Research Article

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Effect of linear and non-linear periodized resistance training on dynamic postural control and functional movement screen

Abstract

Periodization is an important component of resistance training programs. It is meant to improve adherence to the training regimen, allow for constant progression, help in avoiding plateaus, and reduce occurrence and severity of injuries. The aim of this study was to investigate the effects of linear per iodized (LP) and nonlinear per iodized (NLP) resistance training on Dynamic Postural Control and Functional Movement Screen. This study was designed as a randomized controlled trial with pretest and post-test model. The subjects were randomly categorize into a control group (n=15) that underwent linear periodization and an intervention group (n=15) submitted to nonlinear periodization training. A 4-week exercise protocol was applied to both groups. The LP program followed a pattern of intensity and volume changes every week. After the trial, both groups presented significant gains in Dynamic Postural Control and Functional Movement Screen. The findings of the current study indicate greater improvement in Functional Movement Screen (p=0.001) and Y Balance Test (p=0.001) scores for the Nonlinear Periodization model. In conclusion, both LP and NLP are effective, but NLP may lead to greater gains in Dynamic Postural Control and Functional Movement Screen over a 4-week training period. However, more research is needed in this area, particularly among trained individuals and clinical populations. Future studies may benefit from using instruments that are more sensitive for detecting changes in outcome measures.

Keywords: training volume, resistance training, injury risk, y-balance test, hypertrophy

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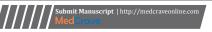
Abbreviations: LP, linear periodization; NLP, nonlinear periodization; RT, resistance training; RM, repetition maximum; YBT, y-balance test; FMS, functional movement screen

Introduction

Efforts to achieve progressive gains in strength and muscle size are encountered with plateaus along the way, in the form of a period of stagnation where muscles adapt to training. Trainers and coaches are finding ways to solve this conundrum and get back on the path to hypertrophy. Periodized training program is considered as one of the best solutions to overcome this training debacle. Periodization is a method of planning periods or cycles in which training specificity, intensity, and volume changes within an overall training program.[1] Linear Periodization (LP) is the classic form of periodization that gradually increases the training intensity while decreasing the training volume within and between cycles. Non-Linear Periodization (NLP) is characterized by more frequent changes in intensity and volume. Rather than making changes over a period of months, the model makes these changes on a weekly or even daily basis. According to,[2] the goal of periodization is to create metabolic fatigue, mechanical overload or a combination of both to allow favorable adaptations over a prolonged period, by manipulating the training stimulus. The underlying physiological mechanisms that explain the differences between per iodized and non-per iodized programs remain to be fully investigated and explained.[3] Most strength professionals agree that strength-training programs should be per iodized.[4] However, they have not yet reached a consensus on what type of per iodized program is the most effective.[5] Moreover, linear and nonlinear models of resistance exercise have been investigated in tennis, indicating that the nonlinear model of exercise could have better training theory for strength and conditioning because of avoiding the overtraining.[6] On the contrary, a few studies have shown that per iodized training programs are more effective in eliciting strength and body mass improvements than non-per iodized resistance training programs.[7] Nonetheless, several researches have reported contradictory results in the performance effect by these two types of resistance exercise theory. Hoffman and colleagues have illuminated that the linear model could be more effective in improving 1RM in freshman football players in comparison with the nonlinear model.[8] Being that adaptations to exercise are specific to the training method used,[1] it is important to assess the impact of various training methods. However, it is unclear whether LP compared to NLP programs elicit greater strength gains, and how this strength gains get translated to improved dynamic postural control and functional movement screen. Screening tools developed to predict injury in various athletic populations, like the functional movement screen (FMS) and the Y-balance test (YBT) are increasing in popularity.[9] The FMS and the YBT identify individuals who have functional limitations or asymmetries by examining the ability of the subject to perform very specific movements.[12] Low scores in these tests have been linked to higher risk of injuries. Studies comparing periodization models in individuals not trained in resistance training are scarce. To our knowledge, this is the first study that examined the impact of LP and NLP training programs on dynamic postural control and FMS that have been widely used as screening tools to predict risk of injury in several populations. Improving the data in comparing these two exercise strategies will help the coaches to choose the best

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way to achieve promising results. There is limited research regarding the impact of various training methods in relationship to injury risk assessments, thus the purpose of the current study was to examine the effects of non-linear per iodized resistance training on YBT and FMS scores of young adults compared to a linear per iodized training program.

Materials and methods

Participants

Thirty healthy young adults were randomly distributed in two groups for the study. Participants had been put into the intervention group and the control group using block randomization. This was to ensure that roughly equal numbers of participants were randomly assigned to the two groups in such a way that both known and unknown prognostic factors were balanced at the start of the trial. Randomization was performed using computer-generated random numbers (Research Randomizer). Both males and females aged between 18 to 25 years were included. All individuals reported not to have experience in resistance training. Among the participants, there were 16 males (53.33%) and 14 females (46.67%). The proportion of the number of males and females in each group were almost similar. The age of participants were ranging from 19 to 24 years, (n=30, age; 20.43±1.14). Gender and anthropometric measurements of control and intervention group are given in (Table 1).

Table 1 Gender and anthropometric measurements of control and intervention group

Variables	Control group(N=15) N(%)/Mean±SD	Intervention group(N=15) N(%)/Mean±SD
Gender		
Male	8(53.33)	8(53.33)
Female	7(46.67)	7(46.67)
Age	20.33±0.98	20.53±1.30
Height(cm)	164.30±9.82	165.07±9.32
Weight(kg)	59.31±12.50	56.95±9.44

Procedure

This study was designed as a randomized controlled trial with pretest and post-test model. Subjects were recruited among students of Universiti Tunku Abdul Rahman (UTAR), Sungai Long campus, Malaysia by convenience sampling. The participants were screened to prevent any risky condition during the experimental protocols using Physical Activity Readiness Questionnaire (PAR-Q). Subjects with any neuromuscular disorders, cardiovascular diseases, congenital disorders and pregnancy were excluded. Subjects with any history of recent fractures, disc prolapse or surgery were also excluded. The trial was conducted in accordance with the Declaration of Helsinki. All participants signed a consent form for participation in the research and were informed about tests and training protocol procedures to be performed during the study period. The study was approved by Scientific and Ethical Review Committee (SERC) of UTAR. The trial was conducted at the Physiotherapy Center and Gymnasium of UTAR, Sungai Long campus, Malaysia. After determining the 1 Repetition Maximum (RM) of participants, they were included into a control group and experimental group. Participants of the control group were submitted to linear periodization resistance training while participants of experimental group underwent non-linear per iodized resistance training. A pre-post-test design was followed by using two outcome measures; YBT and FMS. YBT was used for assessing dynamic postural control, whereas FMS for determining the quality of the movements. The resistance training was conducted three times a week for four weeks consecutively. Seated leg press and dead lift were performed by all participants. Participants were instructed to perform the correct pattern of exercise before training. The periodization models suggested for the study were applied to all exercises. The protocol for resistance training is given in (Table 2). At the end of the trial after fourth week; the outcome measures were assessed again to determine and compare the effect of both periodization methods on dynamic postural control and functional movement screen.

Outcome measurements

Y-Balance Test: In order to evaluate the dynamic postural control of participants, Y-Balance Test (YBT) modified from Star Excursion Balance Test (SEBT) was used. Dynamic postural control is defined as the ability of the body to maintain the center of mass (COM) within the base of support (BOS), whether it is with or without perturbations. The YBT has demonstrated high intra-tester (0.85-0.89) and inter-tester reliability (0.97-1.00).[13] The movements were demonstrated by the tester and subjects were provided with 1-2 practice trials prior to performing the test. Subjects were given three criterion trials, and the best performance was recorded to the nearest half centimeter. For the YBT measures, participants stood with one foot flat at the junction (toes at the center line) of the three parts of the "Y". While maintaining balance, and without their reaching foot touching the ground, the participant slid the bar on each of the three parts of the "Y" (anterior, postero-medial and postero-lateral) one part at a time.

Functional movement screen: FMS consists of seven basic movement patterns which include deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up as well as rotational stability. Each of the components is scored from 0 to 3, where a '0' score is given when there is presence of pain associated with the movements. An intrarater test-retest and interrater reliability study of FMS was conducted by Teyhen DS et al.[14] and it was found that the composite score shows moderate to good reliability with acceptable levels of measurement error.

Statistical analysis

All the analyses of data were performed using the SPSS Statistical software.[15] Mean and standard deviations were reported as the descriptive data. Student t-test was applied to determine the differences of the mean and standard deviations. All statistical analyses were done in 95% of CI and significance level of p<0.05 to prevent any type I

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error. Data are presented as group mean values±standard deviations (SD). YBT scores were compared for left lower extremity pre-test and after the trial. The results are shown in (Table 3). Intervention and Control groups' research scores of YBT for right lower extremity are compared with findings in (Table 4). Intervention and Control groups'

FMS Scores were compared using independent t test and the results are presented in (Table 5).Total of 30 participants distributed between control and intervention groups. Data expressed with n(%) for categorical data and mean±SD for continuous data. A paired samples t-test was performed, level of significance p<0.05*, significant results.

Table 2 Resistance training protocol for LP and NLP groups

Week	Linear periodization		Non-linear periodization	
	Volume (Set/Rep)	**Intensity**	**Volume (Set/Rep)**	**Intensity**
1	3x8	70%1RM	3x8	70%1RM
	3x8	70%1RM	3x6	80%1RM
2	3x8	70%1RM	3x4	85%1RM
	3x8	70%1RM	3x8	70%1RM
3	3x6	80%1RM	3x6	80%1RM
	3x6	80%1RM	3x4	85%1RM
4	3x6	80%1RM	3x8	70%1RM
	3x6	80%1RM	3x6	80%1RM

Table 3 Distribution of the YBT for left extremity score averages according to intervention and control groups

Scores	Pre-test mean (SD)	Post-test mean (SD)	Mean difference(S)	T	P value
Control Anterior Reach	61.78(5.13)	66.36(6.56)	-4.58(2.95)	-6.02	<0.001*
Intervention Anterior Reach	62.39(6.23)	67.70(5.46)	-5.31(3.96)	-5.19	<0.001*
Control Postero-medial Reach	89.57(10.88)	98.72(9.77)	-9.15(7.26)	-4.89	<0.001*
Intervention Postero-medial Reach	85.69(10.91)	97.28(9.88)	-11.59(8.29)	-5.42	<0.005*
Control Postero-lateral Reach	83.89(11.03)	92.73(8.62)	-8.85(7.40)	-4.63	<0.001*
Intervention Postero-lateral Reach	82.19(12.39)	92.26(11.3)	-10.07(5.93)	-6.58	<0.001*
Control Composite	91.20(7.88)	100.08(6.26)	-9.01(5.42)	-6.01	<0.001*
Intervention Composite	87.62(9.04)	97.99(8.85)	-10.37(4.62)	-8.7	<0.001*

Table 4 Distribution of the YBT for right extremity score averages according to intervention and control groups

Scores	Pre-test mean (SD)	Post-test mean (SD)	Mean difference (SD)	T	P value
Control Anterior Reach	62.69(4.99)	67.47(6.09)	-4.78(3.57)	-5.19	< 0.001*
Intervention Anterior Reach	62.47(7.68)	68.25(7.10)	-5.78(4.53)	-4.94	< 0.001*
Control Postero-medial Reach	87.18(11.72)	96.87(8.53)	-9.63(7.85)	-4.78	< 0.001*
Intervention Postero-medial Reach	86.45(11.74)	96.99(11.33)	-10.54(5.57)	-7.34	< 0.001*
Control Postero-lateral Reach	83.83(14.78)	93.94(11.57)	-10.11(6.44)	-6.08	< 0.001*
Intervention Postero-lateral Reach	88.20(11.30)	94.42(9.03)	-6.22(6.26)	-3.85	<0.002*
Control Composite	88.67(9.42)	98.24(7.98)	-9.57(4.13)	-8.97	< 0.001*
Intervention Composite	91.37(9.00)	99.79(6.81)	-8.42(5.19)	-6.28	< 0.001*

Table 5 Distribution of the FMS score averages according to intervention and control groups

Scores	Pre-test mean (SD)	Post-test mean (SD)	Mean difference (SD)	T	P value
Control FMS Score	16.20(2.15)	17.93(1.34)	-1.73(1.83)	-3.67	0.003*
Intervention FMS Score	16.20(2.46)	18.33(1.25)	-2.00(1.25)	-1.31	0.001*

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Results and discussion

The purpose of this study was to examine the effects of different types of periodization training on Dynamic Postural Control and Functional Movement Screen. Participants of the NLP group showed statistically significant greater scores than the LP group for YBT and improvement in FMS scores as well. Specifically, significant improvements were seen in both the LP and NLP training groups for total FMS scores YBT scores. Functional movement screening (FMS) and Y-balance test (YBT) are assessment procedures used to examine the 'quality' of movement patterns and identify individuals that might have specific limitations or asymmetries. The FMS helps identify muscle asymmetries, tightness, weakness and other risk factors for injury by examining the mobility and stability of the hips, core, shoulders, knees, spine and ankles. Statistically significant improvement was seen in participants that underwent NLP. Nonlinear periodization is based on the concept that volume and load are altered more frequently in order to allow the neuromuscular system longer periods of recovery as lighter loads are performed more often.[16] In the NLP model, there are more frequent changes in stimuli. These more frequent changes may be highly conducive to strength gains.[17] Due to scarce research including intervention and control groups on training programs to improve FMS and YBT scores, it is difficult to compare our results with previous literature[18] compared the effect of LP and NLP on strength gains in previously trained individuals with a 3 sessions per week, whole-body program. The authors found significant increase in leg press after LP and NLP. However, NLP induced superior increase in maximal strength compared with LP, 55.8 vs. 25.7% for leg press.

Linear periodization group demonstrated a comparatively low performance in YBT and FMS. Linear periodization is criticized for being ineffective in the development and maintenance of hypertrophy. It has limitations to increase lean body mass, the principal mechanism by which strength is enhanced. It is thought that long periods of low volume, high intensity training characterized by linear periodization models resulted in less favorable hypertrophic adaptations and may induce neural fatigue.[19] Found that NLP induced a greater percent increase in maximal strength for the bench press, the 45^0 leg press, and the arm curl after 12 weeks of training compared with LP (NLP 25.08, 40.61, and 23.53% vs. LP 18.2, 24.71, and 14.15%, respectively). The Functional Movement Screen (FMS) is a set of seven physical tests of coordination and strength that have been translated from the increased strength of muscles gained through NLP. The NLP may also have superior effects on other aspects of physical health and performance when compared with LP. A recent study reported that a NLP program produced greater upper and lower body strength gains, power, and jumping capacity compared with LP in trained firemen.[20] This result highlights the superiority of NLP training. NLP allows for a more efficient recovery pattern, while still allow maintaining the adequate intensity and volume needed to increase strength and stimulate or maintain hypertrophic development. NLP allows for an increased training frequency through the alternation of stimulus during a shorter period of time. As a result, a greater neuromuscular adaptation is achieved compared to the linear model. Neural adaptations can include improved synchronization of motor unit firing and improved ability to recruit motor units to enable a person to match the strength elicited by electrical stimulation.[3] This probably has improved the performance in YBT scores of participants in the NLP model. Nevertheless, the presence of strength at all times keeps the muscles and joints well adapted to stress, thus minimizing injury risk. Participants of the NLP group were able to present greater improvement in their YBT and FMS scores, since the 'unloading training strategy' potentially allows full expression of their non-fatigued physical, technical and tactical capabilities. Further research with longer trial period and a larger sample size is warranted in multiple athletic populations. Truly, this is a relatively unexplored area of research and there are vast opportunities for studies to be conducted, all with the goal of maximizing long-term athletic rehabilitation, development, and performance.

Conclusion

Trainers and coaches should work towards increasing non-linear periodized resistance training participation via feasible and efficacious interventions to reduce the risk of injuries. Thus coaches and fitness enthusiasts can use nonlinear periodization plans with confidence that this type of periodization will result in significant fitness gains.

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Conflict of interest

The author declares no conflict of interest.

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