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# Brain Stimulation Exercises Using the Visual (Fit Light) Technique with Timing at Race Distances and their Effect on the Electrical Activity of the Rectus Femoris Muscles of 400-Meter Runners

# Latihan Stimulasi Otak Menggunakan Teknik Visual (Fit Light) dengan Pengaturan Waktu pada Jarak Lomba dan Dampaknya terhadap Aktivitas Listrik Otot Rectus Femoris pada Pelari 400 Meter

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## ABSTRACT

The study aimed to prepare brain stimulation exercises using the visual (Fit Light) technique with timings at race distances after being divided into four consecutive and continuous stages. Then, it aimed to identify its effect on the electrical activity of the rectus femoris muscles of 400-meter runners. The experimental method was adopted with a one-group design, involving eight elite runners from first-division clubs in Iraq. They were all intentionally selected from their original community at a rate of 100%. The researcher distributed (4) devices of the (Fit Light) technology, which operate with daylight (LED) lighting or twilight lighting, distributed over race distances of 100, 200, 300, and 400 meters. They are illuminated with high brightness before the runner reaches 10 meters for each distance. The work continued with the training during the special preparation period for competitions for (10) consecutive training weeks at a rate of (3) training units each week. The researcher also adopted the EMG device with a Bluetooth transmitter using two sensors for each rectus femoris muscle on the right and left. To obtain EMG signal results by reading both the peak and the area for each of the muscles at distances of (300) and (400) meters from the race using two systems of the EMG device, each placed in front of the specified distance. After completing the experiment with pre-measurement, application of the technique, and post-measurement, the researcher verified the results using SPSS. The conclusions and applications indicate that applying brain stimulation training using the visual (Fit Light) technique at timed intervals over the race distances improves the peak of the electrical signal activity (EMG). Also, it reduces the area in both the right and left rectus femoris muscles of the elite 400-meter runners. Based on these results, the researcher recommends that first-class athletics clubs should pay attention to developing the expertise of their employees on how to apply the (Fit Light) visual technology, in a manner that is appropriate and compatible with modernity in this field, so that these training methods suit the specificity of elite (400) meter runners.

**Keywords**: Fit Light, Technology, EMG device, Training

## ABSTRAK

Penelitian bertujuan untuk mempersiapkan latihan stimulasi otak menggunakan teknik visual (Fit Light) dengan pengaturan waktu sesuai jarak perlombaan setelah dibagi dalam empat tahap berturut-turut dan berkesinambungan. Kemudian bertujuan untuk mengetahui pengaruhnya terhadap aktivitas listrik otot rektus femoris pelari 400 meter.

Metode eksperimental diadopsi dengan desain satu kelompok, yang melibatkan delapan pelari elit dari klub divisi satu di Irak. Mereka semua sengaja dipilih dari komunitas aslinya dengan tingkat 100%. Peneliti mendistribusikan (4) perangkat berteknologi (Fit Light) yang beroperasi dengan pencahayaan siang hari (LED) atau pencahayaan senja, didistribusikan pada jarak lomba 100, 200, 300, dan 400 meter. Mereka diterangi dengan kecerahan tinggi sebelum pelari mencapai 10 meter untuk setiap jarak. Pekerjaan dilanjutkan dengan pelatihan selama masa persiapan khusus untuk kompetisi selama (10) minggu pelatihan berturut-turut dengan kecepatan (3) unit pelatihan setiap minggunya. Peneliti juga mengadopsi perangkat EMG dengan pemancar Bluetooth menggunakan dua sensor untuk masing-masing otot rektus femoris di kanan dan kiri. Untuk memperoleh hasil sinyal EMG dengan membaca puncak dan luas masing-masing otot pada jarak (300) dan (400) meter dari perlombaan menggunakan dua sistem perangkat EMG yang masing-masing ditempatkan di depan jarak yang ditentukan. Setelah menyelesaikan percobaan dengan pra pengukuran, penerapan teknik, dan pasca pengukuran, peneliti memverifikasi hasilnya menggunakan SPSS. Kesimpulan dan penerapannya menunjukkan bahwa penerapan pelatihan stimulasi otak menggunakan teknik visual (Fit Light) pada interval waktu tertentu sepanjang jarak lomba meningkatkan puncak aktivitas sinyal listrik (EMG). Selain itu, hal ini juga mengurangi area otot rektus femoris kanan dan kiri pada pelari elit 400 meter. Berdasarkan hasil tersebut, peneliti menyarankan agar klub-klub atletik kelas satu hendaknya memperhatikan pengembangan keahlian para pegawainya tentang bagaimana penerapan teknologi visual (Fit Light), dengan cara yang sesuai dan sesuai dengan modernitas di bidang tersebut, sehingga metode latihan ini sesuai dengan kekhususan pelari elite (400) meter.

**Kata Kunci : Fit Light, Teknologi, Alat EMG, Pelatihan**

## INTRODUCTION

The human brain needs stimuli to activate its cognitive processes, which generate signals for repetitive movements that can sometimes lead to pharmacological fatigue. The signals that enhance brain function are classified into three types based on their intensity, as follows: Sub-threshold signals: These are signals with an intensity lower than the minimum threshold and, therefore, do not cause excitation or response unless they are accumulated over distance and time. Threshold signals: These signals have an intensity that reaches the minimum threshold, causing excitation and subsequent response. Above-threshold signals: These are signals with an intensity higher than the minimum threshold, which inevitably causes excitation as long as the neural tissue is in an excitable state (Mohammed, 2002). In many cases, the sensory receptors distributed throughout the muscles work to internally stimulate the brain. We are unable to coordinate our body movements without these receptors, which provide us with information about our muscles, movement positions, and joints. The nerve endings in the muscles, tendons, and joints, along with the information they transmit, form the foundation for coordinated movement. These receptors also work in conjunction with the vestibular sense (the sense of orientation and body balance) (Michael W. Passer & Ronald E. Smith, 2001). Additionally, the more frequently a response to a specific stimulus is repeated, the faster the decision-making process becomes, reducing reaction time and increasing response speed (Ya'rub, 2002).

Coaches utilize repetitive running movements as a means to enhance brain stimulation processes and increase levels of excitation. This is because nerve signals in the muscles are strengthened through physical exercises that improve the efficiency of the motor system, stimulate motor centers in the cerebral cortex, and inhibit emotional centers (Sadiq et al., 2012). Additionally, varying the exercises within the same sport helps prevent mental confusion and increases motivation for training. Furthermore, experience in diverse sports performances equips athletes with a range of physical attributes and abilities (Kamal, 2001). The nervous system plays a crucial role in stimulating various vital systems in the body to ensure their continuous function. With sustained excitation, the speed of motor activity in living organisms increases (Ali & Ikhlas, 2005). The organization of work within the central nervous system depends on its structure and function, with the complexity and coordination of these elements managed by this vital system. The central nervous system's primary role is to quickly determine the appropriate response to various stimuli, with effects that can be observed immediately (Awis, 2000). Furthermore, due to excessive stimuli, fatigue, or mental exhaustion, the brain may experience a type of sluggishness that affects working memory. Activating this memory enhances perception, particularly auditory and visual perception, and facilitates the brain’s ability to receive, store, and retrieve information. This process ultimately aids in producing the desired response.

This activation depends on the type and intensity of the stimulus or calming factor received by the individual. Advanced psychological studies in this field confirm that activation can occur either involuntarily or through personal willingness. However, the brain cannot be forcibly stimulated to produce desired responses. Instead, those responsible for organizing the training environment must create conditions that promote activation while avoiding coercion, regardless of the type of stimulus affecting the receptors." (Nazer, 2010). Furthermore, when the body responds to external stimuli, complex chemical reactions and mild electrical charges occur, rapidly traveling through nerve fibers (axons). This is followed by additional neural messages triggered by subsequent stimuli, resulting in millions of electrical neural impulses transmitted every second throughout human conscious and unconscious life. These impulses travel to and from the brain, muscles, and glands. The synchronization and integration of these countless neural messages in the cerebral cortex, along with the cerebellum's regulation of their signals, ensure coordinated responses (Wilmore & Costill, 2007). The 400-meter running event requires precise brain signals that ensure accurate control over rapid muscle contractions. Maintaining this high-efficiency level throughout the entire race distance without any distractions or decline in performance is crucial. This necessitates understanding the neural signal dispersion that occurs due to repeated muscle contractions during running, based on the biological nature of the nervous system.

The primary cause of this dispersion is continuous exertion without allowing the body and mind adequate rest or relaxation. As a result, neural energy gradually depletes, leading to a general sense of physical fatigue, mental distraction, and cognitive exhaustion. Consequently, the individual may lose the motivation to continue their task and sustain performance." (Meijman, 2000). Mental distraction affects self-regulation processes, including performance control, which plays a fundamental role in goal-directed behavior. On the other hand, research findings have shown that simple tasks can still be performed automatically even after prolonged sleep deprivation or after completing effort-intensive tasks. However, when performing complex tasks under the influence of mental distraction, intentional control becomes necessary to execute them correctly (Job & Dalziel, 2001). The issue is not limited to mental distraction alone but is also closely linked to biochemical processes that cause delays in performance or running speed. These delays depend on the runner's ability to effectively distribute and manage energy according to race distance requirements. Notably, these biochemical processes are initiated by neural impulses that trigger the release of the enzyme ATPase, accompanied by changes in the polarity of the sarcolemma membrane and alterations in its electrical charge. These changes influence the interaction of protein molecules within the muscle fiber. The active (ATPase) site on the cross-bridge separates myosin from actin, leading to the breakdown of ATP into ADP and an inorganic phosphate ion. This breakdown supplies the necessary energy to return myosin to its active, 'cockeda™ ' position in normal conditions. The energy demand further drives the sequence of contraction power across the cross-bridge, ensuring continued muscle contraction. While myosin is in its activated state, ADP and the inorganic phosphate ion remain attached to the myosin heads. At this stage, the myosin heads can bind to another actin unit further along the thin filament. This binding cycle requires electrical signals originating from the brain to facilitate the repeated detachment and activation of myosin, enabling the sliding filament mechanism to continue. This process persists as long as calcium ions remain present in the sarcoplasm at an increased concentration of 10 μM.

When calcium is returned to the calcium pump in the sarcoplasmic reticulum, ATPase and ATP work to re-block tropomyosin, preventing cross-bridge formation and allowing the muscle fiber to relax (Hussein and Aid, 2013). Additionally, the rate of motor unit activation and the control of excitation patterns are the key factors distinguishing good performance from poor performance (Mohammed, 2000). For this reason, sports coaches, athletes, and sports scientists are constantly searching for modern methods to enhance athletic performance and gain a competitive edge. Visual stimulation is considered one of the most important techniques in the field of sports. This type of stimulation involves a repetitive series of eye-training exercises designed to improve fundamental visual abilities, which are essential for athletes in all competitive sports (Isabel Walker, 2001). This matter is not merely a divergence between chemistry, physiology, and physiological psychology, as the knowledge provided by these fields converges into a single scientific reality: physiology is inseparably linked to the psychological and cognitive interpretations of movement. Therefore, utilizing runners' visual perception through activation provided by visual stimuli in training—such as brain stimulation using the Fit Light technique—supports the training process in ways that directly relate to the decline in bioenergetic production and the challenge of race fatigue. This topic has received extensive attention in research aimed at assisting athletes in maintaining a consistent running speed or managing their energy distribution in a way that minimizes distraction and reduces the sensation of fatigue. Thus, the Fit Light technique in training does not impose restrictions on training load as much as it acts as a stimulus that enhances attention and concentration, particularly in team sports that require mastery of skills and quick responses to sudden movements encountered by players. In this context, the technique is primarily focused on visual perception. In running sports, the purpose of using Fit Light is to serve as a warning stimulus against the decline in mechanical energy during running. It functions to strengthen neural signals and elevate their efficiency according to the requirements that mitigate this decline. Here, visual perception takes control of the stimulation processes, as "perception is an active process that involves multiple activities such as attention, sensation, awareness, and memory, where attention is considered the key to perception (Ahmed, 2002).

Through the researcher's training and academic experience in training physiology, she observed the need to leverage cognitive processes, particularly visual perception, to activate the biochemical mechanisms of muscle contraction in repetitive running movements. This issue is essential in the physical training environment to control the phenomena of distraction and fatigue associated with high-intensity running in the 400-meter race for men. Accordingly, this study aims to prepare brain stimulation training using the Fit Light visual technique, applied at specific intervals along the race distance, which is divided into four continuous sequential phases. Examine its effect on the electromyographic (EMG) activity of the rectus femoris muscles in 400-meter runners.

To achieve these objectives, the researcher hypothesized: There are statistically significant differences between the pre-test and post-test mean results of the experimental and control groups in the peak and area of the EMG signal of the rectus femoris muscles in 400-meter runners, at a 0.05 significance level. There are statistically significant differences between the post-test mean results of the experimental and control groups in the peak and area of the EMG signal of the rectus femoris muscles in 400-meter runners, at a 0.05 significance level.

## RESEARCH METHODOLOGY

The researcher adopted the experimental method, which is defined as a deliberate and controlled modification of specific conditions of a given phenomenon, followed by observation and interpretation of the resulting changes in the phenomenon itself" (Rahim, 2008). The study employed a one-group experimental design with pre- and post-testing under controlled conditions.

The study population consisted of elite 400-meter runners from the Al-Jaish Sports Club who were preparing for the 2020–2021 sports season and were officially registered with the Iraqi Central Athletics Federation. The total population included eight runners, all of whom were intentionally selected (100%) as they represented the targeted phenomenon under investigation.

### Measurement Devices, Techniques, and Research Procedures

The researcher deployed four Fit Light devices equipped with LED lights, which were placed at distances of 100, 200, 300, and 400 meters along the race track. Each device was manually activated by the coach—standing at the center of the track—10 meters before the runner reached the marked distance. This activation was done using a remote control powered by dry batteries. The purpose of these lights was to serve as a stimulus for the brain, alerting the runner to maintain speed and avoid deceleration. The devices were integrated into the training environment alongside the athletes' regular training routines, without any interference from the researcher in terms of training load, methods, or techniques. The experiment lasted 10 consecutive weeks, with three training sessions per week during the special preparation period for competitions.

The researcher also used an EMG (Electromyography) device of the type MyoTrace 400 (USA-made), equipped with a Bluetooth transmitter. Two sensors were attached to each thigh muscle (left and right) to record EMG signals, which were then analyzed using Myo Research XP 1.06.67 software on a laptop. A Sony digital camera (recording at 75 frames per second) was synchronized with the EMG system to measure both peak and total EMG signal area at 300 and 400 meters of the race. Two EMG units were placed at the designated distances to capture the data.

After conducting both pre-test and post-test measurements, the researcher analyzed the results using SPSS (Statistical Package for the Social Sciences) version V26. The statistical analysis included: percentage values, AM (arithmetic mean), SD (standard deviation), and paired sample t-test (t-test for dependent samples).

## RESULTS AND DISCUSSION

Table (1) The results of the pre-tests.

| The tests | | EMG | N | Leven | (Sig) | Ass. |
|---|---|---|---|---|---|---|
| 300 M | Rectus muscle right | Peak | 8 | 0.019 | 0.817 | N.S |
| | | area | 8 | 0.464 | 0.515 | N.S |
| | Rectus muscle left | Peak | 8 | 0.369 | 0.789 | N.S |
| | | area | 8 | 3.449 | 0.100 | N.S |
| 400 M | Rectus muscle right | Peak | 8 | 0.455 | 0.519 | N.S |
| | | area | 8 | 2.428 | 0.158 | N.S |
| | Rectus muscle left | Peak | 8 | 2.661 | 0.154 | N.S |
| | | area | 8 | 1.215 | 0.133 | N.S |

Significance level = 0.05; t-test value is significant at p-value ≤ 0.05

Table (2) The results of the pre- and post-tests.

| The tests | | EMG | Pretest | | Posttest | | Mean Differences | SD Error Man | (t) | (Sig) | Ass. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | AM | ±SD | AM | ±SD | | | | | |
| 300 M | Right | Peak | 558.25 | 35.888 | 611.63 | 10.309 | 53.375 | 29.174 | 5.175 | 0.001 | S |
| | | area | 80.63 | 4.274 | 76.75 | 4.334 | 3.875 | 2.031 | 5.396 | 0.001 | S |
| | Left | Peak | 554.38 | 35.347 | 647.63 | 26.126 | 93.25 | 35.205 | 7.492 | 0.000 | S |
| | | area | 80.25 | 5.064 | 66.75 | 5.651 | 13.5 | 3.546 | 10.769 | 0.000 | S |
| 400 M | Right | Peak | 470.38 | 15.343 | 482.88 | 9.79 | 12.5 | 8.536 | 4.142 | 0.004 | S |
| | | area | 91.38 | 4.838 | 86.38 | 4.138 | 5 | 3.162 | 4.472 | 0.003 | S |
| | Left | Peak | 470.25 | 14.469 | 495.75 | 2.121 | 25.5 | 15.602 | 4.623 | 0.002 | S |
| | | area | 89.75 | 5.471 | 80.75 | G4.4 | 9 | 5.155 | 4.938 | 0.002 | S |

Significance level = 0.05; t-test value is significant at p-value ≤ 0.05, df (N-1)

The pre-test and post-test results indicate an improvement in the research group across all electrical signal variables. Specifically, there was an increase in the peak EMG signal and a decrease in signal area, which suggests stronger muscle contractions with reduced fatigue.

The researcher attributes these results to the effectiveness of brain-stimulating training using the Fit Light technique at timed intervals along the four race distances. This training enhanced the athletes' ability to control the phenomenon of delayed neural signals, which otherwise leads to speed reduction. The Fit Light system acted as a neuromuscular stimulus, reinforcing the nervous command to sustain peak muscle activation and optimize energy expenditure. The observed reduction in EMG signal area further confirmed this improved energy efficiency and neuromuscular coordination. The precise positioning of the Fit Light system and the calculated activation distances played a crucial role in optimizing its effectiveness. The remote activation of the lights 10 meters before the runner reached them served as a sufficient stimulus to activate brain function and enhance mental alertness. This, in turn, facilitated the recovery of neural signal strength, ensuring greater control over fatigue management. Fatigue has various causes, each affecting the brain differently, beginning with the sensation of tiredness and extending its impact to muscle contraction mechanisms, potentially disrupting their function. As highlighted in previous research, "There is no debate regarding information processing without examining automatic and controlled processing. Automatic processing relies on a network of nerves that activate in response to specific stimuli without requiring dynamic control over a given task. This occurs as a result of well-established learning, where stimuli are either structured as a schema or sent directly to the appropriate response areas in the brain with minimal processing (Sareeh and Wahbi, 2010),

Stress, regardless of its source, leads to fatigue in sensory receptors and the nervous system. This strain negatively affects the activity of the central nervous system (CNS) (Adel, 2009). On a biochemical level, stress is linked to chemical dynamics. A cell's function depends on metabolic transformation, where nutrients are converted into energy and waste products are expelled. This process requires energy expenditure. For optimal performance, the energy produced through metabolism must exceed the waste expelled. If the balance shifts in the opposite direction, a toxic effect occurs, leading to functional deficits at the cellular level and, ultimately, cognitive distraction and mental fatigue (Souad, 2006). Additionally, training induces physiological adaptations that affect various body systems. As these adaptations become more positive, an athlete's performance improves, achieving physiological adaptation to workload and enhancing overall athletic capacity (Bahaa, 2018).

Training tools play a crucial role in helping both athletes and coaches streamline the learning and training process. These tools reduce effort and enhance efficiency, provided they are suitable for the sport or specialized activity and appropriately aligned with the athlete's age and training experience (Duane, 2007). The variation in muscle fiber contraction speed is attributed to differences in how ATP (adenosine triphosphate) is broken down. This process occurs at the heavy chain region of the myosin, where energy is derived for muscle contraction (Lewandrowski, 2000).

## CONCLUSIONS AND APPLICATIONS:

1. Implementing brain stimulation training using the Fit Light visual technique at specific race distances enhances peak EMG activity while reducing its amplitude in both the right and left rectus femoris muscles among elite 400-meter runners.
2. Elite-level athletic clubs should focus on developing the expertise of their staff in applying the Fit Light visual technique. Training methodologies should be adapted based on the findings of this study, ensuring that these tools align with the specific needs of elite 400-meter runners while integrating the latest advancements in the field.

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