

An eight-weeks resistance training programme with elastic band increases some performance-related parameters in pubertal male volleyball players

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ABSTRACT: The main aim was to evaluate the changes in dynamic, reactive, and power strength, and balance (as volleyball performance-related parameters) in pubertal volleyball players when a part of their normal in-season training regimen was replaced by an elastic band training (EBT). 27 male elite volleyball players were randomly allocated to intervention (N = 14; 14.86 ± 0.52 years) or control group (N = 13; 14.74 ± 0.36 years). The intervention consisted of an 8-week EBT program focused on the training of the lower limb, with different volumes and intensities. Countermovement jump (CMJ) and standing long jump (SLJ) were used to assess the power strength, squat one repetition-maximum, and reactive strength index to assess dynamic and reactive strength, respectively. Also, the balance was assessed through different parameters of the foot centre of pressure (CoP) displacements obtained with a force platform. An ANOVA of repeated measurements and post-hoc tests evaluated differences between groups and between baseline and post-intervention. Dynamic and power (CMJ and SLJ) strength, and anteroposterior displacement of the CoP were improved after the intervention. The control group only improved the dynamic strength. No statistically significant difference ($p > 0.05$) were found in the rest of the variables. EBT improves jump performance and other volleyball performance-related parameters in adolescent male athletes and should be considered to complement regular volleyball in-season training.

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INTRODUCTION

It is important for all youth athletes to refine and develop physical capacities due to the athletic and health-related benefits that are associated with this process [1–3]. In a recent umbrella review on youth resistance training (RT), Lesinski et al., [4] summarised findings from multiple systematic reviews and meta-analyses which indicated that different types of RT (e.g., plyometrics, machine-based RT) have the potential to improve health- (e.g. improved body composition, psychological well-being) and performance-related parameters (e.g. gains in muscle strength and muscle power) in youth. On this basis, the evidence for the use of such methods can now be considered irrefutable.

Some of these RT modalities, try to improve ergonomics, to simplify design, and to make these training techniques more accessible to potential users of different ages and in different settings [5–7]. Further to the above, there is considerable interest in simple-to-implement, yet effective, RT methods that are inexpensive and which may be similarly executed than traditional weight machines or free weights. From this point of view, the elastic band training (EBT) serves as a safe and effective progressive overload method that requires no special infrastructure and can be used even at home to activate all muscle groups, being also a time-saving method of improving muscle strength and functional capacity across the lifespan [8].

Different studies have employed elastic bands in their intervention programs and have shown positive improvements in muscular strength, muscular power, body composition, balance, and functional mobility in adults and older adults [5, 6, 9–17]. However, there are fewer studies on the effects of elastic band training programs in under-age populations [3, 18–20], with none of them checking the efficacy of this training tool in early adaptations in the physical performance of pubertal volleyball players. In addition, there have been no previous investigations examining the effects of EBT in parameters of neuromuscular performance, such as reactive and dynamic strength, vertical jumping, and postural sway, in this population group.

Therefore, the present investigation aimed to evaluate the changes in some performance-related parameters of pubertal volleyball players when a part of their normal in-season training regimen was replaced by EBT. We hypothesised that such an approach would enhance the muscular strength and power of the lower limbs, and postural sway parameters in pubertal volleyball players.

MATERIALS AND METHODS

Experimental design

This study was designed to assess the effects of an eight-week, in-season, EBT programme on muscle strength, power, and postural sway in male pubertal volleyball players. 27 elite players were randomly assigned to either an EBT group ($n = 14$) or a control group (CG, $n = 13$) which maintained its standard in-season training regimen and did not follow any intervention during this period. The EBT was performed twice weekly, along with regular volleyball training. The test protocol included assessments of maximal dynamic one repetition maximum (1RM) and reactive strength index (RSI), muscle power (countermovement jump [CMJ] and standing long jump [SLJ]), and postural sway parameters relative to the centre of pressure (CoP; surface area [CoP SA], lateral and anteroposterior displacement [CoP X and CoP Y], and velocity [CoP V]).

Subjects

Twenty-seven male, pubertal volleyball players, from a first division Tunisian volleyball club (AS Marsa Volleyball Club, Tunisia), participated in this study. Descriptive data for these players are presented in Table 1. All participants were from similar socio-economic backgrounds and had the same daily school training schedules. None were involved in any after-school activities or any formalised strength and conditioning programmes. No participants withdrew from the intervention due to injury; however, two players were excluded from the study because they did not complete the post-intervention testing protocol. To estimate the maturity status of participants, a non-invasive and practically approved method to predict years from peak-height-velocity (PHV) using anthropometric variables was calculated according to previous research [21–23]. Subjects were randomly assigned to EBT and CG groups.

Intervention

The eight-week EBT program included sessions devoted to moderate strength training (squats, jump squats, forward lunges, lateral lunges, and standing frontal stabilisation). The subjects were familiarised with these exercises during the first 2 sessions after the baseline testing sessions. The training station has several anchorages where the elastic handles for the elastic tubing can be attached to the bodyweight, which allowed the subject to perform all of the prescribed exercises. The elastic band (looped CLX elastic bands; TheraBand®, Hygenic Corporation, Akron, OH, USA) system involved the use of three latex bands of differing elasticity: black (heavy), silver (hard), and gold (very hard). The way to change the exercise intensity with elastic bands or tubing has been described previously [5, 6]. Training sessions for the EBT group were preceded by a 15-minute warm-up and lasted for 30 minutes (a total of 45 minutes). The 8 weeks program periodization is shown in Table 2

TABLE 1. Characteristics of the study participants.

Characteristic	EBTG		CG		<i>p-value</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age (years)	14.86	0.52	14.74	0.36	0.29
Height (cm)	182.14	7.19	179.08	3.12	0.52
BM (kg)	70.93	12.46	68.15	6.14	0.43
BF%	14.29	4.03	14.39	1.87	0.74
PHV	1.55	0.67	1.32	0.45	0.28
APHV	13.30	0.40	13.40	0.30	0.96

Notes: Values are presented as mean (*M*) and standard deviations (*SD*), and level of significance (*p-value*) of the comparison between groups. BM: body mass; BF%: body fat percentage, PHV: peak height velocity, APHV: predicted age at PHV, EBTG: elastic band training group, CG: control group. Previous research on the calculations of PHV and APHV can be consulted [21–23].

TABLE 2. Details of elastic band resistance training performed by the experimental group over the 8-week intervention.

Exercises	^a Week 1	^a Week 2	^a Week 3	^a Week 4	^b Week 5	^b Week 6	^c Week 7	^b Week 8
Squat	2 × 10	2 × 12	3 × 10	3 × 12	4 × 10	4 × 12	4 × 15	4 × 15
FL	2 × 10	2 × 12	3 × 10	3 × 12	4 × 10	4 × 12	4 × 15	4 × 15
LL	2 × 10	2 × 12	3 × 10	3 × 12	4 × 10	4 × 12	4 × 15	4 × 15
SFL	2 × 10	2 × 12	3 × 10	3 × 12	4 × 10	4 × 12	4 × 15	4 × 15

Notes: Displayed values are sets and repetitions. ^a: weeks 1–4 black band (Heavy), with a 60-second rest period between sets; ^b: weeks 5–6 silver band (Hard), with a 90-second rest period between sets; and ^c: weeks 7–8 gold band (Very hard), with a 90-second rest period between sets. FL: forward lunge; LL: lateral lunge; SFL: standing frontal stabilisation. Rating of perceived exertion (RPE) at the beginning of each set performed was of about 4, and it was always immediately stopped the set if RPE exceeded the value of 6. Each one of the repetitions, of each concentric phase of each set, was always performed at a volitional maximum speed.

Data collection procedure

All procedures were performed during the final period of the competitive volleyball season (April and May 2019). One-week before the commencement of the study, all athletes participated in three orientation sessions to familiarise themselves with the general environment, equipment, and experimental procedures, intending to minimise any learning effects during the intervention. Initial and final test measurements were made at the same time of day (17:00–19:00), under approximately the same environmental conditions (16–19°C), at least three days after the most recent competition, and five to nine days after the final EBT session. Each player's height and body mass were collected using a wall-mounted stadiometer (Holtain Limited, Crosswell, Wales, UK) and electronic scale (Scale Electronics Development, New York, USA), respectively. The sum of skinfolds was monitored with a Harpenden skinfold callipers (Baty International, West Sussex, United Kingdom). Body measurements were conducted according to the procedure of Deurenberg et al. [24] who reported similar prediction errors between adults and young adolescents. Subjects maintained their normal intake of food and fluids, but they abstained from physical exercise for one day, drank no caffeine-containing beverages for four hours, and ate no food for two hours before testing. The tests were conducted after a general warm-up that consisted of running, calisthenics, and stretching. Verbal encouragement ensured maximal effort throughout all tests.

Dynamic strength

Lower-body dynamic strength was assessed with a 1RM squat as reported by Keiner et al. [25]. Before attempting the 1RM, subjects performed three sub-maximal sets of 1–6 repetitions with a light-to-moderate load. Subjects then performed a series of single repetitions with increasingly heavier loads. The increments in weight were dependent on the effort required for the lift and became progressively smaller as the subject approached their 1RM. Failure was defined as a lift falling short of the full range of motion on at least two attempts, spaced at least two minutes apart. The 1RM was typically determined within 6 to 8 trials. Throughout all testing procedures,

an instructor-to-subject ratio of 1:1 was maintained and uniform verbal encouragement was offered to all subjects. Test-retest reliability is high for the back squat in youth athletes with a reported ICC value of 0.99 [25].

Vertical jump tests

Two vertical jump types were used in this study: countermovement jump (CMJ) and maximal hopping protocol to measure the RSI. These tests have been shown to be reliable and valid measures in paediatric populations [26, 27]. For each test, participants were instructed to place their hands on their hips to minimise lateral and horizontal displacement during the performance and to prevent any influence of arm movements on the vertical jumps. Participants had to leave the ground with the knees and ankles extended, landing in the same position and location from which they initiated the movement and were encouraged to minimise horizontal displacement. All vertical jump tests were performed using an Ergojump® system (Ergojump Apparatus, Globus Italia, Codogne, Italy), which recorded jump height, contact, and flight times.

The CMJ involved the participants lowering themselves as quickly as possible from an upright standing position to a self-selected depth, followed immediately by a vertical jump. Three trials were performed with a two-minute recovery and the best result was used for analysis.

The maximal hopping protocol (used to measure the RSI) was performed in the same manner as previously described in the expert literature [26, 27]. Participants performed five repeated bilateral maximal vertical hops in place on the contact mat. Participants were instructed to maximise jump height and minimise ground contact time [27]. The first jump in each trial was excluded from the analysis. Jump height and ground contact time were averaged across the four remaining hops and used to calculate the reactive strength index as follows: $RSI = \text{Jump height (m)} / \text{ground contact time (s)}$.

Horizontal jump test

The standing long jump test (SLJ) was used to assess maximal jump distance according to the described protocol of Ramirez-Campillo

et al. [28]. The test was performed using a five-metre fibreglass metric tape, affixed to a wooden floor. Participants were instructed to use their arms to aid in the jump, using a bilateral legged stance. They then performed a fast-downward movement, to a knee angle of approximately 120°, followed by a maximal effort jump. The test was performed three times and a one-minute rest was given between efforts, the best of which was recorded for analysis. The intra-class correlation coefficient of this test has been stated by previous research [21] at 0.91, with a 95% confidence interval of 0.83–0.96, and with a SEM of 1.78, indicating good reliability.

Balance

Balance performance was evaluated using a force platform (PostureWin®, Techno Concept®, Cereste, France; 40 Hz frequency, 12-bits A/D conversion) which records the displacements of the

centre of pressure (CoP in mm/s) with three strain gauges. The force platform was embedded in the floor and levelled with the surrounding surface. The participants were asked to stand as still as possible on the platform with their arms comfortably placed downward on either side of the body, their bare feet separated at an angle of 30° and their heels positioned 5cm apart. To maintain the same foot positions for all the measurements, a plastic device, provided with the platform, was used. The participants were first requested to maintain balance with the eyes open (EO) on the stabilometric platform. They were instructed to look straight ahead at a white cross placed on the wall, two metres away, at eye level. Each trial lasted an average of 51.2 seconds. CoP excursions were computed from the ground reaction forces and their associated torques in the standing stance. As participants oscillated during upright standing postures, with their body relatively rigid, the reaction force applied to the body

TABLE 3. Between and within groups differences in experimental and control groups before and after the 8-week intervention.

Variable	Group	Pre		Post		$\Delta\%$	ANOVA (group x time)	Bonferroni post-hoc (time) p-value (ES: <i>d</i>)
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Muscle strength								
1RM (kg)	EBTG	99.14	21.60	124.36*	26.86	25.44	F(1, 25) = 118.95, <i>p</i> < 0.001, $\eta^2 = 0.83$	< 0.001 (2.74) 0.02 (0.50)
	CG	92.69	11.31	97.15	12.42	4.81		
RSI	EBTG	1.35	0.15	1.57	0.16	16.30	F(1, 25) = 2.40, <i>p</i> = 0.13, $\eta^2 = 0.09$	0.03 (1.91) 0.95 (0.02)
	CG	1.37	0.26	1.39	0.42	1.46		
Muscle power								
CMJ (cm)	EBTG	33.36	3.70	36.83*	4.00	10.40	F(1, 25) = 3.97, <i>p</i> < 0.05, $\eta^2 = 0.14$	< 0.001 (1.34) 0.25 (0.34)
	CG	32.89	5.97	31.62	4.84	-3.86		
SLJ (cm)	EBTG	201.29	24.93	220.00*	26.02	9.30	F(1, 25) = 24.25, <i>p</i> < 0.001, $\eta^2 = 0.49$	< 0.001 (1.65) 0.79 (0.07)
	CG	190.00	7.25	190.54	5.53	0.28		
Balance								
CoP SA (mm²)	EBTG	465.18	265.21	483.24	310.11	2.88	F(1, 25) = 0.05, <i>p</i> = 0.82, $\eta^2 = 0.002$	0.99 (0.003) 0.24 (0.35)
	CG	380.29	163.22	389.38	166.98	2.39		
CoP X (mm)	EBTG	533.97	211.61	498.47	212.94	-6.65	F(1, 25) = 2.18, <i>p</i> = 0.14, $\eta^2 = 0.08$	0.19 (0.37) 0.17 (0.41)
	CG	477.46	61.33	481.68	58.80	0.88		
CoP Y (mm)	EBTG	637.21	234.58	526.31	200.38	-17.40	F(1, 25) = 13.26, <i>p</i> < 0.001 $\eta^2 = 0.35$	< 0.001 (0.97) 0.15 (0.42)
	CG	510.64	100.81	516.06	106.88	1.06		
CoP V (mm/s)	EBTG	17.84	6.02	16.48	5.53	-7.62	F(1, 25) = 2.31, <i>p</i> = 0.14, $\eta^2 = 0.09$	0.09 (0.49) 0.58 (0.16)
	CG	15.73	2.25	16.59	3.73	5.47		

*: Statistically significant difference between experimental and control group in post-intervention values. Numbers in bold type highlight statistically significant differences ($p < 0.05$). Values are presented as mean (*M*), standard deviation (*SD*), and percentage of variation from baseline to follow up ($\Delta\%$); *F* values, level of significance (*p*-value), and effect sizes (ES; eta partial squared (η^2); Cohen's *d* (*d*)) in brackets of the between and within groups comparison are also displayed. EBTG: elastic band training group; CG: control group; 1RM: one repetition maximum; reactive strength index (RSI) was calculated as a ratio of the jump height (m) divided by the contact time with the ground (s); CMJ: countermovement jump; SLJ: standing long jump; CoP SA: centre of pressure sway area (representing the ellipse area covered by the trajectory of the CoP); CoP X: centre of pressure displacement in the mediolateral plane; CoP Y: centre of pressure displacement in the anteroposterior plane; V: velocity of the displacement of the CoP. For all the balance parameters (CoP), the lower the value the better the result.

was relatively constant and so the variations of the associated torque depended mainly on CoP excursions [29]. In addition, the centre of pressure velocity (CoP V) indicated the total distances covered by the CoP divided by the duration of the sampled period and sway area (CoP SA), representing the ellipse area covered by the trajectory of the CoP [30]. In this study, the CoP SA, CoP X, and CoP Y were selected as postural balance parameters. For these parameters, the lower the value, the better the postural control [31]. The test was performed three times and a one-minute rest was given between efforts, the best of which was recorded for analysis. High interrater (ICC = 0.87–0.99) and test-retest (ICC = 0.59–0.99) reliability for the standing-legged stance has been reported in children [32].

Ethics

Legal guardians and participants provided informed consent and assent after a thorough explanation of the objectives and scope of the research project, including the procedures, risks, stress, and benefits of the study. This study was conducted in accordance with the latest version of the Declaration of Helsinki and it is in line with the standards for ethics in sport and exercise science research. All players received written and verbal information on the aim of the study and the potential risks and benefits. Written informed consent (parents/legal representatives) and assent (participants) were obtained before the start of the study". No player had a history of any musculoskeletal, neurological, or orthopaedic disorder that might impair their ability to execute the prescribed training.

Statistical Analysis

Statistical analysis was carried out using commercial software IBM SPSS Statistics for Macintosh (Version 25.0; IBM Corp., Armonk, NY). Data normality was determined with the Shapiro Wilk test. Prior to analysis, data were log-transformed due to non-uniformity. Descriptive variables from both groups were compared using an unpaired t-test. A repeated-measurements two-way ANOVA was used to determine the effects of the group (Control and EBT) and time (baseline and post-intervention) as the between-and within-subject factors in the dependent variables. All cases complied with Mauchly's sphericity assumptions. Effect size (ES) was evaluated with eta partial squared (η^2), where $0.01 < \eta^2 < 0.06$ constitutes a small effect, $0.06 \leq \eta^2 \leq 0.14$ constitutes a medium effect, and $\eta^2 > 0.14$ constitutes a large effect. When statistically significant ($p < 0.05$) effects were detected, post-hoc multiple comparison analyses with Bonferroni adjustment were conducted to determine within-group changes from baseline to follow up. Cohen's *d* effect sizes (ES) were calculated and interpreted as 'trivial' (< 0.2) 'small' ($> 0.2-0.6$), 'moderate' ($> 0.6-1.2$), 'large' ($> 1.2-2$), or 'very large' (> 2) [34, 35].

RESULTS

There were no significant differences ($p > 0.05$) between the EBT and control groups in any of the variables, at baseline (see Table 1 and 3). Significant improvements in some of the tests were observed

in the experimental group compared to the controls. The outcomes of the tests obtained by both groups (both pre-and post-intervention) and further comparisons are displayed in Table 3.

DISCUSSION

To our knowledge, this study is the first that investigate the effects of a training program based on the use of elastic bands in certain parameters of strength, power, and balance in adolescent volleyball players. This research is the first of its kind that uses functional and postural sway tests for balance measurements. Also, the population used in our study differs from previously studied populations as mentioned in the introduction. The young volleyball players in our study represent a step forward when trying to confirm the efficacy of the elastic band training, supporting the idea that it may be easier to produce adaptations in youth [5]. EBT can be performed as explosive, multi-joint movements against resistance, exemplifying many athletic actions, and accentuating the task or action specificity of sport in children [18] and youth [3, 5, 19, 20] athletes.

We aimed to assess the effectiveness of an eight-week EBT intervention in improving dynamic (1RM) and reactive strength (RSI), jumping (CMJ and SLJ), and balance performance in adolescent male volleyball players. Our results (see Table 3) revealed significant improvements from pre- to post-intervention in the experimental group for 1RM, RSI, CMJ, SLJ, and CoPY. In the control group only 1RM improved from pre- to post-intervention. Significant differences between groups were observed in CMJ, SLJ, and 1RM, with no significant post-intervention differences between groups for RSI and CoPY. For balance performance, there were significant group x time interactions for the anterior displacement of the CoP (CoP Y) after EBT intervention. These results imply that while relative strength and anteroposterior displacement improved from baseline values due to the effect of the intervention, follow up results were not statistically different between groups. All those aforementioned results are going to be discussed and compared with the expert literature in the lines below.

In this study, anteroposterior displacement of the CoP was improved from pre- to post-intervention with EBT, being the change non-significant ($p > 0.05$) in the control group. It seems that EBT can provide the required training stimuli to enhance balance capability. The coordinated control and stability to efficiently move a resistance using EB through an extended range of motion may necessitate strong balance capabilities. In brief, while high-intensity dynamic action (moving back and forward before throwing the ball) is very prevalent in volleyball training [36], EBT can be observed as a technical method to enhance specific displacement (in the sagittal plane) that lead to enhancing balance performance. In the current study, EBT was performed under less stable conditions with high-speed dynamic contractions performed within a more limited base of support or with the centre of gravity being moved outside the base of support, which would be affected to a much greater extent by balance and strength/power output [26, 37]. Furthermore, better balance

improvement likely occurred due to the muscle adaptation towards the strengthening exercises with neural or structural adaptation both possible [18]. Given that balance and coordination are not fully developed in children [38], the implementation of 8-weeks of EBT into a youth resistance training programme seems an efficient method to improve balance performance in youth volleyball players.

Further to the above, the current study showed significant interactions relating to vertical and horizontal jump performance (see Table 3). These results are in contrast with those presented by Aloui *et al.* [5] who showed no significant improvements in vertical jump after 8-weeks of EBT in elite youth (aged 18.7 ± 0.8 years) handball players. Competitive performance in volleyball depends on the ability to exert force at speed in actions such as jumping and throwing [36, 39]. It may be that jumping ability is not well developed in the age group of adolescent volleyball players who could improve much more jumping performance after EBT. These values are in our study, due to the selected sample (circa-PHV adolescent athletes) and also because the implemented program was aimed to improve plantar and dorsiflexion strength. Within the present study, strengthening exercise using EB consisted of simultaneous multi-joint flexion/extension of the lower limb. Another possible explanation for the present results is related to the variations in individual responses to training, which could potentially be explained by differences in the timing, tempo, and magnitude of maturation [40]. Meylan *et al.* [41] showed that adolescent athletes who are around PHV are less responders than the post-PHV group in jump performance (small improvement: 6.5–7.4%). Maturity-dependent responses are indicative of “synergistic adaptation”, which refers to the symbiotic relationship between specific adaptations of an imposed training demand and concomitant growth and maturity related adaptations [42]. Overall, the present study demonstrates that the varied stimulus of the EBT increased the jumping performance, highlighting the strength/power related improvements. On this, adaptations in lower body power probably occur because of improved stored elastic energy utilization resulting in a higher jump and increased flight time (and thus reduced ground time) [36, 43]. Overall, the importance of challenging stimulus to an elastic band training is emphasized by improving jumping in youth volleyball players.

In addition to the above points, several researchers [5, 36, 44, 45] have demonstrated a performance spurt in dynamic strength with no improvement in RSI around 0.5 to 1.0 years after PHV. We partially agree with these findings as both variables (1RM and RSI) improved in our study, without differences between groups in the follow up RSI values. For young athletes and as mentioned above, improvements in muscle power performance may be attributed to the rise of hormone levels (testosterone and growth hormones) associated with puberty around PHV. Radnor *et al.* [42] demonstrated that combined training and traditional strength training resulted in more positive responders in tasks that required higher levels of reactive strength and maximal running velocity in post PHV boys. These

researchers showed that individual responsiveness to stimuli is training mode dependent with adaptations being specific to the type of training stimulus that is applied [44]. Accordingly, in the present study, the BET exercises required prolonged contractions, and such a prescription seems best suited to maximizing strength [5, 19].

Limitations and future directions

The current study is not without limitations and is considered primarily applicable to a particular age category of male volleyball players at a specific level of competition, and there is a need to extend observations to cover female players, other age groups, and other skill levels. It is possible that with larger sample size and a long-term program, some other significant differences between the baseline and the post-intervention tests could have been detected. Furthermore, future studies should compare the effectiveness of different combinations of strength training programmes (e.g. EBT and isotonic) in improving other parameters such as body composition or explosive force in youth according to maturity status.

Practical implications

An 8-week elastic band training programme focused on the lower limb (squats, jump squats, forward lunges, lateral lunges, and standing frontal stabilisation) is an appropriate method to implement altogether with in-season training in pubertal volleyball players looking forward to improving their jump performance, squat 1RM, and anteroposterior balance. EBT is a cheap, simple-to-implement method of resistance training that could be done even at home to improve volleyball performance-related physical capacities.

CONCLUSIONS

This investigation supports the idea that EB provide enough stimuli to improve power (CMJ and SLJ) and dynamic strength (1RM), and anteroposterior balance in adolescent male volleyball players. These aforementioned parameters are related to the performance in volleyball and thus, we can state that EBT improves young volleyball athletes' performance. Reactive strength (RSI) and other parameters related to the balance (horizontal CoP displacement, displacement velocity, sway area) did not change with EBT. The evidence presented in this study may potentially help the strength and conditioning professionals in the programming of in-season training for pubertal volleyball athletes to improve their performance.

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Conflict of interest declaration

The authors declare no competing interests.

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