THE DEVELOPMENT OF THE DIAGNOSTIC AND TRAINING DEVICE FOR ARMWRESTLING

Gabriel **HARČARIK** [1 ABCDEF],

[1] *Faculty of Manufacturing Technologies in Košice with its seat in Presov, Presov, Slovakia*

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- testing
- strength
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Abstract

In the introduction to the article, the author deals with the issue of strength testing in armwrestling, stating that current motor tests do not correspond to the biomechanics of movement. The author states the main reasons for conducting his research into the development of isokinetic testing and training equipment, which would have its primary use for testing and developing strength abilities in armwrestling. The author also provides a detailed description of how the whole process went from testing the potential of the AbEx device, through its modification to the current form of TENDO IsoFORCE. The paper also describes how the creation of an additional, positionable construction took place so that it would meet all the demands for its use. During the testing, it was necessary to solve multiple details, shortcomings, especially in the construction and adjust them to the desired form. The author also informs that, during the research, he verified the basic armwrestling strength tests. In the results section, the author states that the test of the imitation of the "top roll" technique proved to be applicable for the needs of armwresling. The article describes exactly how this exercise is to be performed. This is followed by a comparison of the performance of the athletes on IsoForce and during the match. Those who had the best results in the "top roll" imitation technique test achieved better results in matches. In the conclusions, the author of the paper informs what specific modifications have been made to the device, what TENDO IsoFORCE can measure and what are the author's plans for the future in improving this device. In the upcoming research, the author will focus on the verification of other tests, which according to him should have an informative value for armwrestling.

INTRODUCTION

The modern techniques of strength testing are based on using devices that allow continuous recording of forces acting under dynamic conditions at a constant speed in the so-called isokinetic mode. The advantage of these devices is the possibility of measuring the acting forces and associated parameters in the entire range of motion during the concentric phase of movement and, with some devices, the eccentric phase of movement [Cvečka Schickhofer 2011]. In a particular test, the increase in effort does not result in the acceleration of motion as in standard dynamic tests. An increase in effort results in an increase in force,

which at a constant speed causes an increase in power [Hamar 2007].

A number of studies has shown that isokinetic dynamometry results show high reliability [Brown, 2000; Dvir 2004]. To determine the ideal testing model for assessing isokinetic muscle strength, the model must be compared with a lot of sports performances. Isokinetic concentric and eccentric actions should be assessed with and without isometric pre-activation [Perrin, 1993].

The best test of strength in armwrestling is the match itself. Armwrestling is a power sport. We can clearly determine only the winner, but we do not know the strength parameters the winner produced during the match against an opponent. We can still measure the time of the duel and say whether the opponent was overcome by explosive strength after the start, or whether the match was even, long and the athlete with a higher strength endurance level won. However, we still do not know how much strength the winner has produced using a particular technique. Muscle strength is considered one of the determinants of athletic performance in armwrestling. According to Harčarik [2008], "obsolete" field tests have been used in armwrestling (pull-ups, bench press, biceps curls with EZ barbell against the wall, rolling thunder® grip ...) so far. These tests do not correspond to the biomechanics of movement in armwrestling. Currently, a wide range of methods is used, using which we can test strength and speed. However, we see great potential in the use of isokinetic devices in training, but especially in testing armwrestlers. The advantage of the whole diagnostic/training device is that it allows the athlete to perform the same biomechanics of movement as he uses in the armwrestling match itself. It is therefore a complex technique and not just a single-joint isolation movement. On the other hand, this machine can also be used for isolation testing or training.

According to Harčarik [2018], the main issues to be addressed when testing strength abilities in armwrestling are as follows:

- **Time consuming process:** for larger groups, testing takes up to 4 hours and it is difficult to maintain the attention, motivation and performance of athletes for such a long time. Another reason is the need to test both arms. Sometimes the time was shortened only by testing the dominant hand, which was a mistake, because the athlete achieved better results in the competition in the other hand (which often happened). With such a mistake, we had no picture of the athlete's progression in the non-dominant arm. Another serious mistake that was made was the use of bilateral tests.
- **Pyramid progression:** field tests using loadable dumbbells and pulleys are still administered today. Athletes had multiple trials with one weight in some tests, which made them fatigued, extending the testing time.
- **Inaccuracy of the result:** in case of repeated attempts and growing fatigue, or a bad judgment of the athlete, we, for instance, recorded a valid attempt of 75 kg during the standing biceps curl test against the wall. In reality, the athlete had 2 foul attempts at 80 kg, but maybe could have handled 78 kg.
- **Differences in testing equipment:** in different gyms, tests were performed with different dumbbells, plates or using various pulleys and their weight was difficult to measure.
- **Unsuitable isometric dynamometry:** When using a back-leg lift or hand dynamometers (load cell), the testing time decreased, and we achieved accurate and repeatable results. The device was accurate and portable. According to Harčarik [2006] and Mazurenko [2016 ab], the dynamometer did not work because the athletes reported to feel elbow or wrist pain during and following testing and did not want to undergo repeated testing.
- **Isolation exercises:** So far, mostly 3 isolation exercises have been used for muscle groups, which have been defined as limiting. We see a problem in the fact that armwrestling (as well as other sports) is not an isolation movement, but a complex of movements,

and therefore we are also interested in the performance of the whole body, similar to the armwrestling technique.

Based on the description of these problems, we started looking for a machine that would help us solve them. During the market research, we analyzed a number of isokinetic machines such as Keizer, Excentrix, 1080 Quantum, which would be suitable for our testing purposes, but are financially expensive and non-portable. We also came across the TENDO AbEx exercise machine for strengthening the torso and measuring the strength of the abdominal muscles, which uses isokinetic devices with a hydraulic resistance system. Its 6-level resistance system is different from previous machines and measures only the concentric phase of movement, which suits us.

MATERIALS AND METHODS

The initial acquaintance with AbEx and the beginning of the development of TENDO IsoFORCE began in August 2018, when the potential of the machine manifested itself. We saw its advantages in terms of measurement purposes, the simplicity of the device and the possibility to adapt for the needs of armwrestling or for training various muscle groups. During the initial testing, we thought that it would be sufficient to connect the tow cable to the AbEx arm and attach it to the armwrestling table. We were thus able to apply the basic "top roll" technique by pulling backwards and the "hook" technique (if the device was placed at the side of the table). When verifying the accuracy of the data measured, we concluded that it was necessary to define the exact point from which the cable would run so that the angles did not change and it was possible to standardize these tests. We applied the calibration height of 110 cm, which was coincidentally also ideal from the point of view of the armwrestling table (105 cm height also with an elbow pad).

We needed to design a construction so that this height could be maintained for all tests and for any of the armwrestling tables. We also started to use this height to verify the "top roll" test/technique. Based on experiments, we moved the axis of this pulley to 27 cm from the edge of the table. The dimensions of the calibration pulley and the pulley we used for our additional device were the same. The outer diameter of the plastic pulley is 88.5 mm, with a ball bearing and a spacer with an inner diameter of 10 mm. While the cable passes over the calibration pulley along the upper edge, the cable goes over the lower edge on the pulley used on our construction, but at the same height of 110 cm (see Figure 1). The main reason why we had to set it this way is that we check the loaded weight by hanging (downwards) a calibration weight of 30 kg on the calibration rod over the upper edge of the pulley. We need to make an upward pulling movement at this height.

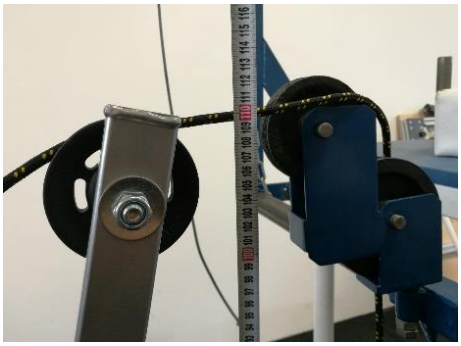

Figure 1.
Incorrectly set calibration height during initial testing of AB EX

Figure 2.
Initial testing of the 'top roll' technique

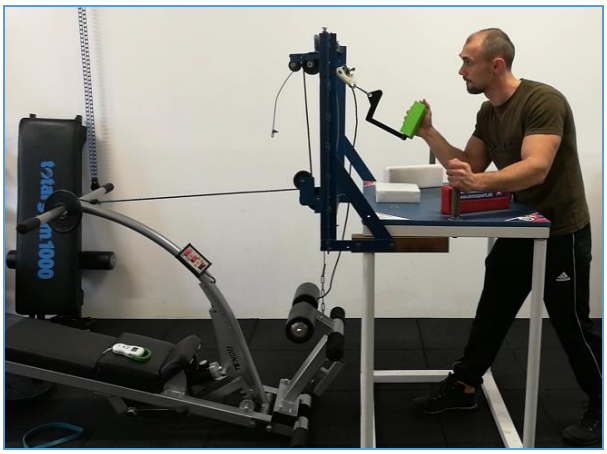

Figure 3.
Testing carried out using the high pulley

The initial testing session of AbEx in armwrestling took place on March 16, 2019 in Prešov at the national team's camp before the European Championships. This device was not designed for this, but we tested its potential. We also worked with an additional portable device, which was attached to the legs of the armwrestling table (see Figures 2 and 3).
We tested/carried out the following tests/exercises:

- imitation of the "top roll" technique
- imitation of the "hook" technique (high pulley)
- sideward pronation with strap (pulley in line with the hand)
- wrist flexion using the winding extension

During the testing, we encountered multiple problems and therefore we had to modify or adjust the additional construction. When imitating the "hook" technique, the construction (rod), which was attached to the table between the legs and the upper structure of the table, was bending. During the wrist flexion test, we could not find an ideal position in which the work of the wrist could be sufficiently isolated. In the sideward pronation test with the strap, for instance, the cable got stuck due to the curved welding of the pulley and it also required an adjustment to the structure. When designing an additional diagnostic device (today's TENDO IsoForce), we wanted to embed a hydraulic isokinetic piston directly into the additional structure, so that we needed only 2 testing devices, not three.

We wanted to design the Iso Force only as a leverless exercise machine. Unfortunately, it would not work. When connecting the tow cable directly to the piston, there would be a very small range of motion (approx. 200 mm) and a large pulling force would be required. So we had to solve it using a lever (arm). We shortened the arm length during development, but this had to be taken into account in the calibration. The fact that the arm was shorter also shortened the range of motion, but this was sufficient for our purposes, which we checked several times. In order to be able to conduct testing and test other exercises or muscle groups, it was necessary to devise and make a construction with a second pulley, which would be height-adjustable and rotatable (Figure 4). The whole construction was to be portable and suitable for the needs of armwrestling. This additional construction has been redesigned several times due to the identified shortcomings and continued to be improved, while the position and height of the "calibration" pulley were no longer changed (Figure 4). The additional construction is firmly attached to the table during testing by means of clamps to avoid unwanted movement and displacement. In this way, we can move the construction along both the length and width of the table, depending on which test/exercise we want to perform.

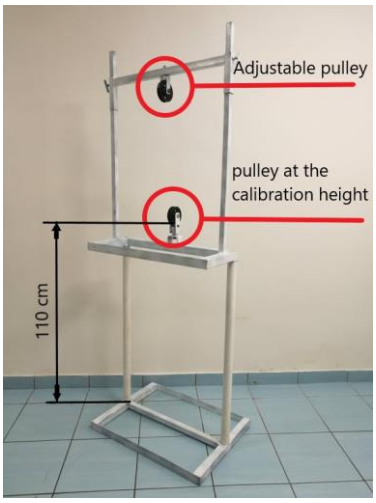

Figure 4.
Free standing construction

RESULTS AND DISCUSSION

The first modified test that we decided to include were hammer curls, i.e. imitation of the "top roll" technique. We attached one end of the climbing rope (5 mm in diameter) to the arm of the IsoForce machine. The rope passed through the calibration pulley at a height of about 110 cm, which was rotatable on both sides and thus allowed the technique to be performed smoothly. There was a 5 kg counterweight (plate) on the arm of the machine to ensure the return of the arm to the initial position, as the piston is only concentric and the weight of the arm itself was not enough to return it. The other end of the rope was attached to a climbing ascender (universal rope blocker without handle), which allowed us to quickly attach the handle and easily adjust the distance according to the individual length of the forearm so that the hand was in the starting position. We used a shortened judo belt to achieve a better grip comfort. The starting position in the test corresponded to the starting position in the match. Without command, the athlete began to perform individual repetitions of the "top roll" technique or hammer curls as it was natural for him.

a) b)

Figure 5. Top roll imitation technique test: a) initial position b) final position

This test proved to be meet the needs of armwrestlers. Based on empirical observations, we concluded that the results achieved by athletes in the TENDO IsoForce strength test correlated with performance at the table, as sparring training followed in the afternoon.

TENDO AbEx was developed for completely different training purposes and therefore we have made adjustment necessary to meet the needs of armwrestling. Based on almost a year of machine testing, testing, setup and other modifications of AbEx, we devised the final form of TENDO IsoForce, which had to be modified as follows:

- reduce the size of the machine, easy to disassemble to fit in the trunk of a normal car,
- attach the piston to the higher portion of the arm so that the level-6 resistance on the AbEx is about 3 on the new device. This means that 6 will be much slower on the new device,
- make a removable arm so that the machine takes up less space during transfer,
- shorten the handle at the end of the arm, because the one on AbEx was unnecessarily long,
- make an eyelet to which the cable is to be attached at the end of the arm,
- make a removable counterweight loadable bar on the machine,
- extend the cable to the Tendo Force Gauge so that the microcomputer can be attached to the table,
- reduce the weight of the construction for easy handling,
- remove excess parts such as deck chair, foot fixators ...,
- keep the calibration rod at exactly the same height as in the case of AbEx (proved to be satisfactory).

To test strength abilities in armwrestling, we need 3 pieces of equipment:

1. Measurement system: TENDO IsoFORCE + Tendo Force Gauge
2. Portable foldable construction
3. Armwrestling competition table (standardized according to the rules)

Measurement system consists of 2 functional components: sensor unit and microcomputer

Figure 6. Tendo IsoForce

Figure 7. Tendo Force Gauge

What data are provided by TENDO IsoFORCE + Force Gauge?

- the system measures the average force and the peak (maximum) force at the point of pulling the arm.

- by entering the weight of the athlete, it is possible to calculate the relative force per 1 kg of body weight.
- the system measures the time during which force acted on the shoulder.
- the system counts the number of repetitions.
- the system calculates the percentage value of the force, compared with the best repetition.
- the system enables to set the time interval of force measurement.
- the system enables to set units of measurement (kg, lb, N)
- the system enables to set the amount of force for the beginning and end of force measurement.

The portable adjustable construction had to meet the following requirements:

- light, strong, portable, detachable so that the construction together with the TENDO IsoForce could fit in the trunk of a car,
- standardized height of the calibration pulley, which had to be rotatable to the sides,
- the second pulley had to be height-adjustable and rotatable to the sides,
- it had to be easily and firmly attached to the armwrestling table from the front and from the side
- it should also be usable as a loadable pulley for plates, which will allow us to connect velocity and movement trajectory such as, for instance, fitrodyne, tendo, myotest.

CONCLUSION

TENDO IsoFORCE is a high-quality isokinetic hydraulic resistance system with 6 speed levels. This device is also equipped with a force gauge (Tendo Force Gauge) with an LCD display, which provides immediate feedback on the force produced. In the following research, we will focus on the verification of other tests that are meaningful for armwrestling and their subsequent standardization. In the future, our goal is to design such a device that allows the diagnosis and training of strength abilities in as many sports as possible and can also be used in the field of fitness for commercial purposes. At the same time, the machine should be universal, portable and affordable. It will also be a challenge to work on a software that records all the data in a computer system, similar to other diagnostic devices. Another task will be to determine the relationship between the results achieved during tests and matches.

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