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Research of the Axillary and Accessory Nerve Conduction Velocities of Wrestlers

Investigación de las Velocidades de Conducción de los Nervios Axilares y Accesorios en Luchadores

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SUMMARY: Wrestling subjects athletes to frequent neck and shoulder impacts and compressions. This study examines axillary and accessory nerve conduction velocities in wrestlers and a control group while considering their correlation with anthropometric data. Additionally, it explores preclinical nerve conduction changes in these injury-prone areas. The study includes 41 male participants: 20 national elite wrestlers (mean age 21.4 ± 3.49) and 21 controls (mean age 23.14 ± 2.9). Anthropometric measurements and hand grip strength assessments were performed, along with monofilament tests for hand touch sensitivity. Motor nerve conduction latencies of the axillary and accessory nerves were evaluated using surface electromyography (EMG). Results reveal that accessory nerve latencies are significantly higher in wrestlers on both sides, indicating reduced nerve conduction velocity. Axillary nerve latencies did not significantly differ between groups. Correlation analysis shows a moderate connection between axillary nerve latency and weight, body mass index, and hand circumference. Hand grip strength exhibits a high correlation with hand length and a moderate correlation with arm circumference, forearm circumference, hand circumference, neck circumference, chest circumference, and sports age. Monofilament tests do not reveal significant differences in hand touch sensitivity between groups. This study suggests that accessory nerve conduction velocity may decrease in wrestlers due to repetitive neck and shoulder impacts, potentially affecting muscles like the trapezius and sternocleidomastoideus, which these nerves innervate. This may lead to limitations in scapula and head-neck movements. To prevent subclinical changes from progressing to symptomatic conditions, proactive measures, such as head and neck exercises, hand manipulation, massage, electrotherapy, and regular head and neck rest intervals, are recommended. This research underscores the importance of safeguarding the health of wrestlers in these vulnerable areas.

KEY WORDS: Wrestler; Electromyography; Accessory nerve; Axillary nerve; Nerve Conduction Velocity.

INTRODUCTION

The eleventh cranial nerve, composed of special visceral efferent fibers, consists of both cranial and spinal components. The cranial portion originates from the motor nucleus known as the nucleus ambiguus, while the spinal portion arises from the first six cervical segments of the spinal cord and the nucleus nervi accessorii. The spinal root ascends through the foramen magnum, while the cranial root emerges from the retroolivary sulcus in multiple roots and joins the spinal root near the jugular foramen, forming the truncus nervi accessorii. As it exits the cranial cavity through the foramen jugulare, the accessory nerve gives rise to internal and external rami. Fibers from the nucleus ambiguus join the vagal nerve and ultimately terminate as the recurrent laryngeal nerve in the pharynx and larynx. Meanwhile, the external ramus fibers originating from the spinal root travel downward alongside the internal jugular vein and innervate the trapezius and sternocleidomastoid muscles (Taner *et al*., 2014) (Fig.1).

Due to its superficial and lengthy course, the accessory nerve is susceptible to injury. After exiting the cranium, it descends through the neck, traversing the posterior triangle formed by the anterior sternocleidomastoid muscle and the posterior trapezius muscle (Ellis *et al*., 2023). Hypertrophy of these muscles can potentially compress or impinge upon the accessory nerve, resulting in motor dysfunction. This can manifest as muscle weakness, pain,

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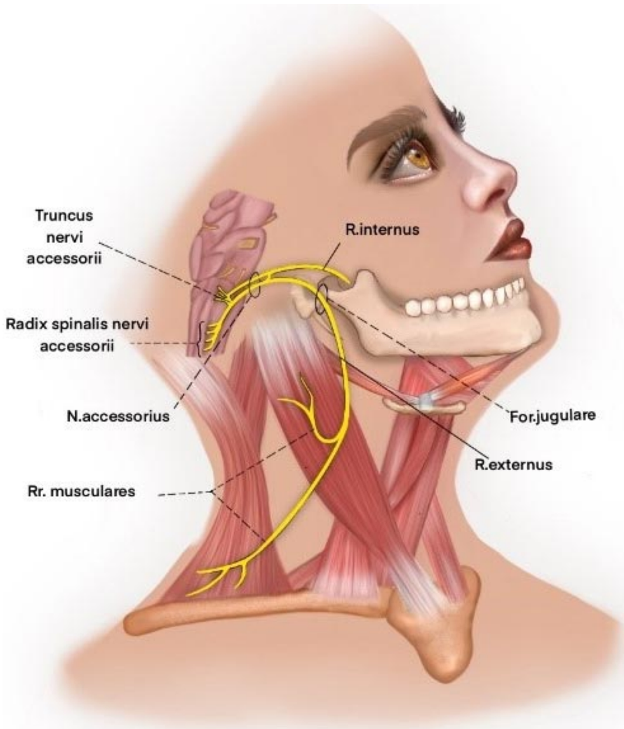

Fig. 1. The course of accessory nerve in the neck.

and limited range of motion in the affected muscles. In cases of accessory nerve lesions, sternocleidomastoid and trapezius muscles exhibit flaccid paralysis. The paralysis in the sternocleidomastoid muscle weakens the rotation of the head to the opposite side, while trapezius muscle damage leads to shoulder joint sagging, impaired shoulder abduction beyond 90 degrees, and possible winging of the scapula. Furthermore, in the presence of a supranuclear lesion of this nerve, damage to the fibers going to the trapezius muscle occurs contralaterally, while that of the sternocleidomastoid muscle is limited to the ipsilateral side (Taner *et al*., 2014).

The axillary nerve, one of the two terminal branches of the brachial plexus, originates from the C5-6 segments and passes through the lateral axillary space. Upon reaching the deltoid muscle, it bifurcates into anterior and posterior branches. The posterior branch contains sensory and motor fibers that provide innervation to the deltoid and teres minor muscles (Fig. 2) Sensory fibers from this branch become superficial as the superior lateral cutaneous nerve of the arm, supplying sensation to the skin covering the deltoid muscle. The anterior branch encircles the humerus's front side and reaches the deltoid muscle's deep surface, sensing the skin around its distal area.

In terms of its course, the axillary nerve travels laterally to the radial nerve, passes beneath the shoulder joint, and reaches the deltoid muscle. Acute traumas such as humerus fractures or dislocations are the primary causes of damage to this nerve, resulting in impaired arm abduction, deltoid muscle atrophy, and sensory disturbances in the shoulder region. While partial damage can often be managed with physical therapy, complete damage typically necessitates surgical intervention (Radic *et al*., 2018). Additionally, the compression of the axillary nerve and posterior humeral circumflex artery within the quadrilateral space can lead to a condition known as quadrilateral space syndrome, characterized by diffuse shoulder pain, nondermatomal paresthesia, and tenderness above the quadrilateral space (Hangge *et al*., 2018).

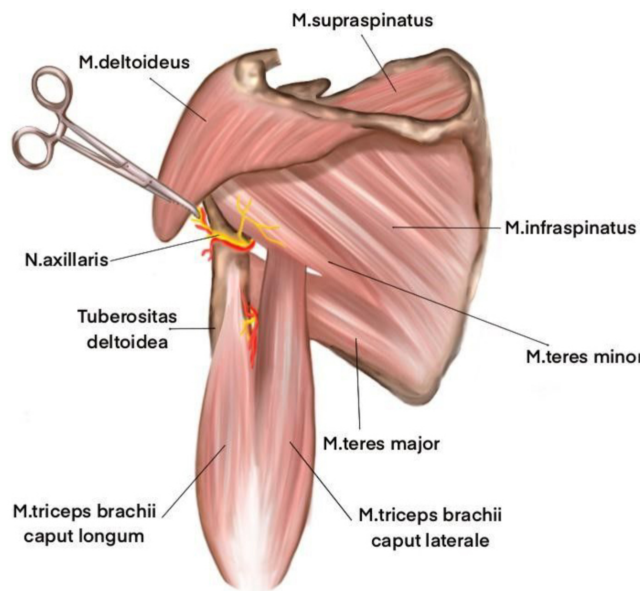

Fig. 2. The course of the axillary nerve in the shoulder.

Wrestling is a globally popular sport with origins dating back to the Sumerians in 5000 BC (Akbarnejad & Sayyah, 2012; Agarwal & Mann, 2016). It demands not only high physical fitness but also enduring mental resilience. Wrestling matches consist of two 3-minute halves separated by a 30-second break. Victory is achieved by either pinning the opponent to the ground or obtaining a higher score. In Olympic competition, athletes participate in both freestyle and Greco-Roman wrestling across seven weight classes. While Greco-Roman wrestling exclusively employs upper limbs, freestyle wrestlers can utilize both upper and lower limbs (Thomas & Zamanpour, 2018).

Sports injuries occur when the body's tissues endure forces beyond their normal endurance limits during athletic activities (Emrah *et al*., 2017). Wrestling, due to its grappling-based nature, poses a higher risk of injury compared to other sports (Pirruccio *et al*., 2022). Although various sports lead to positive morphological changes like increased muscle strength in the utilized body parts, they can also result in negative consequences such as joint degeneration and nerve injuries from overuse and compression (Colak *et al*., 2004). Several studies have investigated peripheral nerve injuries related to sports (Colak *et al*., 2009; Selekler *et al*., 2014; Colak *et al*., 2018). Overuse of muscles during sports can subject nerves to pressure at specific transition points, potentially leading to reduced nerve conduction velocity (Colak *et al*., 2004; Ozbek *et al*., 2006; Selekler *et al*., 2014).

Nerve conduction velocity studies, crucial in diagnosing nerve and muscle disorders, have become routine in recent years (Akyuz *et al*. 1998). These studies involve applying an external electrical stimulus to motor, sensory, or mixed-type nerves to initiate an impulse. This process provides information about the nerve's normophysiological or pathophysiological conditions, typically evaluating fibers with the highest conduction velocities. Nerve conduction velocity slowdowns can occur due to various factors, including neuropathy and nerve injury.

In this study, we aim to investigate whether wrestling, which heavily involves the head and neck regions, affects the conduction velocities of the accessory and axillary nerves compared to a control group. Additionally, we aim to explore the relationship between nerve conduction velocities and anthropometric data.

MATERIAL AND METHOD

The study adhered to the Declaration of Helsinki, obtaining ethical approval from the local Research Ethics Committee of Kocaeli University (ethical clearance number 2018/150).

Subjects. A total of 41 male participants were included, comprising 20 elite wrestlers (mean age 21.4 ± 3.49 years) and 21 individuals in the control group (mean age 23.14 ± 2.9 years). Wrestlers had a minimum of 3 years of professional wrestling experience, no history of surgery in the assessed areas, and were free from conditions impacting nerve conduction velocity, such as diabetes mellitus or polyneuropathy. The control group consisted of non-athletic medical school students without a history of surgery or conditions affecting nerve conduction velocity.

Table I. Participant characteristics.

	Control Group Mean ± SD (n:21)	Wrestler Group Mean ± SD (n:20)	p value
Age	23,14 ± 2,9	21,4 ± 3,49	0,089
Height	181,48 ± 7,02	178,95 ± 7,98	0,288
Weight	83,67 ± 15,29	89,33 ± 21,8	0,434
BMI	25,48 ± 4,9	27,65 ± 5,37	0,183
Sports Age	0 ± 0	8,8 ± 3,44	**0,000**

Table I displays participants' average age, height, weight, BMI, and sports age. Efforts were made to ensure the control group and wrestlers had similar mean ages, heights, and weights to facilitate meaningful comparisons of nerve conduction velocities.

Research Procedures. Participants provided written informed consent, demonstrating their understanding of the study's procedures, benefits, and risks. Assessments occurred at Kocaeli University Faculty of Medicine, Department of Anatomy, and the EMG Clinic within the Department of Neurology.

Anthropometric measurements were conducted using a non-foldable, non-elastic tape measure with a 7 mm width, ensuring rigidity to prevent deformations during measurements (Otman *et al*., 2014). Various body dimensions were assessed, including total upper limb length from the acromion process to the middle phalanx tip, arm length from acromion to olecranon, forearm length from olecranon to the styloid process, and hand length from styloid process to middle phalanx tip. Shoulder circumference was measured beneath the acromion with arms slightly abducted, while shoulder joint circumference was taken in an upright position with the tape passing over the acromion and encircling the axillary region. Neck circumference was measured below the prominentia laryngea, chest circumference at the midpoint of tidal volume, and waist circumference was measured at the level of the umbilicus. Arm and forearm circumferences were measured approximately 15 cm above the medial epicondyle and styloid process, respectively, with the subject standing. Wrist circumference was measured at the styloid process of the radius during a standing position (Norton & Olds, 2006; Otman *et al*., 2014).

Hand Grip Strength. Baseline Digital Hand Dynamometer with a 300-pound (136.078 kg) capacity (Fabrication Enterprises, Inc., Irvington, NY) was employed for hand grip strength measurements. Measurements were taken with participants in a seated position, shoulders adducted, elbows flexed at 90°, forearms in a midrotation position, and supported. The procedure adhered to the standards recommended by the American Association of Hand Therapists (AEHT). We allowed 1-1.5 minutes between measurements, taking the average of three measurements for each hand in kilograms of force (Haidar *et al*., 2004). The dynamometer was calibrated and adjusted to fit each athlete's hand.

Light Touch Sensitivity. Light touch sensitivity was evaluated with Semmes-Weinstein monofilaments (Baseline®, White Plains, New York, USA) Filaments were applied perpendicular to predefined points on each hand until bending, with the participant identifying the lowest-weight filament perceived (Kahl & Cleland, 2005).

Nerve Conduction Measurements. Axillary motor nerve conduction was conducted by stimulating the nerve with electrical stimulation from the supraclavicular fossa (Colak *et al*., 2009). The accessory nerve was stimulated just above the midpoint of the posterior margin of the sternocleidomastoid muscle (Barbero *et al*., 2012). Neurophysiological measurements focused on motor nerve conduction velocities of the axillary and accessory nerves, using a Neuropack M I. MF.B-9204K. Nerve latencies, amplitudes were recorded. The conduction velocity of a nerve is inversely proportional to latency.

Statistical Analysis. IBM SPSS (Statistical Package for Social Sciences) v20 software was used for data analysis, employing descriptive statistics, the Kolmogorov-Smirnov test to assess normal distribution, the Mann-Whitney U Test for group comparisons. Pearson and Spearman correlation tests were used for parametric data. A significance level of $p<0.05$ was applied.

RESULTS

Anthropometric length measurements were analyzed and compared between the control group and wrestlers. The analysis revealed that wrestlers had significantly longer hand lengths than the control group ($p<0.05$). However, no significant differences were observed in other length measurements.

When the average anthropometric circumference measurements examined, notably, wrestlers showed significant advantages in these measurements compared to the control group in every region. Because, the wrestlers exhibited significant muscle hypertrophy in various body regions due to their rigorous wrestling training.

The hand grip strength measurements for the control group and wrestlers were also analyzed. That wrestling's demands on physical strength and intense training programs resulted in a noticeable difference in both right and left hand grip strength in favor of wrestlers ($p<0,001$)

Table II provides a comparison of axillary and accessory nerve latencies and amplitudes between the control group and wrestlers. Wrestlers showed significantly higher accessory nerve latencies on both the right and left sides ($p<0.05$). When comparing axillary nerve latencies, it was noted that wrestlers had a slightly higher average on the right side, but this difference was not statistically significant ($p>0.05$). However, wrestlers demonstrated a statistically significant difference in favor of higher right axillary nerve amplitude, potentially attributed to their hypertrophic shoulder muscles and dense muscle fiber composition in the measured region.

Table III presents correlations between sports age, weight, BMI, anthropometric length measurements, and nerve latencies. Notably, moderate correlations were found between weight, BMI, hand length, and axillary nerve latency ($p<0.01$, $r<0.6$). Additionally, a weak positive correlation was found between accessory nerve latency and sports age ($p<0.05$, $r<0.4$). However, no significant correlations were observed between accessory nerve latency and age, weight, BMI, or length measurements ($p>0.05$).

Correlations between anthropometric circumference measurements and nerve latencies were explored. Moderate positive correlations were identified between left shoulder joint circumference and left axillary nerve latency ($p<0.01$, $r<0.6$). Furthermore, a weak positive correlation was found between forearm circumference and axillary nerve latency ($p<0.01$, $r<0.4$). Additionally, a moderate correlation was observed between hand circumference and axillary nerve latencies ($p<0.01$, $r<0.6$).

While correlations between dynamometer measurements and age, sports age, height, weight, BMI, and

Table II. Accessory and axillary nerve amplitudes and latencies of the participants.

	Side	Control Group Mean ± SD (n:21)	Wrestler Group Mean ± SD (n:20)	p value
Axillary nerve latency	Right	3,5 ± 0,75	3,99 ± 1,92	0,531
	Left	3,55 ± 0,66	3,54 ± 0,53	0,969
Axillary nerve amplitude	Right	10,93 ± 6,22	15,04 ± 6,04	**0,014**
	Left	11,54 ± 5,28	13,99 ± 5,03	0,142
Accessory nerve latency	Right	2,56 ± 0,4	3,21 ± 0,96	**0,043**
	Left	2,66 ± 0,39	3,47 ± 1,14	**0,01**
Accessory nerve amplitude	Right	18 ± 5,87	18,64 ± 7,93	0,775
	Left	16,36 ± 5,72	16,7 ± 6,28	0,861

Table III. Correlation among sports age, weight, BMI, anthropometric length measurements and nerve latencies.

	Right axillary nerve latency	Left axillary nerve latency	Right accessory nerve latency	Left accessory nerve latency
Sports age	r:0,109	r:0,112	**r:0,314**	**r:0,338**
	p:0,497	p:0,088	**p<0,05**	**p<0,05**
Weight	**r:0,466**	**r:0,553**	r:0,252	r:0,080
	p<0,01	**p<0,001**	p:0,117	p:0,624
BMI	**r:0,407**	**r:0,532**	r:0,284	r:0,117
	p<0,01	**p<0,001**	p:0,076	p:0,473
Stroke lenght	**r:0,313**	r:0,244	r:-0,029	r:-0,015
	p<0,05	p:0,13	p:0,861	p:0,928
Right total upper	**r:0,325**	r:0,185	r:0,092	r:0,062
limb length	**p<0,05**	p:0,254	p:0,573	p:0,705
Left total upper limb	**r:0,327**	r:0,164	r:0,066	r:0,139
length	**p<0,05**	p:0,311	p:0,687	p:0,393
Right hand length	**r:0,447**	**r:0,359**	r:0,131	r:0,089
	p<0,01	**p<0,05**	p:0,420	p:0,585
Left hand length	**r:0,472**	**r:0,375**	r:0,146	r:0,139
	p<0,01	**p<0,05**	p:0,373	p:0,393
Right hand	**r:0,421**	**r:0,496**	r:0,264	r:0,049
circumference	**p<0,01**	**p<0,01**	p:0,1	p:0,763
Left hand	**r:0,402**	**r:0,500**	r:0,265	r:0,047
circumference	**p<0,01**	**p<0,01**	p:0,099	p:0,772

length measurements were analyzed, strong correlations were observed between sports age, hand length, and dynamometer measurements ($p<0.01$, $r<0.8$; $p<0.001$, $r<0.8$, respectively).

Correlations between hand dynamometer measurements and anthropometric circumference measurements were investigated. A moderate correlation was found between dynamometer measurements and arm circumference, forearm circumference, hand circumference, neck circumference, and chest circumference ($p<0.001$, $r<0.6$).

Correlations between dynamometer measurements and nerve latencies were researched. Weak positive correlations were observed between axillary nerve latency and hand grip strength ($p<0.05$, $r<0.4$), as well as between right accessory nerve latency and right hand grip strength ($p<0.05$, $r<0.4$).

Lastly, it is important to note that there were no significant differences in light touch senses of the hands between the control group and the wrestlers.

DISCUSSION

Wrestling is a sport that incorporates different functional features. Besides muscle strength, agility, fast reaction time, neuromuscular dexterity, an excellent static and dynamic balance are important factors for performance in this sport.

Nerve conduction velocity can be affected by age, anthropometry and temperature parameters (Jagga *et al*., 2011). In this study, it was reported that there was an inverse relationship between height and sural nerve conduction velocity, but a weak inverse relationship that was not significant between BMI and sural nerve conduction velocity. In our study, care was taken to ensure that both the age and anthropometric data of the wrestler and control group were close to each other, and the room temperature was the same during the test phase.

There were studies showing that peripheric nerves could be effected in sports. For example, that conduction velocities of median and ulnar nerve in rowers, radial nerve in tennis players, axillary, radial and musculocutaneus nerve in ice hockey players, ulnar nerve in volleyball players, sural and tibial nerves in footballers had been diminished was found in other studies (Colak *et al*., 2004; Ozbek *et al*., 2006; Colak *et al*., 2018; Aksu *et al*., 2023).

Cases between 2009 and 2018 were evaluated in an epidemiological study examining sports-related peripheral nerve injuries in the USA. It was found that 21.9 % of the 551,612 cases with peripheral nerve damage were associated with sports, exercise and recreational activities. It has also been reported that the number of sports-related peripheral nerve injuries increased from 6,550 in 2009 to 16,775 in 2018 (Li *et al*., 2021).

Football and wrestling are the two sports branches with the highest risk of serious injury for athletes (Akbarnejad & Sayyah, 2012; Agarwal & Mann, 2016). In a study examining injuries in college wrestlers, match injury rates as high as 30.7 per 1000 athlete contacts were reported. This rate is second only to injury rates in college football players (Jarret *et al*., 1998; Agarwal & Mann, 2016). The highest rate of injuries in which an athlete is away from training for more than 7 days is in wrestling (32.6 %) and baseball (31.0 %) (Powell & Barber-Foss, 1999; Agarwal & Mann, 2016). Among all wrestling injuries, the most common injuries occur in the knee and shoulder joints (Pasque & Hewett, 2000; Barroso *et al*., 2011). In a different study examining 200 sports-related peripheral nerve injuries in high school students, wrestling ranks third among the sports causing peripheral nerve damage (Perlmutter *et al*., 1997).

In a study conducted on a total of 313 Korean male and female wrestlers, when the areas of injury are examined, it was observed that shoulder injuries (12.7 %), head-neck injuries (9.7 %) had been in the top 5 after lower and upper limb injuries. In a study on 125 American wrestlers, when the percentages of injury were examined, the shoulder was at the top with 9.8 % and the neck with 6 % (Otero *et al*., 2017). In our study, we detected a slowdown in the nerve conduction velocity (NCV) of the accessory nerve, which is one of the important nerves in the neck and shoulder region.

Many studies have been conducted on knee injuries in wrestlers (Agarwal & Mann, 2016; Emrah *et al*., 2017). However, some actions of wrestling (yoke, pulling the nape of the hand, etc.) could damage to the shoulder and neck in wrestlers. This damage may possibly increase axillary and accessory nerve latencies. In this study, the latencies of the axillary and accessory nerves, were compared with the control group. Due to the fact that the latency of the spinal part of the accessory nerve in the neck region, is significantly higher than the control group. It seems possible for wrestlers to develop injuries in these areas in the future. No statistically significant difference was found in the axillary nerve latencies. However, a statistically significant difference was found in favor of the wrestlers in the amplitudes of the right axillary nerves. Trainings and matches in wrestling require high muscle activity. It is thought that the hypertrophy of the muscles in the shoulder region caused high muscle fiber density in this region. In cases where the amplitude is low, axonal pathologies in the nerves are considered.

In one study, a significant difference was found nerve conduction velocities of the median and tibial nerves between obese and nonobese groups. Furthermore, a negative correlation was found between BMI and waist hip ratio with motor neve conduction velocities (Majumdar *et al*., 2017). When the relationship between anthropometric measurements and nerve conduction latencies was examined, it was observed that there was a moderate positive correlation between weight and BMI and right accessory nerve latencies ($p<0.01$, $r<0.6$). Because of the fact that latency and nerve conduction velocity was inversely proportional, our results were similar with the reference study.

The monofilament test is an inexpensive method that reliably tests light touch sensation in clinical conditions that interfere with nerve conduction, such as stroke and carpal tunnel syndrome (Suda *et al*., 2021). When monofilament tests were examined; there wasn't any difference in the hand region.

Hand dynamometers, which estimate the force produced by the hand and forearm flexor muscles in different populations, have also become common in the measurement of hand grip strength. It is used in the evaluation of growth, aging, injury, rehabilitation and therapeutic trials (Hogrel, 2015). A high correlation was found between dynamometer measurement data and hand length ($p<0.01$, $r<0.8$), a moderate correlation between arm circumference, forearm circumference, hand circumference, neck circumference, chest circumference, and sports age ($p<0.01$, $r<0.6$). The circumferencial anthropometric measurements evaluate muscle hypertrophy or hypotrophy. The more circumference of a region, the more muscle hypertropy in this region. Therefore, the muscle hypertrophy in synergist muscles effect hand gri strength positively.

The muscles that determine the hand grip strength and are functionally primary are flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus, flexor pollicis brevis, flexor digiti minimi brevis muscles. In terms of anatomical innervation, it is seen that these muscles, which reveal the hand grip function, are innervated by the median and ulnar nerves. The two nerves, accessory and axillary, which we discussed in our study, have no effect on hand grip function except for stabilizing the shoulder, that is, synergist contraction. However, it can be said that the median and ulnar nerves are not affected in order to compensate, while these two nerve conduction velocities decrease due to the overuse of the shoulder and neck regions, which was mentioned before. It was found a strong positive correlation between hand grip strength and median nerve conduction velocity. In our study, a weak positive correlation was found between right accessory nerve latency, which did not contribute to hand grip function, and hand grip strength ($p<0.05$, $r<0.4$).

CONCLUSION

The neck and shoulder regions are the regions that are topographically overused in wrestling, most exposed to impacts and compressions, and frequently injured and degenerated in anatomical structures. In this study, in which the latency of important nerves running in this region was compared with the control group, it was observed that accessory nerve latencies were significantly higher in wrestlers. An increase in latency indicates a slowdown in nerve conduction. The reason for this is thought to be due to the blows to these areas during sports and especially the frequent arm hyperabduction and head rotation movements. As a result, the trapezius and sternocleidomastoideus muscles may be affected, causing restrictions in the scapula and head and neck movements.

Before this subclinical EMG measurement difference detected in wrestlers turns into a symptomatic disease in the future, simple exercises (flexion, extension, rotation of the head, arm hyperabduction, etc.) for the head and neck region can be recommended, methods such as hand manipulation and massage to prevent compression here. In addition, we believe that electrotherapy agents, relaxation, stretching, strengthening exercises and special exercises for these muscles will be beneficial.

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RESUMEN: La lucha libre somete a los atletas a frecuentes impactos y compresiones en el cuello y los hombros. Este estudio examina las velocidades de conducción de los nervios axilares y accesorios en luchadores y en un grupo de control, teniendo en cuenta su correlación con los datos antropométricos. Además, explora los cambios preclínicos en la conducción nerviosa en estas áreas propensas a lesiones. En este estudio se incluyeron 41 participantes masculinos: 20 luchadores de élite nacionales (edad media 21,4 ± 3,49) y 21 controles (edad media 23,14 ± 2,9). Se realizaron mediciones antropométricas y evaluaciones de la fuerza de la garra de la mano, junto con pruebas de monofilamento para la sensibilidad al tacto de la mano. Las latencias de conducción nerviosa motora de los nervios axilares y accesorios se evaluaron mediante electromiografía de superficie (EMG). Los resultados revelaron que las latencias del nervio accesorio ambos lados son significativamente más altas en los luchadores, lo que indica una velocidad de conducción nerviosa reducida. Las latencias del nervio axilar no difirieron significativamente entre los grupos. El análisis de correlación muestra una conexión moderada entre la latencia del nervio axilar y el peso, el índice de masa corporal y la circunferencia de la mano. La fuerza de la garra de la mano exhibe una alta correlación con la longitud de la mano y una correlación moderada con la circunferencia del brazo, la circunferencia del antebrazo, la circunferencia de la mano, la circunferencia del cuello, la circunferencia del pecho y la edad deportiva. Las pruebas de monofilamento no revelan diferencias significativas en la sensibilidad al tacto de la mano entre los grupos. Este estudio sugiere que la velocidad de conducción del nervio accesorio puede disminuir en los luchadores debido a los impactos repetitivos en el cuello y el hombro, lo que potencialmente afecta a músculos como el trapecio y el esternocleidomastoideo, que inervan estos nervios. Esto puede conducir a limitaciones en los movimientos de la escápula y la cabeza-cuello. Para evitar que los cambios subclínicos progresen a cuadros sintomáticos, se recomiendan medidas proactivas, como ejercicios de cabeza y cuello, manipulación de manos, masajes, electroterapia e intervalos regulares de descanso de cabeza y cuello. Esta investigación subraya la importancia de salvaguardar la salud de los luchadores en estas áreas vulnerables.

PALABRAS CLAVE: Luchador; Electromiografía; Nervio accesorio; Nervio axilar; Velocidad de conducción nerviosa.

REFERENCES

Agarwal, S. & Mann, E. Knee injuries in wrestlers: a prospective study from the Indian subcontinent. *Asian J. Sports Med., 7(4)*:e35000, 2016.

Akbarnejad, A. & Sayyah, M. Frequency of sports trauma in elite national level greco-roman wrestling competitions. *Arch. Trauma Res., 1(2)*:51-3, 2012.

Aksu, E.; Colak, T.; Selekler, H. M.; Colak, E.; Mulayim, S.; Son, M.; Bamac, B. & Colak, S. Comparison of nerve conduction velocities of lower extremities between football players and controls. *S. Afr. J. Res. Sport Phys. Educ. Recreat., 45(1)*:1-10, 2023

Akyuz, G.; Ofluoglu, D. & Kayhan, O. Saglikli yasli bireylerde motor ve duyusal sinir iletimi degerleri. *Geriatri, 1(2)*:97-9, 1998.

Barbero, M.; Merletti, R. & Rainoldi, A. *Atlas of Muscle Innervation Zones: Understanding Surface Electromyography and Its Applications*. Cham, Springer, 2012.

Barroso, B. G.; da Silva, J. M. A.; da Costa Garcia, A.; de Oliveira Ramos, N. C.; Martinelli, M. O.; Resende, V. R.; Duarte Júnior, A. & Santili, C. Musculoskeletal injuries in wrestling athletes. *Acta Ortop. Bras., 19(2)*:98-101, 2011.

Colak, S.; Bamac, B.; Mulayim, S.; Dincer, O.; Colak, T.; Selekler, H. M.; Turker, M.; Colak, E.; Ozbek, A. & Sivri, I. Nerve conduction studies of ulnar and median nerves in elite rowers. *J. Anat. Soc. India, 67 Suppl. 2*:S6-S9, 2018.

Colak, T.; Bamac, B.; Alemdar, M.; Selekler, H. M.; Ozbek, A.; Colak, S. & Dinçer, O. Nerve conduction studies of the axillary, musculocutaneous and radial nerves in elite ice hockey players. *J. Sports Med. Phys. Fitness, 49(2)*:224-31, 2009.

Colak, T.; Bamac, B.; Ozbek, A.; Budak, F. & Bamac, Y. S. Nerve conduction studies of upper extremities in tennis players. *Br. J. Sports Med., 38(5)*:632-5, 2004.

Ellis, S.; Brassett, C.; Glibbery, N.; Cheema, J. & Madenlidou, S. The spinal accessory nerve and its entry point into the posterior triangle of the neck. *Folia Morphol. (Warsz.), 82(2)*:256-60, 2023.

Emrah, A.; Tanir, H. & Cetinkaya, E. Gurescilerde sakatlik bolgelerinin arastirilmasi. *Adnan Menderes Universitesi Saglik Bilimleri Fakultesi Dergisi*, *1(1)*:1-4, 2017.

Haidar, S. G.; Kumar, D.; Bassi, R. S. & Deshmukh, S. C. Average versus maximum grip strength: which is more consistent? *J. Hand Surg., 29(1)*:82-4, 2004.

Hangge, P.; Breen, I.; Albadawi, H.; Knuttinen, M.; Naidu, S. & Oklu, R. Quadrilateral space syndrome: diagnosis and clinical management. *J. Clin. Med., 7(4)*:86, 2018.

Hogrel, J. Y. Grip strength measured by high precision dynamometry in healthy subjects from 5 to 80 years. *BMC Musculoskelet. Disord., 16*:139, 2015.

Jagga, M.; Lehri, A. & Verma, S. K. Effect of aging and anthropometric measurements on nerve conduction properties—A review. *J. Exerc. Sci. Physiother., 7(1)*:1-10, 2011.

Jarret, G. J.; Orwin, J. F. & Dick, R. W. Injuries in collegiate wrestling. *Am. J. Sports Med., 26(5)*:674-80, 1998.

Kahl, C. & Cleland, J. A. Visual analogue scale, numeric pain rating scale and the McGill pain Questionnaire: An overview of psychometric properties. *Phys. Ther. Rev., 10(2)*:123-8, 2005.

Li, N. Y.; Onor, G. I.; Lemme, N. J. & Gil, J. A. Epidemiology of peripheral nerve injuries in sports, exercise, and recreation in the United States, 2009 - 2018. *Phys. Sportsmed., 49(3)*:355-62, 2021.

Majumdar, S.; Chaudhuri, A.; Ghar, M.; Rahaman, W. & Hai, A. Effect of obesity on nerve conduction study in an urban population of a developing country. *Saudi J. Sports Med., 17(3)*:162, 2017.

Norton, K. & Olds, T. (Eds.). *Anthropometrica: A Textbook of Body Measurement for Sports and Health Courses*. Delhi, CBS Publishers & Distributors, 2006.

Otman, A. S.; Demirel, H. & Sade, A. Tedavi hareketlerinde temel degerlendirme prensipleri. Pelikan Yayincilik, 2014.

Otero, J. E.; Graves, C. M. & Bollier, M. J. Injuries in collegiate wrestlers at an Elite Division I NCAA Wrestling Program: an epidemiological study. *Iowa Orthop. J., 37*:65-70, 2017.

Ozbek, A.; Bamac, B.; Budak, F.; Yenigun, N. & Colak, T. Nerve conduction study of ulnar nerve in volleyball players. *Scand. J. Med. Sci. Sports, 16(3)*:197-200, 2006.

Pasque, C. B. & Hewett, T. E. A prospective study of high school wrestling injuries. *Am. J. Sports Med., 28(4)*:509-15, 2000.

Perlmutter, G. S.; Leffert, R. D. & Zarins, B. Direct injury to the axillary nerve in athletes playing contact sports. *Am. J. Sports Med., 25(1)*:65-8, 1997.

Pirruccio, K.; Hoge, C. & Kelly Iv, J. D. Comparison of in-season and off-season wrestling injuries presenting to United States emergency departments: 2000-2018. *Phys. Sportsmed., 50(1)*:54-9, 2022.

Powell, J. W. & Barber-Foss, K. D. Injury patterns in selected high school sports: A review of the 1995-1997 seasons. *J. Athl. Train., 34(3)*:277-84, 1999.

Radic, B.; Radic, P. & Durakovic, D. Peripheral nerve injury in sports. A*cta Clin. Croat., 57(3)*:561-9, 2018.

Suda, M.; Kawakami, M.; Okuyama, K.; Ishii, R.; Oshima, O.; Hijikata, N.; Nakamura, T.; Oka, A.; Kondo, K. & Liu, M. Validity and reliability of the Semmes-Weinstein monofilament test and the thumb localizing test in patients with stroke. *Front. Neurol., 11*:625917, 2021.

Taner, D.; Atasever, A. & Durgun, B. *Fonksiyonel Noroanatomi.* ODTU Gelistirme Vakfi, 2014.

Thomas, R. E. & Zamanpour, K. lnjuries in wrestling: systematic review. *Phys. Sportsmed., 46(2)*:168-96, 2018.

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