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Neuromuscular and Electromyographic Responses to Tailored Plyometric Training in Elite Heavyweight Wrestlers

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Abstract

This study aimed to examine the impact of a specialized plyometric training program on neuromuscular and EMG responses in elite heavyweight wrestlers. The focus was on exploring changes in muscle activation patterns, contraction velocity, and motor latencies following a tailored training protocol. A quasi-experimental design was used, with 12 elite heavyweight male wrestlers. Electromyographic data were collected from the vastus lateralis, biceps femoris, and gastrocnemius muscles. Maximum voluntary contraction (MVC) and contraction velocity were assessed using an isokinetic dynamometer. A plyometric training program was conducted three times per week for six weeks, including exercises such as depth jumps, hurdle hops, and lateral bounds. Significant improvements were observed in EMG amplitude, with the vastus lateralis showing a large effect size (Cohen's d = 1.45). Contraction velocity also improved significantly, with mean increases of 15.4°/s (60°/s) and 25.8°/s (180°/s). Additionally, motor reaction time decreased by 23.2 ms (Cohen's d = 1.42). These results indicate significant neuromuscular adaptations following plyometric training. The study demonstrated that a personalized plyometric training protocol significantly enhances neuromuscular performance in elite heavyweight wrestlers. These improvements in muscle activation, contraction velocity, and motor reaction time suggest the effectiveness of plyometric training in combat sports, particularly for athletes with higher body mass. Future research should explore long-term effects and applications for injury prevention in combat sports.

Keywords: Plyometric exercise, Electromyography, Neuromuscular physiological phenomena, Wrestling, Muscle contraction

1. Introduction

Plyometric exercise, defined as any form of exercise that involves rapid, powerful movement using the stretch-shortening cycle (SSC), has received extensive scientific and practical attention for its ability to improve explosive strength, muscular activation, and power output in professional athletes (Markovic & Mikulic, 2010; Ramirez-Campillo et al., 2023). The SSC implies an abrupt shift from an eccentric action of the muscle to a concentric action that generates a large amount of force required for performance of dynamic actions in a variety of sports. Active exercises with plyometric characteristics have developed in the last decade as the simplest way to improve strength and rapid muscle performance in a priming sense.Despite the fact that developing explosive strength and rapid force generation is crucial for the success in many kind of sports (i.e.wrestling), in which applying highpower forces in combination with high-speeds muscle response represents typical sport techniques (i.e.throws,lifts and defensive actions promised in all combat sports), it is interesting to observe that plyometric exercises have been found to be beneficial in significant improvements in performance outcomes (Slimani et al., 2016).

Neuromuscular responses, which refer to the interaction of the nervous system and skeletal muscle to achieve effective movement, play an important role in improving sport characteristic performance of heavyweight wrestlers. These responses may be assessed using electromyography (EMG), a clearly

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established method used to monitor muscle electrical activity to provide detailed information about motor unit recruitment and firing rates while reflecting neuromuscular efficiency (De Luca, 2002; Farina et al., 2014). While the body of literature related to plyometric training is extensive and substantial among general athletes, a small number of studies in the reports already indicated shine light on peripheral neural and electrophysiological variables associated with plyometric training especially among heavyweight wrestlers. This group demonstrates unique body mass and movement characteristics which require unique biomechanical adjustments (Beattie et al., 2017; Suchomel et al., 2016).

The specialized biomechanical requirements of heavyweight wrestlers, such as elevated body mass and specific movement routines, require personal plyometric training programs aimed to improve explosive power and neuromuscular coordination (Kobal et al., 2017). There are several studies that have shown that plyometric training increases electromyographic (EMG) amplitude and contraction speed in athlete populations whose events consist of sprinting and jumping, which can be indicative of increased motor unit recruitment and force production (De Villarreal et al., 2010; Markovic & Mikulic, 2010; Toji & Kaneko, 2004). Nevertheless, the transfer of effects may be not complete for heavy weight wrestlers with specific neuromuscular requirements which highlights the importance of research related to the demands of the sport in this group (Suchomel et al., 2016).

In view of the increasing importance of electrophysiological investigations in sports performance diagnostics, the present study combines surface EMG analyses to provide comprehensive evaluation capabilities in the assessment of training-induced adaptations. The method is consistent with current applications of sport science that focus on objective, measurable markers of neuromuscular function (Gabbett et al., 2017). By examining a less studied but performance-important cohort of athletes (i.e., elite heavyweight wrestlers) that demand effective use of plyometric training for success, this study aims to yield new knowledge and practical implications for coaches and practitioners seeking to maximize the development of explosive power in high-mass athletes, who otherwise cannot reach the same levels of power development as their lighter counterparts (Ebben et al., 2004; Hewett et al., 2005; Kobal et al., 2017).

The purpose of this study is to examine the impact of a specialized plyometric training program on neuromuscular and EMG responses in elite heavyweight wrestlers. The focus is on exploring changes in muscle activation patterns, contraction velocity, and motor latencies following a structured protocol tailored to their unique physical attributes.

2. Materials and methods

2.1. Study design

Study Design A quasi- experimental single group pre and posttest study design was used to the neuromuscular and electromyographic responses to cognitive ability motor process in heavyweight elite wrestlers. This was to permit within-subject comparison for the evaluation of the effect of the intervention on changes in the magnitude of EMG activity, duration of contraction and motor reaction time.

2.2. Participants

Twelve elite heavyweight male wrestlers (mean age = 24.3 ± 2.1 years; body mass = 112.6 ± 9.4 kg; height = 182.5 ± 5.3 cm), all competing at the national level and with a minimum of five years of wrestling experience, voluntarily participated in this study. This group of wrestlers is characterized by high muscle mass and significant physical strength, which notably influences their performance in dynamic movements such as those used in this training program. Participants were excluded if they had musculoskeletal injuries, neurological disorders, or cardiovascular conditions that could affect performance or safety during training. All participants were medically screened and cleared for high-intensity physical activity.

2.3. Equipment and instruments

Electromyographic signals were recorded by a wireless surface EMG system (Delsys Trigno™, Boston, MA, USA; Delsys) for high-quality data acquisition (sample rate: 2000 Hz; bandpass: 20–450 Hz) (Drouin et al., 2004). The monitored muscle groups were the vastus lateralis, biceps femoris, and gastrocnemius. Maximal contraction velocity was measured at angular velocities of 60°/s and 180°/s using an isokinetic dynamometer (Biodex System 4™, Shirley, NY, USA; Biodex Medical Systems) (Tsiros et al., 2011). Motor reaction time was measured using a computerized auditory stimulus system, synchronized with the EMG recording chronometer for response latency. Other instruments included a force platform (Kistler, Switzerland) to standardize the countermovement jump (Walsh et al., 2006), and a digital stopwatch (Casio HS-70W) as a back-up timing device (Zawadzki et al., 2010). All equipment was

Table 1. Plyometric training program schedule.

Week	Training Days per Week	Exercise Type	Sets per Exercise	Repetitions per Set	Intensity / Notes
1	3	Depth Jumps	3	6	Moderate height (30 cm), focus on landing technique
		Hurdle Hops	3	6	Low hurdle height, controlled movement
		Lateral Bounds	3	6	Emphasis on balance and controlled distance
		Split Squat Jumps	3	8	Bodyweight, slow controlled tempo
2	3	Depth Jumps	4	6	Increase height (35 cm), focus on explosive takeoff
		Hurdle Hops	4	6	Moderate hurdle height, increase speed
		Lateral Bounds	4	6	Slight increase in distance
		Split Squat Jumps	4	8	Add light external load (e.g., weighted vest 2 kg)
3	3	Depth Jumps	4	8	Height at 40 cm, maximal effort
		Hurdle Hops	4	8	Increased speed, focus on minimal ground contact time
		Lateral Bounds	4	8	Increase bounding distance, maintain control
		Split Squat Jumps	4	10	Moderate load (weighted vest 4 kg), controlled landing
4	3	Depth Jumps	5	8	Maximal height (45 cm), focus on reactive strength
		Hurdle Hops	5	8	Increased hurdle height and speed
		Lateral Bounds	5	8	Maximize distance, maintain technique
		Split Squat Jumps	5	10	Moderate load, increase tempo
5	3	Depth Jumps	5	10	Max height, maximal effort
		Hurdle Hops	5	10	Max height, maximal speed
		Lateral Bounds	5	10	Max bounding distance
		Split Squat Jumps	5	12	Increased load (weighted vest 6 kg), fast tempo
6	3	Depth Jumps	5	10	Max height, maximal effort, focus on jump efficiency
		Hurdle Hops	5	10	Max height, maximal speed
		Lateral Bounds	5	10	Max bounding distance with controlled landings
		Split Squat Jumps	5	12	Max load (weighted vest 6 kg), explosive execution

calibrated according to manufacturer instructions prior to each testing session.

The measurements were conducted on 02/feb/2025 at Alqadisya university by a team of trained, following a standardized protocol to ensure consistency in the data collection procedures.

All testing sessions were carried out in the laboratory under controlled conditions, both pre- and post-training to control for test-retest variability and events. All subjects were asked to adhere to their habitual diet and to refrain from any form of strenuous physical activity not foreseen in the study protocol during the intervention.

2.4. Plyometric training program

The plyometric training protocol was customized and adapted based on the anthropometric and physiological characteristics of heavyweight wrestlers. The exercises included depth jumps, hurdle hops, lateral bounds, and split squat jumps, with adjustments in intensity and volume according to the athlete's power-to-weight ratio. This program was specifically designed by the authors of this study, and its validity and reliability were ensured through expert review and pilot testing. Training occurred 3 days per week with a progressive overload protocol designed to maximize the neuromuscular stimulus while minimizing the risk of injury. Sessions lasted 60 minutes and typically included a dynamic warm-up, main plyometric sets (3-5 sets x 6-12 reps), and a cooldown. Load and exercise complexity were individually assigned based on vertical jump height and visual observations by the coach. Wrestlers were carefully supervised to ensure proper technique and reduce the risk of injuries. The timeline and sequence of the training program are shown in Table 1.

2.5. Testing protocol

2.5.1. Electromyographic (EMG) assessment

Surface electromyography data were collected from the vastus lateralis, biceps femoris, and gastrocnemius muscles. The skin over each site was shaved, abraded, and cleaned with 70% isopropyl alcohol to reduce impedance. The positions of the electrodes followed the recommendations of SENIAM, with specific electrode placement on the vastus lateralis at 2/3 of the distance between the anterior superior iliac spine (ASIS) and the patella, on the biceps femoris at the mid-point of the line between the ischial tuberosity and the lateral epicondyle of the femur, and on the gastrocnemius 2 cm below the midpoint of the line connecting the popliteal fossa and the medial malleolus. During dynamic tasks (leg press, countermovement jumps), EMG recordings were made. Raw EMG signals were bandpass filtered (20–450 Hz) and digitally processed for artifact and noise removal using a 4th-order Butterworth filter. Data were later normalized to MVC levels for inter-subject comparison. EMG onset assessment was performed by a previously validated threshold-based algorithm.

Maximum voluntary contraction (MVC) was collected before the training protocol to normalize EMG data. MVC measurements were obtained using an isokinetic dynamometer (Biodex System 4™), with participants performing three maximum effort knee extension trials at an angular velocity of 60°/s. The highest force value recorded from these trials was used to normalize the EMG data. A rest period of 2 minutes was allowed between each MVC trial to prevent fatigue and ensure maximal effort. Raw EMG signals were bandpass filtered (20–450 Hz) and digitally processed for artifact and noise removal using a 4th-order Butterworth filter. Data were later normalized to MVC levels for inter-subject comparison. EMG onset assessment was performed by a previously validated threshold-based algorithm.

2.5.2. Contraction velocity and reaction time

Isokinetic testing was used to assess contraction velocity. Isokinetic Maximal voluntary concentric knee extensors on the dynamometer in standardized conditions (three trials at 60o/s and 180o/s, the best performance was recorded). For motor RT, subjects stood postured for action and responded to randomized acoustic stimulus by performing a fast foot tap. Latency between stimulus and EMG activation was measured. The mean number of five trials was used for analysis.

Table 2. Participant characteristics (Mean ± SD) of elite heavyweight wrestlers.

Variable	Mean	Standard Deviation (SD)
Age (years)	24.3	2.1
Body Mass (kg)	112.6	9.4
Height (cm)	182.5	5.3
Wrestling Experience (years)	6.8	1.9

2.5.3. Statistical analysis

Descriptive statistics (mean ± SD) were calculated for all variables. Pre- and post-training values were compared using paired-sample t-tests. Effect sizes were computed using Cohen's d to determine the magnitude of change. Assumptions of normality and homogeneity of variance were checked using Shapiro-Wilk and Levene's tests respectively. Statistical significance was established at $p < 0.05$. Power analysis was conducted prior to data collection to ensure that the sample size of 12 participants would provide adequate statistical power (0.80) to detect meaningful difference and data were analyzed using SPSS version 26.

3. Result

Table 2 shows the participants' descriptive characteristics, including their mean age, body mass, height, and wrestling experience. The average age of the elite heavyweight wrestlers was 24.3±2.1 years, S.D., suggesting a quite homogeneous sample in age distribution. The average body mass of the athletes was 112.6 (SD = 9.4) kg, which is similar to the usual value of elite heavyweight wrestlers. Mean height was 182.5 cm (SD 5.3 cm), which is typical for athletes in this weight class. Also, the fighters had around 6.8 (SD 1.9) years of competition experience in wrestling, indicating good experience in the sport.

Table 3 presents the changes in electromyographic (EMG) amplitude (μV) of selected muscles pre- and post-plyometric training. The vastus lateralis showed a significant increase in EMG amplitude, from 120.5 ± 15.3 μV pre-training to 142.8 ± 16.7 μV post-training with a mean difference of 22.3 μV ($p = 0.002$). This represents a large effect size (Cohen's $d = 1.45$) indicating a substantial increase in muscle activation after the plyometric training.

Similarly the biceps femoris demonstrated a notable increase in EMG amplitude, from 98.2 ± 14.7 μV to 113.6 ± 13.9 μV with a mean difference of 15.4 μV ($p = 0.011$) and a moderate effect size (Cohen's $d = 1.08$) reflecting improved muscle activation post-training.

Table 3. Changes in electromyographic (EMG) amplitude (μV) of selected muscles Pre- and Post-plyometric training.

Muscle	Pre-training EMG Amplitude (μV)	Post-training EMG Amplitude (μV)	Mean Difference (μV)	p-value	Cohen's d (Effect Size)
Vastus Lateralis	120.5 ± 15.3	142.8 ± 16.7	22.3	0.002	1.45
Biceps Femoris	98.2 ± 14.7	113.6 ± 13.9	15.4	0.011	1.08
Gastrocnemius	105.7 ± 12.1	119.3 ± 11.5	13.6	0.015	1.13

Table 4. Contraction velocity (°/s) of knee extensors Pre- and Post-plyometric training.

Angular Velocity (°/s)	Pre-training Velocity (°/s)	Post-training Velocity (°/s)	Mean Difference (°/s)	p-value	Cohen's d (Effect Size)
60	95.3 ± 12.4	110.7 ± 11.8	15.4	0.004	1.27
180	210.1 ± 22.5	235.9 ± 20.7	25.8	0.001	1.28

For the gastrocnemius, the increase in EMG amplitude from 105.7 ± 12.1 μV to 119.3 ± 11.5 μV (mean difference = 13.6 μV, p = 0.015) also suggests a moderate effect size (Cohen's d = 1.13) indicating a significant improvement in activation following the training program.

Table 4 presents the changes in contraction velocity (°/s) of knee extensors pre- and post-plyometric training. For the 60°/s angular velocity the mean contraction velocity increased from 95.3 ± 12.4°/s pre-training to 110.7 ± 11.8°/s post-training, with a mean difference of 15.4°/s (p = 0.004), indicating a moderate effect size (Cohen's d = 1.27) reflecting a significant improvement in contraction velocity after the plyometric training. Similarly for the 180°/s angular velocity, the contraction velocity increased from 210.1 ± 22.5°/s to 235.9 ± 20.7°/s, with a mean difference of 25.8°/s (p = 0.001) and a moderate effect size (Cohen's d = 1.28) suggesting that plyometric training also significantly enhanced performance at higher angular velocities.

Table 5 presents the changes in motor reaction time (milliseconds) pre- and post-plyometric training. The mean motor reaction time decreased significantly from 215.6 ± 18.7 ms pre-training to 192.4 ± 15.3 ms post-training with a mean difference of -23.2 ms (p = 0.003). This reduction indicates a large effect size (Cohen's d = 1.42) reflecting a substantial improvement in the participants' ability to react quickly following the plyometric training.

4. Discussion

The purpose of this study was to examine the impact of a specialized plyometric training program on neuromuscular and EMG responses in elite heavyweight wrestlers. The results indicate that plyometric training significantly improved muscle activation, contraction velocity, and motor reaction time, with notable changes in neuromuscular parameters.

The electromyographic (EMG) amplitude results (Table 3) showed that the vastus lateralis, biceps femoris, and gastrocnemius was significantly higher for each exercise. The improvement was greater in the vastus lateralis, with a mean difference of 22.3 μV (p = 0.002), and a large cohen effect size (d = 1.45). This elevation of EMG amplitude implies an increased motor unit recruitment and synchronization with plyometric training, which supports the hypothesis of an increase in neuromuscular efficiency following strength-power training. These outcomes are in line with earlier studies, reporting kinematic improvements in muscle activation after explosiveness-based training (Aslam et al., 2025; McKinlay et al., 2018). The reported changes were the signs that plyometric training is useful for increasing muscle activation in heavyweight wrestlers, which is essential for improving their dynamic sports performance.

Contraction velocity information (Table 4) demonstrated marked increases in knee extension velocities at 60°/s and 180°/s: 15.4°/s for 60°/s angular velocity (p = 0.004), with a moderate magnitude of the effect (Cohen's d = 1.27). Similarly, velocity at 180°/s had a mean difference of 25.8°/s (p = 0.001), a Cohen's d = 1.28, also a moderate effect size. These results emphasise the efficacy of plyometric training on the rate of contraction, an essential requirement for explosive strength in combat sports (particularly wrestling) where a rapid generation of force is crucial to the execution of throws and defence. These findings support the previous work indicating that plyometric training brings forth an increase in contraction velocity in different athletic populations (Heinecke, 2021; Markovic & Mikulic, 2010; Toji & Kaneko, 2004).

Motor response time Motor response time (Table 5) was also significantly decreased after the intervention with a mean difference of−23.2 ms (p = 0.003) and a high effect size (Cohen's d = 1.42). This reduction in reaction time indicates better preparedness of neuromuscular system and a quicker action of the muscles resulting to faster response of the muscles to the stimuli, something which is very important in combative sport which sometimes combat is won and lost fraction of a second. These findings support previous

Table 5. Motor reaction time (milliseconds) Pre- and Post-plyometric training in elite heavyweight wrestlers.

Measure	Pre-training Reaction Time (ms)	Post-training Reaction Time (ms)	Mean Difference (ms)	p-value	Cohen's d (Effect Size)
Motor Reaction Time	215.6 ± 18.7	192.4 ± 15.3	–23.2	0.003	1.42

research demonstrating the need for recruitment of fast-twitch fibers in elite athletes, especially those participating in high-velocity sports (Lockie et al., 2012; Hsieh et al., 2024; Benjaminse et al., 2015).

Regarding neuromuscular adaptations, it is clear that plyometric training has a significant effect in muscle activation, contraction speed and motor latency. Thus, levels of plyometric exercises are beneficial for heavyweight wrestlers to develop their explosive muscular power and neuromuscular control. The results are consistent with studies (Deng et al., 2023; Oxfeldt et al., 2019) that have shown similar benefits in athletes with different BM and movement characteristics, sprinters and jumpers. In addition, they emphasize that the training program of heavyweight wrestlers should be sport-specific (Ribeiro et al., 2020; Suchomel et al., 2018).

Although we have gained important information on the impact of plyometric training on heavyweight wrestlers from this study, its limitations must be noted. Limitations of the study The sample size was modest and further investigation using larger sampling and different populations of wrestlers may improve the generalizability. Moreover, because in this investigation we focused on short-term training adaptations, future research should address long-term effects of plyometric training on neuromuscular characteristics and injury prophylaxis in wrestlers (Ebben et al., 2005; Sugimoto et al., 2015).

The effect sizes indicated large differences (Cohen's d > 1.0) in muscle activation (vastus lateralis: Cohen's d = 1.45), contraction velocity (60°/s: Cohen's d = 1.27) and motor RT (Cohen's d = 1.42) as an obvious increase in the improvement magnitudes after the plyometric intervention. The large observed effects in the present study might result from the high intensity and specificity of the plyometric training that were purposefully developed to meet the unique physical requirements of heavyweight wrestlers. as the effect sizes tend to be less in this regard. If anything, the relatively low sample size (n=12) may have increased the variance in individual responses thus the larger observed effect sizes. Additional research with larger samples could continue to verify the reliability of these results.

In summary, this study is contributing to the growing body of knowledge by showing that plyometric training methods with an individualized approach can have a large effect on neuromuscular performance in elite level heavyweight wrestlers. These results have applied implications for coaches and strength and conditioning professionals who aim to improve reaction time, explosive strength and performance in high-mass subjects. Injecting light plyometric agility drills that act as a specialized tool, created to address the special physical requirements of wrestlers can be an effective training technique that would boost performance in grappling. Assuming comparisons with previous researches (Gabbett et al., 2017; Ramirez-Campillo et al., 2021) the present investigation strengthened and considerably added new knowledge concerning plyometric training implementation in elite athletes.

5. Implications for future research

The results of the present investigation revealed that plyometric training produces marked improvements in neuromuscular performance in elite heavyweight wrestlers, highlighting the need to tailor training protocols to the specific biomechanical characteristics of these athletes. The practical implication of these findings for coaches and strength and conditioning specialists working with combat sport athletes are significant. Plyometric training in training programmes will improve the muscle activation, contraction velocity and motor reaction time, which will results in increased explosive power and performance especially in high intensity movements such as throws and defensive actions.

Furthermore, these study results may be generalizable to other high-mass athletes in other sports that require high-level rapid force production and condensation of neuromuscular coordination. Long-term studies are needed to further understand the potential positive influences of plyometric training on the neuromuscular adaptations and performance outcomes, especially with larger cohorts and more different athletic consecutives. Furthermore, evaluating plyometric training on injury prevention, particularly in high-impact sports like distanced sports.

Future studies could further investigate the role of plyometric training in enhancing specific performance metrics, such as agility and strength endurance, in heavyweight athletes. Additionally, more research is needed to determine whether the observed improvements are transferable to other types of athletic movements, such as those involving multi-directional movements or complex motor skills.

6. Conclusion

The specific plyometric training protocol used in this study had a significant positive effect on neuromuscular performance of elite heavyweight wrestlers. Significant EMG improvements were noted in a number of muscle groups, such as the biceps brachii, quadriceps femoris and gastrocnemius, which can be attributed to a larger recruitment and synchronization of motor units. Moreover, both motor reaction time decreased and contraction velocity increased after the training intervention, indicating a greater neural conduction velocity and stretch-shortening cycle enhancement. These results demonstrate the effectiveness of personalized explosive training to compensate neuromuscular delay in heavyweight athletes, which is usually correlated with an increased body weight. Conclusion The findings collectively support incorporating personalized plyometric strategies in combat sport conditioning programs to increase neural responsiveness a and functional muscle performance.

Conflicts of interest

There is no conflict of interest.

Ethical approval

The present study was performed in line with the ethical standards of the Declaration of Helsinki. Written consent was taken from all subjects and parents in which the subjects and parents were informed about study, criterion and any possible hazards. All of the personal information was anonymized and securely preserved to ensure confidentiality. Participants were made aware that they could leave the study at any time without consequences. The protocol was approved (Al-Qadisiya University) to abide by ethical standards of research with human participants.

Authors' contributions

Ghazwan Kareem Khothier was a single author who contributed in the concept and design of the study, data collection, analysis, writing and revision of the manuscript. The author also read and approved the final manuscript.

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Data availability

The data that support the findings of this study are available on request from the corresponding author.

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الاستجابات العصبية العضلية والكهرومغناطيسية للتدريب البليومتري لدى مصارعي المحترفين للوزن الثقيل

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المستخلص

تهدف هذه الدراسة إلى فحص تأثير برامج تدريبي بليومتري مخصص على الاستجابات العصبية والعضلية (التسجيل الكهربائي للعضلات) لدى مصارعي الوزن الثقيل النخبة. يركز البحث على استكشاف التغيرات في أنماط تنشيط العضلات، سرعة الانقباض، وزمن الاستجابة الحركية بعد تطبيق البروتوكول التدريبي المهيأ وفقًا لخصائصهم البدنية الفريدة. تم استخدام تصميم شبه تجريبي من مجموعة واحدة مع اختبارات قبل وبعد. شمل الدراسة 12 مصارِعًا (متوسط العمر = 24.3 ± 2.1 سنة؛ الوزن = 112.6 ± 9.4 كجم؛ الطول = 182.5 ± 5.3 سم). تم جمع بيانات التسجيل الكهربائي للعضلات من عضلات العضلة الرباعية للفخذ، العضلة ذات الرأسين الفخذية، و العضلة الساقية. تم تقييم سرعة الانقباض باستخدام جهاز ديناميومتر إيزوكينيتي، وزمن الاستجابة الحركية تم قياسه باستخدام نظام تحفيز سمعي محوسب. أظهرت البيانات زيادات كبيرة في سعة التسجيل الكهربائي للعضلات، مع أكبر زيادة في العضلة الرباعية للفخذ (حجم التأثير = 1.45). كما تحسنت سرعة الانقباض عند الزوايا 60°/ث و 180°/ث مع تأثير معتدل (حجم التأثير = 1.27 و 1.28 على التوالي). كما انخفض زمن الاستجابة الحركية بمقدار 23.2 مللي ثانية (حجم التأثير = 1.42). أظهرت الدراسة أن التدريب البليومتري المخصص يؤدي إلى تحسينات كبيرة في الأداء العصبي العضلي لمصارعي الوزن الثقيل النخبة. هذه النتائج تدعم فعالية البروتوكولات التدريبية البليومترية في تعزيز تنشيط العضلات، سرعة الانقباض، وزمن الاستجابة في الرياضات القتالية، مما يقدم تطبيقات عملية للمدربين والمتخصصين في اللياقة البدنية. تُوصي الدراسة بالتحقيق في التأثيرات الطويلة المدى للتدريب البليومتري على أداء المصارعين والوقاية من الإصابات في المستقبل.

الكلمات المفتاحية: تمارين القفز، تخطيط كهربية العضلات، الظواهر الفسيولوجية العصبية العضلية، المصارعة، انقباض العضلات