



Impact of Intermittent Training and Strength Exercises on the Neuromuscular Efficiency of Football Players Under 15		
تأثير التدريبات المتقطعة وتمارين القوة على الكفاءة العصبية العضلية للاعبين كرة القدم تحت سن 15 عامًا		
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Abstract:

This study examined how different types of training influence athletic performance in U15 male football players. Twenty-five youth athletes from CB Sidi Moussa Football Club (Algeria), aged under 15, with an average height of 1.76 ± 0.07 m, weight of 68.61 ± 6.09 kg, and BMI of 22.1 ± 1.27 , were randomly assigned to an experimental or control group. The experimental group followed a resistance-based training program integrated with intermittent aerobic work, while the control group continued standard football training over one season. Athletic performance was assessed using the Sargent Vertical Jump Test before and after the intervention. Results showed a substantial improvement in vertical jump height for the experimental group, whereas the control group demonstrated minimal or no progress. Statistical analysis confirmed a significant difference between groups, with a large effect size for the experimental group. This indicates that resistance-oriented training significantly enhanced the athletes' neuromuscular ability to produce rapid and explosive muscle contractions. These findings align with previous research suggesting that resistance training during adolescence improves neuromuscular efficiency and supports optimal performance development. Moreover, combining aerobic and resistance training may further enhance neuromuscular effectiveness, allowing young athletes to reach higher levels of athletic potential.

Key words: Intermittent training, Strength exercises, Neuromuscular efficiency, football players under 15

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1 Introduction

Football is a very demanding team sport. Youth athletes will perform repeated, high-intensity bouts of sprints, jumps, rapid direction changes, and tackles during games/practices. Intermittent physical activity(s) impact the cardiorespiratory systems and neuromuscular system of youth football players, creating the need for physical conditioning from an early stage of development. Youth athletes experience continuous maturation of their neuromuscular systems through different developmental stages; thus affecting their ability to control movement, produce force, coordinate motions, and their susceptibility to injuries throughout their youth football career. (Lloyd & Oliver, 2012). This critical period from childhood to adolescence serves as an optimal time to develop neuromuscular efficiency and athletic capabilities. Intermittent or high-intensity interval training (HIIT) have become increasingly popular among youth footballers. These types of training closely resemble the stop-start activity required during match play. Scientific studies have shown that using this type of training results in increasing aerobic capacity as well as repeated sprinting capabilities and all match-specific performance criteria among youth soccer players (Buchheit & Laursen, 2013 ;Kunz et al., 2019). While HIIT has many benefits for metabolism, its impact on explosive strength, rate of force development and jump results are not as clearly defined. Neuromuscular efficiency is the ability of the brain (nervous system) to recruit motor units and coordinate muscle contractions. This efficiency is very important to football because the performance of skills (like running, jumping and stabilising during sudden turns) relies heavily on the rapid activation of the lower-limb muscles (Haff & Nimphius, 2012). Strength training first, improves the neuromuscular system's efficiency by increased motor unit recruiting, synchronisation and generating force more effectively. Secondly, a growing body of literature supports the assertion that supervised resistance training is safe and advantageous for children and adolescents, and often results in increased strength, speed, power and movement competence (Faigenbaum & Myer, 2010 ;Behm et al., 2008 ;Granacher et al., 2016). youth athletes will experience increase of neuromuscular control with the implementation of Integrative neuromuscular training (INT) which will include the component(s) of strength, balance, agility and plyometrics; this will be able to minimise their chance of injury (Sanudo et al., 2025 ;Sañudo et al., 2019). The success of Programs that use intermittent-style activity combined with either neuromuscular or strength, has been proven to

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improve both the metabolic and neuromuscular aspect of performance in youth football populations (Hammami et al., 2023).

Despite the increasing number of published studies about intermittent training, a small number has compared how effectively this type of training on its own may provide neuromuscular adaptation in children (athletes) aged less than 15 years. A smaller number of studies have compared combined the effects of intermittent training and structured strength training on neuromuscular efficiency in children less than 15 years of age. It is of practical and research importance that U15 (groups of 15 players or under) are currently in their transition phase, where there is a high rate of neural adaptation and strength gains are rapid and responsive, so the question is whether or not intermittent training influences neuromuscular efficiency. Accordingly, this research study entitled, "The Effect of Intermittent Training and Strength Training on Neuromuscular Efficiency in Football Players Aged Less than 15 Years", aims to assess the effectiveness of combining intermittent training with strength training for producing improvements in explosive strength and neuromuscular efficiency among the U15 age group of football players. In addition to contributing to the knowledge base, this study will fill a gap in the literature by examining the neuromuscular effects of intermittent training on early adolescents.

2. Methods and Materials

2.1 Participants

The CB Sidi Moussa Algeria football team took part in our research, with each subject being a male U15 player aged between 14 to 15 years old (height=1,76±0,07; weight=68,61±6,09; BMI=22,1±1,27). All subjects regularly attended practices (4-5/week) and had a minimum of 3 years' experience in the sport of football. In addition, prior to the start of the study, all subjects stated that they had not sustained an injury during the 3 months immediately preceding the study, as well as being cleared by a doctor to engage in physical activity at a high-intensity level. Informed consent was obtained from both the subjects and their custodial parent(s)/guardian(s) regarding the purpose of the research and its participation requirements prior to randomisation into two independent groups (an experimental versus a control) to compare differences in neuromuscular performance (assessed via pre-testing during each research group's phase of participation and then again after) between those receiving an

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intermittent structured training program with concurrent strength training and those continuing on with their current practice regimen.

2.2 Materials

Neuromuscular efficiency of the athletes was measured using the Sargent Vertical Jump Test which has undergone rigorous validation to evaluate an athlete's explosiveness in the lower extremities and is commonly found in the field of sports science. Materials needed to complete this assessment included a vertical wall to measure height, a measurement device accurate to within one millimeter, and chalk in order for the athlete to mark the height achieved on the vertical wall. Standard sports training equipment (i.e., cones, resistance bands and stop watches) were utilised to augment the intermittent training sessions provided. Intermittent training sessions occurred on a natural grass football pitch and consisted of segments of repeated bouts of maximum effort running with recovery periods between each bout. The strength-based conditioning component of intermittent training consisted of plyometric exercises, bodyweight circuit training, neuromuscular activation routines as well as lower extremity strength-based activities selected due to their ability to develop explosive strength in developing athletes.

2.3 Design and Procedure

With the objective of measuring the effect of an intermittent strength training program on neuromuscular performance and to establish a baseline measurement, this study utilized a pre-test/post-test quasi-experimentally between the experimental and control groups. The experimental group trained intermittently with strength training three days per week during the duration of the study, while all other groups maintained the typical training schedule for football. Intermittent training reflects the demands of football physiologically; therefore, it was hypothesized that the training would provide benefits by promoting adaptations (nova) in strength and explosive power. During the intervention, all participants participated in a Sargent Jump Test for the same reason. However, each group performed the Sargent Jump Test prior to and after the completion of the training.

2.4 Statistical Analysis

Assessments using SPSS Software of the data collected from pre- and post-test assessments revealed results using descriptive statistics (means, standard deviations, and coefficient of variations) for both groups. For the group comparison (between groups), statistical testing

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using Paired Samples' t-tests assessed within group difference between pre- and post-test scores and Independent Sample's t-tests assessed between experimental and control groups. A $p < 0.05$ was established as the statistical significance. Lastly, effect sizes were calculated (Cohen's d) to assess the magnitude of variance in neuromuscular efficiency and provide additional insight into interpreting the statistical significance.

3 Results

Table (01): Mean, standard deviation, T-value, and significance level between pre-test and post-test Sargent results for the experimental and control groups.

Sample Size	Pre-Test Mean	Pre-Test SD	Pre C.V.	Post-Test Mean	Post-Test SD	Post C.V.
12	42.666	8.793	20.60%	47.166	7.565	16.03%
12	38.416	4.358	11.34%	38.583	4.033	10.45%

Between the two experimental observation periods, there was a marked decrease in the coefficient of variation, from 20.60% down to 16.03%. As a result, there was considerably greater consistency among observations for the post-test vs. pre-test population when compared to the population in the control group. The coefficient of variation for the control population decreased from 11.34% to 10.45%, which represents an improvement of 0.89%.

Table (02): Statistical Indicators for Experimental Group (Sargent Test)

Effect Size	Statistical Sig.	DF	p-Level	"T" Value	SE of Differences	SD of Differences	Mean Diff.	Means
1.61	Significant	11	0.05	5.604	0.802	2.779	4.500	Pre: 42.666
								Post: 47.166

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There was a statistically significant difference between the mean scores of pre and post tests with a higher mean score for post-test than for pre-test ($p=0.0001$), and this difference had an accumulated effect of 1.61 for an overall improvement in explosive strength through the use of the Program.

Graphical Representation of the Sargent Test Before and After Intervention

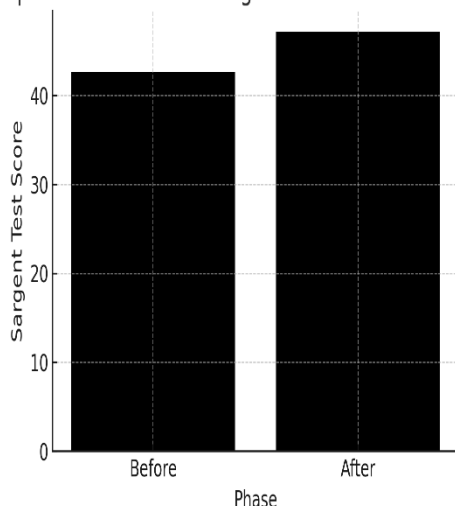


Figure 1: Graphical Representation of the Sargent Test Before and After the Intervention for the Study Group

The Sargent test results show a difference between the initial test and the final results. The bar graph shows that the number of points scored in the final test is higher than in the first test, from around 42.66 to 47.16 points. The difference in scores also matches the number data presented above with an average score of (4.500) and large effect size of (1.61) which confirms that the study group performed significantly better than the pre-training period ($t = 5.604$, $p < 0.05$). Overall the figure supports the claim that the training programme increased the participants' explosive strength.

Table (03): Statistical Indicators for Control Group (Sargent Test)

Effect Size	Statistical Sig.	DF	p-Level	"T" Value	SE of Differences	SD of Differences	Mean Diff.	Means
0.23	Not Significant	11	0.05	0.804	0.207	0.717	0.167	Pre: 38.416
								Post: 38.583

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The control group did not show significant improvements between pre- and post-tests, with a small effect size (0.23), indicating minimal impact of their training routine on explosive strength.

Graphical Representation of Test Results Before and After Intervention

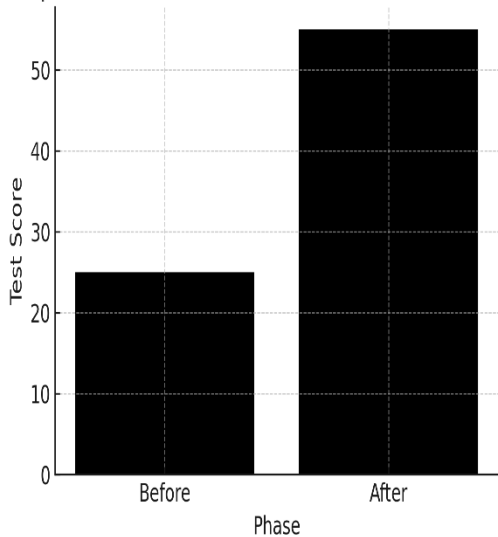


Figure 02: Graphical Representation of Test Results Before and After Intervention

As indicated by the figure (i.e., a comparison of the Sargent test pre- and post-tests), the performance on the Sargent test had notable improvements between pre-test and post-test. A marked increase of around 4.5 points was observed when comparing pre-test to post-test. The summary results indicated a positive mean difference and demonstrated that there was an effective training program associated with the increase in Sargent test performance. The conclusion of the intervention was an improvement in the explosive strength of the participants based on the evidence provided in the figure.

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Figure X: Sargent Test Comparison (Experimental vs Control)

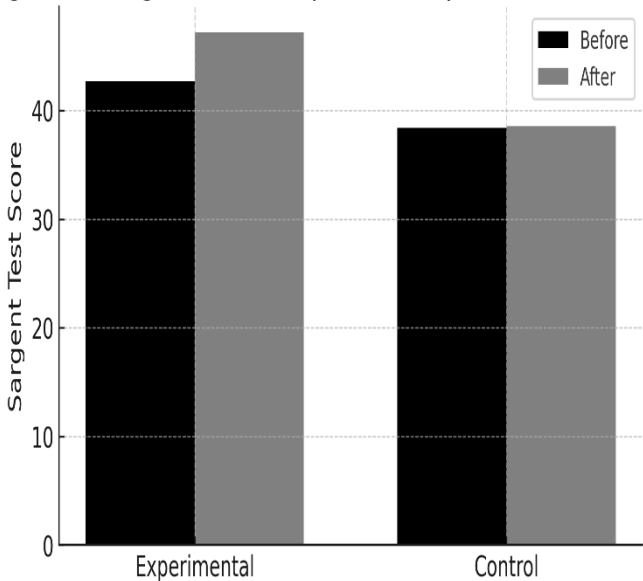


Figure 03: Comparison of Pre- and Post-Test Sargent Scores Between the Experimental and Control Groups

Referring to the Sargent scoring of the participants in this experiment (the Experimental Group and the Control Group), you can see the difference in scores from the time of the intervention. There is a significant increase in the display of explosive strength when comparing the Experimental Group's Sargent Score obtained from the second test compared to the first score (it's much higher), which shows that the training programme helped to increase their explosive strength. However, there is only a small increase in the Control's scores from the first score to the second, which means there was not much difference in the performance of this group. The results in the results section of this article are consistent with the complete results of the experiment discussed in this section.

4 Discussion

This study evaluated whether using two types of training methods helped improve young athletes' (under 15) neuromuscular fitness. Specifically, it aimed to determine how effectively using both types of training methods would affect football players' ability to produce explosive strength from their legs during play. The results indicate that the experimental group's Sargent jump scores were significantly better (post-test) than the pretest scores indicating that the combination of these two training methods produced greater benefits than

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either one alone for improving athletic performance in young male football players. Overall, the combination of the two training techniques produced evidence of increased levels of neuromuscular performance for young football players. The current findings are consistent with previous studies in the fitness industry that have established that intermittent high-intensity interval training (HIIT) is beneficial for stimulating both metabolic and neuromuscular changes in young athletes. Buchheit & Laursen, (2013) stated that HIIT can help to increase oxygen transport, anaerobic metabolism, and one's ability to sprint repeatedly, which all help to indirectly improve a young athlete's neuromuscular efficiency as it relates to the execution of high-force motions, such as jumping. Kunz et al., (2019) also showed that HIIT and small-sided games positively influence youth soccer players' performances; however, they found that the most significant improvement in neuromuscular ability occurred when HIIT was paired with a strength or plyometric training regimen. The current results also add additional support to the existing body of research on youth strength training. Because recent systematic reviews have indicated strength training produces improvements in muscular power and motor unit recruitment as well as overall neuromuscular coordination among adolescents (Faigenbaum & Myer, 2010), our experimental group also produced significantly higher performance on the explosive power tests than the control groups. Therefore, we believe the addition of strength training as part of an intervention will improve a young athlete's ability to develop explosive power. As mentioned by Lloyd & Oliver (2012), ages 12-15 represent a critical window for neuromuscular development and an advantageous time for implementing a structured strength-training programme. In addition, our results are consistent with the findings of previous studies on INT (integrated neuromuscular training) which has combined strength training, balance training, plyometric training, and agility training into one integrated intervention. Sañudo et al (2019) believe that while INT is a well-researched method used to improve neuromuscular control, jump performance, and reduce injury risk for youth athletes. demonstrated similar improvements in male soccer players participating in a neuromuscular training program off-season or during offseason. Conversely, participants in both groups demonstrated similar, but significantly smaller gains in neuromuscular control compared to previous studies that demonstrated little, if any, benefit of traditional training methods for developing high levels of neuromuscular control and coordination. For instance, Ramirez-Campillo et al (2018) indicated that there were very few benefits for developing explosive power after training exclusively using

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"regular" soccer activity; however, the same participants demonstrated substantial increases in explosive power after adding a plyometric training/integration approach to their training program. From this information, it appears that participants wanting to develop maximum neuromuscular efficiency during intermittent endurance events (i.e., soccer) may benefit from the incorporation of an intermittent strength training regime into their overall training program. The benefits seen in the experimental group from a physiological standpoint could have resulted from increased recruitment of motor units, greater firing frequency and more synchronized firing of the motor units due to neural adaptations. Neural adaptations enhance explosive ability before any other changes resulting from hypertrophy take place in an adolescent's muscle mass. The displayed level of neural plasticity that youth athletes exhibit will enhance the apparent neural adaptations compared to older athletes (Lloyd & Oliver, 2012). Overall, these results are in line with the increasing body of evidence that systematic combinations of intermittent conditioning and strength training are superior to purely strength training for the development of neuromuscular structures. This research provides coaches with a variety of recommendations for implementing intermittent and strength-oriented neuromuscular training for athletes. These types of training methods may increase the capacity to produce force quickly, improve sports performance and decrease injury potential in younger football players, but there is also a need to note the limitations of this study. For example, the sample size of this study was relatively limited and it is possible that the length of time over which the participants trained was not adequate for the nervous system to experience maximum adaptations over the long term. Future research is needed to determine the optimal combination of training variables (e.g., intensity, duration and combinations) that would be best for both intermittent and strength-based neuromuscular training, as well as to determine the effects of biological maturation (i.e., age and physical growth) on training adaptation rates. Overall, the findings of this research support the current literature regarding recommendations for developing explosiveness in young athletes involved in organized sports.

5 Conclusion

The present research provides evidence that the combination of intermittent patterns of physical activity with well-structured resistance training leads to an increase in neuromuscular efficiency in youth athletes (football players) aged less than 15. Through the use of a Sargent

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jump test, the experimental group showed a marked increase in ability to produce explosive strength in the lower extremities, whereas the control group only showed a very small increase in this ability. These results provide further evidence that the use of an intermittent training regime, by itself, will not produce an adequate amount of neuromuscular adaptation in youth athletes. On the other hand, when intermittent training is combined with specific strength-training regimens, the result is a measurable increase in neuromuscular function. The findings of this study agree with earlier work that has shown that strength training and neuromuscular training enhance motor unit recruitment, coordination and motor-ability in youth athletes. Additionally, it adds support to findings that suggest that HIIT is most effective when included in conjunction with neuromuscular training to enhance jump performance, sprinting speed, and agility. The rapid neural plasticity of U-15 players likely contributed to the strong response to intervention for the experimental group. Based on the results of the current research, it can be concluded that intermittent training plus strength training / neuromuscular exercises represents a very effective means of improving explosive performance of young football players as compared to traditional training methods alone. In practice, coaches that are training young adolescent athletes should develop and utilize a structured programme of neuromuscular training incorporating flexibility (strength/power), plyometric (vertical jump) ability, and balance as a way to enhance an athlete's physical capacity while assisting them with long term development along the sport. Future research should be directed towards understanding the effects of various frequencies, intensity, volume and type of intermittent training as well as biological maturation in youth football players to provide a better understanding of the adaptation process associated with neuromuscular training in this age group of athletes. However, the current findings provide evidence that a mixture of intermittent and strength based training offers a scientifically proven approach to developing neuromuscular efficiency in youth players under the age of 15.

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