The relationship of some factors affecting dynamic-static balance and proprioceptive sense in elite wrestlers

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Abstract

The aim of this study is to identify and correlate some factors that are thought to affect the dynamic-static balance and proprioceptive senses of elite level wrestlers.

Material and Methods

Descriptive statistics of a total of 13 volunteer elite freestyle wrestlers were determined after body weights, height, WANt, active-squat jump tests, proprioceptive sense measurements, static and dynamic balance test measurements were taken. Then, the relationship test with the values obtained from static-dynamic balance and proprioceptive sense measurements, the Wingate anaerobic power test (WAnT) and vertical jump (active-squat) was examined.

Results

As a result of Pearson Products Moment Relationship analyses, a significant relationship was found between static balance measurements and, WAnT anaerobic performance measurements, anaerobic performance measurements obtained from jumping, lower extremity isoinertial strength imbalance measurements (p>0.05). In addition, a significant relationship was found between dynamic balance measurements and WAnT anaerobic performance measurements (p>0.05). In addition, a significant relationship was found between proprioceptive joint angle deviation values and WAnT anaerobic performance measurements, anaerobic performance measurements obtained from jumping, and lower extremity isoinertial strength imbalance measurements (p>0.05).

Conclusions: In conclusion, as the findings of the study, the determining factors of the balance and angular error rates differ in the left and right legs of wrestlers. Especially, in order to minimize left leg balance and angular errors, training modules that increase proprioceptive performance should be applied to athletes.

Keywords: proprioception, dynamic balance, static balance, wrestling, male

Introduction

In order for the individual to maintain proper motor control, two different senses must work effectively. The sense of balance and vision in the inner ear constitute these senses. Preserving posture together with balance is not a passive fixation, but it is accepted as an active state that includes proprioceptive feedback processes [1]. As the ability to maintain the position, it regulates the proprioceptive sensory, vision and vestibular sensory organs, which provides the coordination between muscle contractions in the lower extremities in balancing the body and significantly affects all activities of daily life. In addition, the relationship between proprioceptive sense and sense of vision emerges as an important factor to control postural sway in static balance [2].

The proprioceptive system, which modulates muscle tone and activity, controls the load applied to bones, joints, tendons and ligaments. These loads are then converted into molecular signals by mechanosensors placed inside tissues. Thus, both growth and stability of the body are regulated [3]. According to some researchers, joint position sense is defined as a specialized model of tactile sense, which is defined in a wide range and includes neuromuscular control [4], while other scientists define proprioception as being aware of position or movement, that is, “afferent input”. The afferent information required for fine tuning of motor control works fine on motor control, and this is provided by visual, vestibular and somatosensory receptors [5]. In addition, proprioception is examined in two subgroups as static and dynamic proprioception. While static proprioception means the conscious perception of the orientation of different extremities in the body with respect to one another; the speed and kinesthesia of the sense of movement is called dynamic proprioception. The knowledge of dynamic and static proprioception is attributed to the awareness of the angular movements in all joints applied in all planes and the ratios of the differences in these situations [6]. Kinesthesia, which includes the dynamic component of proprioception, defined as the sense of speed and joint motion, contains mechanoreceptors that give neuromuscular abilities to athletes for each joint movement and joint sense [7]. Sensory receptors of proprioception in the skin, muscles, joints, ligaments and tendons continuous monitoring of changes in muscle length, joint angle changes of the other corresponding joint that implements the motion, and the forces generated during muscle contraction are of critical importance to the fulfillment of motor tasks. Proprioceptive sensory neurons (PSN) interpret and respond through spinal circuits. The paths to the brain encode this information and transmit it to the central nervous system [8, 9].
Proprioceptive mechanosensors are responsible for the continuous regulation of skeletal muscle length and tension to coordinate motor control [9]. Known and most important ones are specific sensory receptors known as muscle spindles (MS) and Golgi tendon organs (GTO), as axons that extend to the periphery from PSN cell bodies localized in the dorsal root ganglia (DRG) [10]. Among all mechanosensors, the two dominant types are considered as the muscle spindle and the Golgi tendon organ. These mechanosensors differ in morphology, location, measured input, effect and other properties [11-13]. Common to both mechanosensor is that they perceive the biomechanical environment and that special sensory afferent information quickly initiates a neural response in the fibers. As a result, muscle spindles and GTOs modulate local muscle tension, and have the ability to create reflex bridges [14].

Postural performance is defined as the ability to minimize postural sway [15]. In other words, it is accepted as an umbrella term that includes the act of maintaining, regaining or restoring a balance state during any postural balance or activity [16]. In addition to playing a role in sport-specific postural control, balance is also known to play a fundamental role in many athletic activities. Although the relationship between balance and performance is limited, it can contribute to high performance [17, 18]. Factors that change the responses of postural control are sensory information obtained from the somato sensory, visual, and vestibular systems. In addition, it includes motor responses that affect the quality and safety of performance during athletic performance, such as routine functional movements, coordination, range of motion (ROM), high intensity exercises [19] power values [20, 21] vertical protection of the center of mass (COM) of the body on the base of support (BOS) [17]. In order to have an optimal balance, three afferent information must be provided. These are proprioception, vision, and vestibular system [22].

Wrestling is one of the oldest competitive sports in the world as a high-intensity sport that requires regional power and whole-body power [23-26]. While athletes exhibit these skills on the mat, they apply many physical and affective characteristics such as strength, endurance, flexibility, balance, agility, strategy to the opponent during the match, in transforming the skill into points. As these characteristics are being exhibited, the skills enter into a systematic cycle, as successive and alike. During the match, this cycle is provided with conscious and unconscious feelings, awareness of movement, balance and postural control. This is reflected in the central nervous system as neural cumulative input and draws attention to the importance of proprioception in wrestling [27, 28].

Purpose: In this context, our study was conducted to determine the relationship between lower extremity strength imbalances and anaerobic performance, which are thought to affect the dynamic-static balance and proprioceptive senses obtained from elite level wrestlers.

Material and Methods

Participants
In the study, 13 national male athlete students (24.23 ± 2.01 years; 172.84 ± 8.08 cm; 80.67 ± 23.31 kg) who were educated at Bartın University Faculty of Sport Sciences and actively participated in wrestling training have participated voluntarily. The approval of Ankara University Faculty of Medicine Clinical Research Ethics Committee was obtained for the study to be implemented.

Research Design
In the research, there were athletes who competed as licensed athletes in wrestling for the last 5 years and participated in training at least 4 days a week. Athletes who competed in wrestling as freestyle athletes and represented Turkey in the A classification category participated. A randomized single-blind experimental study design with no control group was used in the study.

Anthropometric Measurement Tools
Height and body weight measurements were taken with scales integrated with SECA brand stadiometer. The precision of the device is ±0.01 mm and ±0.1 kg.

Anaerobic power and Capacity Measurement Tools
When determining anaerobic performance, Monark 894 branded Wingate Anaerobic Power Test (WAnT) was used. Participants were subjected to a 30-second test period by applying 75g of external resistance per body weight. In addition, as another method, squat jump and active jump tests were applied on the Lafayette-VertiMetric branded electronic jumpmeter.

Proprioception Measurement
For proprioceptive measurements, Baseline Digital Absolute+Axis 180˚ goniometer was used. In order to provide stability in the knee joint and to prevent any angular error, the digital goniometer is mounted on the Vicromed brand angle adjustable knee brace. Joint Position Sense (JPS) method, one of the proprioceptive measurement methods, was applied to the participants on double leg [29]. While determining the target angles, the knee joint positions during the skills used by the athletes in wrestling sport were examined and the close values, 90°, 105°, 120° were determined as target angle.

Static and Dynamic Balance Measurement
Static and dynamic balance measurements were performed using Pro-Kin Tecnobody, PK200 branded device. Among the static balance data, the parameters of each participant’s static balance scores were recorded. These parameters were determined as FBSD: back and forth sway, MLSD: left and right sway, ACOPY: pressure point to y-axis, ACOPX: pressure point to x-axis. The parameters among the dynamic balance data were determined as PL: total sway, AGP: mean sway velocity in the field, AP: mean degree of sway to the front and back, ML: mean degree of sway to the left and right. On the dynamic balance device, the balance scores of double leg with eyes open, dominant legs with eyes open and nondominant legs with eyes open were recorded.

Isometric Force Distribution Measurements
Isometric force distribution measurements were performed on the DESMOTEC D. device as the force
values applied to double leg in the lower extremities and the percentage of imbalance in force. Isometric Durability test present in the system was used as a protocol. This protocol was applied to the participants for 30 seconds in professional mode. The participant has to pull the load cells (flywheel) upwards to generate the maximum possible force. The flywheel implements downward resistance on the participant by applying the same force. Power values on double leg during resistance and percentages of imbalance during load on double leg were separately recorded.

**Statistical Analysis**

As a result of the data obtained, first descriptive statistics data (standard deviation-mean) were taken from the SPSS 22.0 package program for the relationship level with dynamic-static balance and proprioceptive measurements. Then, the relationship level between the variables was examined with the Pearson Product Moments Relationship method in the SPSS 22.0 program.

**Results**

Of the wrestlers participating in the study; vertical jump, WAnT, isoinertial, proprioceptive sense values are shown in Table 1, while the mean and standard deviation values of static balance and dynamic balance values are shown in Table 2.

**Table 1.** Mean and standard deviation values of vertical jump, WAnT, isoinertial, proprioceptive sense values.

| Measurements                  | n: 13                  |
|-------------------------------|------------------------|
| **Vertical Jump**             |                        |
| Squat Jump                    |                        |
| AP (kg.m.s\(^{-1}\))          | 113,420 ± 28,68        |
| RAP (watt.kg\(^{-1}\))        | 13,9968 ± 1,18         |
| AP (watt)                     | 1134,2000 ± 286,85     |
| Active Jump                   |                        |
| AP (kg.m.s\(^{-1}\))          | 120,7216 ± 31,76       |
| RAP (watt.kg\(^{-1}\))        | 14,8468 ± 0,93         |
| AP (watt)                     | 1207,2162 ± 317,61     |
| **WAnT**                      |                        |
| IMP (watts)                   | 943,78 ± 210,27        |
| RIM (watt / kg)               | 11,77 ± 1,85           |
| MP (watt)                     | 775,49 ± 177,82        |
| RMP (watts / kg)              | 9,67 ± 1,62            |
| AP (watt)                     | 617,08 ± 149,45        |
| RAP (watt / kg)               | 7,61 ± 0,69            |
| **Isoinertial (lower extremity)** |                    |
| Maximum force (kg)            | 279,93 ± 72,04         |
| Average force (kg)            | 161,57 ± 33,77         |
| Left leg imbalance (%)        | 24,00 ± 14,92          |
| Right leg imbalance (%)       | 3,0769 ± 2,06          |
| **Proprioceptive Sense**      |                        |
| Right Leg                     |                        |
| Knee joint 90° deviation error (°) | 3,10 ± 2,96          |
| Knee joint 105° deviation error (°) | 4,92 ± 3,08          |
| Knee joint 120° deviation error (°) | 4,16 ± 3,30          |
| Left Leg                      |                        |
| Knee joint 90° deviation error (°) | 3,62 ± 2,74          |
| Knee joint 105° deviation error (°) | 4,60 ± 2,72          |
| Knee joint 120° deviation error (°) | 4,12 ± 3,00          |

AP: Anaerobic power RAP: Relative anaerobic power, IMP: Instantaneous maximum power, RIM: Relative instantaneous maximum power, MP: Maximum Power, RMP: Relative maximum power, AP: Average power; RAP: Relative average power.
Table 2. Mean and standard deviation values of static balance and dynamic balance values.

| Measurements                     | n: 13 |
|----------------------------------|-------|
|                                  | FBSD (mm) | 5.80 ± 1.27 |
| Right Leg (eyes open)            |        | 7.73 ± 2.20 |
|                                  | MLSD (mm) | 11.64 ± 4.26 |
|                                  | ACOPY   | -5.48 ± 12.87 |
|                                  | ACOPX   | -1.98 ± 13.90 |
| Left Leg (eyes open)             | FBSD (mm) | 5.61 ± 1.04 |
|                                  | MLSD (mm) | 7.06 ± 1.80 |
|                                  | ACOPY   | -6.66 ± 7.93 |
|                                  | ACOPX   | -2.21 ± 4.65 |
| Double Leg (eyes open)           | FBSD (mm) | 2.94 ± 0.79 |
|                                  | MLSD (mm) | 6.25 ± 2.23 |
|                                  | ACOPY   | -10.42 ± 23.87 |
|                                  | ACOPX   | -2.21 ± 4.65 |
| Double Leg (eyes closed)         | FBSD (mm) | 3.71 ± 1.66 |
|                                  | MLSD (mm) | 5.86 ± 2.07 |
|                                  | ACOPY   | -5.97 ± 20.91 |
|                                  | ACOPX   | -3.09 ± 6.20 |

FBSD: Forward-backward standard deviation, MLSD: Right-left standard deviation, ACOPY: Pressure applied to the Y-axis (average), ACOPX: Pressure applied to the X-axis (average), PL: Perimeter length, AGP: Average sway speed, AP: average degree of sway back to front, ML: average degree of sway left-right.

Table 3. The relationship between proprioceptive joint angle deviation values and WAnT anaerobic performance values of the participants

| Measurements | AP   | RAP   | AC    | RAP   |
|--------------|------|-------|-------|-------|
|              | n:13 | MAP (watt) | RMAP (watt/kg) | IMP (watt) | RIMP (watt/kg) | AAP (watt) | AAP (watt/kg) |
| Proprioceptive Sense |      |        |       |        |        |        |        |
| Left Knee Joint | 90 (°) | r ,413 | -278 | ,477 | -245 | ,581 | -127 |
|                 | p ,161 | ,357 | ,099 | ,420 | ,037* | ,678 |
|                 | 105 (°) | r ,091 | -297 | ,223 | -170 | ,314 | -047 |
|                 | p ,767 | ,324 | ,464 | ,578 | ,296 | ,880 |
|                 | 120 (°) | r ,310 | -323 | ,459 | -187 | ,511 | -228 |
|                 | p ,302 | ,282 | ,115 | ,542 | ,075 | ,453 |

p>0.05; AP: Anaerobic power, RAP: Relative anaerobic power, AC: Anaerobic capacity, MAP (watt): 0-5sec maximum average power, RMAP (watt / kg): 0-5sec maximum average power per kg, IMP (watt): instantaneous maximum power, RIMP (watts / kg): instantaneous maximum power per kg, MV (watts): all test average power, OG (watts / kg): all test average power per kg.
Table 4. The relationship between static balance and dynamic balance measurements and WAnT anaerobic performance values of the participants

| Measurements | AP (watt) | RAP (watt/kg) | IMP (watt) | RIMP (watt/kg) | AC (watt) | RAP (watt/kg) |
|--------------|-----------|---------------|-----------|---------------|-----------|---------------|
| n:13         | MAP       | RMAP          | IMP       | RIMP          | AAP       | AAP           |
|              | watt      | (watt/kg)     | (watt)    | (watt/kg)     | watt      | (watt/kg)     |
| Static Balance |           |               |           |               |           |               |
| Right leg (Eyes open) | |               |           |               |           |               |
| FBSD (mm)    | r ,528    | -108          | ,539      | -109          | ,516      | -163          |
| p ,064       | 725       | 057           | 724       | 071           | 596       |               |
| MLSD (mm)    | r ,100    | -141          | ,155      | -108          | ,269      | 127           |
| p ,745       | 646       | 612           | 726       | 375           | 680       |               |
| ACOPY        | r ,191    | ,161          | ,124      | ,108          | ,030      | ,035          |
| p ,532       | ,599      | ,685          | 727       | 923           | ,111      |               |
| ACOPX        | r ,290    | ,175          | ,227      | ,084          | ,244      | ,294          |
| p ,337       | ,337      | ,457          | 784       | 421           | ,329      |               |
| Left leg (Eyes open) | |               |           |               |           |               |
| FBSD (mm)    | r ,440    | ,289          | ,444      | ,285          | ,373      | ,347          |
| p ,132       | ,339      | ,129          | 345       | 209           | ,246      |               |
| MLSD (mm)    | r ,445    | ,161          | ,446      | ,242          | ,607      | ,018          |
| p ,127       | ,600      | ,127          | 425       | 028*          | ,953      |               |
| ACOPY        | r ,023    | ,030          | ,129      | ,128          | ,062      | ,076          |
| p ,940       | ,922      | ,674          | 678       | 840           | ,804      |               |
| ACOPX        | r ,089    | ,381          | ,015      | ,317          | ,105      | ,345          |
| p ,772       | ,199      | ,960          | 292       | ,734          | ,248      |               |
| Dynamic Balance |           |               |           |               |           |               |
| Double Legs (Eyes Open) | |               |           |               |           |               |
| PL (°)       | r ,444    | ,629          | ,391      | ,540          | ,199      | ,473          |
| p ,128       | ,021*     | ,187          | 057       | ,515          | ,103      |               |
| AGP °/sn     | r ,445    | ,630          | ,391      | ,540          | ,199      | ,473          |
| p ,127       | ,021*     | ,186          | 057       | ,514          | ,102      |               |
| AP (°)       | r ,135    | ,371          | ,229      | ,257          | ,302      | ,289          |
| p ,660       | ,212      | ,452          | 397       | 317           | ,338      |               |
| ML (°)       | r ,345    | ,101          | ,360      | ,080          | ,271      | ,076          |
| p ,249       | ,742      | ,227          | ,796      | ,370          | ,805      |               |
| Right Leg (Eyes Open) | |               |           |               |           |               |
| PL (°)       | r ,285    | ,567          | ,073      | ,278          | ,008      | ,352          |
| p ,345       | ,043*     | ,813          | ,358      | ,979          | ,238      |               |
| AGP °/sn     | r ,286    | ,568          | ,073      | ,278          | ,009      | ,353          |
| p ,344       | ,042*     | ,812          | ,358      | ,978          | ,237      |               |
| AP (°)       | r ,007    | ,273          | ,031      | ,294          | ,111      | ,306          |
| p ,983       | ,368      | ,919          | ,329      | ,718          | ,309      |               |
| ML (°)       | r ,341    | ,310          | ,195      | ,121          | ,198      | ,308          |
| p ,254       | ,302      | ,524          | ,694      | ,517          | ,306      |               |
| Left Leg (Eyes Open) | |               |           |               |           |               |
| PL (°)       | r ,271    | ,600          | ,185      | ,517          | ,008      | ,446          |
| p ,371       | ,030*     | ,544          | ,070      | ,980          | ,127      |               |
| AGP °/sn     | r ,270    | ,600          | ,185      | ,517          | ,008      | ,445          |
| p ,371       | ,030*     | ,545          | ,070      | ,980          | ,127      |               |
| AP (°)       | r ,324    | ,012          | ,342      | ,031          | ,342      | ,101          |
| p ,280       | ,969      | ,253          | ,920      | ,252          | ,743      |               |
| ML (°)       | r ,077    | ,069          | ,273      | ,195          | ,239      | ,264          |
| p ,804       | ,822      | ,367          | ,523      | ,431          | ,384      |               |

p>0.05; AP: Anaerobic power, RAP: Relative anaerobic power, AC: Anaerobic capacity, MAP (watt): 0-5sec maximum average power, RMAP (watt / kg): 0-5sec maximum average power per kg, IMP (watt): instantaneous maximum power, RIMP (watt / kg): instantaneous maximum power per kg, MV (watts): all test average power, OG (watts / kg): all test average power per kg.
### Table 5. The relationships between static balance - proprioceptive sense measurements and anaerobic performance values obtained from vertical jumping of the participants

| Measurements | n:13 | SJAP (kg.m.s\(^{-1}\)) | SJRAP (watt.kg\(^{-1}\)) | SJAP (watt) | AJAP (kg.m.s\(^{-1}\)) | AJRAP (watt.kg\(^{-1}\)) | AJAP (watt) |
|--------------|------|------------------------|--------------------------|------------|------------------------|--------------------------|------------|
| **Static Balance** |     |                        |                          |            |                        |                          |            |
| Left leg (Eyes open) |     |                        |                          |            |                        |                          |            |
| FBSD (mm) | r | .352 | .289 | .352 | .316 | .287 | .316 |
| p | .237 | .339 | .237 | .293 | .341 | .293 |
| MLSD (mm) | r | .619 | .713 | .619 | .568 | .042 | .568 |
| p | .024\* | .043\* | .024 | .043\* | .891 | .043\* |
| ACOPY | r | .101 | .268 | .101 | .062 | .159 | .062 |
| p | .743 | .377 | .743 | .841 | .604 | .841 |
| ACOPX | r | -.113 | .329 | .113 | -.105 | .506 | -.105 |
| p | .714 | .272 | .714 | .732 | .078 | .732 |
| **Double legs (Eyes open)** |     |                        |                          |            |                        |                          |            |
| FBSD (mm) | r | -.337 | -.166 | -.337 | -.368 | -.456 | -.368 |
| p | .260 | .587 | .260 | .216 | .118 | .216 |
| MLSD (mm) | r | .000 | -.575 | .000 | -.499 | .077 | -.499 |
| p | .999 | .040* | .999 | .083 | .040* | .083 |
| ACOPY | r | .213 | -.210 | .213 | -.312 | .221 | -.312 |
| p | .485 | .491 | .485 | .468 | .299 | .468 |
| ACOPX | r | .101 | -.343 | .101 | .150 | -.277 | .150 |
| p | .742 | .251 | .742 | .624 | .359 | .624 |
| **Proprioceptive Sense** |     |                        |                          |            |                        |                          |            |
| Left Knee Joint |     |                        |                          |            |                        |                          |            |
| 90 (°) | r | .580 | -.052 | .580 | .554 | -.177 | .554 |
| p | .038\* | .901 | .038\* | .562 | .038\* | .562 |
| 105 (°) | r | .188 | .431 | .188 | .259 | -.289 | .259 |
| p | .538 | .142 | .538 | .533 | .338 | .533 |
| 120 (°) | r | .507 | -.171 | .507 | .535 | -.128 | .535 |
| p | .077 | .578 | .077 | .577 | .299 | .577 |
| **Right Knee Joint** |     |                        |                          |            |                        |                          |            |
| 90 (°) | r | -.225 | .333 | -.225 | .148 | .035 | .148 |
| p | .461 | .266 | .461 | .266 | .109 | .266 |
| 105 (°) | r | .174 | .084 | .174 | .166 | .084 | .166 |
| p | .569 | .785 | .569 | .587 | .785 | .587 |
| 120 (°) | r | .424 | .331 | .424 | .409 | .331 | .409 |
| p | .149 | .269 | .149 | .166 | .269 | .166 |

p>0.05; SJAP: squat jump anaerobic power, SJRAP: squat jump relative anaerobic power, AJAP: active jump anaerobic power, AJRAP: active jump relative anaerobic power

### Table 6. The relationships between the static balance – proprioceptive sense and isoinertial lower extremity imbalance measurements of the participants.

| Measurements | n:13 | MF (kg) | AF (kg) | LLIP (%) | RLIP (%) |
|--------------|------|---------|---------|----------|----------|
| **Static Balance** |     |         |         |          |          |
| Right leg (Eyes open) |     |         |         |          |          |
| FBSD (mm) | r | .391 | .455 | -.127 | -|
| p | .187 | .118 | - | -|
| MLSD (mm) | r | .088 | .282 | -.173 | -|
| p | .775 | .350 | - | -|
| ACOPY | r | .340 | .189 | -.245 | -|
| p | .256 | .537 | - | -|
| ACOPX | r | .470 | .533 | -.618 | -|
| p | .105 | .060 | - | -|
| **Left leg (Eyes open)** |     |         |         |          |          |
| FBSD (mm) | r | .343 | .275 | -.038 | -|
| p | .252 | .363 | .901 | -|
| MLSD (mm) | r | .030 | .306 | .178 | -|
| p | .923 | .310 | .560 | -|
| ACOPY | r | .249 | .111 | .629 | -|
| p | .412 | .718 | .021* | -|
| ACOPX | r | .407 | .326 | -.091 | -|
| p | .168 | .277 | .769 | -|
| **Proprioceptive Sense** |     |         |         |          |          |
| Right Knee Joint |     |         |         |          |          |
| 90 (°) | r | -.225 | .333 | -.035 | -|
| p | .461 | .266 | - | -|
| 105 (°) | r | .174 | .084 | -.166 | -|
| p | .569 | .785 | - | -|
| 120 (°) | r | .424 | .331 | -.409 | -|
| p | .149 | .269 | - | -|
| Left Knee Joint |     |         |         |          |          |
| 90 (°) | r | .367 | .480 | .240 | -|
| p | .217 | .097 | .430 | -|
| 105 (°) | r | .172 | .320 | .080 | -|
| p | .575 | .286 | .795 | -|
| 120 (°) | r | .061 | .148 | .637 | -|
| p | .843 | .630 | .019* | -|

p>0.05; MF: maximum force, AF: average force, LLIP: Left leg imbalance percentage, RLIP: Right leg imbalance percentage.
No relationship was found between static balance with double leg with eyes open and double leg with eyes closed and lower extremity isoinertial force imbalance measurements. No relationship was found between wrestlers' dynamic balance and lower extremity isoinertial force imbalance measurements.

No relationship was found between right knee joint proprioceptive joint angle error values and lower extremity isoinertial force imbalance measurements.

Discussion

According to the findings obtained, it is seen that the mean values of the wrestlers participating in the study have normal values are similar to the literature [30-32].

In static balance, statistically better results were obtained from the means, in favor of the balance measurements with eyes open, between the balance measurements with double leg with eyes open, and the balance measurements with double leg with the eyes closed (Table 2). The degree of sway of the left leg in static balance suggests that this may be related to the mass and volume of the muscles in the thigh and their inter-synergy. When dynamic balance measurements are considered, right leg dynamic balance measurements show statistically more positive results than left leg dynamic balance measurements. Double leg dynamic balance measurements show better scores than both single leg balance measurements (Table 2).

Isoinertial balance parameter distributions were examined on the condition of generating eccentric force after an equal amount of concentric force by means of a flywheel system. While athletes applied maximum force (279.93 ± 72.04kg) and applied average force (161.57 ± 33.77kg), their left leg imbalance percentages were determined as 24.00 ± 14.92%, and right leg imbalance percentages were determined as 3.07 ± 2.06%. As can be understood here, the force on both knee joints exhibits a great imbalance in the percentage force distribution in the left leg. Besides, the test yielded results that prove that the dominant leg is the right leg with percentages of imbalance in force (Table 1). As in the studies on the balance values of wrestlers with auditory special needs [33, 34] in the literature, the results of the studies with the participation of normal wrestlers [35, 36] are similar to the findings of this study. As the “sway” states in the balance parameters move away from the zero (0) point, it leads the athlete to imbalance. So much so that this situation is seen as determinant in both static and dynamic balance. However, it is seen that the anthropometric values of the athletes affect the balance scores [37], and it is also seen that balance studies in different branches are stimulated through different proprioceptive channels [38, 17]. In addition, it has been found that in the balance parameters applied on different surfaces, defense sports such as taekwondo have more single leg sways [39]. This situation is similarly observed in studies conducted in different branches [40]. Contrary to all these results, there are also studies in the literature stating that anthropometric properties may not be considered as descriptive in balance tests and additional research may be required for this [41].

The ability of individuals to do a work for balance performance is not only based on muscle strength, aerobic capacity, but may also be related to the explosive power generation of leg extensors [42-44] hamstring/quadriceps ratio. In case of imbalance, the most important risk factors are muscle strength applied to the knee joint, hip extensors-flexors, and lateral postural balance situation [45,46]. When the anaerobic results are examined at the level of means (Table 1), it is in line with the literature when considering the athletes of being at national level and at the level of training [47-49]. In some studies, it is seen that it has lower maximum, minimum and mean power values than our study in terms of training status and age criteria [50]. In the study examining the anaerobic performance values of different style wrestlers, it is seen that in the wingate lower extremity anaerobic performance test, Greco-Roman style has higher values than freestyle in all variables [51]. There are similarities between the anaerobic performance values of freestyle and Greco-Roman style athletes and the values of the athletes in our study, except for the maximum anaerobic power and fatigue index values.

High number of muscles, muscle mass and muscle fibers that make up the leg area indicate that the force generated by the muscle may be higher [52, 53]. In this respect, the fact that the dominant legs of the wrestling athletes in our group are right legs, and the other leg is lighter while maintaining balance on the mat may provide an advantage. Thus, less load will be placed on the body during balance, and athletes can be made to use their left leg as a limb to demonstrate their strategies.

On the other hand, deep ventilation resulting from anaerobic acidosis (lactic acid accumulation) caused by intense vigorous exercise also increases body release [54, 55]. It is known that affect postural control by causing proprioceptive stimulation, vestibular and visual inputs cause nerve muscle fatigue after vigorous exercise, central and affective weaknesses and cardio-respiratory changes [56-58].

In previous studies on the sense of joint position, traumas in the knee joint in general and the differences in the patient’s return process were examined. Some of these studies included elderly individuals [59-61], young sedentary individuals [62], the relationship between the fall risks of elderly groups and pain syndromes [63-65], patients with knee osteoarthritis [66], the differences in the sense of joint position of the groups with and without athletes, and the position sense within the sports branches [67-69]. In our study, the smaller the angular error value and the closer to the taught degree (90°-105°-120°) in proprioceptive measurements taken using the Joint Position Sense (JPS) method (Table 1), the better the awareness of the limbs. The better the awareness of the joint position, the more effective it will be in practicing the skill and positioning against the opponent in the match and turning this into points. Results showed that right leg values showed better results in 90 degree angular error than left leg 90 degree angular error. In 105 degrees and
120 degrees angular errors, it is seen that the angular error of the left leg is better than the angular errors of the right leg (Table 1). In this situation the posture of the wrestlers, the angular awareness of the support legs, their habits while applying the skill can cause angular errors. In addition, it is known that their weight values may be negatively correlated with the sense of position [70]. Obese individuals [71] and having a higher body mass index causes loss of joint stability and impaired proprioception [72]. However, attention has been drawn to the relationship between anaerobic exercise and muscle strength and proprioceptive sense [52], and it has been observed that the knee joint recovered within 30 minutes after the exercise and returned to its former sensory values at the end of 24 hours [73]. When we look at this acute effect, it is seen that as the anaerobic load increases, the proprioception senses are negatively affected [73]. In effect, it is seen that as the anaerobic load increases, the proprioceptive accuracy [75]. PNF (proprioceptive neuromuscular facilitation) method can be given as an example and widely used technique [76-78].

**Conclusion**

As a conclusion, the determining factors of the balance and angular error rates in the left leg and right leg of the wrestlers differ. Performance enhancing training modules should be applied on left leg balance and angular errors. These training modules should include methods that increase the effectiveness of proprioceptive receptors in muscles, tendons and joints.

**Conflict of interest**

The authors declare no conflict of interest.

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