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STUDY OF WRIST ISOKINETIC POWER AND MUSCLE ACTIVATION IN TEAM SPORTS

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Abstract

Objective: This paper investigated wrist isokinetic strength and electrical muscle activations in volleyball, basketball, and handball players.

Methods: Therefore, the sample consis ted of 36 male volleyball (n=12), basketball (n=12), and handball players (n=12) over 18 years of age. Participants' weight and height were measured. Forearm muscle electrical activation was measured at an angular velocity of 30°/sec and 120°/sec to determine dominant wrist isokinetic strength. One-way analysis of variance (ANOVA) test was used to compare the groups. The Tukey test was used for post-hoc comparisons. Spearman's correlation coefficient was used to check the difference between the values.

Results: There were significant differences in muscle activations at 120ºflex emg and 120ºext emg angles between the groups ($p<0.05$). The source of the difference was the volleyball group. There were significant differences in isokinetic strength values at all angles between the groups ($p<0.05$). The source of the difference was the volleyball and basketball groups. There was a positive correlation between 120º flex emg and 30º peak torque ext and 30º peak torque flex and 120º peak torque flex in the basketball group ($p<0.05$).

Conclusion: In our comparison, the strength characteristics of the team branches we determined have a similar structure, but differences have been detected at the technical level depending on the characteristics of the branch. EMG and Isokinetic values differ in this sense.

Keywords: *Isokinetic dynamometry, surface EMG, wrist biomechanics.*

Introduction

Sports hold a crucial and ever-growing significance in our lives. With each passing day, their importance is rapidly developing and increasing. Similar to other disciplines, researchers have started to establish pathways to success in sports on scientific foundations. Reaching the top, surpassing boundaries, and connecting with the masses are all important objectives of sports. Numerous researchers are foreseeing human limitations and striving to surpass them, aiming to achieve peak performance. Physiological and anthropometric examinations play a significant role in selecting the right athlete and training model and cultivating the intuition for targeted success.[1]
A person requires specific movements to engage in sports. The locomotor system fulfils this need. The locomotor system gives the body a distinct shape and enables it to move and change its position. This system consists of three parts (skeleton, muscles, and joints). Bones and joints serve as attachment points for muscles, but they are incapable of independent movement. The primary elements responsible for movement are the muscles that attach to the bones.[2] There are variations in the physical structures of athletes across different sports branches.[3]
Volleyball, basketball, and handball players must exhibit quick and precise gameplay. Given the duration of the competitions, these players need to possess fundamental motor characteristics such as strength, endurance, speed, mobility, and coordination.[4] However, they must also possess complex motor characteristics, such as enduring strength and quickness, to effectively execute attacks.[5,6] Athletes with the right technique and tactics can achieve success by systematically developing their aerobic and anaerobic capacity. Along with fundamental motor characteristics. Strength is considered the most crucial motor characteristic for technical skills in sports.[7]
It is essential to comprehend the biomechanical properties of skeletal muscles to gain a better understanding of body movements during exercise.
Biomechanics is the scientific field that explores the mechanical structures of the living body. Biomechanical studies specifically concentrate on the mechanisms of active body parts during movement.
Some biomechanical properties are strength, endurance capacity, and power. These three parameters should be well-measurable or well-known by researchers. Since the establishment of the relationship between strength and athletic performance in strength-based sports, the assessment of muscle performance using isokinetic dynamometers has garnered significant importance.[8] Some of the most well-known dynamometers are Biodex, Humac Norm Cybex, Kin-Com, Lido, and Merac brand systems.[9]
Electromyography (EMG) is a specialized field that utilizes electronic devices to measure muscle activity, analyze data, and display results. Electromyography is based on practitioners' knowledge of anatomy and physiology. Electromyography has numerous applications in rehabilitation, assessment, treatment planning, progress monitoring, outcome evaluation, sports training, and research. This technology helps to distinguish muscle function from real function.[10]
EMG enables researchers to record and evaluate muscle activation potentials during various movements. One advantage of EMG is that it offers clearer and more detailed information about deep muscles.[11,12]
Various techniques have a significant impact on performance in multiple sports branches. It is crucial to analyze these techniques thoroughly. In handball, basketball, and volleyball applications, wrist extension and flexion movements, along with the involved muscles, play a vital role in executing techniques like dunking, passing, shooting, and rebounding, thereby achieving top-level performance. With this in mind, our aim was to investigate the wrist isokinetic strength values and electrical muscle activations of volleyball, basketball, and handball players.
Hypotheses:
H_0 (Null Hypothesis): There are no significant differences in wrist isokinetic strength and muscle activation among volleyball, basketball and handball players.
H_1 (Alternative Hypothesis): There are significant differences in wrist isokinetic strength and muscle activation among volleyball, basketball and handball players.

Methods

Participant Selection Criteria

Inclusion Criteria

- ✓ Being 18 years of age or older
- ✓ Actively participating in volleyball, basketball, or handball for at least the past year
- ✓ Having a training history of at least 3 days per week
- ✓ Willingness to participate in wrist isokinetic tests and surface EMG measurements

Exclusion Criteria

- ✓ Having had an injury or surgical intervention in the upper extremity (especially wrist, elbow, shoulder) in the last 6 months
- ✓ Having a history of neuromuscular disorders
- ✓ Use of medications or supplements that may affect performance during testing
- ✓ Having a deformed hand structure or skin conditions that may interfere with EMG electrode placement

A power analysis was performed to determine the sample size. The results showed that a sample of 36 would be large enough to detect significant differences. Therefore, the sample consisted of 36 male volleyball (n=12), basketball (n=12), and handball players (n=12) over 18 years of age.

Ethical Approval and Participant

The study was approved by the Clinical Research Ethics Committee of Ordu University (No: 2018/264 & Date: 27.12.2018). All players were briefed on the research purpose and procedure. Informed consent was obtained from all participants.
Prior to the measurements and tests, all participants received the necessary theoretical information. The measurements did not involve any invasive procedures. Age, weight, height, isokinetic strength (Humac Norm Cybex), and EMG (Noraxon) values were measured. All participants were allowed to warm up before the measurements. Each measurement lasted 50-55 minutes. Some participants withdrew from the study during the measurements. Those who withdrew during the measurements were not included in the study.

Anthropometric Measurements

Body height was measured using a Holtain Harpenden Portable Stadiometer (Crosswell, Crymych, Pembs.UK.). Height was measured in the anatomical position during deep inspiration, with bare feet touching the ground and the distance between the sole of the foot and the anthropometric set in a plane tangent to the upper vertex border. Body weight was measured using a bioelectrical impedance tool (Jawon x-scan plus II, Jawon Medical Co., Ltd., Korea)

Warm-up Procedure

Each participant ran on the treadmill for five minutes to warm up before the test and then completed the warm-up program by performing 3-4 minutes of stretching and stretching exercises for the wrist joint.

Isokinetic Strength Measurements

Wrist flexion and extension muscle strengths were measured at 30º and 120º angles using a Humac Norm Cybex isokinetic dynamometer (Cybex Humac Norm, Cybex International Inc. Ronkonkoma, NewYork, USA).

During wrist flexion muscle strength measurements, the muscles that are activated during joint movement are m. flexor carpi radialis, m. palmaris longus, m. flexor carpi ulnaris, m. flexor digitorum superficialis, m. flexor digitorum profundus, and m. flexor pollicis longus. In wrist extension muscle strength measurements, the muscles activated during joint movement are m. extensor carpi radialis longus, m. extensor carpi radialis brevis, m. extensor digitorum, m. extensor carpi ulnaris.[13]

After the warm-up program, each participant was taken to the isokinetic dynamometer. His dominant wrist isokinetic strength was measured using a computerized isokinetic dynamometer (Cybex Humac Norm, Cybex International Inc. Ronkonkoma, NewYork, USA) at angular velocities of 30°/sec and 120°/sec. Each participant was seated on the isokinetic dynamometer with lumbar support and a knee angle of 90°. Participants were secured to the device with crossed chest straps to stabilize his position. The dominant arm was securely positioned to prevent interference with the measurements and electrodes.

After setting the flexion and extension angles to 30º and 120º, corrections at 45° were calculated by the computer to eliminate the effects of gravity on strength. Each participant underwent maximal isokinetic testing. Isokinetic power was measured by performing six maximal contractions following three trials at an angular velocity of 30°/sec and six maximal repetitions following three trials at an angular velocity of 120°/sec. Each participant rested for one minute between the tests at different speed values. The strength values of the dominant wrist were measured. Each participant had a five-minute rest between the two measurements. He was verbally and visually motivated to exert maximal effort during the tests. Peak torque values were calculated as a muscle strength measurement parameter.

EMG Measurements

EMG (Noraxon, Scottsdale, AZ, USA) device was used as the measurement tool. Excess hair was shaved before recording with the EMG system. The body surface was cleaned with alcohol to ensure improved electrical contact with the electrodes. Electrodes were placed on the flexor and extensor muscle groups following the SENIAM reference. EMG was measured using wireless surface Ag/AGCL electrodes and a Noraxon device (Noraxon, Scottsdale, AZ, USA). EMG data were calculated in microvolts for the entire movement, passing through a 20 Hz high-pass Butterworth filter and a 200ms RMS smoothing filter. %MVIC (Maximum Voluntary Isometric Contraction) was used for the normalization of values.

From the moment of the command to start the movement 10-second intervals were recorded starting from the moment of maximum force. From the moment of maximum force in the analysis. 10 seconds of filtered EMG signals covering 5 seconds before and 5 seconds after was used. The iEMG (integrated EMG) of these 10-second EMG recordings calculated and used in the analysis.

Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS, v. 22.0) at a significance level of 0.05 and 0.01. Descriptive statistics such as arithmetic means (X) and standard deviations (SD) were used for descriptive variables. Normality was tested using the Shapiro-Wilk test, which indicated that the data were normally distributed.

To compare the groups, the one-way ANOVA test was utilized, and post-hoc comparisons were conducted using the Tukey test. Spearman's correlation coefficient was used to assess the relationships between the values.

Results

The volleyball, basketball, and handball groups had a mean age of 22.00±1.41, 19.66±2.87, and 20.08±2.02 years, respectively. They had a mean body height of 181.83±5.14, 184.75±12.00, and 178.75±10.26 cm, respectively. They had a mean body weight of 77.75±11.41, 71.08±13.19, and 80.41±10.94 kg, respectively (Table1).

Table 1. Descriptive Characteristics

Parameter	Branch	n	Mean±SS	Minimum	Maximum
Age (year)	Volleyball	12	22.00±1.41	20.00	24.00
	Basketball	12	19.66±2.87	18.00	24.00
	Handball	12	20.08±2.02	18.00	28.00
Height (cm)	Volleyball	12	181.83±5.14	175.00	195.00
	Basketball	12	184.75±12.00	167.00	203.00
	Handball	12	178.75±10.26	169.00	200.00
Bodyweight (kg)	Volleyball	12	77.75±11.41	64.00	105.00
	Basketball	12	71.08±13.19	48.00	92.00
	Handball	12	80.41±10.94	61.00	96.00

There were significant differences in muscle activation values at 120ºflex emg and 120ºext emg between the groups ($p<0.05$) (Table2).
The volleyball group (54.74±12.87) had a significantly higher mean muscle activation value than the basketball (46.31±9.35) and handball groups (45.51±10.02) at 120ºflex emg. The volleyball group had a significantly higher mean muscle activation value (49.51±12.00) than the basketball (46.61±18.80) and handball groups (43.85±10.00) at 120º ext emg (Table3).

Table 2. Mean Muscle Activation Scores by Groups

Groups		n	X±SD	p
30º flex emg	Volleyball	12	37.44±4.18	
	Basketball	12	39.48±8.68	.678
	Handball	12	36.85±8.98	
30ºext emg	Volleyball	12	47.80±9.24	
	Basketball	12	48.49±12.83	.875
	Handball	12	46.14±11.96	
120ºflex emg	Volleyball	12	54.74±12.87	
	Basketball	12	46.31±9.35	**.023**
	Handball	12	45.51±10.02	
120ºext emg	Volleyball	12	49.51±12.00	
	Basketball	12	46.61±18.80	**.047**
	Handball	12	43.85±10.00	

Table 3. Significant Difference in Muscle Activation Scores

Groups and Parameters			p
30º flex emg	Volleyball	Basketball	.790
	Volleyball	Handball	.981
	Basketball	Handball	.678
30º ext emg	Volleyball	Basketball	.988
	Volleyball	Handball	.932
	Basketball	Handball	.870
120º flex emg	Volleyball	Basketball	**.035**
	Volleyball	Handball	**.041**
	Basketball	Handball	.052
120º ext emg	Volleyball	Basketball	**.044**
	Volleyball	Handball	**.017**
	Basketball	Handball	.881

There were significant differences in isokinetic strength values at all angles between the groups ($p<0.05$). The handball group (25.33±6.67) had a significantly higher mean isokinetic strength score than the volleyball (22.41±7.21) and basketball groups (19.83±7.76) at 30º peak torque ext ($p<0.05$). The handball group (28.58±6.38) had a significantly higher mean isokinetic strength score than the volleyball (22.75±8.50) and basketball groups (25.08±12.83) at 30º peak torque flex ($p<0.05$). The volleyball group (21.43±7.21) had a significantly higher mean isokinetic strength score than the handball (18.83±4.89) and basketball groups (18.66±7.55) at 120ºpeak torque flex ($p<0.05$) (Table4).
The volleyball group (20.66±4.94) had a significantly higher mean isokinetic strength score than the handball (18.16±2.58) and basketball groups (14.58±5.05) at 120ºpeak torque ext ($p<0.05$). The volleyball group (168.66±59.45) had a significantly higher mean isokinetic strength score than the basketball group (123.00±49.94) at 120ºtotal ext ($p<0.05$). The volleyball group (189.58±84.80) had a significantly higher mean isokinetic strength score than the basketball group (164.75±88.89) at 120ºtotal flex ($p<0.05$) (Table4).

Table 4. Mean Isokinetic Strength Scores by Groups and significant Difference in Isokinetic Strength Scores

Parameter	Group	n	Mean±SD	Overall p	Pairwise Comparisons	p
30° Peak Torque (Extension)	Volleyball	12	22.41±7.21		Volleyball – Basketball	.660
	Basketball	12	19.83±7.76	**.016**	Volleyball – Handball	**.020**
	Handball	12	25.33±6.67		Basketball – Handball	**.017**
30° Peak Torque (Flexion)	Volleyball	12	22.75±8.50		Volleyball – Basketball	.824
	Basketball	12	25.08±12.83	**.027**	Volleyball – Handball	**.030**
	Handball	12	28.58±6.38		Basketball – Handball	**.036**
120° Peak Torque (Extension)	Volleyball	12	20.66±4.94		Volleyball – Basketball	**.021**
	Basketball	12	14.58±5.05	**.041**	Volleyball – Handball	**.010**
	Handball	12	18.16±2.58		Basketball – Handball	.123
120° Peak Torque (Flexion)	Volleyball	12	21.43±7.21		Volleyball – Basketball	**.018**
	Basketball	12	18.66±7.55	**.026**	Volleyball – Handball	**.008**
	Handball	12	18.83±4.89		Basketball – Handball	.998
120° Total Work (Extension)	Volleyball	12	168.66±59.45		Volleyball – Basketball	**.037**
	Basketball	12	123.00±49.94	**.036**	Volleyball – Handball	.849
	Handball	12	157.91±30.52		Basketball – Handball	.193
120° Total Work (Flexion)	Volleyball	12	189.58±84.80		Volleyball – Basketball	**.027**
	Basketball	12	164.75±88.89	**.027**	Volleyball – Handball	.922
	Handball	12	177.75±44.70		Basketball – Handball	.907

There was no correlation between muscle activation and isokinetic strength in the volleyball group($p>0.05$) (Table5).
There was a positive correlation between muscle activation and isokinetic strength at 120º flex emg and 30º peak torque ext ($p<0.05$). There was a positive correlation between muscle activation and isokinetic strength at 30º peak torque flex and 120º peak torque flex($p<0.05$) (Table6).
There was no correlation between muscle activation and isokinetic strength in the handball group($p>0.05$) (Table7).

Table 5. The correlation between muscle activation and isokinetic strength (volleyball group)

EMG Parameter	Statistic	30° Peak Torque (Ext)	30° Peak Torque (Flex)	120° Peak Torque (Ext)	120° Peak Torque (Flex)	120° Total Work (Ext)	120° Total Work (Flex)
30° Flexion EMG	r	0.299	0.210	0.097	0.235	−0.145	−0.006
	p	.346	.513	.763	.462	.653	.985
30° Extension EMG	r	0.192	0.273	0.171	0.368	0.132	0.348
	p	.551	.391	.595	.240	.682	.268
120° Flexion EMG	r	0.722	0.699	0.493	0.705	0.110	0.240
	p	**.008**	**.012**	.103	**.011**	.734	.452
120° Extension EMG	r	0.213	0.352	−0.061	0.346	−0.343	0.268
	p	.507	.262	.851	.271	.245	.399

Table 6. The correlation between muscle activation and isokinetic strength (basketball group)

EMG Parameter	Statistic	30° Peak Torque (Ext)	30° Peak Torque (Flex)	120° Peak Torque (Ext)	120° Peak Torque (Flex)	120° Total Work (Ext)	120° Total Work (Flex)
30° Flexion EMG	r	0.266	0.294	0.273	0.100	0.332	0.067
	p	.403	.354	.391	.757	.292	.835
30° Extension EMG	r	0.271	0.108	−0.051	−0.189	0.013	−0.232
	p	.395	.738	.874	.557	.969	.467
120° Flexion EMG	r	−0.162	−0.115	−0.033	−0.091	−0.001	−0.109
	p	.615	.721	.919	.778	.999	.736
120° Extension EMG	r	−0.448	−0.298	−0.284	−0.120	−0.110	−0.038
	p	.144	.347	.371	.710	.733	.907

Table 7. The correlation between muscle activation and isokinetic strength (handball group)

EMG Parameter	Statistic	30° Peak Torque (Ext)	30° Peak Torque (Flex)	120° Peak Torque (Ext)	120° Peak Torque (Flex)	120° Total Work (Ext)	120° Total Work (Flex)
30° Flexion EMG	r	0.476	0.386	0.111	0.146	0.277	0.128
	p	.117	.215	.730	.650	.383	.693
30° Extension EMG	r	0.355	0.370	0.119	0.207	−0.031	0.139
	p	.258	.237	.713	.519	.923	.666
120° Flexion EMG	r	−0.115	−0.009	−0.460	−0.064	−0.197	−0.260
	p	.721	.978	.132	.844	.540	.414
120° Extension EMG	r	−0.051	0.302	−0.139	−0.015	−0.309	0.163
	p	.876	.340	.666	.963	.328	.612

Discussion

Strength is a fundamental motor property enabling skeletal muscles to generate movement and support joint mobility. It can vary according to angular velocity, contraction type, and neural activation potential. In our study, we observed significant differences in both isokinetic strength and muscle activation (EMG) values across sports branches, particularly at 120º flexion and extension. These findings suggest that branch-specific technical demands play a key role in shaping strength characteristics.[8]

Altıncı, conducted a study comparing wrist muscle strength and nerve conduction velocities in volleyball players. The research revealed a positive correlation between dominant forearm radial nerve latency (ms) and dominant wrist flexion peak torque value at 120º/sec.

Additionally, a positive correlation was observed between height and dominant wrist flexion peak torque values at 60º/sec and 120º/sec. The study also explored whether there was a significant difference in wrist extension and flexion peak torque values at 60°/sec and 120°/sec between dominant and non-dominant hands however, no significant difference was detected.[13]

In our study, however, we found no significant correlation between muscle activation and isokinetic strength parameters in the volleyball group. The results are thought to be related to the effect on free throw accuracy rather than ball speed. Muscle strength can increase or decrease based on the angular velocity variable, varying with the types of contraction and electrical potentials. Our results showed differences in different branches. Our study showed that there was a statistically significant difference in muscle activation values at 120ºflex emg and 120ºext emg between the groups. Our results also showed a statistically significant difference in isokinetic strength values at all angles between the groups.

Gürol and Yılmaz conducted a study investigating the relationship between isokinetic strength training and strength in various sports branches, such as wrist, elbow, and shoulder strength training on an isokinetic device for basketball shooting. They concluded that sport-specific isokinetic strength training at specific angles and speeds can yield positive results in terms of sports performance and technical development.

Additionally, they highlighted the value of isokinetic strength training as an effective method for rehabilitation after injuries and evaluating improvements in athletic performance. The versatility of this training method allows for targeting different joints in strength development and monitoring progress over time.[14]

Our results show that the handball group had a higher average isokinetic strength score than the volleyball and basketball groups at 30º maximum torque flexion and extension. The volleyball group, on the other hand, showed better performance than the other groups in 120º maximum torque flexion, extension, and 120º flexion EMG and 120º extension EMG. Additionally, the volleyball group achieved a higher isokinetic strength score than the basketball group at 120º total extension and flexion. This sport-specific difference is consistent with the literature, which attributes it to the decrease in normalized work values during wrist flexion with increasing angular velocity.

During the free throw in basketball, the ball is thrown using the elbow, knee, and hip joints more while also being grasped in hand. Gürol and Yılmaz documented that wrist isokinetic strength affected free throw accuracy rates in basketball players. As previously mentioned, the active use of the wrist joint in the shooting technique of basketball could be a contributing factor to the observed results. Additionally, in volleyball, the wrist joint is utilized more actively in the dunking service technique compared to other service techniques.[14]

Aka investigated the correlation between isokinetic strength of the wrist and shoulder joints and serve and spike speed in elite female volleyball players. The study revealed that the average values of concentric isokinetic forces for wrist extension and flexion, measured at an angular velocity of 90°s-1, were 11.40±4.27 Newton meters (Nm) and 18.90±5.74 Nm, respectively. The results show that volleyball players use their flexor muscles more effectively during serves and spikes, resulting in higher force values during wrist flexion than during extension. Thus, while handball players may develop force at lower velocities due to repetitive gripping actions, volleyball players appear better adapted to producing rapid power at higher speeds.[15]

Our results revealed a positive correlation in muscle activations and isokinetic strength parameters between 120º flex emg ve 30º peak torque ext and 30º peak torque flex and 120º peak torque flex. Our results did not reveal a significant correlation between muscle activation and isokinetic strength parameters in the handball group.[16]

In conclusion, isokinetic measurements are employed to assess the strength, endurance, and power characteristics of muscle groups. In this context, the speed of limb movement can be maintained constant and set at a preselected speed. This allows for the comparison of an equal amount of force against additional resistance. During isokinetic measurement, muscular torque is generated at speeds ranging from 0 to 300 degrees/second. Strength development is measured between 30 degrees and 60 degrees per second, strength continuity between 120 degrees and 180 degrees per second, and power measurement between 120 degrees and 300 degrees per second. There is a positive correlation between strength and EMG.

In this regard, the EMG values in the 120° flex-ext movement differed between the branches in our study, while the difference in terms of isokinetic values also occurred at the 120° flex-ext angle. There is a parallel progression in terms of isokinetic and EMG values.

However, there is greater neural activation in more ballistic movements compared to isokinetic movements. Including isokinetic training in training programs for sport branches may be deemed monotonous, and it is not generally recommended. Nevertheless, it can be valuable for measuring current strength, understanding weak muscle strength, and assessing general strength and strength continuity at the beginning of the season.[17]

Our results show that the strength characteristics of the team branches are close to each other, but at the technical level, there are differences depending on the characteristics of the branches. At 30 degrees and 120 degrees, EMG values show higher electrical potential in the muscles identified from the volleyball branch, particularly at 120 degrees. This difference in EMG values can be attributed to their proficiency in generating power at the highest possible speed, particularly in technical applications such as the slam dunk technique, which is frequently utilized in volleyball. Their specific usage of this technique may explain the variation in the observed EMG values. Our results indicate significant differences in isokinetic values at all angles. The difference in EMG values between handball at 30 degrees and volleyball at 120 degrees can be attributed to the variation in maximum force production during these specific movements.

The variance in EMG values can be attributed to different factors for handballers and volleyball players. For handballers, it may be due to the significant difference in grip strength, which results from continuously holding the ball during gameplay. On the other hand, for volleyball players, the frequent use of wrists and related muscles in both passing and attacking strokes contributes to quick strength (power) development, leading to the observed differences.

In the comparison of the force values of the groups by Tatlıcı, it was found that recreationally active individuals produced significantly higher force than sedentary individuals in both contraction types at 60° s-1 angular velocity, while no significant difference was found at 180° s-1 angular velocity. Regarding strength tests, it was found that recreationally active individuals produced higher strength at slow angular velocities than sedentary individuals.[18]

There is a significant positive correlation between isokinetic strength and muscle electrical potential at 120 degrees flex and 30 degrees ext and flex only in basketball players. This parallelism is believed to arise from the utilization of power and maximum force as key motor characteristics within the respective sports branches.

The goal is to have the strength and muscle potential respond to the stimuli of the central nervous system in the most accurate way, creating an environment that positively impacts performance. In this context, isokinetic and muscle electrical potential measurements can serve as valuable guides to enhance the strength, power, and endurance properties of the muscles utilized.

Conflict of Interest

The authors declare no conflicts of interest.

Compliance of Ethical Statement

Ordu University Clinical Research Ethics Committee Approval (No: 2018-264; Date: 27/12/2018).

Financial Disclosure

There is no individual or organization providing financial support for the study.

Author Contributions

Z.Ç: Study idea/Hypothesis; Z.Ç: Design; Z.Ç: Data Collection; Z.Ç: Analysis; Z.Ç: Literature review; Z.Ç: Writing; Ö.D.: Critical review.

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