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VERIFICATION OF EFFECTS UPON THE SHORT-DISTANCE-DASH-START THROUGH THE DEVELOPMENT OF AN IMPROVED PRECISION SENSOR IN THE STARTING BLOCKS

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Abstract: This study intends to develop a more improved starting block precision sensor for the enhancement of performance and for a kinematic analysis of the short-distance-dash. The production is equipped with a strain gauge attached to the symmetric beam structure for the existing starting block currently on the market. It is found to show that equipment has 5 times more improved effects, indicating that the beam structure devised in this study is effective, and that reliable results can be achieved. In the future, an additional research will be conducted on the impact of training track athletes with this starting block sensor upon correcting their starting positions and improving records in the short-distance-dash.

Keywords: Starting block, Strain Gauge, kinematic.

1. INTRODUCTION

Track and field is the foundation of all sports, comprising basic activities like running, throwing, and jumping, which has a positive impact on the technical development of all other sports. Among them, running has been adopted as an official Olympic event ever since the ancient Olympic Games. Even today, it is considered the foundational sport in all athletic competitions with its importance emphasized more than ever before. Besides, track and field is now given prominence, demanding not only mental power and patience, but also fair play and sportsmanship spirit. In case of the 100-meter dash, whose winning is decided by fractions of a second, a good start plays an important role in breaking records (Hosskisson, 1992; Meir et al, 2001; Korhonen et al, 2003; and Cunha et al, 2002). Accordingly, for a powerful start in a short distance, it is necessary to have a strong reaction and quick reaction time with the use of starting blocks. It is also important to have a technique that connects a good start to top speed dash (Aron et al, 2003; Peharec and Bacic, 2007). Many variance factors with regard to a starting position in a short distance dash have an effect on starting positions, muscular activities, and resilient power. Therefore, in order to shorten the running time in a short distance dash, it is necessary to do a research on the methods of an ideal start that best fits into physical conditions. It is reported that the accelerating power is affected by the resilient power and muscular activities at the start line of the short distance dash (Harrison at al, 2004). It is demanded that we develop equipment which measures the resilient power in starting blocks in order to perform the effective start training along with a research on kinematic variances. Many variance factors with regard to a starting position in a short distance dash have an effect on starting positions, muscular activities, and resilient power. Therefore, in order to shorten the running time in a short distance dash, it is necessary to do a research on the methods of an ideal start that best fits into physical conditions.

Therefore, humanity's global, unceasing interest in new records and competitions makes it necessary to develop human engineering equipment appropriate for the event. Especially in Korea as the host of 2011 Daegu World Track and Field Championships, national interest in new records in track and field has been higher than ever before, so that such equipment has been on demand thanks to political, economic, and social causes, such as the focused investment of the government and the national track and field association, and the support of Ministry of Culture, Sports, and Tourism for the development of a representative sports brand. Considering 2% uncertainty of sensor-embedded starting blocks as reported earlier, it is demanded that a more precise sensor for starting blocks be developed, which would help with the starting position and the best customized starting movement.

2. RESEARCH METHOD

The entire body of equipment is devised in the shape of general starting blocks currently on the market. As shown in Figure 1, it has a foothold with a normal sensor, a combined part that is connected to one side of the foothold, a connecting part with a symmetrical sensor, a fixed part combined with the connecting part, and a support that places equipment horizontally with a fixing tool. Also there are holes on one side of the foothold, and a normal sensor is attached around the holes. As shown in Figure 2, the sensor is attached to four symmetrical beams made on the side of the foothold where the power of the runner is applied. By equipping it with a strain gauge, this starting block enhances the durability against the lateral load and reduces an error about the leaning weight within the foothold more than any of the existing sensor-embedded starting blocks. Also by

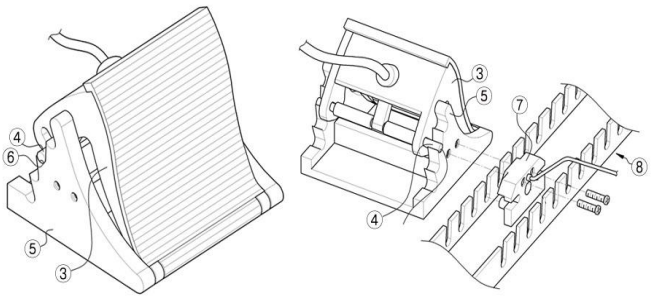

Fig. 1. A Schematic design of the entire body of starting blocks.

making the height of the sensor 1mm lower than the foot part that senses the first load, it is designed to increase precision more than existing starting blocks.

The invented starting block sensor was calibrated by the calibration setup as shown in Fig. 3. Prior to its calibration, pre-loading was performed more than 3 times up to the designated weight during 30 seconds, then the sensor was kept without weight for 2 minutes. The calibration was performed 2 minutes after pre-loading, and at each point of loading, the signal was measured 20 seconds after the stabilization of the load. Calibrations were performed in the order of increasing (0°), increasing and decreasing (120°), and increasing and decreasing (240°). As a result, the maximum 0.36% of relative expanded uncertainty was achieved, which is reliable enough to make it possible to measure the resilient power of starting in a short distance dash. In case of such a relative expanded uncertainty, it shows an improvement more than 5 times better than 2% of relative expanded uncertainty which this research team has reported in the previous study with the sensor-embedded starting blocks. Therefore, the present study demonstrates that the invented symmetrical beam is an effective tool to enhance a short distance dash.

Fig. 2. Photographs of the invented starting blocks with four symmetrical beam sensing parts.

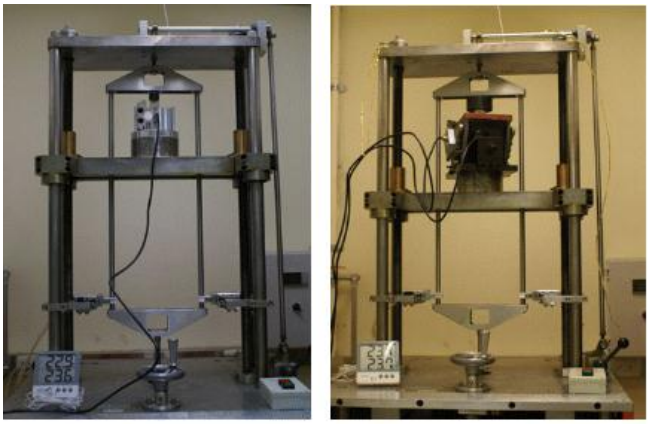

Fig. 3. Calibration setup to evaluate the characteristic of the invented starting blocks.

The objects of this study are three college athletes who have run more than 8 years and won the state or higher championships. Figure 4 shows the camera equipment and experiment analysis system used for the analysis of the kinematic characteristics of short distance crouching start positions. This system includes the camera and its software made by Visol, three sets of JVC cameras, and a precision sensor for starting blocks developed by KRISS as shown in Fig. 2.

3. RESULTS

New designed starting blocks which comply with internationally certified official starting blocks are developed. It is believed that track athletes are accustomed to using existing internationally certified starting blocks. In this situation, it is important to develop new designed equipment which does not cause any rejection from or inconvenience to them. This is the reason why this study tries to develop new designed starting blocks which not only comply with the standards of internationally certified starting blocks but also are equipped with the function of measuring the resilient power and the function of providing the athletes with the most proper positions.

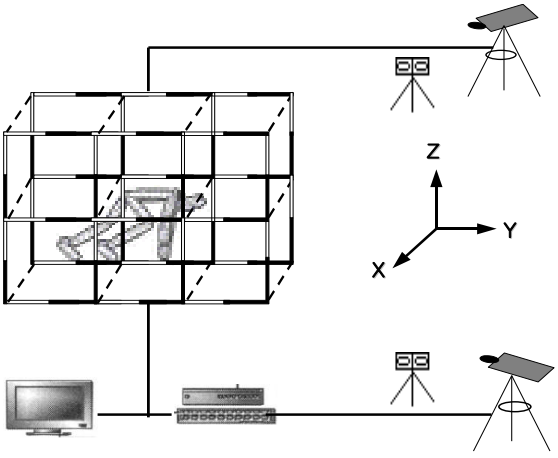

Fig. 4. Camera equipment and experiment analysis system for measuring the kinematic characteristics.

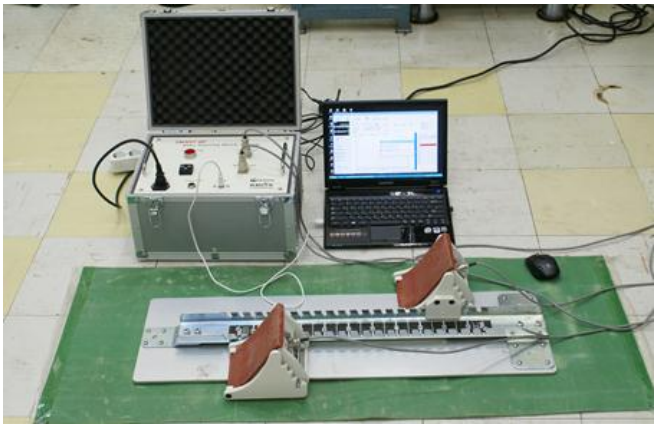

Fig. 5. Measurement equipment of starting block.

Mechanical performances of the developed starting blocks are evaluated by calibration setup (Fig. 3). The precision sensor in the starting blocks developed in this study is calibrated by the dead-weight force-standard-machine, and as a calibration result of the force sensor in the starting blocks, the uncertainty of the force sensor on the left foothold toward the vertical direction is within 0.28% and the uncertainty of the force sensor on the right foothold toward the vertical direction is within 0.36%. And the relative expanded uncertainty includes repeatability error, rotation error, hysteresis error, interpolation error, and force standard measuring device error. After evaluating the characteristics of the force sensor, it shows the measuring error within the maximum 0.36%. This means that new equipment is 5 times more effective than the existing product, and that the beam structure devised in this study is effective and reliable. It is also estimated that reliable measuring results can be obtained. As a result of using evaluation equipment, which was made to estimate the strength of the force sensor in the starting blocks, this study shows the maximum 27% of repeated uncertainty for the starting power of the right foot and the maximum 1.45% of repeated uncertainty for the starting power of the left foot after measuring the fatigue load 105 times by applying the force of 300 N and 600 N at the speed of 5 Hz in the temperature of 23℃ and the humidity of 55%.

In order to check the feasibility of the new starting blocks, a kinematic analysis is conducted with three subjects (S1, S2, and S3) who are top athletes. Each subject is evaluated at three starting positions: (A) the most favorite starting position of subjects; (B) the position with the right (rear) starting block 3.5cm (one level) moved forward while the left (front) starting block is fixed; and (C) the position with the right (rear) starting block 3.5cm (one level) moved backward while the left (front) starting block is fixed. The camera equipment and experiment analysis system, as shown in Fig. 4, and the measurement equipment system with our invented starting blocks, as shown in Fig. 5, are used for the evaluation. Figure 6 shows the evaluation results of starting reaction time of each subject at the three-types starting positions (A, B, and C). Figure 7 presents the evaluation results of three reaction forces of subjects at the tree-types starting positions (A, B, and C): the horizontal force (Fh), the vertical force (Fz), and the normal force (Fn).

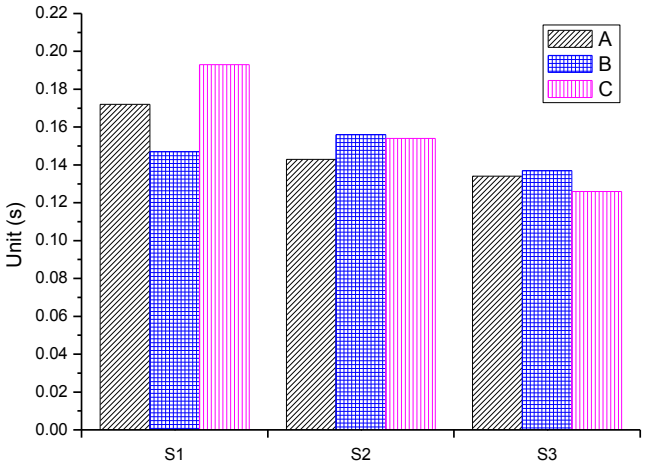

Fig. 6. Evaluation results of starting reaction time of each subject at the three-types starting positions (A, B, and C).

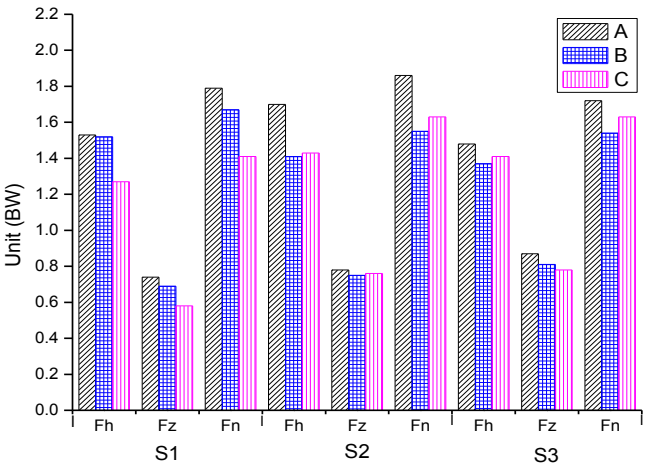

Fig. 7. Evaluation results of three reaction forces of each subjects at the three-types starting positions (A, B, and C): the horizontal force (Fh), the vertical force (Fz), and the normal force (Fn).

4. DISCUSSION

Now the starting blocks are used not only to support the body of track athletes but also to check whether there is a false start which happens within 0.1 second at the start signal. The product devised in this study also has the same functions as mentioned above. Moreover, it is equipped with a force sensor that measures the resilient power of the foothold, which checks in what setting (the distance and the angle of the starting blocks for both footholds) the athlete's resilient power is maximized, helps adjust the most proper distance and angle for the athlete, and corrects his or her starting positions. In addition, unlike the existing starting blocks, it is devised in the rear symmetrical beam structure to which a strain gauge is attached, which enhances precision 5 times more than the existing starting blocks and provides the athletes and coaches with more correct information about their starting positions.

In the kinematic analysis of this equipment, it is found that the type B shows the fastest start reaction time. The start reaction time can be reduced by repeated training at the

start signal, which makes the neurotic circuit respond quickly in sending the order to the spinal nerves and brain. According to recent experiments, we can reduce the reaction time 0.1 second faster if we skip the cerebrum. But according to the regulations of International Association of Athletics Federations, it is considered a false start if anyone starts within 0.1 seconds after the gun has fired.

As a result of analyzing the resilient power by standardizing the body weight, it is found that at the most favorable positions of the athletes, the horizontal force (Fh) or propulsion force totaled from each direction is the greatest. This study finds that, as for the resilient power of the maximum horizontal force in the short distant dash starting, the resilient power reacting in the left (front) starting block is greater.

5. CONCLUSION AND SUGGESTIONS

This study is done to develop a precision sensor for the starting blocks in order to improve the short distance dash and do a kinematic analysis of starting movement. The starting blocks are equipped with a strain gauge attached to the symmetrical beam structure which could enhance precision 5 times more than the existing sensor-embedded starting blocks currently on the market. In the future, we will perform an additional research on the effect of the sensor upon the starting positions and the record breaking by using it to track athletes. It is believed that through the development of this equipment, track athletes in elementary, middle, high schools, colleges, and the professional level have the systematic training to compete with world-class track athletes with the hope of breaking the Korean records which are estimated 30 years behind the world records.

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