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Practice Variability and Training Design: Strategies of Elite Horizontal Jump Coaches

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Schmidt's Schema Theory (1975) predicts that successful motor skill learning and performance are largely determined by the amount of movement variability the performer experiences during practice. This prediction has been consistently validated through a vast amount of research. Within a training environment, practice variability can be integrated by creating variation within the movements of an action, the physical context in which the action takes place, and the situation in which the action is performed. The purpose of this study was to investigate the degree to which elite long jump coaches institute practice variability within their training design to enhance toe-board accuracy. Participants completed an open-ended survey inquiring about their knowledge and strategies to improve toe-board accuracy. Seventy-eight percent of the coaches reported they were aware of research on toe-board accuracy and reported using a variety of strategies. With respect to practice variability, coaches used "measured run" techniques that change the approach distance to the toe-board. Coaches did not report varying movements of the long jump action or situations in which the action occurs. The results suggest that elite long jump coaches stress the importance of toe-board accuracy but do not maximize the use of practice variability for training toe-board accuracy.

Keywords: Contextual Interference, Long Jump, Coaching, Motor Learning, Long Jump, Triple Jump

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Many clichés illustrate the importance of developing motor skills in an effort to achieve optimum skill acquisition: "practice makes perfect," "perfect practice makes perfect," "repetition, repetition, repetition," and "you play how you practice." While these types of statements reveal the importance of skill development (i.e. training and practice), many coaches are unable to design evidence-based practice and training environments to achieve optimal skill development (Porter, Wu, & Partridge, 2010). In order to achieve optimum performance, a coach must integrate a variety of sport science disciplines within the development process that include: biomechanics, exercise physiology, nutrition, sport and exercise psychology, and motor learning and control. Motor learning and control are frequently overlooked when coaches design training programs. While the importance of motor skill development is often stressed, the methods of how to design proper practice environments are rarely detailed. For example, the details of manipulating intensity and volume are common when considering optimal strength for a particular sport within a strength and conditioning context. Within nutritional science, the amount and timing of when to consume carbohydrates, proteins, and fats are carefully measured when considering energy and restorative factors associated with performance. Also, when considering warm-up protocols for endurance or ballistic actions, the terms dynamic and static stretching are easily identified and prescribed. When it comes to optimizing motor skill performance the terms practice variability or contextual interference are terms that are not easily identifiable.

As it relates to skill development within the horizontal jumps of track and field (i.e. long jump and triple jump), motor learning and control play a significant role in optimizing performance. To understand the importance of motor learning and control within these activities, it is important to identify the events or movements that comprise them. For this description, we will use the long jump instead of discussing each and every horizontal jump event. While the following is not a detailed or all encompassing analysis of the long jump, it will provide a basic illustration that demonstrates the important role of motor learning and control in developing optimal performance.

Hay (1993) describes the long jump as consisting of four consecutive events. The first event within the long jump is referred to as the run-up. The goal of the run-up is twofold: create speed and set up optimal body position for takeoff. To create speed the athlete first begins an acceleration phase that covers a distance of approximately 20 meters. Within the acceleration phase, athletes begin their run and aim to build up to around 80% of their max speed; stride length is naturally increasing throughout this section of the run. Athletes demonstrate forward lean while maintaining normal head and spine alignment. The next phase within the run-up is referred to as the sub maximal velocity phase. Occurring after the acceleration phase, sub maximal velocity phase is highlighted by an upright running gait in which 90-95% of max speed is generated. By the end of this phase, athletes should be in an upright running position. According to Hay, the length of the run-up is dependent on the ability of the athlete to control his/her speed at takeoff – longer approaches are recommended for those that can control a greater amount of running speed.

At the end of the run-up, athletes begin their preparation of the takeoff through a series of postural adjustments which include lowering their center of gravity, decreasing the flight distance of the last stride, and increasing the landing distance of the last stride. These technical components must be achieved while at near top speed and while hitting a 20 cm wide takeoff board. As s result, the final strides of the run demonstrate the greatest amount of variability in foot placement as athletes steer themselves to an accurate takeoff point.

The takeoff occurs following the run-up. The takeoff is characterized by a generation of vertical velocity while maintaining horizontal velocity. Once the athlete has obtained vertical lift and has lifted off the ground the athlete enters the flight phase of the action. The primary goal of the flight phase is to obtain optimal body position for landing. The last phase of the long jump, known as the landing phase is highlighted by 2 primary goals. The first goal is to obtain the maximum distance between the takeoff board and the heel marks created in the landing pit. The second goal is to rotate one's body over the feet in a forward direction generating forward momentum to maximize jumping distance.

Based on this brief review of the long jump, it is clear that each phase plays an important role in achieving optimal jump distance. Proper execution of each phase helps to set up what Hay (1993) describes as basic factors of long jump distance: takeoff distance, flight distance, and landing distance. From a motor learning and control perspective, it is important to note the skill development implications associated with each phase or component of the long jump action. As described previously, the run-up distance is dictated by the percentage of max speed the athlete can control prior to takeoff. In addition, the athlete must properly navigate the board so the foot is placed properly at the toe-board. Preparation for this can be seen through Hay's description in which there are stride variations when looking at the final 3 strides prior to takeoff. While an athlete may produce an abundance of speed, the jump does not count if the athlete cannot takeoff at or behind the toe-board. Moreover, an athlete will lose distance if takeoff is too far in front of the board as the measured jump distance is taken from the toe-board to the nearest mark in the sand. Thus, the accuracy of the takeoff is critical to optimizing jump performance.

When viewing the various sports science disciplines, the discipline that best addresses takeoff accuracy is motor learning and control. Specifically, designing practice schedules that organize practice repetitions in a manner that promote the greatest amount of skill acquisition for an athlete. There are two specific principles within the motor learning and control literature that describe practice schedules or how repetitions should be organized during a given practice session. The principles are called practice variability and contextual interference. Often confused as being the same, practice variability consists of practicing variations of an action. While contextual interference addresses the natural interference that exists between two or more tasks that are practiced within the same context; the amount of interference that exist is often mitigated by how the task variations are ordered during practice.

The concept of practice variability was first introduced by Schmidt (1975) as a prediction in his proposal of schema theory. According to schema theory, practicing a task in a variety of ways will promote greater transfer to novel tasks than utilizing a constant practice strategy – practicing one variation of a skill. According to Magill (2011), three aspects of practice can be varied – the physical contexts, movements that comprise the action (skill variations), and the situation in which the skill occurs. Using the long jump as an example, coaches can vary the runway surface (physical context), the angle of takeoff (skill variations), and whether the jump will be the last or the first of a series of jumps (situation). Numerous studies incorporating sports skills have demonstrated the skill learning benefit of practice variability (Cohen, Bloomberg, & Mullavara, 2005; Douvis, 2005; Memmert, 2006; Shoenfelt, Snyder, Maue, McDowell, & Woodlard, 2002). In contrast to a schema theory explanation, a dynamical systems explanation argues that practice variability allows an athlete to explore a larger perceptual-motor "workspace." This allows the athlete to explore and experience the physical laws that govern the action (Davids, Williams, Button, & Court, 2001). Both schema and dynamical systems theory predict that incorporating variability into practice environments facilitates motor skill performance and learning.

While studies of practice variability using sport related tasks have demonstrated the beneficial effects on learning motor skills, research into organizing practice variability has played a significant role in structuring the manner in which practice variation is instituted (see reviews by Brady, 1998; Magill & Hall, 1990). Shea and Morgan (1975) provided the first study to demonstrate the role of contextual interference within the motor skill-learning domain. They found that practicing variations of a skill in a random order led to better learning than practicing with blocks of same task trials. Using the long jump as an example, a coach can utilize practice variability by having athletes run from different approach distances and utilize contextual interference by properly designing the order in which each variation will be practiced. Specifically, if a coach has a jumper practice from a short, medium, and long approach the coach can organize the variability (the 3 different approaches) by having them practice from in a manner in which they do all repetitions of a short approach before the move on to a medium approach. Once the jumper has practiced all the medium approaches, the athlete then practices the long approach; otherwise, know as blocked practice. In contrast, the coach can randomly assign to the athlete which approach to practice so that no approach is practiced consecutively and the jumper does not know which jump will be performed next – random practice. There are other methods to organize practice variability within the motor learning and control literature but for this article we will focus on random and block practice because they represent extreme ends of the contextual interference continuum (see Magill, 2011).

According to Hay (1993), the transition from the run to the takeoff is the most important event in the long jump. In light of this, the purpose of this study was to investigate how elite horizontal jump coaches develop the accuracy component of the horizontal jump events in track and field and to examine whether or not the coaches utilized principles of practice variability and contextual interference found within the motor learning and control literature. Based on previous findings (Porter, Wu, & Partridge, 2010; Williams & Ford, 2009) we hypothesized that elite horizontal coaches will not utilize methods for developing accuracy that are consistent with the practice variability and contextual interference literature.

Method

Participants

Nine elite horizontal jump coaches based in the United States and Europe participated in the study. Coaches were classified as "elite" because they averaged 27.3 years of coaching experience, hold track and field certifications at the highest levels within their respective countries, and serve as track and field certification instructors with their respective countries. In addition to formal training and instruction, the participants have coached World and American record holders, World Champions, Olympic Medalists, and over 100 National Collegiate Athletic Association (NCAA) All-Americans. All experimental methods and written materials were approved by a university Institutional Review Board prior to data collection.

Procedure

Each coach was emailed a questionnaire by a member of the research team. The first two questions asked the coaches to respond about their coaching experience. The questions were:

"How many years have you coached the long jump?"

"List the years of experience you have coaching different levels of athletes:

a. High School: ____ b. College: ____ c. Post Graduate/Professional: ____ "

The next question provided in the questionnaire examined the formal training the coaches received to aid their approach to teaching the long jump event. Coaches were asked,

"List the formal training you have had for the long jump (this may include but is not limited to: certification courses, sport science seminars, mentorships, etc.)"

In order to measure the amount of knowledge the coaches possessed that was derived from the scientific literature, coaches were asked about their knowledge of research that specifically addressed accuracy requirements of the long jump. Coaches were asked to respond to the following,

"Are you aware of scientific research addressing toe-board accuracy during the Long Jump approach? If you are aware of the research, what do you agree and disagree with the findings of the research?"

"Please write down all the resources you use to design the technical portion of training the long jump (this may include but not limited to: other coaches, dvd's, coaching journals, research journals, magazine articles, etc.)"

Coaches were also asked if they believed toe-board accuracy was a skill that could be developed or trained; if in fact they believed it was a skill that could be trained or learned, coaches were asked to provide the methods they use to train accuracy. They were asked to provide responses to the following,

"Do you believe toe-board accuracy is a skill that can be developed or trained?"

"Please write down your methods for training accuracy to the board."

In order to assess methodologies associated with accuracy training within the long jump, coaches were asked the following questions,

"Which section of the approach, in your opinion, is most important in regards to board accuracy and why?"

"Please write down your coaching philosophy with regard to looking at the board during the approach."

After the coaches completed their written responses to the above questions, the surveys were emailed to the first author.

Results

Descriptive statistics were calculated for the first 2 questions of the questionnaire. For the open-ended questions, responses were inductively analyzed by identifying conceptually distinct categories from the data; frequencies and percentages of the categories, for each item, were calculated.

Knowledge of Research

In response to the questions "are you aware of scientific research addressing accuracy during the long jump approach?" 7 out of 9 (77.8%) of the coaches reported being aware of research pertaining to toe-board accuracy. Five of the coaches specifically mentioned Dr. James Hay's work related to the concept of "steering."

Coaching Philosophies

Segment most important to accuracy. When coaches were asked what they thought was the most important segment of the long jump for accuracy, three of the nine coaches (33.3%) indicated that the first 5-7 steps are the most important, while another four (44.4%) indicated that it is the last 4-6 steps. However, the final two (22.3%) stated that both the beginning and end are of equal importance. Moreover, many of the coaches mentioned the importance of these two portions of the run-in, while expressing preference for one over the other. There was no mention of the importance of the middle portion of the run-in.

Looking at the board. When coaches were asked to share their philosophy about looking at the takeoff board while running coaches generally suggested that athletes should not tilt their head down to look directly at the board, particularly as they get closer to the board, as posture would be disrupted. However, most (6 of 9 = 66.7%) stated that the athletes should be tracking the board with their peripheral vision, as they get closer to the board. Two coaches did not specify -- one indicated that he actively teaches tracking, steering, and visual control, and the other said it was advisable to look, but did not specify when in the approach the jumper should begin looking. Another coach indicated that the athlete should not focus on the board in any way during the approach. The final coach stated that both horizontal and vertical jump athletes should look at the board or pole.

Accuracy Methods

All of the coaches surveyed (9 of 9) believed in the idea that toe-board accuracy is a skill that can be trained or developed through practice. When asked about specific strategies they used to develop or train toe-board accuracy there were numerous strategies reported by the group. Strategies include:

- Use measured runs.
- Rhythm work using auditory cues such as music clapping, listening to your feet, or "trusting your brain."
- Questioning athletes by asking questions such as, how far down the runway did you know you would hit the board or miss it?
- Demanding accuracy for each jump during practice.
- Begin "visual strategy" as soon as possible by looking at the board 6 or 7 strides before the take-off (2 of 9 coaches).
- Rewson Method – ask athletes to run the approach several times, then in the next several runs, change the start mark and still require accuracy at the board (4 of 9 coaches).
- Double locus target methods.
- Drills to help the eyes with tracking, then reproducing those abilities with drills on the track.
- Teach the athlete a better system of "energy distribution" during the programming phase, so that visual control (VC) has to be controlled to a lesser extent.
- Using marks or checkmarks (prompting an external focus at specific parts of the run.
- Identifying the board at different parts of the run to prompt an external focus.
- Using hurdles at varying intervals - repetitive takeoffs (3 of 9 coaches)
- Ensure proper motor environment is present in the approach.

- Ensure proper physical body positioning in the approach.
- Provide specific targets.

Coaching Resources

When coaches were asked about additional resources used to design the training for the technical portion of the long jump coaches included:

- Other coaches
- Coaching journals
- DVD's
- Biomechanical analyses
- Video analysis

Discussion

The horizontal jump events in track and field, such as the long and triple jump, are good examples in which motor learning and control principles can make a significant impact on training design and competition performance. As coaches and athletes strive to optimize performance, it is important to understand the unique role that each sports science discipline fulfills in helping athletes achieve their maximum potential. For instance, biomechanics helps to identify optimum movement mechanics, strength and conditioning helps to develop speed and power, proper nutrition provides fuel for the movements, sport psychology helps athletes stabilize and control emotions, and exercise physiology provides methodologies for maximizing physiological adaptations to training. While many of these sport science disciplines are well known or utilized within a training environment, the contributions of motor learning and control are often times overlooked. Why is motor learning and control often times not considered when training athletes? According to Williams and Ford (2009), few sports organizations (Australian Institute of Sport; Sports and Recreation New Zealand) embrace the importance of motor learning and control. According to the authors, there are three potential reasons that may explain the lack of motor learning and control within athletic training programs: 1) measuring the effectiveness of skill acquisition interventions is difficult, 2) designing practice and instruction have traditionally been viewed as the role of the coach, and 3) skill acquisition researchers have been more focused on theoretically driven research rather than translational research.

The purpose of this study was to explore strategies of elite track and field coaches in developing accuracy for the horizontal jumps. Moreover, we investigated if elite coaches use strategies consistent with the motor learning and control literature, namely, principles of practice variability and contextual interference. Based on the findings of Williams and Ford (2009) and Porter et al. (2010), it was hypothesized that elite coaches do not use methods consistent with the motor learning and control literature to develop accuracy. The results of the present study partially supported this hypothesis. While the coaches in this study reported a variety of strategies to train toe-board accuracy, coaches used few strategies that utilized concepts related to practice variability or contextual interference. With respect to practice variability, coaches reported having jumpers vary the distance of their approach runs (4 out of 9 coaches) and using hurdles at varying intervals (3 out of 9 coaches). While these methods are avenues to increase practice variability within the training environment, the variation was organized in a block manner with very low levels of contextual interference. Based on the contextual interference literature, a low level of contextual interference, provided by a block style of practice, is poor for motor learning (Brady, 1998; Magill & Hall, 1990). Moreover, the strategies reported by the coaches revealed that of the three possible avenues to institute variability (movements of the action, situation, and the environment) just one aspect of practice was varied – the environment. With respect to varying movements of the action, one coach reported utilizing a strategy that ensures proper physical body positioning in the approach. Based on this report, this indicates that only optimal movement mechanics were emphasized. According to Magill (2011), one of the learning advantages afforded by practice variability entails learners exploring their perceptual motor workspace. Designing a training environment in which athletes do not solely focus on optimal movement mechanics allows them to explore their perceptual motor workspace, enabling them to independently discover the optimal movement pattern, which leads to better acquisition of the motor skill.

The limited number of reported strategies utilizing principles of variability and contextual interference may be explained by their responses to the following question,

"Are you aware of scientific research addressing toe-board accuracy during the Long Jump approach? If you are aware of the research, what do you agree and disagree with the findings of the research?"

In response to the preceding question, 7 out of the 9 coaches reported being aware of research on toe-board accuracy. Moreover, 5 of the 9 coaches reported the works of James Hay and his concept of "steering." According to Jacoby and Fraley (1995), steering refers to making adjustments in stride length, through the use of visual information, to accurately approach the toe-board. Based on the findings of Hay (1988) and Lee, Lisham, and Thomson (1982), athletes do, in fact, use some form of visual strategy to accurately negotiate the toe-board at takeoff. Similar findings have also been reported in the approach used during the gymnastics vault (Meeuwsen & Magill, 1987). In light of these often used resources for coaches, a predominant response within the study dealt with the role or emphasis of vision during the approach run. That is, coaches reported the use of visual strategies, drills to develop eye tracking, using check marks for visual tracking, tracking the board at different parts of the run, and providing specific visual targets.

When reviewing the scientific resources the coaches use to train toe-board accuracy (Hay, 1986; Hay, 1992; Hay & Miller, 1986; Hay & Nohara, 1990), it becomes clear why coaches in this study primarily used biomechanical descriptions to train toe-board accuracy and under utilize motor learning and control principles. To begin with, James Hay wrote biomechanical texts and conducted biomechanical studies that were specifically targeted at the horizontal jumps. Within his texts and research, he provides detailed mechanical descriptions of all the movement events that comprise the long jump and triple jump. In light of this, Hay's work initiated additional research as it pertains to biomechanical descriptions of the horizontal jumps. Hay conducted many studies on the long and triple jump using elite level athletes. The studies were a product of his involvement, as a sports scientist, with the United States of America Track and Field (USATF) program; he was tasked with providing biomechanical studies to enhance the performance of American athletes in international events. While there were, and still are funded biomechanical projects within the USATF, the same cannot be said for motor learning and control studies.

Finally, as stated by Williams and Ford (2009) researchers within the motor learning and control domain have been more focused on theoretically driven research rather than translational research. Moreover, the academic discipline of motor learning and control has failed to effectively communicate the value of its research to related fields such as sports performance development, military and tactical training, rehabilitation, occupational, and education programs. By point of comparison, the field of sport psychology, a related academic discipline, has effectively advertised and advocated their services to practitioners. This can be seen through their formalized certification process to be a practicing sport psychologist. Based on the findings presented here, it is clear that the sampled elite coaches for this study were not familiar with related motor learning research. If this sample of coaches is not familiar with the related research, it is plausible to assume that less skilled and experienced coaches are also not familiar with research related to practice variability and contextual interference. This suggests that motor learning and control researchers must complement theoretical experimentation with applied studies or translational research. Scientists should reach out to practitioner communities (e.g. coaching organizations, rehabilitative societies, practitioner oriented journals, etc.) not only to share their empirical findings, but to also seek collaborative opportunities. Additionally, methods of research should be adopted that better resemble "real world" constraints. This shift in scientific practice would not only increase the visibility of the field of motor learning and control, it would also assist in developing a culture of acceptance by practicing professionals and affiliated organizations and agencies.

There are limitations to the present findings, many of which highlight the need for continued research. For instance the sample represents elite coaches from one specific event within track and field. Future work needs compare common methods used by coaches from other track and field events (e.g. sprinting, throws, distance running). It would also be valuable to investigate other sports such as baseball and soccer, to identify if the methods used by coaches in other sports are consistent with the research findings reported in this study. Lastly, only American and European coaches were sampled within the study. Consequently, it is not clear if our findings are similar to practices utilized by coaches from other countries. Clearly, much additional research is needed to more fully understand the common methods used by skilled coaches.

In summary, our findings indicate that a unique sample of the worlds best track and field jumping coaches are not using methods that are consistent with motor learning and control research and are unfamiliar with research related to practice variability and contextual interference. We have provided plausible reasons for these conclusions and have also paved several avenues for future research endeavors. Ultimately, these efforts will result in scientists and practitioners working together to develop efficient and effective training methods that will enhance motor skill acquisition.

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