Research Article

# Effects of eight-week progressive resistance training on physical fitness and psychological health in adolescent males

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## Abstract

Physical fitness and psychosocial health might improve through resistance training programs. However, there has been controversy regarding the efficacy of different exercise programs. Therefore, this study attempted to compare the effect of 8-week resistance training with linear and undulating programming on physical fitness and mental health. Twenty-nine healthy and untrained students (age: 16.06±0.83) were randomly divided into three groups: (1) control (n= 6), (2) linear programmed resistance training (LPRT) (n= 12), and (3) undulating programmed resistance training (UPRT) (n= 11). After two weeks of familiarization, 1RM (one-maximum repetition) values were obtained. Thereafter, experimental groups attended a resistance training program of 3 sessions/week (lasted 60 min each) for 8 weeks. Both groups had a similar plan until the fourth week. Then, intensity increased up to 70% of 1RM on a weekly basis for the LPRT group, and varied on a daily basis for the UPRT group. Upper- and lower-extremities strength and endurance, balance, speed, explosive-power, lean body mass, general mental health (GSQ) and physical self-concept (PSCQ) were measured. Experimental groups produced significant improvements in physical outcomes, in comparison with the control group. There were no improvements in GSQ and PSCQ. There were no statistically significant differences between the two programs. Both linear and undulating programs improved physical fitness of previously sedentary adolescent males to a similar extent. For practical purposes, as long as loads are individually adjusted, the type of program may not be relevant in beginner practitioners. Furthermore, both models were ineffective in producing changes in the psychosocial variables.

***Key Words:*** **Linear training, Mental health, Programming, Resistance training, Undulating training**

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## Introduction

Physical fitness is an integrated measurement of the majority of body functions such as skeletal muscles, cardiovascular, blood circulation, psycho-neuronal and hormonal-metabolic activities (Ortega, Ruiz, Castillo, & Sjöström, 2008). When physical fitness is assessed, hence, the functional condition of all body systems is actually examined and that is a reason why the physical fitness is considered a relevant factor in chronic diseases (Ortega et al., 2008). Chronic diseases are usually progressed slowly and are resulted from genetic, environment or poor life-style factors (Anderson & Durstine, 2019). It should be mentioned that quality of life (QOL) is reduced in future generations (Anderson & Durstine, 2019). By incorporating physical activity or exercise in one's life-style, physical fitness as a leading health index could be improved (Anderson & Durstine, 2019; Ortega et al., 2008). Additionally, it is worth noting that childhood and adolescence are very sensitive life periods, since lifestyle and exercise behaviors established in those periods may impact adult behaviors and health status (Dumith, Gigante, Domingues, & Kohl III, 2011; Ortega et al., 2008).

In the context of exercise interventions, several studies have shown that resistance training (RT) is an effective procedure to increase muscle mass and strength, improve performance and stimulate healthy life-style in adolescent (Christou et al., 2006; Hart & Buck, 2019). Furthermore, despite discussions concerning potentially harmful effects of RT in youth (Faigenbaum et al., 2009; Pediatrics, 1983; Ryan & Salciccioli, 1976; Vrijens, 1978), it has been generally recognized that it can improve psychosocial health such as depression, anxiety, fatigue, QOL, and self-estimation (Bull et al., 2020; Kekäläinen, Kokko, Sipilä, & Walker, 2018; Putiri, Gillham, & Ryan Bradley, 2012; Sparrow, Gottlieb, DeMolles, & Fielding, 2011). Even though there are compelling documents considering the effectiveness of resistance training in adolescents, the various factors are contributed to adaptive processes following RT sessions.

Moderator variables and RT model are two involving factor (Peitz, Behringer, & Granacher, 2018). Moderator variables include training principles such as intensity, frequency, type, volume and periodization and so on (Bompa & Buzzichelli, 2019). Of those, RT programming has assumed a special importance and are usually more effective than constant (non-varied) RT program (Fleck, 2011; Harries, Lubans, & Callister, 2015; Moraes, Fleck, Dias, & Simão, 2013; Peitz et al., 2018; Rhea & Alderman, 2004), even if this trend is not universal (Grgic, Lazinica, Mikulic, & Schoenfeld, 2018; Schumann et al., 2020). Linear and undulating programming are two common methods of engaging in RT (Moraes et al., 2013; Prestes et al., 2009). Linear programming is usually associated with a program initiated with high volume and low intensity and gradually by program progression the volume decreased and to intensity increased and typically lasts several months, even if the term linear has been coined a posteriori and was not applied by original periodization models. In undulating programming, the volume and intensity can be changed in every single session (Fleck, 2011), thus providing greater diversity and avoiding load monotony.

To the best of our knowledge, there are no investigations comparing linear and undulating periodized RT, in the critical period of adolescence and evaluating both physical and psychological factors. Consequently, the current investigation aimed at examining the effect of 8-week linear and undulating periodized trainings on physical fitness and psychological factors in male adolescents.

## Materials and Methods

### Experimental design and sample

The current study was quasi-experimental with pre- and post-test design. The participants were healthy but untrained high-school students with an age range of 14 to 18 years-old and after invitation, the details were informed to them. Thereafter, 29 out of 90 participants accepted to participate in the study and the consent form was filled out by their parents. Furthermore, they were screened in sports history and health condition by a self-reported questionnaire. The inclusion criteria were: (1) being aged between 14 to 18 years, (2) not having diseases such as asthma, diabetes or, thalassemia, (3) not having any movement disabilities, (4) not having any injuries, (5) not having any RT experience at least during the last 6 months, and (6) not consuming any dietary supplementations like multi-vitamins, creatine and protein before and during training. Moreover, the exclusion criteria were: (1) no regular attending to training sessions outside the scope of this study, (2) voluntary exit from the study, (3) consumption of dietary supplements during training course, and (4) disability in continuing the training protocol due to injury.

Before assessing the participants' one-maximum repetition (1RM) in leg press and chest press, all groups experienced a familiarization program for two weeks, with three sessions per week. Their 1RM was measured and recorded in the last session of familiarization period. Pre-test rates of considered variables were measured after 48 hours from recording the 1RM. Participants were randomly divided into three groups using a lottery: (1) linear programmed RT (LRT) (n = 12), (2) undulating programmed RT (UPRT) (n = 11), and (3) control (n = 6). The experimental groups implemented an 8-week training program that was specific for each group. Upon reaching to the final of the 4th week (the middle-point of the 8-week training program), 1RM was measured for every single group once again and the remaining four-week program was set with respect to the new 1RM. In addition, all subjects maintained their usual life style in all groups and subjects in control group did not do any extra activity during current study. Collectively, the post-test rates of the considered variables were measured as equal conditions as pre-test measurement 48 hours after the last training session of 8-week training program. It is worth noting that the current study was approved by ethics committee of Razi University in accordance with the declaration of Helsinki (updated version of 2013).

### Assessments of physical fitness

Before conducting all tests, a 5-10 min period was devoted to warm-up phase. Muscle strength was obtained by performing the 1RM test in both pre- and post-tests. However, in order to obtain the 1RM from more repetitions, the 1RM indirectly identified via set the repetitions numbers and work-load which is shifted based on Brzycki Formula (Brzycki, 1993): 1RM = weight lifted/ (1.028 – no. repetitions*0.0278).

To measure the strength of lower and upper extremities, the leg press and chest press were utilized, respectively. A two-week familiarization period was used before the testing. For chest press, the participants used middle grip-width. The chest press ended with the greatest weight or the number of repetitions that participants could perform to the mid-chest and back to the starting position. In the leg press, individuals were instructed to sit on the machine with their heels flat and spaced at hip width. Both in the bench press and leg press, the execution of the greatest weight or the number of repetitions performed by each participant during the test were accounted for calculating the strength of lower and upper extremities (Coburn & Malek, 2012).

The muscular endurance of shoulder girdle, furthermore, was assayed by push-up test and the correct number of actions was counted and then recorded for the participants. Additionally, wall-squat was utilized to measuring the muscular endurance of lower extremities. In this case, the participants were asked to get close

to the wall leaning their back to it with feet shoulder width and 2 feet from the wall. Then, the participant must slide his back down the wall until reaching the proper position, i.e., at 90-degree angle to both the back and lower legs. as the time the participant could able to hold this position was recorded (Mackenzie, 2005).

Y balance test (YBT) was used to measure the dynamic balance. The leg length (right side) was measured prior to performing the main test, since this measurement is needed for results calculations. Before starting the measurement procedure, the Y like-line was drawn by using white strap with a rectangular stance in center. For measuring the dynamic balance, the participants must place on central white stance with standing on one leg. Then, by extending his predominant foot in anterior direction, each participants attempt to push his leg as far as he can while maintaining balance. Such procedure for other directions (posterior-medial and posterior-lateral) must be performed. The free foot should be returned to the starting position under control. The whole performed protocol in one foot must be conducted for another foot. This test was conducted 3 times for each foot and then the dynamic balance for each foot was separately calculated as follows (Shaffer et al., 2013): scores summation of three directions/foot length 3 × 100.

The jump Sargent test was used to measure explosive-power. Before the assessment, participants were given the necessity to take part in warm-up program consisting of 10 squats, 10 alternating high knees and 2 min running in place. Following verbal explanation and physical demonstration by an exercise physiologist, the participants were requested to place close to the calibrated wall with stretching up their hands and the place of their fingertips was marked before jumping. Then, they were requested to squat down and jump up and the highest point on the wall after jumping was again marked. The distance between two positions (stance and jumping marked points) was measured in centimeter and finally explosive-power of feet was obtained in Watts as following (Gibson, Wagner, & Heyward, 2018):

Power = [$\sqrt{}$(4/9)] * weight (kg) * $\sqrt{}$VJ (m) * 9.81.

The speed was measured by 30-meter speed test. A 30-meter distance was identified by a calibrated strap and the start and finish points were marked. Upon starting, the participant must run as quickly as he can. Two trials with 5 min recovery were recorded for each individual and the average time took accounted as their records (Mackenzie, 2005).

Regarding free fat body mass index (FFMI), the height and weight were obtained and body fat percent was also evaluated from right side of 2-point skinfold of triceps and calf by utilizing a caliper (Seyhan, South Korea). Assessments were done by a highly experienced technician in collecting skinfolds. Body fat percent and FFMI were calculated as follows for black or white boys of 6 to 17 years-old (with predictive accuracy of ± 8.6% BF) (Beam & Szymanski, 2010; Eston & Reilly, 2013): (i)

$$\text{FFMI}=\frac{\text{mass (kg)}\times((100-\text{fat\%})/100)+6.1\times(1.8-\text{height (m)})}{\text{height}^2}$$

## Assessments of psychological health factors

### General health question questionnaire

The general health questionnaire-28 (GHQ-28) was utilized for evaluating the four components of physical symptoms, anxiety signs, disturbing in socio-function and depression (Goldberg & Hillier, 1979). The questionnaire is based on a Likert scale and the scoring ranges from 0-3, with higher values indicating worse conditions. The lower- and upper-score limitations of the questionnaire are 0 and 84. The questionnaire's reliability using Alpha-Cronbach test was 0.74. In the current study, the participants were initially explained how to fill-out the questionnaire, which was filled in two occasions: before engaging in the main protocol and after finishing the 8-week intervention.

### Physical self-concept questionnaire

In according to Cronbach formula, the reliability coefficient for this questionnaire was 81.0. The utilization of current four-factor questionnaire is usually to evaluate the assuming of ones about his/her-self body, health, physical appearance and body-strength. Physical self-concept questionnaire (PSCQ) comprises 8 questions, each containing 5 options (Annesi, 2006; Babic et al., 2014). The higher the score, the better the self-concept.

## Training protocols

### Linear programmed resistance training (LPRT)

This training included 8-week training, 3 sessions /week. Two weeks was devoted to participants' familiarization to the program. After defining 1RM for every given exercise at the last session of familiarizing period, the pre-test of the considered variables was administered. Each training session lasted 60 min and included warm-up followed by chest-press, barbell squat, Bulgarian squat, barbell curl, barbell triceps extension, Underhand Cable Pulldowns, plank, hyperextension (back extension) and finally cool-down. The training started with 30% of 1RM and in the fourth week reached to 50% 1RM. At the end of the week four, the 1RM was again evaluated for every single of the movements and the new obtained 1RM was regarded as the basis of the training's 1RM of the remaining of the 4-week (week 4 to end of week 8). Thus, the training program was incremental from 60 to 70% of 1RM during the second half of the program (Table 1). Eventually,

the post-test measurements were obtained after 48 hours of 8-week training protocol in the last session.

### Undulating programmed resistance training (UPRT)

The whole procedure of this training such as duration, session frequency, the time and the training movements was similar to linear programmed resistance training. However, how to implement the volume and intensity of training was the only difference; such that volume and intensity were variables per session from the fourth week onwards. Thus, participants were involved in incremental training protocol each session with new intensity and volume over week for four remaining weeks (Table 1). It should be mentioned that 1RM was also measured by the end of the fourth week. Additionally, the post-measurements of the variables were obtained 48 hours after 8-week training protocol in the last session.

### Statistical analysis

The Shapiro-Wilk test was used to assess normality of the data. Mixed ANOVA was also utilized to measure the significant differences between and within groups and Post hoc test was co--nducted to assess paired comparisons. The significant level was set at 0.05. All data were analyzed by SPSS software, version 22. To identify the changing percent, the following formula was applied: % change = (post value – pre value) *100.

## Results

Some demographic properties of participants are shown in Table 2. The mixed ANOVA results considering upper- and lower-extremities strength indicated that there was statistical significance for time, groups and time × group interaction, with large effect size. By further Post hoc analysis, it has been shown that there were no significant differences among the training groups ($p>0.05$), while such differences were observed comparing to the control group ($p<0.001$) (Table 3), with large effect sizes. In light of statistical significance of time, the pre- and post-measures of two training groups were significantly different ($p<0.001$), with large effect sizes in both factors.

However, there were statistical significances in time, group and interaction in terms of upper-extremities endurance, such significant differences were not observed in lower-extremities endurance, except in pre- and post-measures (Table 3). Detailed

**Table 1. Resistance training protocols (LPRT and UPRT)**

| | Week1 | Week2 | Week3 | Week4 | | Week5 | Week6 | Week7 | Week8 | Days |
|---|---|---|---|---|---|---|---|---|---|---|
| **LPRT** | 30%*15*2 | 35%*15*3 | 40%*14*3 | 50%*13*4 | | 60%*12*4 | 50%*13*4 | 60%*12*4 | 70%*8*4 | *All days* |
| **UPRT** | 30%*15*2 | 40%*14*3 | 50%*13*3 | 60%*12*4 | 1RM retest | 40%*14*4 | 60%*12*3 | 40%*13*3 | 60%*12*4 | *Monday* |
| | | | | | | 50%*13*3 | 40%*13*3 | 60%*12*4 | 50%*13*3 | *Wednesday* |
| | | | | | | 40%*14*4 | 60%*12*4 | 50%*13*3 | 70%*8*4 | *Friday* |

Legend: Linear programmed resistance training (LPRT); Undulating programmed resistance training (UPRT). Data indicates % of 1RM (one-maximum repetition) multiplied by number of repetitions and then by the number of sets.

**Table 2. Baseline characteristics of the participants.**

| Variables / Groups | Age (years) | Weight (kg) | Height (cm) | BMI (kg/m$^2$) | Leg length (cm) |
|---|---|---|---|---|---|
| **Control (n=6)** | 16.09±0.83 | 68.85±7.94 | 177.66±4.22 | 22.07±1.57 | 94.50 |
| **LPRT (n=12)** | 16.20±0.08 | 71.80±21.73 | 174.83±7.16 | 23.18±5.45 | 95.20 |
| **UPRT (n=11)** | 15.90±0.93 | 62.36±12.70 | 176.36±7.74 | 19.83±2.61 | 94.27 |

Legend: Linear programmed resistance training (LPRT); Undulating programmed resistance training (UPRT); BMI, body mass index.

Table 3. Pre- and post-test values for physical fitness tests

| Groups / Variables | Control (n= 6) M ± SD | LPRT (n= 12) M ± SD | UPRT (n= 11) M ± SD | p-value (ES) Time | group | t × g |
|---|---|---|---|---|---|---|
| **Upper-extremities strength** | | | | | | |
| **Pre-test** | 33.29±9.19 | 40.24±9.79 | 42.11±8.58 | 0.001 (0.82) | 0.001 (0.39) | 0.001 (0.68) |
| **Post-test** | 32.69±8.83 | 56.42±8.55*φ | 59.87±10.13*φ | | | |
| **Lower-extremities strength** | | | | | | |
| **Pre-test** | 55.27±8.62 | 61.71±34.13 | 67.21±20.21 | 0.001 (0.75) | 0.009 (0.30) | 0.001 (0.58) |
| **Post-test** | 53.54±9.21 | 125.21±46.75*φ | 151.92±47.57*φ | | | |
| **Upper-extremities endurance** | | | | | | |
| **Pre-test** | 8.83±3.25 | 10.66±9.10 | 15.72±8.91 | 0.001 (0.60) | 0.002† (0.37) | 0.001 (0.51) |
| **Post-test** | 8.83±3.44 | 16.83±8.18* | 28.63±6.90*φ | | | |
| **Lower-extremities endurance** | | | | | | |
| **Pre-test** | 208.83±149.62 | 194.75±176.26 | 166±113.42 | 0.10 (0.09) | 0.43 (0.06) | 0.23 (0.10) |
| **Post-test** | 196.16±139.35 | 364±343.40 | 795.63±132.47 | | | |
| **Y-balance (right leg)** | | | | | | |
| **Pre-test** | 86.10±3.45 | 94.95±6.66 | 101.10±11.19 | 0.001 (0.63) | 0.001† (0.54) | 0.001 (0.54) |
| **Post-test** | 85.88±4.17 | 103.78±10.38*φ | 120.32±12.63*φ | | | |
| **Y-balance (left leg)** | | | | | | |
| **Pre-test** | 87.28±4.36 | 95.93±6.43 | 104.18±9.99 | 0.001 (0.59) | 0.001 (0.57) | 0.001 (0.50) |
| **Post-test** | 85.87±6.32 | 105.41±9.87*φ | 119.85±12.46*φ | | | |
| **Explosive-power** | | | | | | |
| **Pre-test** | 882.90±225.27 | 967.21±333.60 | 883.90±226.27 | 0.04 (0.15) | 0.69 (0.028) | 0.09 (0.16) |
| **Post-test** | 878.66±225.27 | 990.13±288.70 | 946.92±229.18* | | | |
| **Speed** | | | | | | |
| **Pre-test** | 4.89±0.39 | 4.86±0.27 | 4.83±0.33 | 0.95 (0.00) | 0.30 (0.08) | 0.02 (0.24) |
| **Post-test** | 4.91±0.39 | 4.99±0.25 | 4.67±0.20 | | | |
| **FFMI** | | | | | | |
| **Pre-test** | 33.46±10.36 | 27.97±12.38 | 21.91±4 | 0.001 (0.36) | 0.03 (0.23) | 0.004 (0.34) |
| **Post-test** | 34.19±11.24 | 25.68±12.47 | 18.31±4.41*φ | | | |

*Legend*: LPRT, linear programmed-resistance training; UPRT, non-linear programmed- resistance training; FFMI, free fat body mass index; * p≤ 0.05 for significant differences between pre- and post-test; †significant difference between groups; φ significant difference among two participant groups in training protocol and control group.

analysis of upper endurance by Post hoc showed that there were significant differences in UPRT with control group (p< 0.05), large effect size, but such differences were not in LPRT group (p> 0.05). Importantly, there was statistically significant difference between LPRT and UPRT (p< 0.001) (Table 3). In respect to time effect, it has been identified that pre- and post-measures of upper-extremities endurance in two training groups were significantly different following 8-week training protocol (p< 0.001), with large effect sizes.

The findings of balance, which is measured by Y-balance test in right and left legs, indicated that there was significant time × group interaction and Post hoc test, then, revealed a significant difference between two training groups with those in the control group (p> 0.001, Table 3). Accordingly, the differences were precisely present between LPRT and UPRT groups (p< 0.001), with large effect sizes. It has also been found that the pre- and post-measures of right and left balance in all training groups significantly changed after the 8-week protocol (p< 0.001), with large effect size.

As depicted in Table 3, regarding to explosive-power the pre- and post-measures of UPRT group were significantly different after the 8-week training protocol (p= 0.04), relatively large effect size.

There was a statistical significance in interaction in terms of speed factor (p= 0.02), with large effect size. After analyzing the main time effect and group differences by repeated measure test and Post hoc test, respectively, it was identified that there was no significant difference between groups and the pre- and post-measures of each group showed the same result (p> 0.05).

Regarding FFMI, there was statistical significance in time, group and interaction effect (p= 0.002), with large effect size (Table 3).

Post hoc analysis was performed to find differences between groups, but differences did not exist among two training groups (p> 0.05). Additionally, the UPRT group was the only group indicated a significant difference with the control group (p= 0.04) as well as significant changes in pre- and post-measures (p< 0.001), with large effect size. As depicted in Table 4, there were no statistically significant differences between the experimental groups and between them with the control group considering both socio-psychological factors, namely GHQ and PSCQ. It should be mentioned that there did not exist significant differences in pre- and post-measures of the experimental groups (p> 0.05).

## Discussion

Physical fitness seems to play a significant role in general health (Ortega et al., 2008), and also physical fitness in childhood and adolescence profoundly impact future, adult health. In this regard, RT has emerged as powerful modulator of physical fitness levels (Dumith et al., 2011). However, it has not been properly studied whether different programmed approaches to RT with adolescents produce different physical and psychosocial outcomes. The goal of the current study was therefore to compare the effects of 8-week resistance training with linear and undulating programming on physical fitness and mental health of adolescent boys.

Based on the findings, both experimental groups produced significantly greater improvements than the control group in terms of maximal muscle strength. The change percent of upper- and lower extremities strength for LPRT and UPRT groups was +40.19, +42.16 and +102.89, +126.04, respectively. There were no significant differences between the two programs. These findings are consistent with evidence provided by Niazi, Parnow (Niazi, Parnow, & Eslami, 2016).

**Table 4. Pre- and post-test values for psychosocial assessments**

| Groups / Variables | Control (n= 6) | LPRT (n= 12) | UPRT (n= 11) | p-value (ES) | | |
|---|---|---|---|---|---|---|
| | | | | time | group | t × g |
| **GHQ** | | | | | | |
| **Pre-test** | 40.16±5.26 | 41.16±9.09 | 42.45±9.87 | 0.65 (0.008) | 0.88 (0.01) | 0.82 (0.01) |
| **Post-test** | 41.83±4.17 | 40.83±8.37 | 42.81±11.63 | | | |
| **PSCQ** | | | | | | |
| **Pre-test** | 22.66±4.03 | 21.25±5.15 | 18.27±5.56 | 0.41 (0.02) | 0.29 (0.09) | 0.29 (0.08) |
| **Post-test** | 23±3.57 | 20.91±5.99 | 19.18±5.79 | | | |

Legend: LPRT, linear programmed-resistance training; UPRT, undulate programmed-resistance training; GHQ, general health questionnaire; PSCQ, Physical Self-concept questionnaire.

Similarly, both experimental groups generated significant improvements in muscle endurance in comparison with the control group, but without statistically significant differences between LPRT and UPRT. The change percent for upper- and lower- extremities in LPRT and UPRT groups was +87.81, +82.08 and +86.90, +379.29, respectively. The findings are in line with previous investigations (Niazi et al., 2016; Ramalingam & Yee, 2013). In the study performed by Niazi, Parnow (Niazi et al., 2016), they reported that both upper- and lower- extremities endurance increased following two LPRT and UPRT trainings in untrained female adolescents. Another research showed that two programmed modes of resistance training with equated intensity and volume could significantly change muscle endurance in adolescent athletes (Ramalingam & Yee, 2013).

As for balance, there were no significant differences among the three groups considering right leg, although there were meaningful differences after evaluating for left leg balance. Again, it was shown that the two programs similarly improved dynamic balance in male adolescents. Previous studies have shown that combined training modalities are superior to balance-specific and plyometric training in terms of balance gains, while all three are superior to RT (Mohammadi, Alizadeh, & Gaieni, 2013; Motalebi, Cheong, Iranagh, & Mohammadi, 2018).

Explosive power improved in both experimental groups, being statistically significant in comparison with the control group, but not between themselves. Our findings are inconsistent with the results of Niazi, Parnow (Niazi et al., 2016), revealing that an 8-week LPRT and UPRT did not change the explosive-power in untrained female adolescents.

None of the programs changed speed levels significantly, which is in alignment with the research by de Villarreal, Requena (de Villarreal, Requena, Izquierdo, & Gonzalez-Badillo, 2013), and in contradiction with other research findings (Argus, Gill, Keogh, McGuigan, & Hopkins, 2012; Gnaneshwar & Gopinath, 2014) showing the improvement of speed by various interventions including plyometric, resistance training and combined intervention trainings. Perhaps the differences may rely in type, intensity and duration of training protocol, as well as in age and baseline level of physical fitness.

Based on the FFMI findings, there were no statistically significant differences between the training groups. Consistent with our results, Rhea, Ball (Rhea, Ball, Phillips, & Burkett, 2002) compared a 12-week resistance training with LPRT and DUP in changing body composition, and reported no significant differences in both groups. In this regard, another research group also did not find any significant differences between linear and non-linear groups after 12-week training (Prestes et al., 2009).

As for the psychosocial factors, there were no significant differen-ces within and between groups in terms of general health and physical self-concept factors. Therefore, both training programs were ineffective in promoting improvements in the analyzed psychosocial factors. Perhaps eight weeks were not enough for producing significant changes in such complex constructs. Although the change in physical fitness is considered to be a factor capable of modulating self-esteem, initial levels of physical fitness and self-esteem can influence the magnitude of gains (Spence, McGannon, & Poon, 2005).

## Conclusion

Resistance training programs were effective in improving several physical fitness outcomes in comparison with the control group. However, they were not effective in improving psychosocial markers, which may perhaps be due to the short duration of the protocol (8 weeks). Furthermore, the two programs had no statistically significant differences, suggesting that as long as loads are individually adjusted and progressed, the specific programming adopted may not be relevant for beginner practitioners.

## What is already known on this subject?

As it was mentioned above, since resistance training is an effective procedure to increase muscle mass and strength, improve performance and stimulate healthy life-style in adolescents, it can be performed in different models such as linear or undulating model. Performing model of RT would make a challenge for coaches and young athletes.

## What this study adds?

Both RT program had similar effects on physical fitness factors and the results of the current study could recommend to coaches and young athletes to follow linear or undulating programs. In psychological aspects, we should keep ways to future studies with long-term periods.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** The current study was approved by the ethics committee of Razi University in accordance with the declaration of Helsinki (updated version of 2013).

**Informed consent** Participants accepted to contribute to the study and the consent form was filled out by their parents.

## Author contributions

Conceptualization: J.A., AH.P.; Methodology: M.S., O.R.; Software: A.M., AH.P.; Validation: J.A.; Formal analysis: M.S.; Investigation: M.S., O.R.; Resources: J.A.; Data curation: O.R.; Writing - original draft: M.S., O.R.; Writing - review & editing: A.M.; Visualization: J.A., AH.P.; Supervision: AH.P.; Project administration: J.A.; Funding acquisition: M.S.

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