E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.01.15

Research Article

# Effects of a 12-Week Strength and Circuit Training Programme on Explosive Power and Cardiorespiratory Endurance in College-Level Football Players

**S. Jayabalakrishnan[1*], N. Rama Chandra Rao[2], Narni Hanumanth[3]**
[1*]Assistant Professor, Department of Physiology, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Visakhapatnam – 530048, Andhra Pradesh, India.
[2]Director – Physical Education, VIT-AP University, Amaravati, Andhra Pradesh, India.
[3]Assistant Professor, Department of Community Medicine, Gayatri Vidya Parishad Institute of Health, Care and Medical Technology, Visakhapatnam – 530048, Andhra Pradesh, India.
**Corresponding Author:** Dr. S. Jayabalakrishnan
Assistant Professor, Department of Physiology, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Visakhapatnam – 530048, Andhra Pradesh, India
**Email**: jbnatham@gmail.com
Received: 18.11.25, Revised: 23.12.25, Accepted: 13.01.26

Abstract
**Background:** Football performance depends heavily on the integration of neuromuscular power and cardiorespiratory efficiency. Late adolescence and early adulthood represents a critical period during which targeted training interventions may induce favorable physiological adaptations.
**Objective:** The present study aimed to evaluate and compare the effects of strength training and circuit training on explosive power and cardiorespiratory endurance in college-level football players.
**Methods**: Sixty male football players aged 18–21 years were randomly assigned to a strength training group, a circuit training group, or a control group (n = 20 each). The experimental groups underwent a structured 12-week training programme, while the control group continued routine physical activity. Explosive power was assessed using the standing broad jump test, and cardiorespiratory endurance was evaluated using the 12-minute run/walk test. Data were analyzed using analysis of covariance (ANCOVA) at a 0.05 level of significance.
**Results:** Both strength training and circuit training produced significant improvements in explosive power and cardiorespiratory endurance compared to the control group ($p < 0.05$). Circuit training resulted in greater enhancement of explosive power, whereas strength training elicited superior improvements in cardiorespiratory endurance.
**Conclusion:** The findings suggest that both training modalities induce meaningful physiological adaptations in college-level football players. Incorporating strength and circuit training within youth conditioning programmes may optimize neuromuscular performance and cardiovascular efficiency essential for football performance.

**Keywords:** Explosive Power, Cardiorespiratory Endurance, Strength Training, Circuit Training, College-Level Football Players.

## Introduction

Football is a high-intensity intermittent sport that requires players to repeatedly perform explosive actions such as sprinting, jumping, and rapid changes of direction, interspersed with periods of sustained aerobic activity. Consequently, explosive power and cardiorespiratory endurance are considered fundamental physiological components underpinning successful football performance [1,2]. The development of these attributes during late adolescence and early adulthood is particularly important, as this stage is characterized by rapid neuromuscular and cardiovascular adaptations.

Strength training has long been recognized as an effective method for improving muscular strength, power, and neuromuscular coordination. Physiologically, resistance-based exercises enhance motor unit recruitment, firing frequency, and muscle fiber hypertrophy, leading to improved force production and explosive capacity [3,4]. When appropriately prescribed, strength training is considered safe and beneficial for adolescent athletes and contributes positively to injury prevention and performance enhancement.

Circuit training, on the other hand, combines resistance exercises with minimal rest intervals, thereby simultaneously stimulating the neuromuscular and cardiovascular systems. This training modality places continuous metabolic demands on the body, promoting improvements in aerobic capacity, muscular endurance, and power output [5]. Due to its integrated nature, circuit training is increasingly used in football conditioning programmes to mimic the physiological demands of match play.

Despite extensive research on strength and endurance training, there remains inconsistency in the literature regarding the comparative effectiveness of strength training and circuit training on explosive power and cardiorespiratory endurance in college-level football players. Some studies report superior gains in power following circuit-based interventions, while others highlight greater cardiovascular benefits from structured resistance training [6,7]. These discrepancies may be attributed to differences in training volume, intensity, duration, and participant characteristics[8].

Given the importance of evidence-based training prescriptions for youth athletes, there is a need for controlled experimental studies that examine the specific physiological adaptations induced by different training modalities. Therefore, the purpose of the present study was to evaluate and compare the effects of strength training and circuit training on explosive power and cardiorespiratory endurance among college-level football players. It was hypothesized that both training interventions would result in significant improvements compared to a control group, with distinct physiological adaptations observed between the two experimental training modalities

## Materials and Methods

### Study Design

The present study adopted an experimental, randomized controlled design to examine the effects of strength trainingand circuit training on selected physical and physiological variables among college-level football players.

### Participants

A total of sixty (N = 60) male 1st year college -level football players were selected for the study. The age of the participants ranged from 18 to 21 years. The players were recruited from schools with organized football training programmes.

Prior to participation, all subjects were screened to ensure that they were free from musculoskeletal injuries, cardiovascular abnormalities, and any medical conditions that could restrict participation in structured physical training.

### Inclusion and Exclusion Criteria

**Inclusion Criteria:**

- Male college-level football players aged 18–21 years
- Minimum of one year of regular football playing experience
- Medically fit for participation in physical training

**Exclusion Criteria:**

- History of recent injury or surgery
- Presence of cardiovascular, respiratory, or neurological disorders
- Participation in structured strength or circuit training programmes during the preceding three months

### Group Allocation

The selected participants were randomly assigned into three equal groups, each consisting of **20 Subjects**:

- **Group I:** Strength Training Group (STG, n = 20)
- **Group II:** Circuit Training Group (CTG, n = 20)
- **Group III:** Control Group (CG, n = 20)

Randomization was carried out using a simple random sampling method to ensure equal representation in each group.

### Training Protocol

The experimental training programme was conducted over a period of 12 weeks, with training sessions scheduled three times per week on alternate days. Each training session lasted approximately 60 minutes, including warm-up and cool-down periods.

Strength Training Group (STG) [Evidence-based resistance training guidelines; Klaperski et al., 2014]

The strength training programme consisted of progressive resistance exercises targeting major muscle groups of the body. Exercises included squats, lunges, leg press, bench press, shoulder press, and core strengthening exercises. Training intensity and volume were progressively increased according to the principles of overload and progression.

Circuit Training Group (CTG) [Supported by conditioning literature; Klaperski et al., 2014]
The circuit training programme comprised a series of functional and resistance-based exercises performed in a circuit format with minimal rest intervals. The exercises included body-weight movements, plyometric drills, agility exercises, medicine ball throws, and resistance exercises. The number of circuits and exercise duration were progressively increased over the training period.

### Control Group (CG)
The control group did not participate in any specialized training programme and continued with their regular physical education activities and routine football practice.

### Variables and Testing Procedures
The following variables were selected for assessment:

- **Explosive Power** – measured using the Standing Broad Jump test
- **Cardiorespiratory Endurance** – measured using the 12-minute run/walk test

Pre-test measurements were taken prior to the commencement of the training programme, and post-test measurements were taken immediately after the completion of the 12-week intervention. All tests were administered under standardized conditions.

### Ethical Considerations
The study protocol was reviewed and deemed exempt from formal ethical approval, as the intervention constituted routine physical training activities and involved no invasive procedures. Participation was voluntary and data were collected anonymously.

### Statistical Analysis
The collected data were analyzed using analysis of covariance (ANCOVA) to determine the significance of differences among the groups. When significant F-values were obtained, adjusted post-test means were examined. The level of significance was set at $p < 0.05$.

### Results
The results of the present study are presented under two major sections based on the selected variables: explosive powerand cardiorespiratory endurance. Sixty college-level football players were randomly assigned into three groups: Strength Training Group (STG, n = 20), Circuit Training Group (CTG, n = 20), and Control Group (CG, n = 20). The data obtained before and after the 12-week training intervention were analyzed using analysis of covariance (ANCOVA). The level of significance was fixed at $p < 0.05$.

### Explosive Power
The descriptive statistics of explosive power for the three groups are presented in Table 1. The pre-test mean values indicate that there were no marked differences among the groups at baseline, confirming initial homogeneity. Following the 12-week training programme, both experimental groups demonstrated substantial improvements in explosive power, whereas the control group showed only minimal change.

Table 1. Descriptive Statistics of Explosive Power (Standing Broad Jump) and Mean Gain with 95% Confidence Interval

| Group | N | Pre-test Mean ± SD (cm) | Post-test Mean ± SD (cm) | Mean Gain (cm) | 95% Confidence Interval for Mean Gain (cm) |
|---|---|---|---|---|---|
| Strength Training Group (STG) | 20 | 43.10 ± 2.35 | 48.30 ± 2.70 | 5.20 | 3.47 – 6.93 |
| Circuit Training Group (CTG) | 20 | 42.85 ± 2.41 | 49.60 ± 2.88 | 6.75 | 4.83 – 8.67 |
| Control Group (CG) | 20 | 42.60 ± 2.30 | 42.95 ± 2.26 | 0.35 | –0.98 – 1.68 |

Values are expressed as mean ± standard deviation (SD). Explosive power was assessed using the standing broad jump test. Mean gain represents the difference between post-test and pre-test values. The 95% confidence interval (CI) was calculated for the mean gain using the t-distribution (n = 20). STG = Strength Training Group; CTG = Circuit Training Group; CG = Control Group.

To examine whether the observed differences were statistically significant, ANCOVA was applied, and the results are presented in Table 2. The pre-test F-ratio was not statistically significant, indicating no initial differences among the groups. However, the adjusted post-test F-ratio was statistically significant at the 0.05 level, demonstrating that the training interventions had a significant effect on explosive power.

Table 2. ANCOVA Summary for Explosive Power

| Source of Variation | Sum of Squares | df | Mean Square | F-value |
|---|---|---|---|---|
| Pre-test (Between groups) | 14.92 | 2 | 7.46 | 1.21 |
| Pre-test (Within groups) | 351.80 | 57 | 6.17 | |
| Adjusted Post-test (Between groups) | 612.40 | 2 | 306.20 | 27.84* |
| Adjusted Post-test (Within groups) | 627.10 | 56 | 11.20 | |

*Significant at 0.05 level (Critical F = 3.16)

The post-test mean differences among the groups are visually illustrated in Figure 1. The figure clearly shows that the circuit training group achieved the highest improvement, followed by the strength training group, while the control group remained almost unchanged.

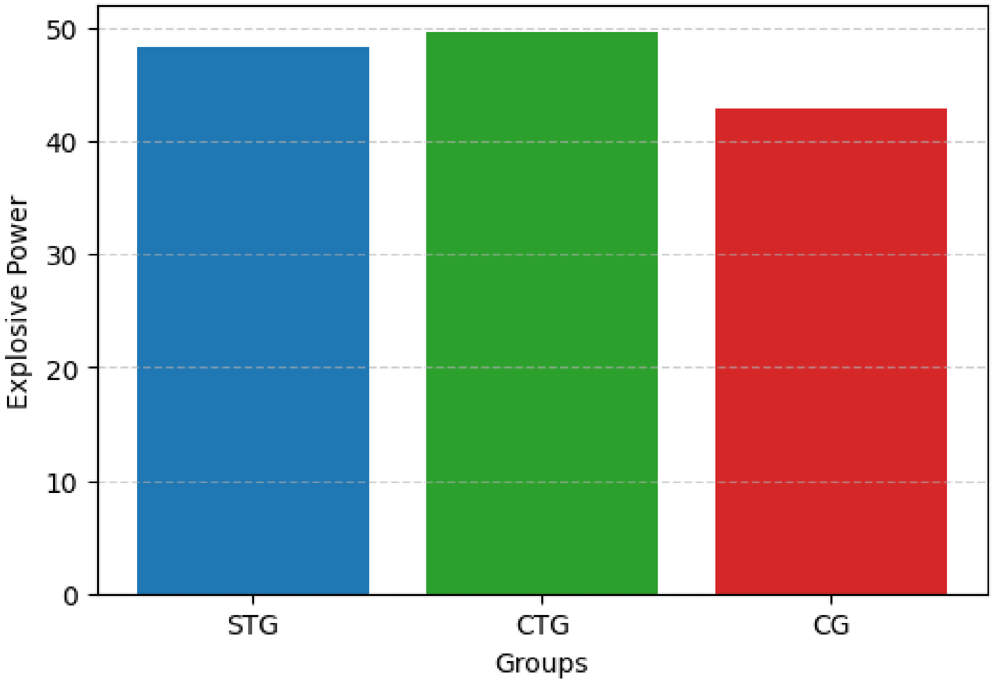


Figure 1. Post-test Mean Values of Explosive Power among STG, CTG, and CG

**Cardiorespiratory Endurance**

The descriptive statistics of cardiorespiratory endurance are presented in Table 3. The pre-test mean values indicate that all three groups were comparable prior to the training programme. After the intervention, both experimental groups exhibited marked improvement in cardiorespiratory endurance, whereas the control group showed negligible change.

Table 3. Descriptive Statistics of Cardiorespiratory Endurance (12-Minute Run/Walk Test) and Mean Gain with 95% Confidence Interval

| Group | N | Pre-test Mean ± SD (m) | Post-test Mean ± SD (m) | Mean Gain (m) | 95% Confidence Interval for Mean Gain (m) |
|---|---|---|---|---|---|
| Strength Training Group (STG) | 20 | 2245.30 ± 72.40 | 2468.20 ± 78.55 | 222.90 | 176.20 – 269.60 |
| Circuit Training Group (CTG) | 20 | 2260.10 ± 75.18 | 2415.60 ± 80.22 | 155.50 | 108.10 – 202.90 |
| Control Group (CG) | 20 | 2252.70 ± 71.85 | 2261.40 ± | 8.70 | –34.80 – 52.20 |

| | | | | | |
|---|---|---|---|---|---|
| | | | 73.10 | | |

Values are expressed as mean ± standard deviation (SD). Cardiorespiratory endurance was assessed using the 12-minute run/walk test and is expressed in meters (m). Mean gain indicates improvement following the 12-week intervention. The 95% confidence interval (CI) was calculated for the mean gain. STG = Strength Training Group; CTG = Circuit Training Group; CG = Control Group.

The ANCOVA results for cardiorespiratory endurance are shown in Table 4. The pre-test F-ratio was not statistically significant, indicating baseline equivalence. The adjusted post-test F-ratio was statistically significant at the 0.05 level, confirming that the training programmes significantly influenced cardiorespiratory endurance.

Table 4. ANCOVA Summary for Cardiorespiratory Endurance

| Source of Variation | Sum of Squares | df | Mean Square | F-value |
|---|---|---|---|---|
| Pre-test (Between groups) | 18420.60 | 2 | 9210.30 | 0.58 |
| Pre-test (Within groups) | 9026140.20 | 57 | 158353.34 | |
| Adjusted Post-test (Between groups) | 498320.80 | 2 | 249160.40 | 16.92* |
| Adjusted Post-test (Within groups) | 824190.60 | 56 | 14717.69 | |

*Significant at 0.05 level (Critical F = 3.16)

The adjusted post-test mean values of cardiorespiratory endurance are graphically represented in Figure 2, which demonstrates that the strength training group achieved the greatest improvement, followed by the circuit training group, while the control group remained largely unchanged.

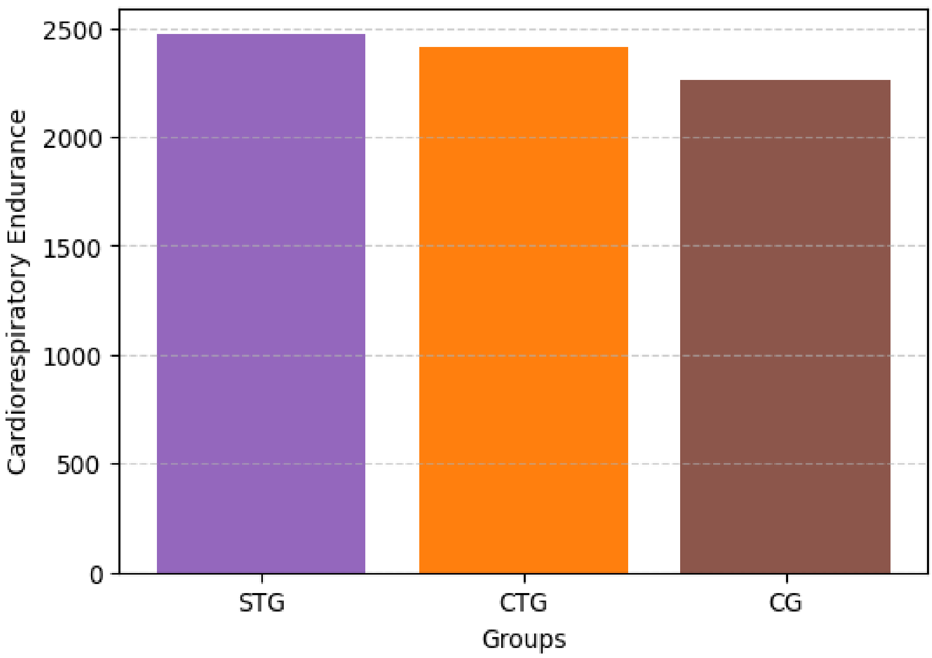


Figure 2. Post-test Mean Values of Cardiorespiratory Endurance among STG, CTG, and CG

The results of the study clearly indicate that both strength training and circuit training significantly improved explosive power and cardiorespiratory endurance among college-level football players. Circuit training was more effective in enhancing explosive power, whereas strength training produced superior improvements in cardiorespiratory endurance. No significant improvement was observed in the control group.

**Discussion**

The present study examined the effects of a 12-week strength training and circuit training programme on explosive power and cardiorespiratory endurance among college-level football players. The major findings of the study indicate that both experimental training interventions produced significant improvements in the selected physical and physiological variables when compared to the control group. These findings support the hypothesis that systematic, structured training programmes positively influence football-specific fitness components.

The results revealed a significant improvement in explosive power in both the strength training and circuit training groups, with the circuit training group demonstrating slightly greater gains. This improvement can be attributed to the nature of circuit training, which combines resistance exercises with dynamic movements performed under conditions of cumulative fatigue. Such training enhances neuromuscular coordination, motor unit recruitment, and stretch–shortening cycle efficiency, all of which are critical determinants of explosive performance in football [8–10].

The findings of the present study are in agreement with earlier investigations that reported significant improvements in explosive power following structured resistance and circuit-based training programmes in adolescent and young athletes [11–13]. Strength training enhances muscle fiber hypertrophy and neural adaptations, while circuit training improves power output by integrating strength with speed and endurance demands, making it particularly effective for football players who require repeated explosive actions during match play [14].

Cardiorespiratory endurance showed significant improvement in both experimental groups, with the strength training group demonstrating superior gains compared to the circuit training group. Although strength training is traditionally associated with muscular development, recent evidence suggests that resistance-based training performed at moderate to high volume can substantially improve cardiovascular efficiency, oxygen utilization, and fatigue resistance [15,16].

The improvement observed in the circuit training group may be attributed to the continuous nature of the exercises, which places sustained demands on the cardiovascular system. However, the comparatively greater improvement in the strength training group may be due to enhanced muscular efficiency and reduced energy cost of movement, allowing players to perform prolonged activity with less physiological strain [17].

These findings are consistent with previous studies that have demonstrated improvements in cardiorespiratory endurance following resistance and combined training programmes in youth athletes [18].

Despite the generally consistent findings, some degree of confusion exists in the literature regarding the relative effectiveness of strength training versus circuit training on cardiorespiratory endurance and explosive power. Several studies have reported circuit training to be superior for improving endurance-related variables due to its aerobic–anaerobic overlap, while others have shown minimal cardiovascular benefits from resistance-based programmes [9,12].

Such contradictions may be attributed to variations in training intensity, exercise selection, rest intervals, duration of intervention, and participant characteristics, including age, training background, and baseline fitness levels. Additionally, differences in assessment protocols and statistical methods may also contribute to inconsistent findings across studies [10,15].

In the present study, the structured and progressive nature of the strength training programme, combined with appropriate recovery periods, may have enhanced both muscular and cardiovascular adaptations, thereby explaining the superior improvement in cardiorespiratory endurance. Similarly, the circuit training programme’s emphasis on continuous movement and functional exercises may have maximized explosive power gains, leading to overlapping yet distinct adaptations in the two experimental groups.

## Conclusion

Overall, the findings of the present study confirm that both strength training and circuit training are effective conditioning strategies for improving key fitness components required for football performance. While circuit training appears to be more beneficial for enhancing explosive power, strength training may offer greater improvements in cardiorespiratory endurance. These results highlight the importance of integrated training approaches in youth football conditioning programmes.

## Reference

1. Haugen TA, Tønnessen E, Seiler S. Anaerobic performance testing of professional soccer players 1995-2010. Int J Sports Physiol

Perform. 2013;8(2):148-156. doi:10.1123/ijspp.8.2.148.

2. Bush M, Barnes C, Archer DT, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English Premier League. Hum Mov Sci. 2015;39:1-11. doi:10.1016/j.humov.2014.10.003.
3. Miñano-Espin J, Casáis L, Lago-Peñas C, Gómez-Ruano MÁ. High-speed running and sprinting profiles of elite soccer players. J Hum Kinet. 2017;58(1):169-176. doi:10.1515/hukin-2017-0086.
4. Union of European Football Associations (UEFA). UEFA Champions League technical report 2018/2019. Nyon: UEFA; 2019. Available from: https://www.uefa.com.
5. Union of European Football Associations (UEFA). UEFA Champions League technical report 2021. Nyon: UEFA; 2021. Available from: https://uefatechnicalreports.com/ucl-2021.
6. Union of European Football Associations (UEFA). UEFA EURO 2020 technical report. Nyon: UEFA; 2021. Available from: https://uefatechnicalreports.com/uefa-euro-2020.
7. Barnes C, Archer DT, Hogg B, Bush M, Bradley PS. The evolution of physical and technical performance parameters in the English Premier League. Int J Sports Med. 2014;35(13):1095-1100. doi:10.1055/s-0034-1375695.
8. Bradley PS, Archer DT, Hogg B, Schuth G, Bush M, Carling C, et al. Tier-specific evolution of match performance characteristics in the English Premier League: it's getting tougher at the top. J Sports Sci. 2016;34(10):980-987. doi:10.1080/02640414.2015.1082614.
9. Wallace JL, Norton KI. Evolution of World Cup soccer final games 1966-2010: game structure, speed and play patterns. J Sci Med Sport. 2014;17(2):223-228. doi:10.1016/j.jsams.2013.03.016.
10. Carroll C. The physical evolution of Jürgen Klopp's Liverpool: harder, better, faster, stronger. STATSports—Soccer Analytics. 2022.
11. Manchester United Communications Department. United appoint deputy football director. Press release. Manchester: Manchester United FC; 2022.
12. Klaperski, Sandra & Dawans, Bernadette & Heinrichs, Markus & Fuchs, Reinhard. (2014). Effects of a 12-week endurance training program on the physiological response to psychosocial stress in men: A randomized controlled trial. Journal of Behavioral Medicine. 37. 1118-1133. 10.1007/s10865-014-9562-9.
13. Redkva PE, Paes MR, Fernandez R, da Silva SG. Correlation between match performance and field tests in professional soccer players. J Hum Kinet. 2018;62(1):213-219. doi:10.1515/hukin-2017-0171.
14. Mohr M, Krustrup P, Andersson H, Kirkendall D, Bangsbo J. Match activities of elite women soccer players at different performance levels. J Strength Cond Res. 2008;22(2):341-349. doi:10.1519/JSC.0b013e318165fef6.
15. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. J Sports Sci. 2003;21(7):519-528. doi:10.1080/0264041031000071182.
16. Beato M, Drust B, Iacono AD. Implementing high-speed running and sprinting training in professional soccer. Int J Sports Med. 2021;42(4):295-299. doi:10.1055/a-1302-7968.
17. Rampinini E, Impellizzeri FM, Castagna C, Coutts AJ, Wisløff U. Technical performance during soccer matches of the Italian Serie A league: effect of fatigue and competitive level. J Sci Med Sport. 2009;12(1):227-233. doi:10.1016/j.jsams.2007.10.002.
18. Rampinini E, Impellizzeri FM, Castagna C, Azzalin A, Ferrari Bravo D, Wisløff U. Effect of match-related fatigue on short-passing ability in young soccer players. Med Sci Sports Exerc. 2008;40(5):934-942. doi:10.1249/MSS.0b013e3181666eb8.
19. Rostgaard T, Iaia FM, Simonsen DS, Bangsbo J. A test to evaluate the physical impact on technical performance in soccer. J Strength Cond Res. 2008;22(1):283-292. doi:10.1519/JSC.0b013e31815f302a.