MEASURING BILATERAL ASYMMETRY IN A LONG-TERM ATHLETE MONITORING

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The purpose of this lecture is to provide examples of how biomechanical testing methods are used to analyse bilateral asymmetry from a long-term athlete monitoring program. This lecture includes the results of bilateral asymmetry data to examine the physical status of both highly competitive and recreational athletes. Athlete monitoring is a vital component of achieving a successful athletic career. It is important to understand how the magnitude of bilateral asymmetry is potentially detrimental to performance. The bilateral asymmetry data has been analysed to understand physical demands of athletes in various sports. Different types of jumping, landing, and isometric tests have provided data showing effectiveness of the tests in displaying the athlete's physical characteristics. Bridging the gap between science and practice is mentioned in the lecture.

KEYWORDS: tests, sports, symmetry.

INTRODUCTION: Athlete monitoring is an important way of tracking the progress that athletes make throughout their careers. From the scientific view point, monitoring athletes with selected physiological and biomechanical variables provides a sense of how training stimulates the physical conditioning towards to a competition phase (Hornsby, 2012). Additionally, monitoring data can be summarized and analysed through statistical methods such as single-subject design analysis and trend analysis to give athletes and coaches observation-based information on how evaluating overall training volume can better prepare the athletes. Within athlete monitoring, some tests can be used as a diagnostic evaluation (Knapik et al., 1991; Nadler et al., 2001). Simple measurements such as body composition, hydration, jumps, and other tests can be done frequently to keep track of athlete's physical condition. At the same time, some diagnostic tests are done to better predict athletic performance, return to play decision, and/or a risk of injury (Knapik et al., 1991; Nadler et al., 2001; Johnston, 2014).

Bilateral asymmetry research has been done mainly in clinical settings with pathological issues comparing the functionality of bilateral movements (Panariello et al., 1994; Thein et al., 1998). In recent years, this idea has been used for athletic populations to evaluate aforementioned information (Bailey et al., 2014; Sato et al., 2012). Although having abnormal functionality such as a certain level of asymmetry from kinetic and kinematic data in bilateral tasks receives attention, asymmetry measures in athletic populations do not receive the same attention in the existing literature and most importantly not for practical use.

Therefore, the purpose of the lecture is to provide information on how bilateral asymmetry testing methods are being used to evaluate athletes in a long-term athlete monitoring program. The lecture consists of methodological procedures, data outcome, and data interpretation in quantitative and qualitative perspectives.

METHODS: Typical participants in these studies are competitive to recreational level athletic populations. Many studies being mentioned in this lecture are based on the athlete monitoring data from National Collegiate Athletic Association (aka, NCAA) Division I athletes (Bailey et al., 2014; Chiang, 2014; Hornsby, 2012; Johnston, 2014; Sato et al., 2012; Sha et al., 2014). The long-term athlete monitoring program at East Tennessee State University is completed through a collaborative effort between the Department of Exercise and Sport Science, Center of Excellence for Sport Science and Coach Education, and the Department of Athletics, called the Sport Performance Enhancement Consortium (SPEC). SPEC athletes go through a battery of testing, which includes the following: hydration, body composition, two types of jumps (static and counter-movement) with unloaded and loaded conditions, and isometric mid-thigh pull (IMTP). Depending on sports, additional tests such as agility and distance-specific sprints are also examined.

All of the jump tests are done on dual force plates (RoughDeck HP; Rice Lake, WI) and athletes are positioned so that their midline is along the center line of two force plates. The force plates measure ground reaction force (GRF) simultaneously at the same sampling frequency of 1,000 Hz. The two types of jumps, static jump (SJ) and counter-movement jump (CMJ), are done using unloaded (0 kg) and loaded (11 and/or 20 kg) conditions. Force data such as peak force (raw and scaled), time specific forces (50, 90, 200, and 250 ms), rate of force development (RFD), peak power, and impulse are considered for the performance measures (Bailey et al., 2013; Chiang, 2014; Johnston, 2014; Sha et al., 2014). The IMTP are done on identical force plate setups to measure GRF variables from both sides to consider similar data to the jumps.

Agility tests are another test protocol with potential for asymmetry identification (Chiang, 2014). It is important to note that this asymmetry consideration is based on limb-dominancy and/or preference. As a measure of performance, the tests are timed using infrared timing gates (TC Timing System, Brower Timing Systems, Draper, UT) and as a measure of foot contact time using an OptoGate system (Microgate, Balzano, Italy). Top-speed sprints are also considered between the limbs using 3-dimensional (3D) motion capture systems (Nexus 1.8.5, Vicon, UK) to identify potential limb kinematic asymmetry. Specific measurements such as joint and segment kinematics between both sides of limb are considered (Sha et al., 2014).

From a rehabilitative perspective, a closed-chain task such as jumps have been examined and utilized as a “return-to-play” decision making tool (Johnston, 2014). Athletes who are coming back from surgery or injury are expected to produce movement compensations. For example, when conducting the jump test during the rehabilitative phase, push-off and landing GRF measures from both sides are a good indication how athlete uses uninjured and injured side differently. Excessive magnitudes of asymmetry indicate the presence of compensation, and it is expected that the magnitude of asymmetry decreases as the rehabilitation progresses.

There are several ways to calculate asymmetry from the literature (Bell et al., 2008; Sato et al., 2012). In order to keep the data coach-friendly for practical use, a typical method being used for the asymmetry calculation is to identify variables with a symmetry index (SI) score. Statistical analysis to answer research questions consists with correlation to associate how strength predicts the level of asymmetry, and how asymmetry in strength can be a carryover to sport-related tasks such as jumping, landing, sprinting, and agility (Bailey et al., 2014; Chiang et al., 2014). Other methods are to compare groups of population to identify if the level of asymmetry matters in certain sport-related tasks (Bazyler et al., 2014; Sato et al., 2012). Cohen’s *d* was used to describe the relevance of differences (Cohen, 1992). Other alternative statistics such as single-subject design and trend analysis are used for tracking the injured athlete for monitoring purpose to determine the return to play (Johnston, 2014).

RESULTS: As results of aforementioned studies, figures and tables are shown below.

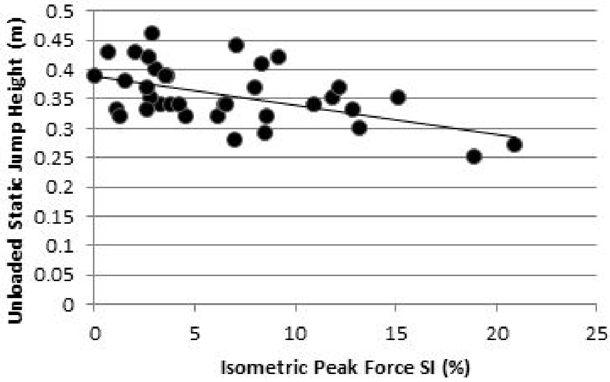

Figure 1: Correlation value of r = -.52 for the relationship between static jump height (m) and a magnitude of isometric mid-thigh pull symmetry index score (%), (from Bailey et al., 2013).

Table 1.

The relationships between isometric mid-thigh pull force symmetry index score and change of direction symmetry index score, (from Chiang, 2014).

	IPF	F50	F90	F250
3m acceleration	-0.13	0.00	0.12	-0.20
Partial time	0.12	0.42*	0.60**	0.20
Total time	0.03	0.23	0.38	0.23

Note: * $p < 0.05$, ** $p < 0.01$,

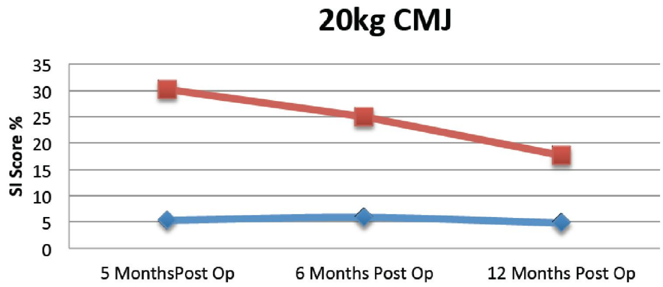

Figure 2: Descriptive comparison on 20kg countermovement jump landing force asymmetry, red square = injured side, blue diamond = uninjured side, (from Johnston, 2014).

DISCUSSION: Overall, based on the various approaches to examine the influence of bilateral asymmetry in sport tasks, there is some justification to the notion that high magnitude of asymmetry may become detrimental to athletic performance such as jumping (propulsion and landing force asymmetry) (Bailey et al., 2013; Johnston, 2014). This supports the idea that individuals with high asymmetry from specific tests can be categorized into a “watch-list”, and should receive attention from athletic trainers, strength coaches, and sport scientists to reduce the level of asymmetry in order to improve the jump-related performance. The results also can be used as a monitoring tool to determine if the certain training is effectively stimulating decreases in the magnitude of asymmetry. Specifically concerning injury, this can be used when athletes are in the rehabilitation process. Making the “return-to-play” decision based on a single field test or an isokinetic symmetry evaluation may not be adequate. Previous evidence has shown that an athlete may return to full symmetry in one assessment method, while still compensating during jump performances (Johnston, 2014). From an athlete monitoring standpoint, when tracking SI scores or any variable of a single athlete, data analysis may become mostly visual (see Figure 3).

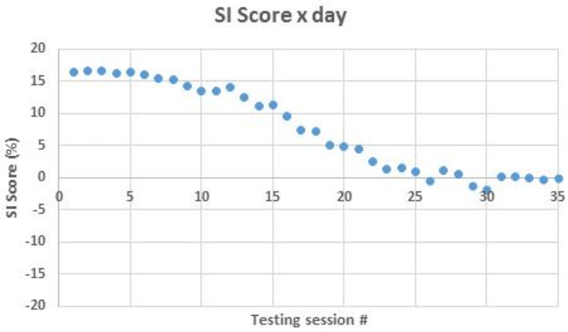

Figure 3: Example of visual nature of the analysis athlete monitoring data.

At the same time, strength training tends to reduce the magnitude of bilateral asymmetry in isometric force production measured by isometric squat tasks (Bazyler et al, 2014). It is important to note that this applies to healthy athletes who are relatively weak. Therefore, if relatively weaker individuals possess strength asymmetry, strength training may help reduce the asymmetry as they become stronger. Especially when considering the data from Bailey et al. (2014), relatively weak individuals who possess large magnitude of asymmetry could benefit from strength training to minimize the strength asymmetry.

On the other hand, agility and change of direction tasks from collegiate athletes showed a weak relationship between the magnitude of bilateral strength asymmetry and the modified version of the 505 change of direction task (Chiang, 2014). Even though this notion may be speculative, sprint performance from collegiate sprinters at peak velocity phase also showed no relationship between strength asymmetry and sprint performance, nor limb characteristic asymmetry (Sha et al., 2014).

It is important to acknowledge that there are some tasks that influence of asymmetry is minimal or non-existent to the task performance. This may mean that coaches should be more attentive to excessive levels of asymmetry in certain tasks and physical characteristics and less attentive in others. Further investigation is certainly necessary.

CONCLUSION: Concerning a performance standpoint, when considering to measure bilateral asymmetry, certain tests have become useful to the understanding of how to improve performance. But at the same time, some tasks are not heavily influenced by presence of asymmetry and may not necessitate evaluation or correction. Thus, further research is warranted to determine which tasks are sensitive to asymmetry and which are not.

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