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# Functional assessment of musculoskeletal system by means of Performance Matrix tests in young classical style wrestlers: a preliminary report

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**Key words:** Performance Matrix tests, injury, wrestling, ANOVA, PCA

## Summary

**Introduction.** Functional assessment, in sport and physiotherapy, is a vital element allowing motor control shortages' determination. The assessment is aimed at weak link finding in wrestlers' musculoskeletal chain. Aim of the research: 1. Defining connection between doing wrestling, location and weak links number; 2. Pointing locations of the greatest influence on weak links appearance; 3. Examining relations between locations and determining groups of similar and dissimilar locations. Hypotheses: 1. Weak links appearance in musculoskeletal system is individually diversified; 2. The occurrence of weak links, in musculoskeletal system, is their locations – dependent.

**Material and methods.** Classical style wrestlers, aged 16.75±1.22, trained for 6.36±2.38 years, weekly training number 5.40±0.49, were tested. The tool assessing weak link presence were low-threshold Performance Matrix tests. Weak links, in musculoskeletal system, occurred in every wrestler.

**Results.** Low-threshold tests' results showed that in every subject (n=25) weak links in musculoskeletal system occurred. The p-value=0.1586, indicates lack of significant wrestling training influence on the number of weak links. Whereas, the P-value<0.000001 indicates essential connection between different locations in musculoskeletal system and the number of weak links.

**Conclusions.** 1. Different musculoskeletal system locations have a prominent influence on weak links appearance, strong relationships were typical of brachial joint and lumbar spine; 2. Application of the grouping features method indicates probability of weak links occurrence for brachial joint and lumbar spine.

## Introduction

Training process in sport requires a complex interaction with general and special manifestations of motor skills. Increasing of its effectiveness is connected with individualization of training loads, which is possible in combination with an effective control system of training effects [1]. Functional assessment has a particular importance because it allows to introduce an individual functional training.

Athletes' functional assessment permits determining shortages of motor control that is essential for finding weak links in competitors' musculoskeletal system. Such an action constitutes a base for appropriate choice of exercises, the usage of which will contribute to stabilization improvement within the trunk. As the result, trunk mobility should increase as well as the competitor's stamina, assessed on the basis of exercise repetitions possible to perform.

The notion of weak link should be comprehended as a place in a competitor's organism characterized by disturbed motor control which is the result of neuromuscular conduction disorders. Their effect is improper work of muscles stabilizing movement and responsible for its performance. It is crucial in sports training not to develop motor skills whilst having a musculoskeletal system dysfunction. To diagnose the presence of weak links, the standardized Performance Matrix tests are used. Bearing in mind the fact of high risk occurrence in martial arts [2,3], the application of functional assessment is justified in the best way. What is more, such assessment should be applied in order to determine some preventive measures against the occurrence of injuries in wrestlers. The injury occurrence is the main reason of renouncing further sports career by them [4].

On account of the importance of the undertaken issues, the following aims have been out-lined:

1. Defining the connection between doing wrestling and location and number of low-threshold weak links.
2. Pointing the location having the greatest impact on the presence of low-threshold weak connections.
3. Examining the relations between the locations and defining groups of similar and dissimilar locations.

The following research hypotheses were formulated:

1. H1. The occurrence of weak links in musculoskeletal system is individually diversified.
2. H2. The appearance of weak links in musculoskeletal system is dependent on their locations.

# Material and methods

*Participants.* The research was carried out on the group of 25 young classical style wrestlers, aged 16.75±1.22 (mean ± standard deviation), of body weight 77.72±18.67 kg and body height 175.16±14.14 cm. Their training experience was 6.36± 2.38 years and weekly number of trainings was 5.4± 0.49. The subjects were Polish representatives in junior wrestling category. The control group was not used for the group of competitors in the research because the tests which were carried out, were also used as the entry assessment for the wrestlers.

*Testing Procedures.* The tool to assess the presence of weak link were low-threshold Performance Matrix tests [5,6 - basic papers]. By analysis and identification of the movement performed by a competitor, the weakest links of the musculoskeletal system were found. Before the testing, the procedure of testing was explained to the competitors and a demonstration, how to perform the test, was shown. The results were inscribed into a specially designed sheet. There were 5 tests of low-threshold carried out (test 1 – standing control on slightly bent leg, test 2 – spine dissociation, test 3 – control of brachial joint in standing, test 4 – limbs control with bent knee joints while lying on back, test 5 – limbs control in lean kneeling).

*Statistical analyses.* To determine the relation between the locations of weak links, the following notations were used: a – cervical spine, b – thoracic spine, c – brachioscapular joint, d – brachial joint, e – lumbar spine, f – hip joint, g – knee joint. The locations of weak links were assessed and groups were compared using the Analysis of Variance (ANOVA). Next, an analysis of individual diversity of weak links occurrence was conducted by means of the Tukey's HSD test. To determine similar and dissimilar groups of weak links' locations in wrestlers, the Principal Component Analysis (PCA) and cluster analysis were applied. All statistical analyses were conducted with the statistical package R [7].

# Results

Training loads in wrestling cause the occurrence of weak links in musculoskeletal system. After making an appraisal of musculoskeletal system by means of Performance Matrix tests, it was found that there were weak links in every tested wrestler (n=25). The biggest number of locations was found in lumbar spine. In the direction of rotation, the locations were found in 24 wrestlers, and in the direction of flexion and lateral flexion, in 10 wrestlers. The brachial joint was another location where weak links were observed which appeared in the direction of front slip in 19 wrestlers and in the direction of rotation in 10 wrestlers. The smallest number of weak links was found in cervical spine. The weak links were only found in the direction of flexion in 2 wrestlers. Whereas, in thoracic spine in the direction of flexion in 3, and in the direction of rotation in 9 competitors. Only in 2 wrestlers lack of scapula control in brachioscapular joint, was observed. In knee joint only among 5 subjects, a weak link in the direction of rotation occurred. There were no weak links noted in the hip joint (Figure 1).

Heading for verification of wrestling sports training influence on weak links occurrence and their location, there was a two-factor ANOVA performed, where places (locations) and wrestlers are the main effects tested by the ANOVA method (Table 1). The P-value=0.1586, indicates lack of vital influence on doing a sports discipline and the number of weak links in

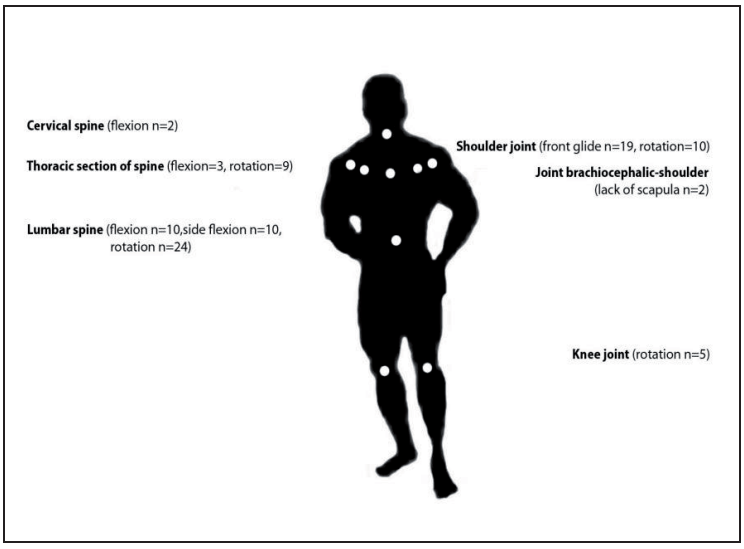


Figure 1. Weak links occurrence in wrestlers' musculoskeletal system

wrestlers. However, different locations in musculoskeletal system have substantially various impact on the number of weak links occurrence (P-value< 0.000001).

Next, by means of Tukey's HSD test, a graphical analysis of individual diversity of weak links occurrence, was done (Figure 2). It was stated that the weak links occurrence in musculoskeletal system is significantly individually diversified and it is dependent on their locations.

The next step of the statistical analysis was a detailed establishment of location influence on the occurrence of weak links, as well as examining relations between the locations (Table 2). Some vital differences (P-value<0.005) were stated

Table 1. ANOVA for sports discipline influence on the location and occurrence of weak links

| Source | Df | SumSq | MeanSq | Fvalue | P-value |
|---|---|---|---|---|---|
| Place | 6 | 69.589 | 11.5981 | 44.4723 | <0.000001 *** |
| Wrestlers | 24 | 8.286 | 0.3452 | 1.3238 | 0.1586 |
| Residuals | 144 | 37.554 | 0.2608 | | |

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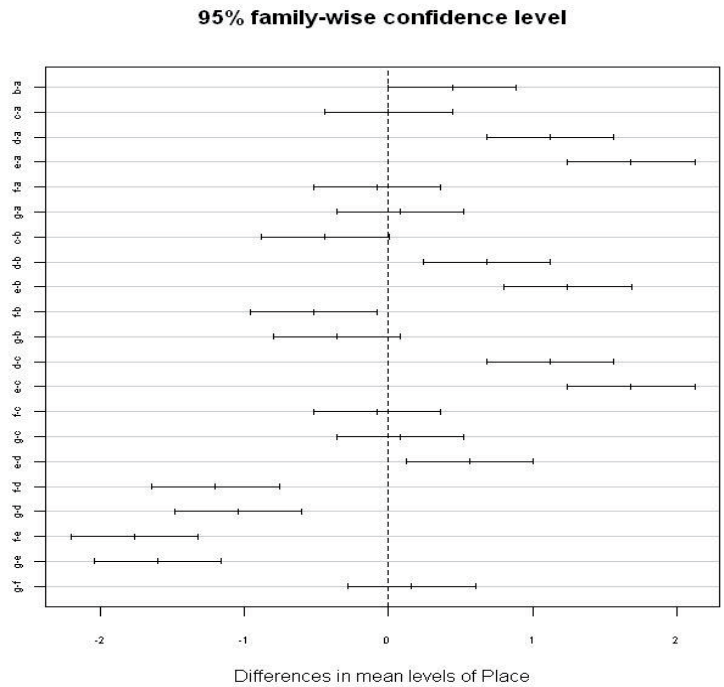


Figure 2. Tukey's HSD test, where the scattering bars present the set of confidence intervals of the differences between the means of the factor levels defining the locations of weak links; x-y in Y axis denotes a comparison between the location x and the location y of weak links

Table 2. The connection of locations with the occurrence of weak links and defining the rela-tions between locations (a – cervical spine, b – thoracic spine, c – brachioscapular joint, d – brachial joint, e – lumbar spine, f – hip joint, g – knee joint)

| Places | p-value | Places | p-value | Places | p-value |
|---|---|---|---|---|---|
| b-a | 0.051 | d-b | <0.005 | g-c | 0.998 |
| c-a | 1 | e-b | <0.005 | e-d | <0.005 |
| d-a | <0.005 | f-b | 0.009 | f-d | <0.005 |
| e-a | <0.005 | g-b | 0.190 | g-d | <0.005 |
| f-a | 0.998 | d-c | <0.005 | f-e | <0.005 |
| g-a | 0.998 | e-c | <0.005 | g-e | <0.005 |
| c-b | 0.051 | f-c | 0.998 | g-f | 0.932 |

for the comparisons of brachial joint locations (d) and the lumbar spine (e) in low-threshold tests. By defining relations between the following locations, it was observed that the brachial joint and the lumbar spine had an important correlation with the frequency of weak links occurrence in different directions of movement.

Next, the PCA (Figure 3). On the basis of obtained results, it can be stated that the thoracic spine (b), brachial joint (d) and lumbar spine (e) were the most important and the most distinguishable locations from the others. While the remaining locations, that are cervical spine (a), brachioscapular joint (c), hip joint (f) and knee joint (g) constituted a group of similar locations.

The next stage of the analysis was grouping the characteristics in order to determine the occurrence of similar and dissimilar groups of weak links locations in musculoskeletal system in young wrestlers (Figure 4). The graphical interpretation of the obtained results for the weak links locations in musculoskeletal system in wrestlers, indicates the fact that the locations of brachial joint as well as the lumbar spine are included in the most similar group for wrestlers.

# Discussion

The conducted research partially proved the first hypothesis. The low – threshold Performance Matrix tests results

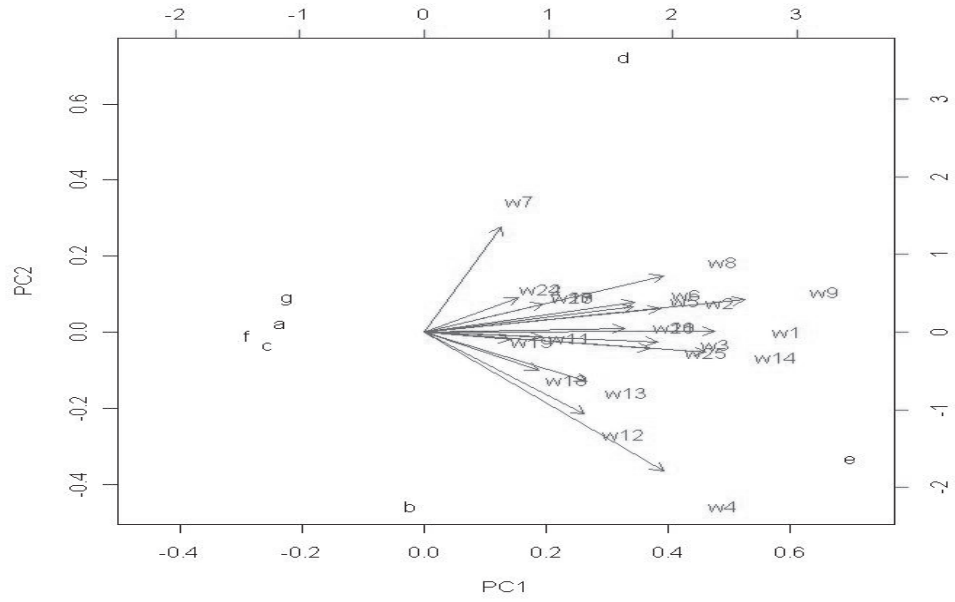


Figure 3. PCA plot of the occurrence of similar and dissimilar groups of weak links locations in wrestlers (a – cervical spine, b – thoracic spine, c – brachioscapular joint, d – brachial joint, e – lumbar spine, f – hip joint, g – knee joint)

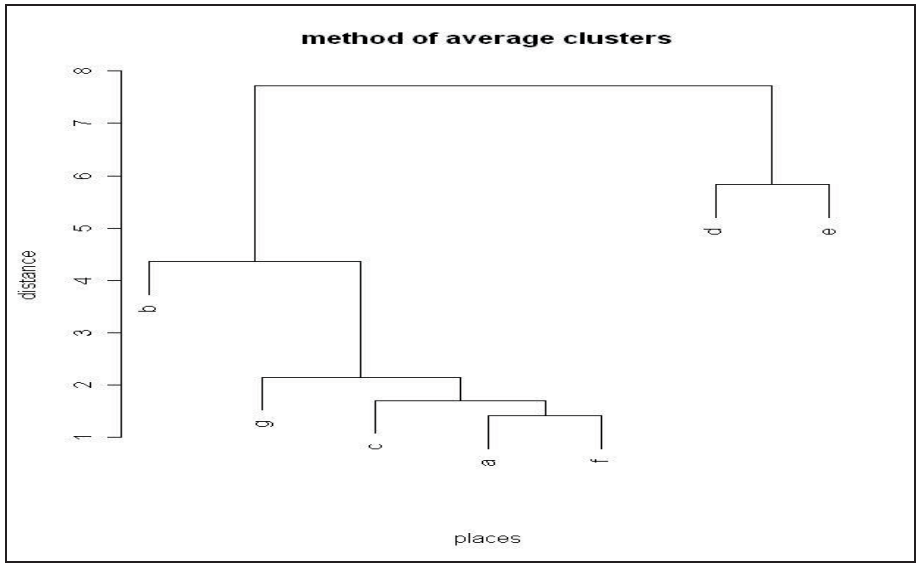


Figure 4. The dendrogram for the occurrence of similar and dissimilar groups of weak links locations in wrestlers (a – cervical spine, b – thoracic spine, c – brachioscapular joint, d – bra-chial joint, e – lumbar spine, f – hip joint, g – knee joint)

entitle to state the fact that there were weak links in musculoskeletal system of young wrestlers who underwent the tests (Figure 1, P-value=0.1586, Table 1). However, different locations in musculoskeletal system have a prominent impact on the number of weak links in wrestlers (P-value< 0.000001, Table 1).

The second hypothesis was confirmed that the occurrence of weak links in musculoskeletal system is vitally different for individual competitors (Figure 2). The dependency between the occurrence of weak links and their location was observed. The important differences P-value<0.005 for brachial joint (d) and lumbar spine (e) indicate the presence of weak links in these locations (Table 2, Figure 3). By analyzing of the relations between the locations of the weak links occurrence in musculoskeletal system, it was stated, that the most common occurrence was present in the location of brachial joint and the lumbar spine (Table 2). These locations constitute the most similar group of weak links occurrence in musculoskeletal system in the subjects (Figure 4).

Wrestling is characterized by more frequent occurrence of injuries among the competitors than in other sports disciplines [8]. Doing contact sports causes an increase in the risk of injuries and wrestling belongs to a group of sports of high risk injury occurrence [2,3,9-11]. Among 95 subjects who were highly advanced wrestlers, in over 80% of them injuries of musculoskeletal system soft tissues, within their sports career, were found. After a comeback to doing a sport, within the period of 24 months injuries appeared again [12].

Henceforth, it is necessary to undertake measures that lead to a decrease in injury frequency in wrestlers [8]. Nowadays, in the process of sports training, measures aimed at wrestlers' prevention against injuries are often included. These measures are: exercises on unstable ground, techniques of muscle stretching, coordination exercises, training means to enhance muscle power and strength [11]. On the basis of the digest of publications concerning prevention of sports injuries, it can be acknowledged, that an actual and effective way of injury prevention is a TRIPP model [12].

The TRIPP (Translating Research Into Injury Prevention Practice) includes three main areas of prevention of sports injuries through an adequate motor training, using appropriate footwear and foundation during exercising, application of the right equipment for exercises as well as adjustment to appropriate rules and law regulations that are applicable in separate sports disciplines [12]. In martial arts much effort is put into working on the increase in muscle power and strength [13]. In the prevention of injuries in martial arts, the assessment of their occurrence, as the result of falls, is done by means of the SBIDF index (Susceptibility to Body Injuries During Fall) [14]. Teaching how to fall ought to be one of the elements in sports training [15]. Nevertheless, in sport, not much attention is devoted to a functional assessment as something very important, new possibility of risk assessment concerning the injury occurrence [6]. More frequently applied kind of training in sport, according to Core Stability concept, concerns working on shaping local and global trunk muscles, upper and lower limbs, in symmetrical and asymmetrical movements, combined with trunk muscles' activity [6]. Disorders of neuromuscular trunk control cause an increase in injury occurrence in sport, and as a consequence, it gives a disturbed pattern of movement [16,17]. It is crucial in sport to determine the risk factors for the occurrence of injuries, their mechanism and prevention of them [18].

# Conclusions

1. Different locations in musculoskeletal system have a prominent influence on the presence of weak links, especially strong dependencies were typical of brachial joint and the lumbar spine.
2. By application of the Principal Component Analysis together with the grouping method, a big probability within the range of weak links occurrence for brachial joint and the lumbar spine, was found.

***Acknowledgement***

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