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The Effects of Complex Training in Male High School Athletes on the Back Squat and Vertical Jump

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Abstract Lower body muscular strength and power output are fundamental requirements for individuals seeking success in competitive athletics. The optimal resistance training protocol for improving the aforementioned attributes for high school aged male athletes is a topic of ongoing research. **Purpose:** This study focused on a sample of high school male athletes and examined the effects of two resistance training protocols that differed only in that one experimental group used a complex training protocol. **Methods:** High school male athletes (n=38; 15-18 years) were separated into two groups (RTG-resistance training group and CTG-complex training group) via a randomized matched pair design based on initial 1-RM back squat (BS) ability. Both experimental groups employed linear periodization models with respect to the BS over a 6-week resistance training intervention period with auxiliary lower body resistance training exercises (leg extensions, hamstring curls, calf raises, etc.) and volume held equal between the study groups. Additionally, the CTG performed box jumps following the BS. Dependent variables (i.e., the 1-RM BS and the vertical jump (VJ)) were collected pre and post the study intervention period. Dependent t-tests were used to compare the BS and VJ scores from pre to post study within experimental groups. **Results:** Both the RTG and CTG improved their lower body leg strength as measured by the 1-RM BS ($p<0.01$). However, only the CTG improved from pre to post study intervention for the VJ ($p<0.01$). **Discussion:** The results of this study are consistent with previous literature in that lower body strength and power will increase when pairing both the BS and explosive, ballistic type exercises in a RT protocol known as CT. **Conclusion:** Within the parameters of this study, CT improves both muscular strength and power output in male high school athletes.

Keywords PAP, Post activation potentiation, Resistance training

1. Introduction

Resistance training (RT) is recognized to have positive adaptations in bone health, body composition, motor skill development, a reduction in sport related injuries, and potentially improved psychological well-being in youth [1-4]. Further, there appears to be evidence that sport performance may be boosted as a result of RT, albeit limited [1]. The investigators of the aforementioned research suggest that further exploration is warranted with respect to RT and youth in the areas of health related benefits, physiological mechanisms, and the ideal RT program variables for youth [1-3]. In this regard, youth is approximately defined to range from children to adolescents [3].

A base level of muscular strength is the underpinning for building muscular power, which is of particular significance for young individuals with aspirations to participate in a meaningful fashion in recreation or competitive sports. Exercise modalities such as the squat have been used to increase strength (and hence power) in the trunk and lower body known as the power zone [5]. In young individuals, modality selection is of particular importance and exercise selection is advised to progress from basic to more challenging movement patterns [3].

Complex training (CT) is a resistance training routine that is considered as an approach for improving lower body power output [6]. CT involves the combination of performing a resistance exercise (e.g., back squat) followed soon thereafter by a biomechanically similar explosive movement (e.g., a ballistic countermovement jump). The combination of movements is referred to as a complex pair [7]. Both of the aforementioned movement patterns could be considered basic and fit well within Faigenbaum's et al. [3] advice regarding exercise selection for youth.

CT is based on the concept of postactivation potentiation (PAP). PAP is an acute heightened level of muscle function subsequent to an intense muscle activity [8]. The suggested mechanisms leading to the PAP occurrence have been

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elucidated elsewhere [9]. It is postulated that the potentiated state of neuromuscular activity may acutely increase performance capabilities of the muscle, which repeated over time in a training program may produce superior chronic adaptations compared with other training approaches [10]. CT attempts to exploit the effects of PAP where by an explosive movement is performed soon after a heavy loading conditioning activity (i.e. back squat) while the neuromuscular system is in an “excited” state [7, 10].

The National Strength and Conditioning Association (NSCA) suggest that PAP as a RT modality be “reserved for resistance-trained power athletes with high relative strength” [9] as it does not manifest as an observable phenomena in recreationally trained individuals [9]. However, we are aware of three previous studies where training status and/or relative strength was well below the NSCA’s recommendations and positive results were evidenced as a result of implementing a PAP warm up protocol [11-13].

Given the need to determine the ideal RT program variables for youth [1-3] as well as to provide further insight into the benefits of CT that relies upon the PAP phenomena, we decided to conduct a CT study with a sample of high school aged male athletes. The complex pair of movements used in the current study were the back squat (BS) and the box jump (BJ). It was hypothesized that vertical jump (VJ) height and 1-RM back squat strength would increase to a greater level in a RT protocol utilizing CT (CTG) than an identical RT (RTG) protocol without CT.

2. Methods

2.1. Participants

Thirty-eight high school aged (15-18 years old) male athletes that play different sports (i.e. participated in organized high school football, wrestling, basketball, soccer, and track) from Murray High School in Murray, Utah volunteered for the study. Permission to conduct this study was obtained through the University Institutional Review Board, and each participant and their parent or legal guardian gave written consent prior to engaging in the study. Criteria for study inclusion was that the participants be injury and disability free such that they would not be prevented from full participation in the study training and testing protocols.

2.2. Instruments and Apparatus

Study training and testing sessions were conducted in the Weight Room at Murray High School in Murray Utah. Equipment required to collect the 1-RM BSs in this study included a 20.45 kg barbell and weighted plates (ranging from 1.14-20.45 kgs) as well as squat racks housed in the Weight Room. VJ measures were collected with a Vertec (Sports Imports, Columbus, Ohio) on a basketball court in the Auxiliary gym located in near proximity to the Weight Room. The Weight Room also housed the ancillary RT equipment that was used during the course of the study.

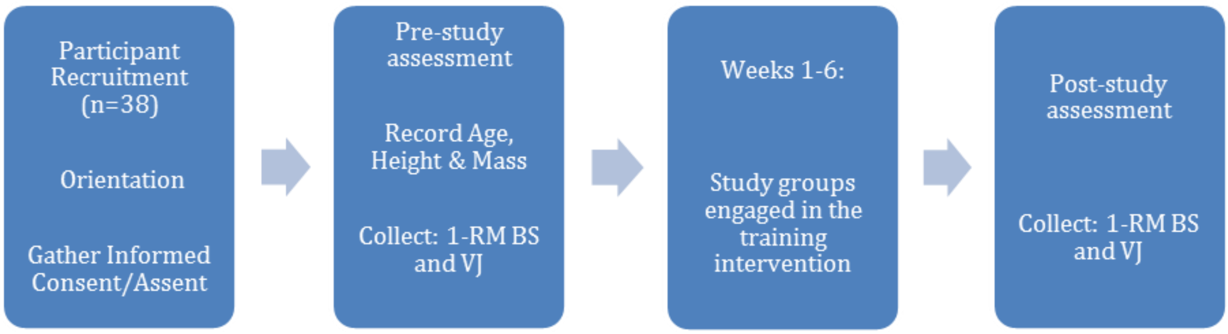

Figure 1. Study time line (BS-back squat; 1-RM-one repetition maximum; VJ-vertical jump)

Figure 2. Weight Room at Murray High School in Murray Utah

Table 1. Experimental Group Training Protocols for First Training Session of the Week

	Back Squat				Box Jumps			
	Week	Sets	Repetitions	% 1-RM	Rest	Sets	Repetitions	Box Height
RTG	1	2	10	60-70				
	2	3	10	60-70				
	3	4	5	70-80				
	4	4	5	80-90				
*	5	4	10-4	60-90				
**	6	4	8-3	70-95				
CTG	1	2	10	60-70	3 minutes	2	15	51.4 cms
	2	3	10	60-70	3 minutes	3	10	51.4 cms
	3	4	5	70-80	3 minutes	3	15	51.4 cms
	4	4	5	80-90	3 minutes	4	10	51.4 cms
*	5	4	10-4	60-90	3 minutes	4	10	51.4 cms
**	6	4	8-3	70-95	3 minutes	5	8	51.4 cms

*Week 5: 4 progressive sets (repetitions x % 1-RM) set 1: 10x60, set 2: 8x70, set 3: 6x80, set 4: 4x85-90.
**Week 6: 4 progressive sets (repetitions x % 1-RM) set 1: 8x70, set 2: 6x80, set 3: 4x85, set 4: 3x90-95.

2.3. Procedures

Prior to the RT intervention, the participant's height, mass, and age were recorded. Participants then had their 1-RM BS assessed and recorded in the manner prescribed by Baechle [14]. Participants also had their VJ assessed, with three countermovement VJ attempts separated by 2-3 minutes allowed. The highest VJ was recorded as their maximal score. (Study timeline is illustrated in Figure 1 and Murray high school Weight Room is pictured in Figure 2).

Following the collection of the 1-RM BS scores, experimental groups were randomly formed based on rankings of the 1-RM BS scores. Specifically, the participants with the two highest ranking in 1-RM BS scores were randomly assigned to the two experimental groups. Next, the participants with the next two highest ranking in 1-RM BS scores were randomly assigned to the two experimental groups. This process continued until the experimental groups were fully formed, with 19 participants in each group. This group assignment procedure assured that the experimental groups were essentially equal with respect to initial 1-RM BS scores.

The two experimental groups formed were the CTG and the RTG. Both groups performed the identical resistance training protocol (2 days/week, Tuesday and Friday) with the exception being that the CTG group used complex training where the BS was paired with subsequent sets of box jumps. The primary movements scheduled (periodized) for the experimental groups are detailed in Table 1 for the first exercise session of the week. On the second training day of the week, both groups performed the same workout that was scheduled on day 1 of week one. The participants were required to perform the BS to a depth in which the top of the quadriceps were parallel with the floor. Box jumps were performed with countermovement, with both feet pushing off the ground at the same time and both feet landing on the top surface of a plyometric box (height of ≈51.4 cms) at the same time. All of the sets of the BS were completed prior to executing the box jumps. The BS and box jumps were separated by 3 minutes rest. Each work set of BS and box jumps were separated by 2-3 minutes rest. Auxiliary lower body exercise not listed in table 1 included: leg extensions, prone position hamstring curls, and calf extensions all performed at 3 sets of 10-12 repetitions ≈ @ 75% of 1-RM.

All training and testing sessions included a dynamic warm-up using the basketball court in the Auxiliary gym. The warm-up consisted of the participants going to half court (12.8 meters or 42 feet) performing the following movements: lunges forward, lunges going backwards, high knees, butt kickers, skip extensions, Frankenstein's, step twist and turn, karaoke, rolling shoulders out, leaning starts.

Following the 6-week study period the dependent variables were retested using identical procedures as in the pre-test. The principal investigator monitored and tracked all training sessions and conducted the testing sessions.

2.4. Reliability

The dependent variables were collected as prescribed by Baechle [14]. The VJ has been reported to have a reliability coefficient of ICC=0.95 [15]. The NSCA recognizes 1-RM measures as a reliable assessment of muscular strength [14]. Reported reliability coefficients of $r \geq 0.90$ and $ICC \geq 0.90$ suggest that 1-RMs and 3-RMs are highly reliable measures of muscle strength [16, 17].

2.5. Design and Analysis

VJ height and 1-RM BS scores were compared pre- and post-intervention RT with a paired t-test. A common gain score was also calculated for the dependent variables (post-pre) of VJ and 1-RM BS. Gain scores were compared between experimental groups (CTG and RTG) for each dependent variable with an independent t-test. Statistical significance was set at $\alpha \leq 0.05$. P-values approaching the critical value of $\alpha = 0.05$ are reported as there may be practical program design implications. Statistical calculations and data management were conducted with Microsoft Excel 2013.

3. Results

Thirty-eight high school aged male (15-18 years) athletes participated in this study. Each experimental group had 19 participants. One participant from the CTG was not able participate in the 1-RM BS post-study assessment due to an illness and hence the statistical analysis for the CTG 1-RM BS was based on 18 participants. No participant missed two or more training sessions (the threshold for dismissal from the study).

Table 2 presents the mean and standard deviation results for participant descriptive information. Table 3 shows the mean and standard deviation results for the participant's VJ and 1-RM BS scores.

Both groups were assessed on VJ height and 1-RM BS pre and post the 6 week training intervention. Both the CTG and RTG significantly improved 1-RM BS strength as a result of training ($p<0.01$).

The 1-RM BS gain scores for each group were near significantly different ($p=0.071$) where the mean of the 1-RM BS gain scores for the CTG and RTG were 19.6±12.1 and 13.6±11.9 kgs respectively.

Table 2. Participant Descriptive Information

	Age (years)	Height (cms)	Body Mass (kgs)
CTG	15.9±0.7	186.4 ±8.6	73.1 ±9.3
RTG	15.7±0.7	183.6 ±5.8	74.2 ±11.0

[1]Participant means and standard deviations for descriptive information.

Regarding VJ, the CTG improved significantly from pre to post training ($p<0.01$), while the RTG failed to do so ($p>0.05$). The VJ gain for the CTG and RTG were 3.6±4.2 and 1.9±6.1 cms respectively.

4. Discussion

The purpose of this study was to determine the effects of a RT protocol that employed CT in a sample of high school aged male athletes. In order to do so, two experimental groups were formed where one group (RTG) engaged in a linear periodized RT protocol for a period of six weeks. The second group (CTG) performed the identical linear periodized RT protocol as the RTG with the exception that the CTG employed CT (pairing the BS with subsequent sets of box jumps). It was hypothesized that both groups would improve 1-RM BS ability but that the CTG would experience a greater improvement. Likewise, it was hypothesized that both groups would improve VJ ability but that the CTG would improve to a greater extent.

The results of the study were mixed with regards to the research hypothesis. Both the RTG and CTG significantly improved 1-RM BS ability following the study intervention. However, the CTG did not experience a significantly greater increase in 1-RM BS ability than the RTG, albeit it was very close to significant ($p=0.071$). The CTG significantly improved VJ ability following the study intervention ($p<0.01$) while the RTG failed to do so ($p>0.05$).

The initial mean VJ scores for both experimental groups ranged from 51.8-56.9 cms which are comparable to 40$^{th\%ile}$ VJ scores for 10th grade male North American football players [18]. The initial mean 1-RM BS scores for both experimental groups was 107.3 kgs which is comparable to 20$^{th\%ile}$ 1-RM BS scores for 14-15 year old male North American football players [18]. The 1-RM BS/body mass ratios for the CTG and RTG were 1.47 and 1.45 respectively.

The effect size (ES) for the 1-RM BS strength gains for the CTG was 0.60 and for the RTG it was 0.39. The ES in 1-RM BS strength gains for the CTG and the RTG were reasonably consistent with three meta-analyses regarding strength gains as a result of RT in youths [19-21]. However, VJ only improved in the CTG and not the RTG which is consistent with and in contrast to the findings of previous research. Consistent with our findings regarding the RTG, some previous research regarding RT protocols and youth have recorded significant gains in strength without improvements in motor skill performance [22-25]. In contrast to our findings regarding the RTG, many studies have documented enhanced motor skill performance in youth as a result of RT [24, 26-30]. The mixed results of the aforementioned research efforts are likely due to the specificity of the RT protocols employed in the studies. Like adults, youth respond to the specificity of the RT program (velocity of movement, body mechanics, muscle fiber recruitment, rate of force development, etc.) [3].

The focus of this study was on the effects of a CT protocol on high school male aged athletes where we choose to pair sets of the BS with subsequent sets of box jumps. A prior study from our research team suggested that "future studies should integrate plyometric and/or power oriented exercises such as the Olympic lifts into RT protocols with the intent of facilitating the transfer of newly acquired strength to the attributes of speed and muscular power" [31]. Hence, we were optimistic that the CT protocol we employed in the current study would validate our previous assertion, which was the case.

Table 3. Participant Descriptive Information

	VJ (cms)				1-RM Back Squat (kgs)			
	Pre	Post	Gain	ES	Pre	Post	Gain	ES
CTG	56.9 ±4.8	60.4±7.1*	3.6±4.2	0.75	107.2±32.7	126.8±34.2*	19.6±12.1	0.60
RTG	51.8±10.2	53.8±10.5	1.9±6.1	0.19	107.4±34.8	121.1±33.7*	13.6±11.9	0.39

[1]Participant means and standard deviations for dependent variables. * Significant improvement pre to post RT intervention $p<0.01$.
[2]ES-Cohen's pair wise effect size (d) = (variable mean Post- variable mean Pre)/ SD Pre. [3]SD-standard deviation.

Several researcher endeavours have found evidence that CT has a positive impact on motor skill performance in youth (e.g. sprinting, VJ, throwing) [10, 32, 33]. What is unique to each of these studies including our current work is the "complex pair" [7] and loading patterns implemented in the CT program. For example, Roden et al. [10] used a pairing of the BS immediately followed by counter movement VJ, were the sequence was repeated three times within the training session. In the current study, the BS was paired with box jumps; however, all of the box jumps occurred after all BS sets were concluded. The intensity and volume of the BS sets used in the Roden et al. study also differed from the current study. Hence, the optimal program variables to employ in a CT protocol appear varied and are far from understood.

With that said, a CT protocol for youth should consider pairing with stretch-shortening cycle modalities initially with low intensity exercises (e.g. bi-lateral leg hops) and progress to more complexed and intense exercises (e.g. iso-lateral leg hops) [1, 34]. We chose the box jump for the current study as the explosive pairing movement for this reason. Jumping on to the box is a bi-lateral non-complex movement that upon landing has a very low ground reaction force compared to jumping activities that conclude by landing on a non-elevated or de-elevated surface. Hence, the individual has the training benefit of performing the lift-off phase of the jump without the negative effects of the musculoskeletal "pounding" upon impacting the ground.

There were two limitations that we were concerned with in our study. The volume of the BS sets was essentially controlled between the two experimental groups. The initial 1-RM BS scores were used for the purpose of creating two stratified and random experimental groups, noting that the initial mean 1-RM BS scores were 107.2 and 107.4 kgs for the CTG and RTG respectively. The subsequent training sets for the BS were held constant for both groups with the intensity of the BS training sets established as a percentage of the 1-RM BS, hence essentially equalizing training volume between experimental groups. Given the design of our study we cannot definitively state whether the additional volume of the box jumps and/or the pairing of the box jumps subsequent to the BS sets was responsible for the increase in VJ experienced by the CTG. The second limitation is the duration of the study. Should an attempt be made to replicate the current study, lengthening the intervention period from 6 to 8-12 weeks (or using a cross-over design) may provide further insight on the benefits of CT in this population.

The results of the current study may prove beneficial to coaches looking to implement a CT program for their high school athletes. Specifically, one option is to complete the explosive activity subsequent to the completion of the BS sets; noting, that in our opinion, all high school athletes should be performing the BS as a corner stone of any RT program. Should a coach endeavour to develop a CT program for their high school athletes they should consider reading the works by Macaluso [35] and Carter and Greenwood [36]. Macaluso explains a detailed model of a periodized CT program for high school athletes. Carter and Greenwood provide a comprehensive review of CT with recommendations regarding the implementation of a CT protocol.

5. Conclusions

This study demonstrated that the two types of linear periodized RT protocols were well tolerated and can be used to improve 1-RM BS strength in high school aged male athletes. However, if the training priority is to improve lower body power output, one should employ a CT protocol. Finally, performing box jumps subsequent to the completion of BSs is a viable CT program design for enhancing VJ ability.

REFERENCES

[1] Behm, D.G., Faigenbaum, A.D., Falk, B., & Klentrou, P. (2008). Canadian Society for Exercise Physiology position paper: resistance training in children and adolescents. *Applied Physiology Nutrition Metabolism*, 33(3), 547-561.

[2] Faigenbaum, A.D., Lloyd, R.S., & Myer, G.D. (2013). Youth resistance training: past practices, new perspectives, and future directions. *Pediatric Exercise Science*, *25*(4), 591-604.

[3] Faigenbaum, A.D., Kraemer, W.J., Blimkie, C.R., Jeffreys, I., Micheli, L.J., Nitka, M., & Rowland, T.W. (2009). Youth resistance training: updated position statement paper from the national strength and conditioning association. *Journal of Strength and Conditioning Research*, 23S, 60-79.

[4] Lloyd, R.S., Faigenbaum, A.D., Stone, M.H., Oliver, J.L., Jeffreys, I., Moody, J.A., Brewer C. et al. (2013). Position statement on youth resistance training: the 2014 International Consensus. *British Journal Sports Medicine*, bjsports-2013.

[5] O'Shea, P. (2000). *Quantum Strength Fitness II (Gaining the winning edge). Applied strength training & conditioning for winning performance*, Patrick's Books, Corvallis, OR, USA.

[6] Docherty, D., Robbins, D., & Hodgson, M. (2004). Complex training revisited: A review of its current status as a viable training approach. *Strength and Conditioning Journal*, 26, 52-57.

[7] Chu, D. (1996). *Explosive Power and Strength: Complex Training for Maximal Results*. Human Kinetics. Champaign, IL, USA.

[8] Hodgson, M., Docherty, D., & Robbins, D. (2005). Post-activation potentiation. *Sports Medicine*, 35(7), 585-595.

[9] NSCA (2016). NSCA Hot Topic: Post-Activation Potentiation (PAP). https://www.nsca.com/Education/Articles/Hot-Topic-Post-Activation-Potentiation-%28PAP%29/.

[10] Roden, D., Lambson, R., & DeBeliso, M. (2014). The effects of a complex training protocol on vertical jump performance in male high school basketball players. *Journal of Sports Science*, *2*, 21-26.

[11] Ah Sue, R., Adams, K.J., & DeBeliso, M. (2016). Optimal timing for post-activation potentiation in women collegiate volleyball players, *Sports*, 4(27), 1-9.

[12] Hamilton, C., Berning, J., Sevene, T., Adams, K.J., & DeBeliso, M. (2016). The effects of post activation potentiation on the hang power clean, *Journal of Physical Education Research*, 3(1), 1-9.

[13] Tano, G., Bishop, A., Berning, J., Adams, K.J., & DeBeliso, M. (2016). Post activation potentiation in North American high school football players. *Journal of Sports Science*, 4(6), 346-352.

[14] Baechle, T.R., & Earle, R.W. (2008). *Essentials of Strength Training and Conditioning*, (3. Ed.). Champaign, IL. Human Kinetics.

[15] Nuzzo, J.L., Anning, J.H., & Scharfenberg, J.M. (2011). The reliability of three devices used for measuring vertical jump height. *The Journal of Strength & Conditioning Research*, *25*(9), 2580-2590.

[16] McCurdy, K., Langford, G. A., Cline, A. L., Doscher, M., & Hoff, R. (2004). The reliability of 1-and 3RM tests of unilateral strength in trained and untrained men and women. *Journal of Sports Science and Medicine*, 3(3), 190-196.

[17] Tagesson, S. K., & Kvist, J. (2007). Intra-and interrater reliability of the establishment of one repetition maximum on squat and seated knee extension. *The Journal of Strength & Conditioning Research*, 21(3), 801-807.

[18] Hoffman, J. (2006). *Norms for fitness, performance, and health*. Human Kinetics, Champaign, IL, USA.

[19] Behringer, M., vom Heede, A., Yue, Z., & Mester, J. (2010). Effects of resistance training in children and adolescents: a meta-analysis. *Pediatrics*, Peds-2010.

[20] Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children. *Sports Medicine*, *22*(3), 176-186.

[21] Payne, V.G., Morrow Jr, J.R., Johnson, L., & Dalton, S.N. (1997). Resistance training in children and youth: a meta-analysis. *Research Quarterly for Exercise and Sport*, *68*(1), 80-88.

[22] Faigenbaum, A.D., Milliken, L., Moulton, L., & Westcott, W.L. (2005). Early muscular fitness adaptations in children in response to two different resistance training regimens. *Pediatric Exercise Science*, *17*(3), 237.

[23] Faigenbaum, A.D., Zaichkowsky, L.D., Westcott, W.L., Micheli, L.J., & Fehlandt, A.F. (1993). The effects of a twice-a-week strength training program on children. *Pediatric Exercise Science*, *5*, 339-346.

[24] Flanagan, S.P., Laubach, L.L., De Marco Jr, G.M., Alvarze, C., Borchers, S., Dressman, E., & Poeppelman, J. (2002). Effects of two different strength training modes on motor performance in children. *Research Quarterly for Exercise and Sport*, *73*(3), 340-344.

[25] Gorostiaga, E.M., Izquierdo, M., Iturralde, P., Ruesta, M., & Ibáñez, J. (1999). Effects of heavy resistance training on maximal and explosive force production, endurance and serum hormones in adolescent handball players. *European Journal of Applied Physiology and Occupational Physiology*, *80*(5), 485-493.

[26] Faigenbaum, A.D., & Mediate, P. (2006). Effects of medicine ball training on fitness performance of high-school physical education students. *Physical Educator*, *63*(3), 160.

[27] Falk, B., & Mor, G. (1996). The effects of resistance and martial arts training in 6-to 8-year-old boys. *Pediatric Exercise Science*, *8*, 48-56.

[28] Hetzler, R.K., DeRenne, C., Buxton, B.P., Ho, K.W., Chai, D.X., & Seichi, G. (1997). Effects of 12 weeks of strength training on anaerobic power in prepubescent male athletes. *The Journal of Strength & Conditioning Research*, *11*(3), 174-181.

[29] Lillegard, W.A., Brown, E.W., Wilson, D.J., Henderson, R., & Lewis, E. (1997). Efficacy of strength training in prepubescent to early postpubescent males and females: effects of gender and maturity. *Pediatric Rehabilitation*, *1*(3), 147-157.

[30] Szymanski, D.J., Szymanski, J.M., Bradford, T.J., Schade, R.L., & Pascoe, D.D. (2007). Effect of twelve weeks of medicine ball training on high school baseball players. *The Journal of Strength & Conditioning Research*, *21*(3), 894-901.

[31] Blanchard, J., Berning, J., Adams, K.J., & DeBeliso, M. (2016). Effects of the trap bar deadlift and leg press on adolescent male strength, power and speed. *Journal of Physical Education Research*, 3(2), 11-22.

[32] Ingle, L., Sleap, M., & Tolfrey, K. 2006. “The effect of a complex training and detraining programme on selected strength and power variables in early pubertal boys.” *Journal of Sports Sciences* 24 (9): 987.

[33] Santos, E.J., & Janeira, M.A. (2008). Effects of complex training on explosive strength in adolescent male basketball players. *The Journal of Strength & Conditioning Research*, *22*(3), 903-909.

[34] Faigenbaum, A.D., & Chu, D.A. (2014). Plyometric training for children and adolescents. Retrieved from: http://www.acsm.org/docs/current-comments/plyometrictraining.pdf.

[35] Macaluso, T.D. (2010). Periodization and complex training in a high school summer program. *Strength & Conditioning Journal*, *32*(6), 95-98.

[36] Carter, J., & Greenwood, M. (2014). Complex training reexamined: Review and recommendations to improve strength and power. *Strength & Conditioning Journal*, *36*(2), 11-19.