Relationship between Neuromuscular Mechanisms with Dynamic Balance and Upper Extremity Function of Wrestlers

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Submitted: 2018-04-05; **Accepted**: 2018-06-09

Abstract

Introduction: Wrestling is always accompanied by damage to various body parts. Most trainers recommend exercises to increase balance in order to improve performance and reduce the risk of injury. Therefore, the present study examines the relationship between neuromuscular mechanisms with dynamic balance and upper extremity function of wrestlers. Materials and Methods: This is a correlation study whose participants include free-style and Greco-Roman wrestlers of 21.05±2.25 years old in Rasht. This study was conducted on 42 wrestlers who met the criteria to enter the research and were selected by the available sampling method. In this study, in order to evaluate the dynamic balance and the upper extremity function, Y Balance Test and Upper Quarter Y-Balance Test (YBT-UQ) were used, respectively. In addition, to measure the depth of shoulder flexion, ankle plantar flexion, shoulder flexion amplitude, and ankle plantar flexion, and to assess the strength of shoulder flexion force, ankle plantar flexion, muscle flexion of shoulder, and ankle plantar flexion, an electrogonimeter device and a dynamometer were used, respectively. Pearson correlation coefficient and multivariate regression were used to study the research hypotheses. Results: The results show that there is a significant positive relationship between the range of motion of ankle plantar flexion (r=0.64) and the normalized power of plantar flexors (r=0.85) with lower limb dynamic balance (*P*=0.03). There is also a significant negative relationship between the sensory errors of ankle plantar flexors force (r=-0.84) and the reconstruction of ankle plantar flexion (r=-0.85) with the lower limb dynamic balance (*P*=0.02). Moreover, the results show that there is a significant positive relationship between the range of motion of the Shoulder flexion (r=0.71) and the normalized power shoulder flexor (r=0.74) with upper limb function (*P*=0.001). There is also a significant negative relationship between the sensory error of shoulder flexor (r=-0.72) and the sense of reconstruction of shoulder flexion angle (r=-0.75) with upper limb function (*P*=0.03). Conclusion: It appears that the neuromuscular mechanisms are effective factors in upper extremity function and dynamic balance of wrestlers. Therefore, consideration of these neuromuscular mechanisms is necessary to prevent injury and improve wrestlers' athletic performance.

Keywords: Wrestling; Dynamic Balance; Upper Extremity Function

Please cite this paper as: Tabasi SR, Noraste A, Mirzaei B, Zarei H. Relationship between Neuromuscular Mechanisms with Dynamic Balance and Upper Extremity Function of Wrestlers. J Clin Physio Res. 2018; 3(2): 70-77.

Introduction

In spite of all advantages of regular physical activity, injury is an inevitable risk, specifically in competitive sports and, due to its invasive nature, wrestling in not an exception. It always accompanies injuries to various parts of the body (1). In all reports on the prevalence of injuries, it can be observed that injuries in wrestling are significant. Research has shown that about 34% of injuries in competitions and 28% in training sessions result in more than 10 days of non-participation in wrestling training. Shoulder injuries and ankle sprains have been repeatedly reported in wrestling, due to the frequent use of shoulders and ankles in wrestling techniques (2). Researchers have indicated that in wrestling competitions and training sessions, the ultimate goal should be reducing the incidence of injuries, while maintaining the competitive spirit of the sport. A few studies have looked at the combination of factors that cause injury in a particular field of sport (3). Also, the factors that contribute to the wrestling injuries are not mentioned in any the studies, but, generally, the factors that contribute to the sports injuries are

The results of Plisky *et al.* indicated that in some cases, chronic ankle instability is associated with power loss (4). Also, Bradic *et al.* illustrated that the risk of ankle sprain is five times higher in athletes with lower moving range and flexibility in the ankle than others (5). The proprioception of muscle reflexes plays a protective role in preventing acute

injury (6). In addition, the proprioception signals from the calf muscles and the trunk play an important role in maintaining the postural stability (7). A lot of evidence has shown that understanding the position and motions of the shoulder joint is accomplished by the slow adaptation of muscular mechanical receptors, including the muscular spindles and strongly respond to the Golgi tendon organs that transmit the overall muscular tension (8). Studies in swimmers show that with a decrease in the range of motion of the glenohumeral joint, the muscular strength of the rotator cuff plays an important role in the shoulder injury in the swimmers (8). In wrestling, rarely any techniques could be found that do not involve the trunk and upper extremities. Accordingly, the key role of shoulder joint in this sport can be ascertained, but it is yet to be determined whether the neuromuscular mechanisms of the shoulder are involved in the shoulder injuries of the wrestlers. Also, it has not been determined what causes ankle injuries in the wrestlers.

One of the integral and key components of many daily and sports activities is balance. Balance is dynamic phenomenon consisting of a combination of stability and motion, and is necessary to maintain a spatial state or to move in a coordinated and controlled state (9). Consequently, most trainers instruct trainings to increase balance, in order to improve performance and reduce the risk of injury (10). Researchers show that YBT-UQ (Y Balance Test - Upper Quarter), is the first validated test to assess the unilateral dynamic performance of the upper extremity in a closed kinetic chain, in which, stability and movement are simultaneously involved at the highest level in the upper extremity. In the YBT-UQ, the person transfers his body weight to the upper extremity and must maintain his balance on one hand without disturbing the balance, while reaching out with the other hand to a maximum of distances in three directions (11). Westrick *et al.* concluded that this test is suitable for evaluating and diagnosing a damaged limb and those who score high in this test may reduce the risk of upper extremity injury (12). A review of the literature has shown that increasing the balance and stability of upper extremity function can play a major role in reducing the incidence of sports injuries. The study of the causes and methods of prevention of sports injuries have always been very important and brought into the attention of experts and researchers. This research aims at reducing the costs of treatments and promoting athletes' performance and community health level. In this regard, consideration of risk factors and injuries in sports fields and the methods of prevention of injury and risk reduction have always been considered by sports experts. Considering the role and importance of wrestling, specifically in championship and competitions, as well as its historical and athletic background in the Iranian community, there is a clear need for scientific studies on this field of sports. Because of the high incidence of injuries among wrestlers and the lack of comprehensive information on the cause of these injuries, the necessity of examining the mechanisms and causes of injuries in wrestlers is evident. As mentioned above, the balance of the lower and upper extremities plays an important role in predicting the incidence of sports injuries. In order to determine whether the neuromuscular mechanisms play a role in the wrestling injuries, the relationship between muscular mechanisms and balance and performance of the upper extremities should be investigated. So, the present study examines the relationship between neuromuscular mechanisms with dynamic balance and upper extremity performance of wrestlers.

Materials and Methods

Participants

This is a correlation study whose participants include free-style and Greco-Roman wrestlers of 21.05±2.25 years old in Rasht. This study was conducted on 42 wrestlers who met the criteria to enter the research and were selected by the available sampling method. The inclusion criteria included an experience of professional sports between 2 and 6 years (at least 3 sessions per week, each 45min to 1h practice) and no history of injury or lower extremity surgery or neuromuscular disease in the last year (13). Exclusion criteria included history of hearing, visual, and atrial impairments, fracture or surgery in the lower extremity ankle sprains (in the last year), history of surgery in the lower extremity in the last year, abnormalities (in upper and lower extremities) affecting the process of research, visual differences in the length of the limbs, neurological and concussion problems, the use of neurological drugs affecting balance, insulin-dependent diabetes, arthritis rheumatoid, cerebrovascular disease, or any peripheral or central diseases that may interfere with sensory input (13).

Ethical considerations

This study was ethically approved by the College of Physical Education and Sport Sciences of Guilan University. Before the beginning of the study, the research process was explained to the subjects (including the research objectives, how the variables were measured, and the length of the research period). All participants attended the research voluntarily after filling in the consent form. This study did not have any risk or harm to the subjects in terms of the measurement methods.

Table 1. Describing the demographic characteristics, dynamic balance and the upper extremities performance

Variables	Mean (SD) (n=42)
Age (years)	21.05 (2.25)
Weight (kg)	75.57 (7.50)
Height (cm)	171.71 (7.17)
BMI (kg/m^3)	23.91 (2.88)
Sports experience (years)	4.09 (1.47)
Dynamic balance of the lower extremities (percentage of the length of the leg)	83.71 (11.64)
Performance of the upper extremities (percentage of the length of the leg)	85.97 (13.06)

Table 2. Mean (SD) of measured variables and the results of Pearson correlation test to examine the relationship between neuromuscular mechanisms with dynamic balance and upper extremity performance of subjects

Variable	Mean (SD)	Dynamic balance of lower extremities		Performance of upper extremities	
		r	r^2	r	r^2
Ankle plantar flexion motion range (degree)	36.29 (2.92)	0.64*	0.40	0.12	0.01
Shoulder flexion motion range (degree)	174.43 (4.28)	0.16	0.02	0.71*	0.50
Normalized strength of ankle plantar flexors (max moment percentage)	2.26 (0.31)	0.85*	0.72	0.12	0.01
Normalized strength of shoulder flexors (max moment percentage)	3.88 (0.23)	0.15	0.02	0.74*	0.54
Force sensory error of ankle plantar flexors (force/m^3)	1.50 (1.21)	-0.84*	0.70	-0.27	0.07
Force sensory error of shoulder flexors (force/m^3)	1.95 (1.07)	0.13	0.01	-0.72*	0.51
Sensory error of ankle flexion angle reconstruction (degree)	2.67 (1.26)	-0.85*	0.72	0.17	0.02
Sensory error of shoulder flexion angle reconstruction (degree)	1.24 (0.54)	-0.16	0.02	-0.75*	0.56

** Indicates a significant relationship at P≤0.05*

Table 3. Regression equation for predicting dynamic balance of lower extremities and performance of upper extremities in terms of neuromuscular mechanisms

Model	Variable
Dynamic balance of lower extremities	$y=(0.215\ x_1)+(0.432\ x_3)+(-0.422\ x_5)+(-0.472\ x_7)$
Performance of upper extremities	$y=(0.323\ x_2)+(0.174\ x_4)+(-0.232\ x_6)+(-0.192\ x_8)$

In regression abovementioned relations, y indicates the dynamic balance of lower extremities and the performance of upper extremities; x1 is the motion range of the ankle plantar flexion; x2 is motion range of the shoulder flexion; x3 is normalized plantar ankle flexors; x4 is normalized strength of shoulder flexors; x5 is force sense error of ankle flexors; x6 force sense error of shoulder flexors; x7 is the force sense error of ankle plantar flexion angle reconstruction; x8: is the sense reconstruction error of shoulder flexion angle reconstruction

Data collection

Wrestlers' data were gathered in four stages; the first was the collection of data related to age, height, weight, length of the leg, hand length and length of the lever arm. Then, warm-up exercises were performed by stretching and simple exercises and the subjects were taught to do the tests and they were asked to repeat and practice the test of dynamic balance under the supervision of the experimenter, by equipments installed in different places on the floor of the gym. The second stage was the collection of Y-Balance Test and YBT-UQ for the upper extremity. The third stage was related to the isometric power measurements and the power sense of ankle plantar flexor and shoulder flexor. The fourth step included measuring the sense of joint reconstruction and foot and shoulder motion amplitude. It should be noted that each subject passed all the tests in one day (at the evening session) and all measurements were performed on the upper hand and the dominant hand and leg. The descriptive information of the research was gathered by one researcher and the measurement of the research variables by another.

To measure the actual length of the leg, the subject was asked to lay without shoes and to put his legs in free position. With the help of a tape measure, the distance between the anterior superior iliac spine (ASIS) and the internal ankle was measured and recorded in cm (14). The dominant leg of the subjects was determined by strongly blowing a ball on the ground.

To measure the actual length of the hand, the subject was asked to stand and flex his hand 90 degrees. The distance between the acromion and the tip of the fingers was measured in cm by a tape measure (14). The dominant hand of the subjects was specified by throwing a small ball.

The length of the lever arm of the ankle and shoulder joints was measured by tape measure: ankle joint, proximal sign, MMT center (MMT: dynamometer device used on muscle strength to measure muscle strength) and distal sign, external ankle. Shoulder joint; proximal sign of the MMT center and the distal sign, acromion (15).

To measure dynamic balance, the Y-balance test was used by Coughlan *et al.* (Figure 1) (16).

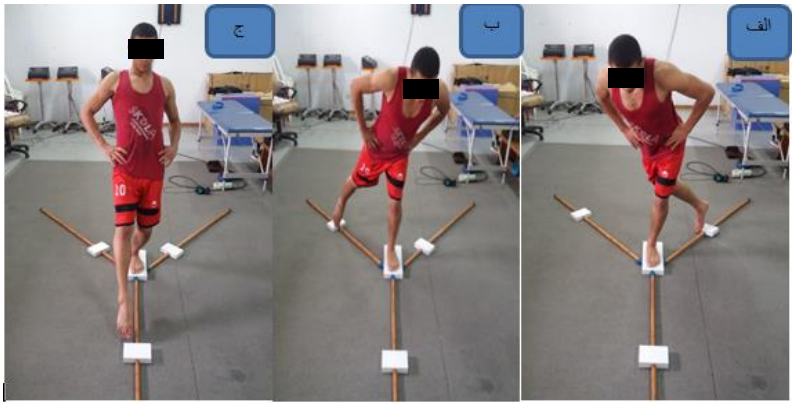

Figure 1. reaching out directions in the lower extremities, a. superior direction, b. internal posterior; c. external posterior

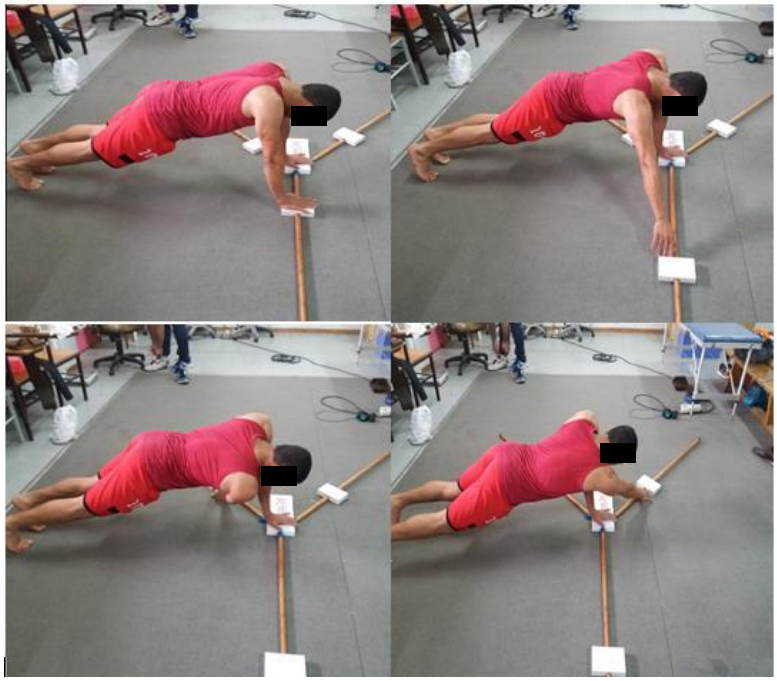

Figure 2. Hand reaching directions in the upper extremity, a. the starting position; b. internal reaching; c. inferior external reaching direction; d. superior external reaching direction

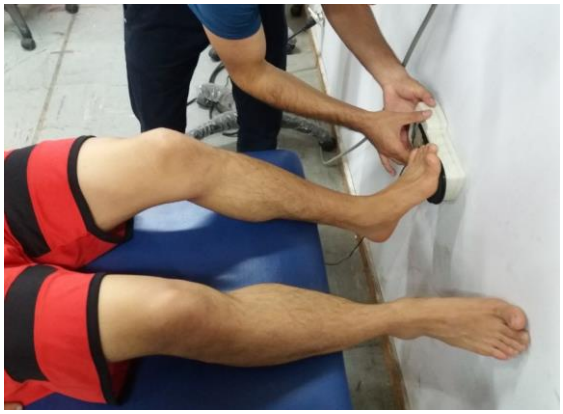

Figure 3: Measuring the isometric strength and the plantar power sensation of the ankle flexors

Figure 4. Measuring the power and strength of the shoulder flexors

Figure 5. Measuring the sense of joint reconstruction and the motion range of the plantar ankle flexors

Figure 6. Measuring the sense of joint reconstruction and the motion range of shoulder flexors

To measure upper extremity function, the YBT-UQ balance test was used by Gorman *et al.*, and Westrick *et al.* The test was designed in three directions (internal, external inferior, external superior) with an angle of 135 degrees relative to each other. To keep balanced, the subject put his dominant hand on a fixed plate to be in the position of push-ups. Then he moved the non-dominant hand in the mentioned direction. He then returned to the primary position of the test (Figure 2) (12, 13).

The isometric strength of the muscles was performed by a manual dynamometer by Krause *et al.*, and Mentiplay *et al.*; also, the measurement of the sense of power was performed by reconstruction of the target power by the method provided by Bock *et al.* (Figures 3 and 4) (17-19)

To measure the motion range of the ankle plantar flexion and the shoulder flexion, use was made of electrogoniometer and the method of Norkin *et al.* (20). To measure the sense of ankle joint position, the active reconstruction of ankle joint angle test by the Li K-y *et al.* method was used (21); and to measure the sense of the shoulder joint the active reconstruction of shoulder flexion test based on Lee *et al.* methodology was used (Figsures 5 and 6) (22).

Statistical analysis

Descriptive statistics were used to describe the variables and inferential statistics to analyze the findings. Shapiro–Wilk test was used to assess the normal distribution of data. According to the Shapiro–Wilk test, Pearson correlation coefficient was used to examine the relationship between the neuromuscular arrangements and the dynamic balance and the performance of the upper extremities of wrestlers; also, the multiple regressions was used to determine the regression linear equation. Data was analyzed using SPSS v.16 software.

Results

The mean and standard deviation of subjects' individual characteristics and the dynamic balance of the lower extremities and upper extremities performance of subjects are shown in Table 1.

The results of this study showed that there was a significant positive correlation between the motion range of the ankle plantar flexion (r=0.64) and the normalized power of the leg plantar flexors (r=0.85) with the dynamic balance of the lower extremities; also, there was a significant negative relationship between force sense error in the ankle plantar flexors (r=-0.84) and the sensory error of the angle reconstruction of the ankle plantar flexors (r=0.85) with the dynamic balance test of the lower extremities. Moreover, the results showed that there was a significant positive correlation between the shoulder flexion motion range (r=0.71) and normalized power of the shoulder flexors (r=0.74) with the performance of upper extremities; also, there is a significant negative relationship between force sense error of the shoulder flexors (r=-0.72) and the reconstruction sensory error of shoulder flexion angle (r=-0.75) with performance of the upper extremities.

In this study, the errors independence theory was investigated by the Durbin-Watson test, the statistic of which, at all intervals, stood between 1.40 and 2.5, indicating that the errors independence theory is acceptable. The statistical results of the study showed that the proposed model for the present study was significant in different scenarios ($P \leq 0.05$), so this is a linear model. All coefficients of linear equations are significant (Table 3).

Discussion

The present study aims at investigating the relationship between neuromuscular mechanisms with dynamic balance and performance of upper extremities in wrestlers. The results of this study showed that there is a significant positive relationship between the range of motion of the ankle plantar flexion and the normalized power of the legs planar flexors and the dynamic balance of the lower extremities; and also the significant negative relation between the ankle plantar flexors and the sensory error of ankle plantar flexion angle reconstruction with the dynamic balance test for the lower extremities. The results of this study are consistent with the results of Plisky *et al.* (4). They showed, in their study, that the muscular strength and the ankle motion range of the individuals with chronic sprain are decreased, so the balance fluctuations are higher in them. In addition, Shah Heydari *et al.* found a significant positive relation between hip motion range and the balance in the athletes of different sports but their study did not show a significant relationship between the motion range of ankle joint and athlete's balance (23). Also, the results of studies by Gollhofer and Granacher (24), Richardson *et al.* (25) and Thorpe *et al.* (26) revealed that there is no significant relation between the muscular strength of the lower extremities and the balance. The reason for the disagreement between the results of this and their study may be the type of sport and that in their study, athletes of

different sports have been employed, but in the present study only wrestlers have been used. Another reason for the significance of this relationship is that, because wrestlers use the ankle joint more than the other joints of the lower extremities, the ankle joint in wrestlers has a strong relationship with their balance.

Ribeiro and Oliveira reported that the proprioception is the most important system for sensory control of balance and can help stabilize the body and joints through two mechanisms of feedback and feed-forward (27). Allen *et al.* emphasized the relationship between the proprioception and muscle contraction level, and consequently increased balance and increased postural stability (28). In their study, Knapp *et al.* (29) and Pope *et al.* (30) showed that individuals with chronic ankle instability and decreased proprioception, have higher fluctuations in their postural and balance control. Among the joints of the body, the ankle is especially important due to bearing the weight of the body and the variety of movements during wrestling training and competitions. With the help of soft joints and surrounding ligaments, this joint provides movements and strength of the ankle joint. The accuracy of the proprioception receptors in the ankle joint is vital in maintaining the proper functioning of this joint, especially during exercise activities (30). As Earl and Hertel argued, impairment of the activation of mechanical receptors increases the delayed response of the muscle and prolongs the recovery and restoration time of the center of balance (31). In the present study, it was also determined that the proprioception and ankle force sense of the wrestlers play important roles in their balance.

In addition, the study results show that there is a significant positive relationship between motion range of the shoulder flexion and normalized strength of shoulder flexors with the performance in the upper extremities; also, there is a significant negative relationship between shoulder flexor force sensory error and the sensory error of reconstruction of shoulder flexion angle with the performance in the upper extremities. The results of this study are consistent with the results of Agel *et al.* (32) and Kurdi *et al.* (33). The researchers stated that most of the shoulder injuries include springs, strains and shoulder dislocations, which are due to weakness in musculoskeletal mechanisms, the reason being that wrestling includes a lot of throwing and clinch movements and usually places the shoulder joint in dangerous situations, and most of the muscles, ligaments and joints are pressured beyond their physiological range, which is a mechanism for these injuries. In the present study, it was found that there is a significant relationship between neuromuscular mechanisms with YBT-UQ test. It has been stated that the YBT-UQ test is a comprehensive method for ascertaining the performance, strength or failure in shoulder movements. Researchers believe that this test requires balance, strength and range of motion that can increase the accuracy of identifying athletes at risk of injury. In the present study, it was also observed that neuromuscular mechanisms had a significant relationship with the YBT-UQ test (12). Therefore, a special attention should be given to these neuromuscular mechanisms in preventing injury and increasing the performance of wrestlers.

The present study was had the following limitations: lack of control over the psychological conditions and the motivation of subjects to participate in the research, lack of control over the intensity of work and daily activities, and the lack of control over the nutritional, social, cultural, economic and health status of the participants. The strengths of this study were: all subjects were in the age range of 18 to 24 years old, all subjects had at least 2 years of professional experience and also the way the test was performed for all subjects.

Conclusion

It seems that neuromuscular mechanisms are key factors in the performance of upper extremities and dynamic balance of wrestlers; therefore, consideration of these neuromuscular mechanisms is necessary in order to prevent injury and improve wrestlers' athletic performance.

Acknowledgement
This article is an inference of Sayed Reza Tabasi's master's thesis, supervised by Dr. Ali Asghar Nourasteh. I would like to thank all those who helped us with this research. I am grateful to the College of Physical Education at the University of Guilan for their relentless support.

Conflict of interest:
None

Funding support:
None

Authors' contributions:
All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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