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METHODOLOGY FOR MONITORING FREESTYLE WRESTLERS' TECHNICAL ACTIONS USING A SENSOR-BASED PLATFORM AND INDIVIDUALIZING PRE-COMPETITION TRAINING LOADS

Abdunazar Khamidjonov
Uzbekistan State Academy of Sport
Head of the Department of Scientific Research, Innovation, and Training of Scientific and Pedagogical Personnel
Email: khamidjonovabdunazar@gmail.com
Toshkent, Uzbekistan

ABOUT ARTICLE

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Abstract: This article examines the monitoring of freestyle wrestlers' technical actions using a sensor-based platform and the individualization of pre-competition training loads based on the analytical indicators obtained. Particular attention was paid to determining the overall support force and its distribution between the legs during the performance of technical actions, as well as the load on the left and right legs and support stability. The data obtained from the sensor-based platform were used to assess the effectiveness of technical actions, identify existing deficiencies, and select specific exercises according to the individual capabilities of each athlete. Based on the identified indicators, a sequence was developed for adjusting the volume and intensity of training loads to the athlete's technical and physical condition during the pre-competition period. The proposed methodology enables objective assessment of freestyle wrestlers' technical actions, consideration of individual characteristics of athletic preparedness, and targeted management of pre-competition training loads.

Introduction. In freestyle wrestling competitions, the effectiveness of a technical action is determined not only by how quickly an athlete performs the movement, but also by how effectively body weight is transferred to the support, support points are changed at the appropriate moment, and the generated force is utilized in the direction of movement. In particular, during attacking entries, disrupting the opponent's balance, and taking the opponent to the mat, the support position of the legs changes continuously. Therefore, although the same technical action may appear externally similar when performed by different athletes, its internal force distribution can differ considerably.

Quantitative indicators of support reaction provide important information for identifying such individual characteristics of technical actions. The contribution of the left and right legs to support, changes in total force, and the distribution of load between the legs make it possible to determine at which stage of the movement the athlete actively applies force. Variability in these indicators also makes it possible to identify certain differences in the execution of technical actions that may not be apparent from their external appearance.

In practical training, the effectiveness of technical actions is often assessed through coach observation, video recordings, and the final outcome of the performed action. Although such approaches can demonstrate the final result of a movement, they have limitations in fully characterizing how support forces are distributed throughout the action. Consequently, it becomes more difficult to determine at which support phase the athlete fails to utilize their force capacity sufficiently or on which leg excessive load is generated.

The use of a sensor-based platform makes it possible to examine this issue through force indicators recorded directly during the movement. The left-leg force, right-leg force, total force, and load ratio between the legs obtained from the platform can be considered individual indicators for analyzing the support mechanism of technical actions. Joint analysis of these data with the characteristics of technical action execution creates a basis for developing an individual technical profile of the athlete.

The importance of such analysis becomes even greater during the pre-competition period. At this stage, the primary task is not simply to increase training load, but to accurately determine the training stimulus aimed at correcting the technical and force-related deficiencies identified in the athlete. For example, if excessive load on one leg, insufficient development of total force, or unstable support is observed during a technical action, the training content can be specifically directed toward improving the corresponding indicator. In this way, the results

of sensor-based monitoring serve not only as a means of assessment but also as an important source of information for determining subsequent training loads.

State of the problem study. A number of scientific studies have been conducted on the biomechanical characteristics of technical actions in wrestling. In particular, A.U.Xamidjonov, S.A. Gonzales, R.A.R. Rodriguez, D.L.E. Loaiza, and co-authors analyzed wrestling techniques from the perspective of the interaction of mechanical forces and substantiated the importance of the direction and application mechanisms of force in the formation of offensive, defensive, and counterattack actions. The authors emphasized the need to analyze the mechanical structure of movements in order to improve wrestling techniques.

A biomechanical classification of technical actions in competitive wrestling was developed by A.G. Levitsky, D.A. Matveev, A.A. Potsipun, O.V. Oshina, and O.V. Kholodkova. In their study, standing techniques were classified into mechanical groups such as force couples, levers, mechanical blocks, and combined throwing techniques. This approach makes it possible to assess technical actions not only according to their external appearance but also based on their mechanical structure and mechanisms of force generation.

Instrumental measurement methods have also been used in studies aimed at determining the force and movement mechanisms of attacking actions in freestyle wrestling. In particular, a study of the double-leg attack employed a three-dimensional motion capture system in combination with a force platform to analyze ground reaction forces and whole-body movement mechanics. This approach demonstrates the possibility of establishing a relationship between force indicators generated during a technical action and the kinematics of the movement.

T. Jang, C. Chang, S. Chen, and co-authors investigated defensive movements in freestyle and Greco-Roman wrestlers using a three-dimensional motion capture system and two force platforms. The study analyzed lower-limb joint kinematics and center-of-pressure (COP) movement. This research demonstrates the potential of instrumental methods for assessing the relationship between support conditions and body movement during wrestling actions.

Research objective – to identify changes in support-force characteristics during the technical actions of freestyle wrestlers using sensor-based platform indicators and to establish these indicators as criteria for managing pre-competition training loads.

Main part. The effectiveness of technical actions in freestyle wrestling is closely associated with the athlete's movement speed, force capabilities, ability to control the support position, and capacity to distribute body mass in accordance with the direction of movement. In particular, during attacking entries, disrupting the opponent's support, double-leg and

single-leg attacks, counterattacks, and throwing actions, the force generated through the athlete's legs directly affects the subsequent phase of the technical action. Therefore, when studying technical actions, it is necessary to consider not only their external appearance but also the indicators characterizing their support mechanism.

In traditional training practice, the quality of technical actions is often assessed through coach observation, video analysis, and the athlete's final performance outcome. Although these methods are important for identifying technical errors, they cannot directly demonstrate the amount of force generated during the movement or its distribution between the legs. As a result, even when an athlete appears to perform a technical action correctly from an external perspective, individual differences in the effectiveness of support utilization may not be fully identified.

The use of a sensor-based platform makes it possible to examine this issue through quantitative indicators. The left-leg force, right-leg force, total force, left-leg load, and right-leg load recorded by the platform characterize the functional state of the support system during a technical action. Rather than considering the individual values of these indicators separately, their interrelationship is more important for understanding the support mechanism through which the athlete performs a technical action.

The ratio between the force generated by the left and right legs is one of the important indicators characterizing the athlete's use of support. However, differences between the forces of the two legs should not always be interpreted as a negative indicator. In some technical actions in freestyle wrestling, one leg may perform a supporting function while the other contributes to the continuation of the movement or formation of the attack. Therefore, the differences recorded by the platform should be analyzed in conjunction with the technical structure of the movement.

Figure 1. Technical and biomechanical interpretation of sensor-based platform indicators

The magnitude of total support force reflects the athlete's ability to generate force during a particular movement. A low value of this indicator does not necessarily indicate the presence of a technical deficiency. The athlete's body mass, type of technical action, duration of support, and specific phase of the movement may all influence the recorded result.

Load distribution between the legs is also an important component of a technical action. Changes in the proportion of load placed on the left and right legs demonstrate how the athlete controls and transfers body weight. For example, a sudden transfer of support to one leg during an attacking entry may be a natural feature of certain technical actions. However, if the athlete is unable to reorganize the support position effectively, this may lead to a reduction in movement stability.

Table 2.

Criteria for assessing technical actions and determining individual training loads based on sensor-based platform data

N	Technical action	Platform indicators monitored	Identified condition	Technical-biomechanical interpretation	Recommended exercise direction	Individual load criterion

1	Leg attack	Total force, left/right leg force	Insufficient support force generation during the attacking entry	Limited ability to effectively transfer force from the support during the attacking phase	Single-leg strength and speed-strength exercises	Initial individual force value and its dynamics
2	Single-leg attack	Left/right leg force and load distribution	Significant difference between the lead and support legs	Insufficient functional stability of single-leg support	Single-leg static and dynamic exercises	Dynamics of reducing the difference in leg force
3	Double-leg attack	Total force and leg load distribution	Low force or greater load distribution toward one side	Reduced effectiveness of simultaneous use of both support legs	Two-leg explosive-strength exercises	Individual baseline level of total force
4	Hip throw	Left/right load, %	Sharp changes in support load during movement	Difficulty in controlling the center of body mass and transferring support	Lateral movement and support-transfer exercises	Degree of stabilization of load distribution
5	Counterattack	Total force and leg force	Instability of support and force-generation indicators	Insufficient support-force coordination when responding to the opponent's movement	Reactive speed-strength exercises	Execution intensity while maintaining technical quality
6	Throwing actions	Total force and leg load distribution	Insufficient transfer of force in the direction of movement	Reduced efficiency of force transfer from the support to the athlete's body and the opponent	Specialized throwing exercises aimed at force transfer	Repeated dynamics of movement quality and platform indicators

The most important requirement when applying the criteria presented in the table is to take into account the athlete's individual indicators. It is natural for the force values recorded on the platform to differ between two athletes performing the same technical action. These differences may be influenced by body mass, athletic qualification, muscular strength, technical style, and individual characteristics of support utilization. Therefore, determining training loads solely by comparing one athlete's results with those of another is not methodologically sufficient. The athlete's own baseline indicators should be used as the primary reference for comparison.

This approach is particularly important during the pre-competition preparation period. At this stage, the main objective of training is not to increase the number of new technical actions or bring training volume to its maximum level, but rather to stabilize existing technical capabilities and correct identified deficiencies within a limited period. Therefore, the exercise modality, resistance level, number of repetitions, rest interval, and execution intensity should be determined individually according to each condition identified by the platform.

If the support force of one leg is consistently lower than that of the other leg, the proportion of specialized exercises aimed at developing the strength and stability of the weaker supporting leg may be increased. In this case, not only the amount of external resistance but also the preservation of technical quality during movement should be controlled. If an athlete is able to perform an exercise with the prescribed resistance but the support structure of the technical action deteriorates, increasing the training load is not considered appropriate.

If platform data indicate that support force is being generated adequately and the distribution of load between the legs remains stable, the pre-competition training load may be directed toward maintaining the existing technical-force condition without unnecessarily increasing training volume. In this case, monitoring results serve not only as a basis for providing additional training load but also as a means of preventing excessive loading.

Another important aspect of sensor-based platform monitoring is the possibility of repeated measurements. While the initial measurement establishes the athlete's baseline condition, repeated measurements conducted during the training process make it possible to assess the effects of selected specialized exercises and training loads. If repeated monitoring demonstrates positive changes in support force, load distribution between the legs, or total force indicators, the appropriateness of the selected training methods can be evaluated. If no improvement is observed or technical indicators deteriorate, the training load parameters should be reconsidered.

Within this approach, the sensor-based platform is regarded not merely as a measurement instrument but also as a source of information for training management. The numerical data obtained from the platform provide coaches with an additional basis for more accurately characterizing problems in an athlete's technical actions, selecting appropriate specialized exercises, and determining their training load. At the same time, the final pedagogical decision should not be based on a single indicator but on a comprehensive assessment of technical execution quality, platform results, and the athlete's individual state of preparedness.

Conclusion. The study analyzed the possibilities of monitoring the technical actions of freestyle wrestlers using a sensor-based platform and identified the importance of support force and load distribution between the legs in the execution of technical actions. Left-leg force, right-leg force, total support force, and left- and right-leg load were identified as key indicators characterizing the support mechanism of technical actions. Analyzing these indicators in conjunction with technical actions makes it possible to determine the athlete's individual force distribution and characteristics of support utilization.

Linking the data obtained from the sensor-based platform with the content of technical actions makes it possible to identify the athlete's support-force characteristics, select appropriate specialized exercises, and individually determine training load parameters. In this process, the importance of considering the athlete's baseline indicators, the quality of technical execution, and the dynamics of changes in platform measurements when determining training loads was substantiated.

The use of sensor-based monitoring during pre-competition preparation makes it possible to manage training loads not only in terms of volume and intensity but also according to the athlete's technical and force-related condition. Based on repeated monitoring results, selected exercises and training load parameters can be maintained, modified, or adjusted. Thus, in addition to assessing the technical actions of freestyle wrestlers, the sensor-based platform serves as a practical tool for individualizing pre-competition training loads and managing the training process based on objective data.

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