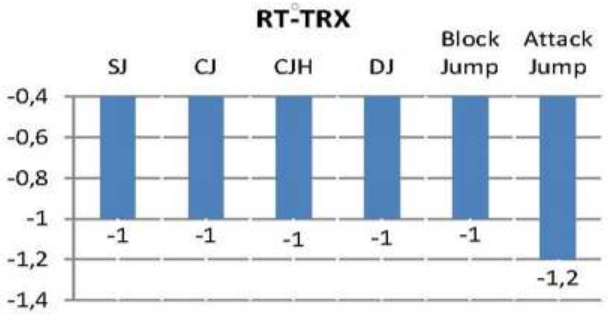
Interruption of training resulted in a slight decrease in the performance of the three experimental groups (0.5% -1.2%) compared to the previous measurement (Figure 2). However, the differences remained significantly higher than the initiative measurement (Table 5). In addition, after 20 weeks of training, the performance of the muscle strength and TRX groups in the “Jump Attack Jump” test was significantly higher than the CG performance ($p < .019$ and $p < .039$, respectively). No statistically significant differences between measurements were observed in CG. Figure 3 presents the percentage changes in the performance of the three experimental groups after 8, 16, and 20 weeks of intervention, relative to the beginning.



Group 1: resistance training (weights)



Group 2: TRX Belt Training



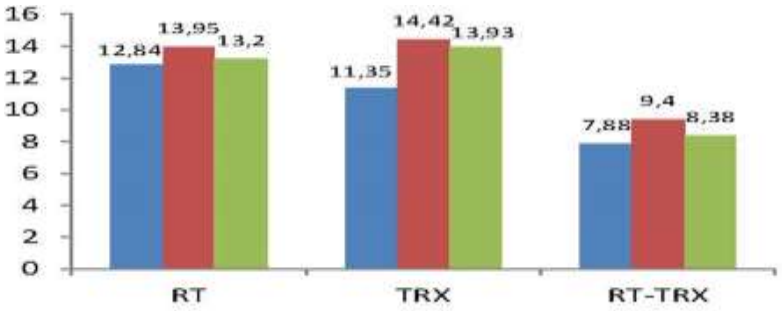
Group 3: TRX resistors and straps

Figure 2. Percentages of change in performance of the three experimental groups in tests of elasticity between the 3rd and 4th measurement. Abbreviations as before**.**

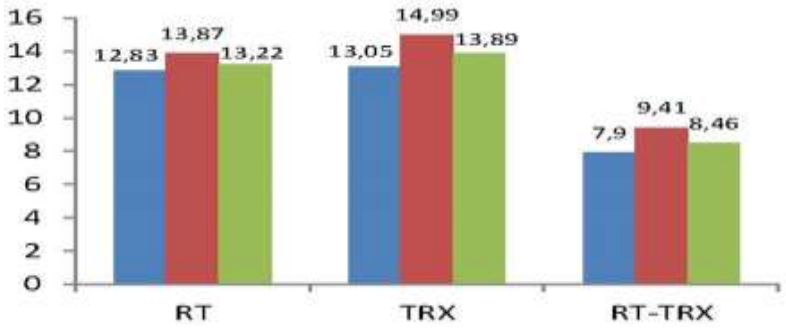
4 Discussion

In the present study, the effect of different muscle training protocols, such as the interruption of training during the transition period,of amateur female volleyball athletes was studied. The results of the study found that both resistance training and strap training, combined with multimeter exercises, had a significant effect on improving the athletic ability. Specifically, after 8 weeks of intervention, Group 1 performance improved to 13% (SJ: + 12.84%, CJ: + 12.83%, CJH: + 12.79%, DJ: + 12.80%, Jump Block: +12.78 %, Attack Block: + 12.65%). Correspondingly, in Group 2 the percentage improvement ranged from ~ 11-13% (SJ: + 11.35%, CJ: + 13.05%, CJH: + 13.14%, DJ: + 13.13%, Jump Block: + 13.15%, Attack Block: + 13.11%). Lower were the

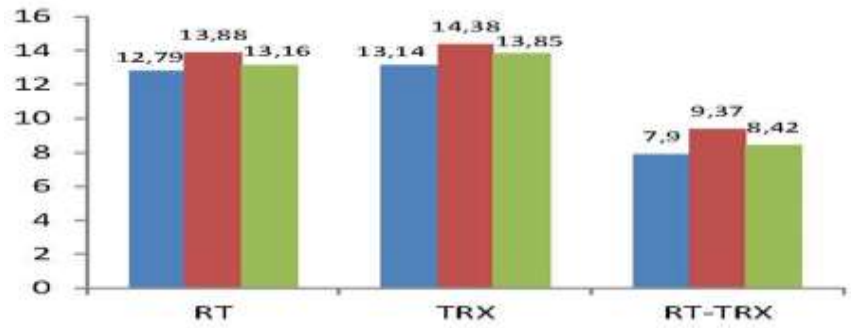
improvement rates for Group 3, which increased its performance from 7.88% to 8.80% (SJ: + 7.88%, CJ: + 7.90%, CJH: + 7.90%, DJ: + 7.92%, Jump Block: + 7.93%, Attack Block: + 8.80%). Field Volleyball training did not improve the jumping ability of female athletes.



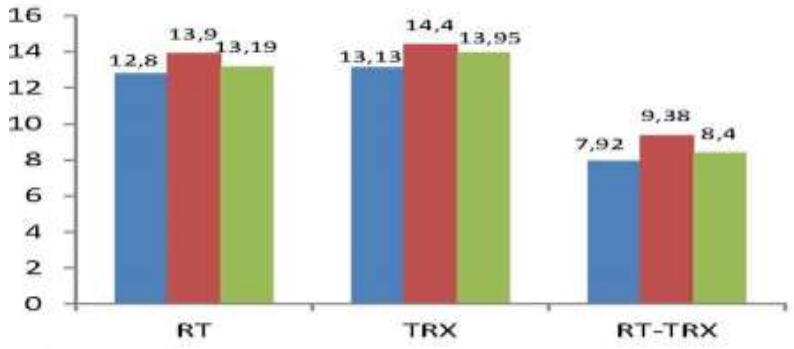
SJ (% Variability)



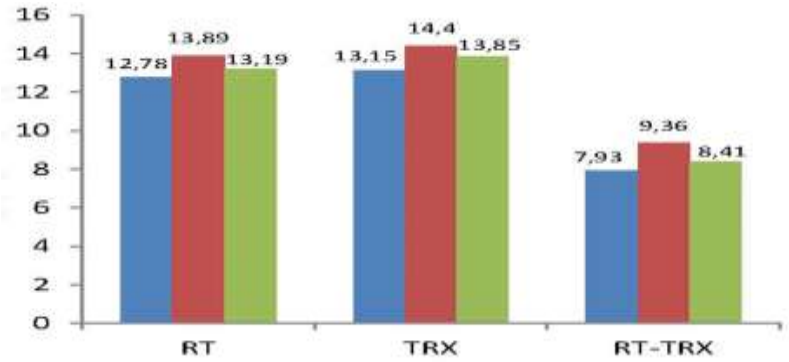
CJ (% Variability)



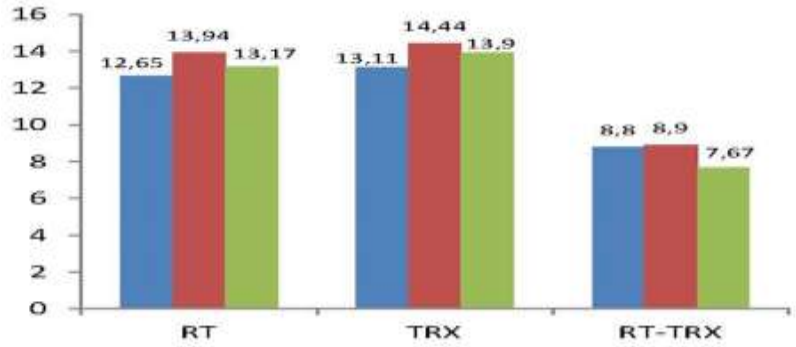
CJH (% Variability)



DJ (% Variability)



Block Jump (% Variability)



Attack Jump (% Variability)

Figure 3. Percentages of change in performance of the three experimental groups in the tests after 8, 16, and 20 weeks of training. All changes were statistically significant compared to the beginning at p <.001. Abbreviations as above.

The results of the study are in line with previous studies, where combinatorial exercise protocols (resistance training and multimeter training) are capable of making significant adjustments and improvements in jumping ability. The percentage improvement of the jumping ability in these specific researches, ranged from 4% to 15% and it seems that is was different depending on the duration of the intervention (4-12 weeks), the frequency of training (2-4 training units per week), burden intensity (60-

80% of 1 RM), as well as the alternation of exercises, that alternated either in the same training unit or in different training units (Adams et al., 1992; Fatouros et al., 2000; Mihalik, Libby , Battaglini, & McMurray, 2008; Toumi, Best, Martin, & Poumarat, 2004). Significant training adjustments are already observed after 3 weeks of intervention (Mihalik et al., 2008), while the observed changes in vertical jump performance parameters can be attributed to both nervous system adjustments (Gabriel, Kamen, & Frost, 2006), and adaptations in muscle tissue (Fry, 2004). Nervous system adaptations include improvements in muscle ability, morphological adaptations to neuromuscular contractions, changes in the timing of neural adaptations, as well as quality of nerve stimulation. Factors affecting muscle fiber adaptations include muscle hypertrophy, muscle fiber conversion, and connective tissue adaptations (Fleck & Kraemer, 1997).

Although some researchers have expressed the opinion that the percentage of work during training in an unstable environment, may not be sufficiently stimulating to bring significant adjustments in strength or power (Anderson & Behm, 2004; Drinkwater et al., 2007; Kornecki & Zschorlich (1994), in the present study, a training program with TRX can make equally important adjustments to jumping ability. Improvements have been reported in healthy young men who were trained with TRX for 7 weeks (3 training units / week) (Maté-Muñoz, Antón Monroy, Jiménez, & Garnacho-Castaño, 2014). It seems that because of the unstable training setting, the activation of the body increases and more than one muscle group is activated. The alternation between TRX and resistance and TRX exercises per training unit, lead to significant improvement of the jumping ability which was in a slightly lower level, comparing to the other two training programs. As the differences between the three protocols were not statistically significant, coaches could exploit similar power / speed protocols, expecting both strength and elastic fitness adjustments as well as the benefits of functional training (balance, coordination, and flexibility).

In addition, training in the form of circular workout at stations resulted in a significant improvement in the athletic ability. The increase in performance was slightly higher for Groups 1 and 2 compared to Group 3, however, with no differences in statistical significance. After 8 weeks of application of the program and compared to the initiative measurement, there was an improvement by ~ 14% in Group 1, from ~ 14.40% to 15% in Group 2 and from 8.90% to 9.41% in Group 3. According to previous research, multimeter training significantly improves vertical jump parameters (Adams et al., 1992; Fathi et al., 2018; Gjinovci, Idrizovic, Uljevic, & Sekulic, 2017; Markovic & Mikulic, 2010; Pereira , Costa, Santos, Figueiredo, & João, 2015; Singh, Kumar, Rathi, & Sherawat, 2015), while benefits are greater in programs longer than 10 weeks (Stojanović, Risti ć, McMaster, & Milanović, 2017). Differences in training, make it difficult to compare the results between surveys, as the training status of participants, the number of exercises, the number of jumps, the height of the drop in depth jumps, significantly differentiate the effect of coaching stimulus (Fleck & Kraemer, 1997). In addition, the above-mentioned studies examined the effect of multimeter training compared to resistance training or combined strength / speed protocols, while the present study evaluated the ability of a multimeter cycling training program to make further adjustments to jumping. It has been found that circular plyometric training causes a training stimulus capable of further improvement, in athletes who had previously used different muscle training protocols.

The field training that the athletes followed during their active rest, kept the adaptations which had been achieved previously, to a large extent. The jumping performances of the three experimental groups decreased slightly (0.5% -1%) compared

to the previous measurement, but remained significantly higher compared to the beginning of the training. Thus, in Group 1 the performance remained ~ 13% higher than the original measurement, in Group 2 ~ 14% and in Group 3 ~ 8%.

Interruption or reduction of the training leads to a decrease in performance, which is expressed through a proportional reduction in anatomical and physiological adjustments. The results of research on the effect of stopping training, indicate that the jumping ability is reduced as well as the jump itself, which varies (Fleck & Kraemer, 1997). However, performance after the interruption period, is still higher than at the beginning of the training (Marques & González-Badillo, 2006). The rate of decline in performance appears to depend on the duration of the pre-interruption training, the type of training, the training condition of the participants, as well as the interruption time (Fleck & Kraemer, 1997; Marques & González- Badillo, 2006; Sousa et al., 2018). In addition, according to Thorstensson (1977), the performance in complex skills which include elements of power, such as the vertical jump, can decrease if these skills are not included in the program that is implemented in the transitional period. Therefore, the athletes of the three experimental groups in the present study may keep the adaptations they had achieved until the 16week, because the 4-week program they followed during the active detraining, contained several jumping exercises (jumping exercises by the net, competitive attacks and defenses on the net, etc.).

5 Conclusion

To sum up, TRX training can cause significant adaptations in jumping ability testings of amateur female volleyball players, after 8 weeks of intervention. Additionally, the implementation of plyometric exercises in the form of cyclical training in points causes training stimulus that is able to bring further positive adaptations on the athletes' jumping ability. Finally, the break in the training can cause a minor decrease in the jumping ability testings, however, the majority of the adaptations is maintained as long as the transitional period program contains exercises which simulate the vertical jump.

The results of the present study can be used by the volleyball coaches, taking advantage of the TRX training as an alternative method of power training, independently or together with other already tried and tested methods. Future researches can investigate the (possible) different influences of TRX training on the jumping ability in relation to the gender, the different age group and the different sports. Finally, the possible differentiation of the results in relation to the different characteristics of the training charges could be investigated simultaneously.

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