ELECTROMYOGRAPHIC INDICATORS INVESTIGATION IN FEMALE ATHLETES ENGAGED IN POLE ACROBATICS

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ABSTRACT

Background. The sensorimotor system is a key component of general physical preparedness in athletes, especially in sports disciplines that require high levels of coordination and reaction speed. One such discipline is pole acrobatics, characterized by complex movements demanding high sensorimotor integration.

Aim. To determine the effects of regular pole acrobatics training on sensorimotor system response parameters and to identify asymmetries between the right and left sides of the body in female athletes.

Materials and Methods. The investigation was conducted using electromyography methods: specific H-reflexometry and nerve conduction velocity measurements. The study was carried out at the Research Institute of the National University of Physical Education and Sports of Ukraine. The study involved 20 women in the early (group 1) and middle (group 2) stages of mature adulthood who regularly practice pole acrobatics. Data analysis was performed using the Mann-Whitney U test and the Sign test.

Results and Conclusions. Statistically significant differences between groups in terms of reaction latency, signal amplitude, reaction duration, and the area under the compound muscle action potential curve (H-wave) curve were found. Specifically, differences were observed in the functional activity of the peripheral nervous system between the right and left sides of the body, as evidenced by a decrease in signal amplitude and changes in the area under the curve. The findings suggest that regular pole acrobatics training can have a significant impact on the sensorimotor system and functional asymmetry between the right and left sides of the body in female athletes. This study represents an important step in understanding the specific effects of pole acrobatics on the functional state of the nervous system, which can be utilized to optimize training programs and enhance athletic performance.

Keywords: *neural asymmetry, women athletes, electromyography*.

Introduction

The sensorimotor system is a key component of the overall physical preparedness of athletes, particularly in sports requiring high levels of coordination and rapid reaction speed [1; 2]. One such athletic discipline is pole acrobatics, characterized by complex movements that demand a high degree of sensorimotor integration [3]. However, there is insufficient research on how regular pole training affects the functional state of the sensorimotor system in female athletes. An analysis of the literature indicates that most studies focus on the general effects of physical exercise on the nervous system [4–6], without addressing the specific questions related to the influence of pole training on the parameters of the sensorimotor response. Moreover, contradictions exist regarding how regular training in this sporting activity may alter functional indicators such as reaction latency, signal amplitude, reaction duration, and the area under the curve H-wave [7]. rheumatoid arthritis, dysmenorrhea, and migraine. Importantly, at therapeutic concentrations, celeco-

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Aim and Objectives of the Study

The aim of this study was to determine the impact of regular pole training on the sensorimotor response parameters in female athletes. To achieve this aim, the following objectives were set:

1) evaluate reaction latency, signal amplitude, reaction duration, and the area under the curve of the compound muscle action potential of the H-wave (i.e. the area between the first positive and last negative phases of the potential) (hereinafter referred to as the "area under the curve") in female athletes who engage in pole training;

2) compare response parameters between the left and right arms upon stimulation at the wrist and elbow;

3) identify potential asymmetries in the functional activity of the arms associated with pole training.

Materials and Methods

The research was conducted using electromyography methods: specifically H-reflexometry and nerve conduction velocity measurements. The study was carried out at the Research Institute of the National University of Physical Education and Sports of Ukraine. The M-TEST 4 computerized electromyograph (manufactured by "DX-Systems", Ukraine) was used. The research involved two groups of female pole acrobats: Group 1 (10 women in the early stage of mature adulthood, aged 23–35 years) and Group 2 (10 women in the middle stage of mature adulthood, aged 36–48 years). Age, anthropometric characteristics and training experience of women of both groups are shown in *Tables 1* and *2*.

Table 1. Characteristics of women in Group 1

Characteristic (measurement units)	Value
Age (years)	23.5±10.5
Training experience (years)	6.7±4.9
Body mass (kg)	59.1±10.4
Height (cm)	168.5±18.5

Table 2. Characteristics of women in Group 2

Characteristic (measurement units)	Value
Age (years)	40.5±8.1
Training experience (years)	7.1±4.4
Body mass (kg)	61.1±9.9
Height (cm)	166.3±16.6

Calculations of the indicators were performed using Statistica version 10 (StatSoft, Inc., USA). During our study, data analysis was performed using the Mann-Whitney U test and the Sign test. Both statistical methods were employed to evaluate the significance of differences between groups and to test hypotheses about data distribution.

Mann-Whitney U test – nonparametric test compares two independent groups by ranking all observations and assessing whether their distributions differ in location; it is an alternative to the independent-samples t-test when normality cannot be assumed.

Sign test – nonparametric paired-sample test evaluates whether the median of differences between two related samples is zero by counting the number of positive and negative differences. It is particularly useful when the distribution of differences is unknown or when outliers may distort other tests.

Results

The results of the Mann-Whitney U test (*Tables 3–6*) showed that the p-value was below the set significance level ($p<0.05$), which led to the rejection of the null hypothesis of no differences between the groups. This indicates statistically significant differences in the data distribution between the two groups.

Overall, the results of the Mann-Whitney U test demonstrate that some parameters of the sensory system show statistically significant differences between female athletes of groups 1 and 2. In particular, under wrist stimulation, significant differences were observed in the area under the curve in the left arm ($U=22.0$, $p=0.037$) and signal amplitude in the right arm ($U=11.0$, $p=0.004$). Under elbow stimulation, a statistically significant difference was found in the area under the curve for the left arm ($U=21.0$, $p=0.031$). These findings may indicate changes in the functional activity of the peripheral nervous system due to the specific loads involved in pole training.

For the motor system, no statistically significant differences were detected in any of the parameters, which could suggest that the influence of age-related changes is less pronounced in the motor system compared with the sensory system. This may be attributable to adaptive mechanisms that maintain the effectiveness of motor functions even in the presence of age-related changes.

In summary, the Mann-Whitney U test results indicate statistically significant differences in certain sensory parameters between female athletes in the early and middle stages of mature adulthood. Specifically, significant differences were found in the area under the curve for the left arm ($p=0.037$) and signal amplitude in the right arm ($p=0.004$) when stimulating the wrist, as well as in the area under the curve for the left arm ($p=0.031$) when stimulating the elbow. These findings suggest potential alterations in peripheral nervous

Table 3. Results of sensory system response to wrist stimulation in adults in the early and middle stages of mature adulthood (Mann-Whitney U)

Parameter (measurement units)	Sum of ranks		U	Z	p
	Group 1	Group 2			
Left side of the body					
Reaction latency (ms)	97.50	112.50	42.50	-0.53	0.60
Signal amplitude (µV)	128.00	82.00	27.00	1.70	0.09
Reaction duration (ms)	124.00	86.00	31.00	1.40	0.16
Area under the curve (ms×mV)	133.00	77.00	22.00	02.08	0.04
Right side of the body					
Reaction latency (ms)	105.50	104.50	49.50	0.00	1.00
Signal amplitude (µV)	144.00	66.00	11.00	2.91	0.01
Reaction duration (ms)	117.50	92.50	37.50	0.91	0.36
Area under the curve (ms×mV)	117.50	92.50	37.50	0.91	0.36

Notes: U – Mann-Whitney U statistic;
Z – standardized Z value;
p – significance level.

Table 4. Results of sensory system response to elbow stimulation in adults in the early and middle stages of mature adulthood (Mann-Whitney U)

Parameter (measurement units)	Sum of ranks		U	Z	p
	Group 1	Group 2			
Left side of the body					
Reaction latency (ms)	85.50	124.50	30.50	-1.44	0.15
Signal amplitude (µV)	130.00	80.00	25.00	1.85	0.06
Reaction duration (ms)	113.50	96.50	41.50	0.60	0.54
Area under the curve (ms×mV)	134.00	76.00	21.00	2.15	0.03
Right side of the body					
Reaction latency (ms)	103.50	106.50	48.50	-0.08	0.94
Signal amplitude (µV)	130.00	80.00	25.00	1.85	0.06
Reaction duration (ms)	102.50	107.50	47.50	-0.15	0.88
Area under the curve (ms×mV)	108.00	102.00	47.00	0.19	0.85

Notes: U – Mann-Whitney U statistic;
Z – standardized Z value;
p – significance level.

Table 5. Results of motor system response to wrist stimulation in adults in the early and middle stages of mature adulthood (Mann–Whitney U)

Parameter (measurement units)	Sum of ranks		U	Z	p
	Group 1	Group 2			
Left side of the body					
Reaction latency (ms)	123.50	86.50	31.50	1.36	0.17
Signal amplitude (µV)	110.00	100.00	45.00	0.34	0.73
Reaction duration (ms)	83.50	126.50	28.50	-1.59	0.11
Area under the curve (ms×mV)	110.00	100.00	45.00	0.34	0.73
Right side of the body					
Reaction latency (ms)	118.50	91.50	36.50	0.98	0.33
Signal amplitude (µV)	96.00	114.00	41.00	-0.64	0.52
Reaction duration (ms)	110.00	100.00	45.00	0.34	0.73
Area under the curve (ms×mV)	100.00	110.00	45.00	-0.34	0.73

Notes: U – Mann-Whitney U statistic;
Z – standardized Z value;
p – significance level.

Table 6. Results of motor system response to elbow stimulation in adults in the early and middle stages of mature adulthood (Mann-Whitney U)

Parameter (measurement units)	Sum of ranks		U	Z	p
	Group 1	Group 2			
Left side of the body					
Reaction latency (ms)	95.50	114.50	40.50	-0.68	0.50
Signal amplitude (µV)	104.00	106.00	49.00	-0.04	0.97
Reaction duration (ms)	104.50	105.50	49.50	0.00	1.00
Area under the curve (ms×mV)	101.00	109.00	46.00	-0.26	0.79
Right side of the body					
Reaction latency (ms)	92.00	118.00	37.00	-0.94	0.34
Signal amplitude (µV)	108.00	102.00	47.00	0.19	0.85
Reaction duration (ms)	115.50	94.50	39.50	0.76	0.45
Area under the curve (ms×mV)	113.00	97.00	42.00	0.57	0.57

Notes: U – Mann-Whitney U statistic;
Z – standardized Z value;
p – significance level.

system activity related to the specific demands of pole training.

For the motor system, no statistically significant differences were identified, indicating that age-related changes may be less pronounced in the motor system than in the sensory system. Adaptive mechanisms could be maintaining motor function effectively despite age-related factors.

For the motor system, the Sign test was used, and calculations were performed on the combined group because there were no statistically significant differences between participants in the early and middle stages of mature adulthood (*Tables 7–12*).

Meanwhile, the Sign test revealed that, for most comparisons, there were no statistically sig-

Table 7. Motor system response to wrist stimulation in adults in the early and middle stages of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	17.00	47.06	0.01	1.00
Signal amplitude (μV)	20.00	45.00	0.22	0.82
Reaction duration (ms)	19.00	52.63	0.00	1.00
Area under the curve (ms×mV)	20.00	45.00	0.22	0.82

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

Table 8. Motor system response to elbow stimulation in adults in the early and middle stages of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	20.00	25.00	02.01	0.04
Signal amplitude (μV)	20.00	50.00	-0.22	0.82
Reaction duration (ms)	20.00	50.00	-0.22	0.82
Area under the curve (ms×mV)	20.00	55.00	0.22	0.82

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

Table 9. Sensory system response to wrist stimulation in adults in the early stage of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	10.00	70.00	0.95	0.34
Signal amplitude (μV)	10.00	10.00	2.21	0.03
Reaction duration (ms)	9.00	33.33	0.67	0.50
Area under the curve (ms×mV)	9.00	44.44	0.00	1.00

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

Table 10. Sensory system response to wrist stimulation in adults in the middle stage of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	10.00	50.00	-0.32	0.75
Signal amplitude (µV)	10.00	30.00	0.95	0.34
Reaction duration (ms)	10.00	50.00	-0.32	0.75
Area under the curve (ms×mV)	9.00	55.56	0.00	1.00

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

Table 11. Sensory system response to elbow stimulation in adults in the early stage of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	10.00	30.00	0.95	0.34
Signal amplitude (µV)	10.00	70.00	0.95	0.34
Reaction duration (ms)	10.00	30.00	0.95	0.34
Area under the curve (ms×mV)	10.00	30.00	0.95	0.34

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

Table 12. Sensory system response to elbow stimulation in adults in the middle stage of mature adulthood: right vs. left side (Sign test)

Parameter (measurement units)	Number of mismatches	(v<V), %	Z	p
Reaction latency (ms)	10.00	20.00	1.58	0.11
Signal amplitude (µV)	10.00	50.00	-0.32	0.75
Reaction duration (ms)	9.00	44.44	0.00	1.00
Area under the curve (ms×mV)	10.00	60.00	0.32	0.75

Notes: (v<V) – number of negative differences (mismatches) in the Sign test;
Z – standardized Z value; p – significance level.

nificant differences between the left and right arms. However, one notable exception was reaction latency during elbow stimulation in the combined group, where a statistically significant difference emerged (p=0.044171). Additionally, there was a statistically significant difference in signal amplitude between the left and right arms during wrist stimulation in the early stage of mature adulthood (p=0.026857), which may point to asymmetric load distribution or adaptation patterns in pole acrobatics. These findings provide insights into how regular pole acrobatics training could influence both sensory and motor parameters in female athletes, emphasizing the need for targeted training strategies to address potential asymmetries and enhance overall performance.

Discussion

The Sign test analysis confirmed that no significant differences were found between left and right arm indicators in the motor system under wrist stimulation. The majority of our tests revealed no statistically significant differences between the two age groups, suggesting an absence of notable age-related changes in the motor system. A significant difference in reaction latency between the left and right arms was identified only under elbow stimulation (p=0.044171), which may indicate possible asymmetries in functional activity.

With respect to the sensory system, only one metric showed statistically significant differences when comparing stimulation at the wrist and elbow: signal amplitude between the left and right arms in the early stage of mature adulthood under wrist stimulation (p=0.026857). This finding may point to more pronounced age-related changes in the sensory system of younger athletes compared to their older counterparts.

Overall, the results of the Sign test suggest that age-related changes in the sensory system may be more pronounced than those in the motor system. Such insights could prove beneficial in developing targeted training and rehabilitation programs that take into account the specific age-related differences observed in female athletes.

Conclusions

The findings of our study indicate that probably, regular pole training does not lead to significant differences in most parameters of the sensorimotor system's response between the left and right arms. An exception is reaction latency under elbow stimulation, where a statistically significant difference was observed. This suggests potential asymmetries in the functional activity of the arms, possibly due to the specific demands involved in pole acrobatics training.

Regarding the sensory system, statistically significant discrepancies emerged only under wrist stimulation, specifically in signal amplitude between the left and right arms. This could point to more pronounced changes in the sensory system, driven by the particular exercises included in pole acrobatics training.

Thus, our results suggest that regular pole training may affect the sensorimotor system in female athletes by inducing asymmetries in arm function. These findings could be applied to the design of more effective training programs that take such features into account and enhance athletic performance.

DECLARATIONS

Disclosure Statement

The authors declare that there is no conflict of interest that could have influenced the study's results.

Data Transparency

All data generated during the study can be made available upon reasonable request from the corresponding author.

Ethics Statement

No ethical standards were violated in the course of this research. All participants took part voluntarily on a volunteer basis and provided written informed consent.

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Consent for Publication

Both authors confirm their consent to publish this article and guarantee that there are no violations of copyright.

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