International Journal of Human Movement and Sports Sciences 11(2): 299-305, 2023 http://www.hrpub.org
DOI: 10.13189/saj.2023.110206

Effects of Strobe-Image Feedback on Hurdle Sprint Times in Physical Education Classes

Akihiro Azuma*, Kazuhiro Matsui

Course of General Education (Natural Science), National Institute of Technology, Fukui College, Japan

Received November 18, 2022; Revised January 5, 2023; Accepted February 10, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Akihiro Azuma, Kazuhiro Matsui , "Effects of Strobe-Image Feedback on Hurdle Sprint Times in Physical Education Classes," International Journal of Human Movement and Sports Sciences, Vol. 11, No. 2, pp. 299 - 305, 2023. DOI: 10.13189/saj.2023.110206.*

(b): *Akihiro Azuma, Kazuhiro Matsui (2023). Effects of Strobe-Image Feedback on Hurdle Sprint Times in Physical Education Classes. International Journal of Human Movement and Sports Sciences, 11(2), 299 - 305. DOI: 10.13189/saj.2023.110206.*

Abstract This study aimed to examine the effect of using strobe-image feedback on hurdle sprint times in physical education classes. The participants were 57 male students aged between 16 and 17 years. They were divided into the following two groups: strobe-image learning (SL) group (n = 25), wherein the participants set practice tasks based on strobe-image feedback that allowed them to view their movements, and group learning (GL) group (n = 32), wherein groups of three or four students examined the movements of a target learner in the group and provided feedback to set the subsequent practice tasks. A two-way analysis of variance revealed that the main effect of the groups (SL and GL) was not significant ($P > 0.05$, effect size (ES) = 0.03), whereas the main effect of time (pre-test and post-test) was significant ($P < 0.05$, ES = 0. 36). Furthermore, the interaction was significant ($P < 0.05$, ES = 0.24), that is, a difference between pre- and post-test in the SL group was noted ($P < 0.05$, ES = 0.24). Therefore, the time of the 50-m hurdle run was significantly improved in the post-test in the SL group. Unlike the GL group, the feedback guided the SL group to make "hurdling without jumping too high" their main practice task, which presumably resulted in the shorter 50-m hurdling times and suggested that strobe-image feedback could provide effective, rational information for athletic improvement.

Keywords Feedback, Hurdle Run, Physical Education Class, Strobe Image

1. Introduction

Hurdling in physical education (PE) is a track and field event that is incorporated into the Japanese government curriculum guidelines from elementary to high school. In high school, the main aim is to develop skills to hurdle low and rhythmically while maintaining a constant running speed [1]. However, it is also significant that learners understand how to solve their problems when learning these skills [1], which requires feedback on their movements during class practice. Even if the learner has high sprinting abilities, if the hurdling motion is undeveloped, the time will be poor; therefore, it is reasonable to assume that the learner's interest in improving their hurdling movements will be high.

Traditionally, videos have been used for effective motion feedback [2,3,4]. Recently, digital video applications on tablet-type devices with cameras have replaced video cameras in PE classes [5,6,7]. In addition to playing back the movements, videos also allow for a repeated confirmation of the actions by pausing, sending frames, and repetition; however, specific equipment and operations are needed. If the strobe image is printed, no equipment is available for the feedback of viewing the image itself. Sequential photographs, which are frames taken from the video at certain time intervals and arranged side by side, have also been found to be useful feedback tools for sports movements [8,9]. Printed sequential photographs can be picked up and carried, and the motions in a particular phase can be observed over time. However, a low frame rate decreases the amount of information, and a

higher frame rate increases data quantities [10]. In the case of a strobe image, increasing the frame rate only increases the number of afterimages in a single image, which is only one image itself. Furthermore, it is more difficult to fully understand the continuity as each motion is depicted in a separate photograph.

A strobe image is a single (processed) image wherein the movement afterimages are depicted at certain time intervals. The strobe image allows the viewer to view a series of postures (afterimages) in a single image without having to separately arrange and compare several images, as with sequential photographs. Additionally, the distance between the afterimages reflects the speed (dense and coarse afterimages indicate slow and fast movement, respectively), making it easier to intuitively visualize the movements than that with sequential photographs. The advantages of these strobe images are evidenced by several software programs available to create sports movement strobe images [11,12,13]. Matsui and Azuma (2019) and Matsui and Azuma (2021) found that the use of strobe images to derive physical variables for long jump (such as initial velocity, the angle at takeoff, and hip height at landing) was highly useful for learners [14,15]. Studies have concluded that strobe images enable simple motion analysis and are easy to distribute. However, whether strobe images can easily and intuitively visualize movements and provide effective feedback for students in PE classes has yet to be explored. Moreover, it is significant to verify the effectiveness of strobe images in PE classes, where students of various readiness and motivation levels are mixed.

Therefore, this study aimed to investigate whether strobe-image feedback for hurdling could effectively reduce 50-m hurdling times in PE classes and examine the effect of strobe-image feedback on movement self-evaluation and PE learning.

2. Materials and Methods

2.1. Participants

The participants were 57 male students between the ages of 16 and 17 who were taking PE classes at the National Institute of Technology in Japan. The participants included students who learned to hurdle in elementary and junior high school PE classes, but none were hurdling athletes. In addition, none of the participants had any experience with video or strobe image feedback of their own hurdling movements. The purpose and procedure of this study were explained to the participants, and written consent was obtained from all participants. This study was approved by the Research Ethics Committee of the National Institute of Technology, Fukui College (Approval number: R3-6).

2.2. Procedure

The participants were divided into a strobe-image learning group (SL group, n = 25; height: 169.6 ± 5.8 cm, weight: 56.7 ± 8.7 kg) and a group learning group (GL group, n = 32; height: 171.2 ± 6.4 cm, weight: 64.2 ± 10.1 kg) and were required to complete five consecutive PE classes (90 min/class), each of which comprised a hurdling unit. All participants were male students in the same grade with the same teacher although in two different classes. After the pre-test, one class was designated as the SL group and the other class as the GL group. The difference in the number of participants in the two groups was because of the difference in the number of male students in the two different classes. On day 1, both groups practiced running over one hurdle while walking or jogging to practice swinging and following through with their legs. On day 2, they practiced the approach phase by running over one hurdle (first hurdle) that was placed 13 m from the start line. The goal of this practice was to ensure that they had the correct number of steps before the first hurdle (Figure 1). The number of hurdles was set up as one per lane on day 2 (this was denoted as one hurdle). On day 3, to become aware of the interval between the hurdles, three hurdles were set up 7.5 m apart (Figure 2), which the participants practiced running over to ensure they had the same number of steps in each run (Figure 1, three hurdles). On day 4, five hurdles were set up, and the 50-m hurdling time (50 mH) was measured (Figure 1, pre-test). The hurdle height was set at 0.61 m. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) curriculum guidelines for high school health and PE state that the hurdle distance should be between 50 and 110 m, and there should be between five and ten hurdles [1]; therefore, this study followed the lower limit of the guidelines. On days 2 and 3, the participants were provided with instructions on the widely recognized general hurdling skills (S1–S5 in Figure 1), after which, they practiced them by referring to the Japan Association of Athletics Federations (JAAF) instruction manual [16] and the supplemental textbook [17] (Figure 1).

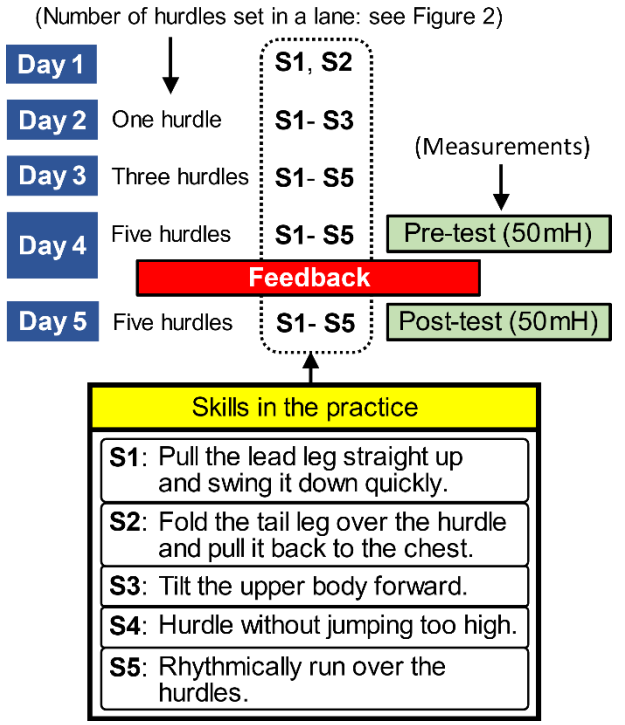

Figure 1. Schematic diagram for the days 1–5 practice and measurement schedules. S1–S5 practice skills are also detailed

All participants in both groups had their 50-m hurdling times measured on day 4 (pre-test). The overall view of the hurdling motions over the first hurdle of the SL group was recorded from 7.5 m on the right side (sagittal plane) using an iPad® (Apple Inc., A1701 model) and a pre-installed software (Cripstro, SPLYZA Inc., Version 3.1 [12]), which made a strobe image in which the afterimages were depicted at intervals of 8/30 s (=0.2667 s) (day 4). The participants in the SL group were provided with individual strobe images immediately after day 4 (Figure 3) through groupware (Microsoft® Teams, Microsoft® Corp., Ver. 1.0), which provided them the feedback to objectively analyze their movements and establish practice tasks before day 5. The SL group was provided with one week to decide on their practice tasks after receiving the feedback on a strobe image without suggestions from other participants provided during day 4. In the GL group, feedback was given to the target participant on day 4, while three to four other participants observed and pointed out (in terms of S1–S5) the target's movements. Based on that feedback, each participant set his or her own practice task by day 5. Moreover, the fact that participants in both groups trained according to their own practice tasks was verified by the PE teacher through worksheets, wherein they subsequently described their training. Examining whether this was sufficient to improve their skills would be a topic for another study, we just examined the feedback effects within the limited practice time in a PE class. Following the feedback, both groups were asked to write down the practice tasks they had established based on their feedback on a designated form. On day 5, for the first half of the class (approximately 30 min), the SL and GL groups repeated the training based on the practice tasks they had set themselves on day 4; subsequently, their 50-m hurdling times were remeasured (post-test).

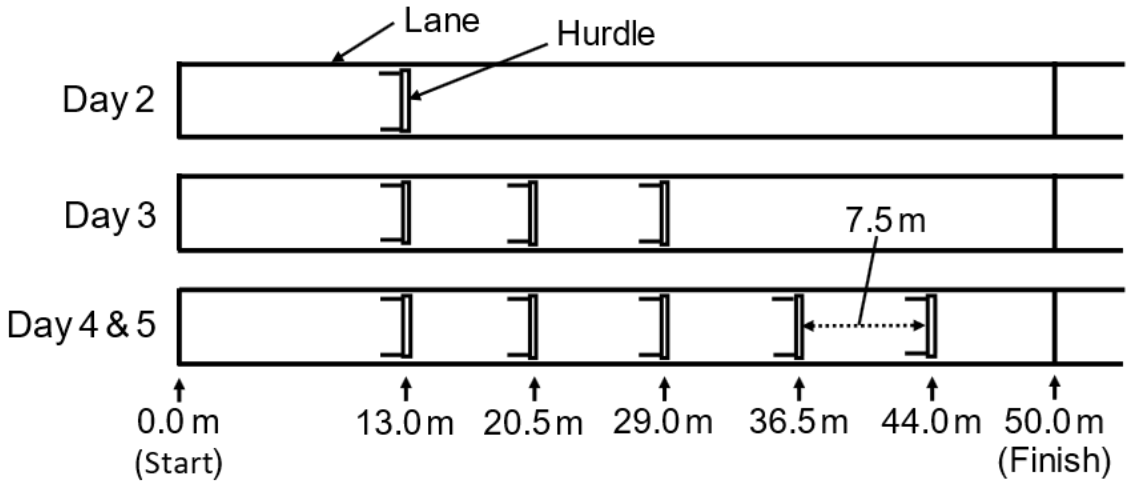

Figure 2. Lane with the hurdles used in the practice and the measurements for days 2–5

Figure 3. Example of the strobe image provided to the strobe-image learning (SL) group

2.3. Analysis

To examine the effects of the strobe-image feedback on the 50-m hurdling times, the pre- and post-test times were compared, with the GL and SL groups being the control and experimental groups, respectively. The GL group is not a pure control group because of intervention as group learning, but group learning is one of the conventional methods of motor learning in PE classes, and the SL group is designed as the intention of being compared to it. In this sense, we considered the GL group to play the role of a control group. The practice tasks (written by the participants) in the SL and GL groups were categorized based on the S1–S5 skills, and the total number was counted (in some cases, more than two skills were set by a participant). Subsequently, the two groups (SL and GL) were integrated and divided into a group that had better times (decreased time group) and a group that had slower times (increased time group). No participants had the same time (no change) in the pre- and post-test. Furthermore, the total number of tasks in each group was counted.

2.4. Statistics

An unpaired t-test was used to examine the differences in the average value of height and weight of the participants between the SL and GL groups. Moreover, a two-way analysis of variance (ANOVA) was used to compare the 50-m hurdling times for pre- and post-test in the SL and the GL groups, and the Holm method was used as the post-hoc test. The significance level was set at 5%, and Cohen's *f* was adopted to calculate the effect size (ES).

3. Results

Regarding the physical characteristics of the participants, the two groups showed a significant difference in weight ($P < 0.05$, SL < GL group). Height and weight data are presented in the Materials and Methods section.

A two-way ANOVA showed that the main effect of group (the SL and GL groups) was not significant ($F = 0.06$, $P > 0.05$, $ES = 0.03$, Table 1), whereas the main effect of time (pre- and post-test) was significant ($F = 7.15$, $P < 0.05$, $ES = 0.36$, Table 1). Additionally, the interaction was significant ($F = 3.27$, $P < 0.05$, $ES = 0.24$, Table 1), that is, a difference between pre- and post-test in the SL group was noted ($F = 10.05$, $P < 0.05$, $ES = 0.24$, Table 1). Therefore, in the SL group, the 50-m hurdling time was significantly improved in the post-test. Furthermore, in the SL group, the total number of practice tasks set for S1, S2, S3, S4, and S5 was 5, 10, 7, 10, and 2, respectively, and the respective percentages were 14.7%, 29.4%, 20.6%, 29.4%, and 5.9%. In the GL group, the total number of practice tasks corresponding to S1, S2, S3, S4, and S5 was 15, 18, 13, 12, and 1, respectively, and the respective percentages were 25.4%, 30.5%, 22.0%, 20.3%, and 1.7%. Therefore, the SL group had more practice tasks for "hurdling without jumping too high" (S4; SL group: 29.4% vs. GL group: 20.3%), whereas the GL group had more practice tasks for "swinging the leg" (S1; SL group: 14.7% vs. GL group: 25.4%).

Table 1. Pre- and post-test means and standard deviations for the 50-m hurdling times for the SL (n = 25) and group learning (GL) groups (n = 32) and results of ANOVA

Time	Group		Main effect		Interaction
	SL	GL	Group	Time	
Pre-test (s)	9.54±1.03	9.51±1.08	ns	P < 0.05	P < 0.05
Post-test (s)	9.29±0.88*	9.46±1.09			

* Significant between pre- and post-test in the SL group (post−hoc test).

"ns" indicates no significance.

4. Discussion

Unlike competitive athletes who participate in extracurricular or community sports club activities, it is difficult for learners in PE classes to adequately practice or train in the limited time they are provided with, suggesting that improving their performances is not easy [14,15,18,19]. PE classes allow students to learn the properties and skills of sports and challenge themselves through actual practice. Therefore, planning and practicing strategies to overcome their challenges (tasks) need to be part of their learning activities [1], that is, competitive athletes focus on performance improvements, whereas learners in PE classes engage in learning activities to solve problems. However, this could lead to increased learning motivation if the performance is improved as a result of these learning activities. Therefore, the development of productive learning and teaching methods is essential to these types of learning activities. While this study was an experimental study, it was also a practical study, and the hurdle practice was set up within a limited weekly class routine. It was considered that examining the effectiveness of the use of strobe images in the class presented in this study would play a role in establishing a protocol to practice.

This study found that the SL group, which was provided with strobe-image feedback, had faster post-test hurdling times. In this study, the practice tasks set by both the SL and GL groups were developed by the participants, with the feedback method differences being the observation object (strobe image vs. actual movement) and the evaluation object (self vs. others). Consequently, a two-way ANOVA was carried out with group and time as the main effects, respectively. The results showed a statistically significant time reduction in the SL group. Strobe images depict an afterimage as a static image of the momentary posture in each phase, indicating that the postures can be observed over time. Subsequently, the postures before and after a particular phase were compared, and the movement was imagined. However, when observing the actual performance, the posture in a particular phase remains in the memory as an impression. Since the strobe image is a projection of the participants' movement at a given interval, the participants may be able to design practice tasks while evoking the motor senses (such as force, speed, and timing) as they gaze at and visualize the movements before and after the particular posture that the individual wants to focus on. If such an assumption was deemed correct, then it was considered that the practice tasks set by the SL group would be derived from the integration of the participants' motor sense (subjective) and the objective perspective gained from the strobe-image feedback. Conversely, despite the GL group being slightly heavier than the SL group, no significant difference in the initial (pre-test) 50-m hurdling time was noted. This suggests that the weight differences observed in this study do not affect hurdle sprinting in PE classes. The improvement in time may be more dependent on the practice task rather than on the body weight.

The SL group set more S4 practice tasks, which are a skill for hurdling in a low posture, than the GL group. A low hurdling posture is considered a basic hurdling skill [20] that is related to the forward lean of the upper body (S3) and not jumping too high over the hurdle (S4). As the relationship between the vertical movement of the body mass center and hurdling performance has been reported in several studies [21,22,23], S3 and S4 could be factors in the improved running times of the decreased time group. It is unclear why no apparent difference between the two groups was observed in S3 (forward lean of the upper body); however, it is possible that both groups recognized the significance of the S3 in prior instruction. In the SL group, more participants set and practiced S4 than those in the GL group, which may have also contributed to the significant decrease in their 50-m hurdling times. In contrast, the GL group practiced leg carrying (S1).

The reason that the SL group employed S4 (29.4%) more frequently (compared to the GL group; 20.3%) could be because of the different feedback methods as "hurdling without jumping too high" is a movement on a vector perpendicular in the direction of travel, which is detrimental to the hurdling time. The strobe visual afterimages may have strongly emphasized S4. It is difficult for learners to subjectively perceive the vertical movement degree (jump) when they are attempting to move forward. Therefore, the strobe images could have bridged the gap between the subjective and objective perceptions of the spatial motion, vertical axis, and motion on the line from the start to the goal (horizontal axis) of the hurdle distance.

The practice tasks set by the SL group using the strobe-image feedback were compared with those set by

the GL group, from which it was found that the practice tasks set by the SL group resulted in lower 50-m hurdling times. Specifically, the strobe-image feedback for the "hurdling without jumping too high" skill was perceived from a spatial rather than a subjective motor sense, that is, the movements were biomechanically considered to improve performance. Therefore, it appeared that strobe-image feedback could effectively promote active PE class learning for hurdling, be a valuable method to ensure rational practice tasks, and contribute to performance improvements.

In a strict sense, since this was one of the practical studies that examined student learning activities that could be practiced during limited classes (days 1–5) in a PE class, the physical characteristics and readiness of participants were not controlled beforehand. The quantity and quality of feedback and the number of practice sessions should be considered significant factors for skill improvement. These are issues for future research, and this study can be regarded as having provided the basic data for such research.

5. Conclusions

This study examined the effects of strobe-image feedback on learners' 50-m hurdling times and movement self-evaluation in PE classes, for which a control group and an experimental group were established: one that used strobe images to provide feedback on their movements to set their consequent practice tasks (SL group) and one that observed each other's movements and used these as the feedback to set their consequent practice tasks (GL group). Only the 50-m hurdling times in the SL group significantly decreased after the feedback. Furthermore, the SL group adopted the "hurdling without jumping too high" skill more frequently as one of the set practice tasks after the feedback, which was inferred to be related to the decrease in hurdling times. The experiment suggested that strobe-image feedback increased the PE students' awareness that their vertical axis movement could be disadvantageous to their hurdling running times; therefore, strobe-image feedback could lead to a more effective rational practice.

Acknowledgements

This work was supported by JSPS KAKENHI (Early-Career Scientists) Grant Number 22K13774. Portions of this study were presented orally at the CHK Forum at University of the Philippines Diliman (August 2022) and at the Coaching the Coach Series at De La Salle Lipa (September 2022).

REFERENCES

[1] Ministry of Education, Culture, Sports, Science and Technology, "Series of Health and Physical Education in Curriculum Guidelines for High School," pp. 77-94, 2018. (in Japanese)

[2] T. Weir, and S. Connor, "The use of digital video in physical education," *Technol. Pedagog. Educ.*, vol. 18, no. 2, pp. 155-171, 2009, doi: 10.1080/14759390902992642.

[3] R. G. Fukkink, N. Trienekens, and L. J. C. Kramer, "Video feedback in education and training: putting learning in the picture," *Educ. Psychol. Rev.*, vol. 23, no.1, pp. 45-63, 2011, doi: 10.1007/s10648-010-9144-5.

[4] J. Rohleder, and T. Vogt, "Teaching novices the handstand: A practical approach of different sport-specific feedback concepts on movement learning," *Sci. Gymnastics J.*, vol. 10, no. 1, pp. 29-42, 2018.

[5] A. Sinelnikov, "Using the iPad in a sport education season," *J. Physic. Educ. Recreat. Dance*, vol. 83, no. 1, pp. 39-45, 2012, doi: 10.1080/07303084.2012.10598710.

[6] R. Franklin, and J. Smith, "Practical assessment on the run–iPads as an effective mobile and paperless tool in physical education and teaching," *Res. Learn Technol.*, vol. 23, p. 27986, 2015, doi: 10.3402/rlt.v23.27986.

[7] J. E. Lee, and Z. Gao, "Effects of the iPad and mobile application-integrated physical education on children's physical activity and psychosocial beliefs," *Phys. Educ. Sport Pedagog.*, vol. 25, no. 6, pp. 567-584, 2020, doi: 10.1080/17408989.2020.1761953.

[8] T. Noda, M. Asaoka, K. Hasegawa, and S. Kato, "Effects of differences in methods of presenting visual information on the understanding of movement processes: Observation of movements in apparatus gymnastics," *Jpn. J. Phys. Educ. Health Sport Sci.*, vol. 54, no. 1, pp. 15-28, 2009, doi: 10.5432/jjpehss.a540102. (in Japanese)

[9] C. H'mida, O. Degrenne, Souissi N, and G. Rekik, "Learning a motor skill from video and static pictures in physical education students-effects on technical performances, motivation and cognitive load," *Int. J Environ. Res. Public Health*, vol. 17, no. 23, p. 9067, 2020, doi: 10.3390/ijerph17239067.

[10] T. Noda, M. Asaoka, K. Hasegawa, and S. Kato, "A study on the discrimination of movements on horizontal bar exercise by observing sequential photographs," *Jpn. J. Phys. Educ. Health Sport Sci.*, vol. 53, no. 1, pp. 111-122, 2008, doi: 10.5432/jjpehss.a530108. (in Japanese)

[11] Morpho, Inc., "Morpho strobo video," Online available from https://www.morphoinc.com/technology/strobo. (in Japanese)

[12] SPLYZA Inc., "Clipstro: update to 2.0.," Online available from https://products.splyza.com/clipstro/.

[13] SONY corporation, "How to use Motion Shot Video," Online available from https://www.sony.com/electronics/support/articles/00070778.

[14] K. Matsui, and A. Azuma, "A study on self-analysis of the movement using a strobe picture: its effect on college male students' long jump performance," *Research Reports of*

National Institute of Technology (KOSEN), Fukui College, Natural Science and Engineering, vol. 53, pp. 29-34, 2019. (in Japanese)

[15] K. Matsui, and A. Azuma, "The effect of self-analysis of the movement of running long jump using a strobe picture on college male students' performance in PE class," *Adv. Phys. Educ.*, vol. 11, no. 3, pp. 331-339, 2021, doi: 10.4236/ape.2021.113028.

[16] Japan Association of Athletics Federations, "Hurdle Race," In Japan Association of Athletics Federations ed., "*A Guide for Coaching Athletics in Junior High School Club Activities*," pp. 29-33, Online available from https://www.jaaf.or.jp/development/jhs/. (in Japanese)

[17] Taishukan Publishing Co., Ltd., "STEP UP HIGH SCHOOL SPORTS TAISHUKAN," pp. 64-67, 2021. (in Japanese)

[18] K. Matsui, and A. Azuma, "A study on the optimal distance of approach-run for running long jump based on quadratic regression equation approximation using graphing calculator in PE class of the National Institute of Technology," *Bull. Hokuriku Soc. Phys. Educ. Health Sport Sci.*, vol. 54, pp. 1-7, 2018.

[19] K. Matsui, and A. Azuma, "Optimal Distance of The Long Jump Approach Run Calculated Using Quadratic Regression Equation Approximation in Female College Students Attending a Physical Education Class," *Asian J. Kinesiol.*, vol. 21, no. 3, pp. 31-36, 2019, doi: https://doi.org/10.15758/ajk.2019.21.3.31.

[20] T. Gavin, "Low the hurdles at elementary and junior high school levels," *Ath. J.* vol. 57, pp. 42-43, 1977.

[21] J. K. Ryu, J. K. Chang, H. C. Yeo, and J. W. Lin, "Comparison of Kinematic Variables of the Elite Woman's 100 m Hurdler," *Korean J. Sport Biomech.*, vol. 17, no. 4, pp. 149-156, 2007, doi: 10.5103/KJSB.2007.17.4.149.

[22] M. Coh, and J. Iskra, "Biomechanical studies of 110 m hurdle clearance technique," *Sport Sci.*, vol. 5, no. 1, pp. 10-14, 2012.

[23] G. Mauroy, B. Schepens, and P. A. Willems, "The mechanics of jumping over an obstacle during running: a comparison between athletes trained to hurdling and recreational runners," *Eur. J. Appl. Physiol.*, vol. 114, no. 4, pp. 773-784, 2014, doi: 10.1007/s00421-013-2805-6.