“Measuring the Coefficient of Variability in Marching-In-Place Test Using OptoGait System”

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ABSTRACT

The purpose of this study is to determine normal variance percentages using Microgate OptoGait's marching-in-place test in a normal, asymptomatic population. By collecting data from a normal population, we can establish a set of normal values. Knowing what is normal for a patient can then be applied to the patient that experiences an injury. Catena and Donkelaar showed us that a person experiencing a concussion later presents with a change in their gait, showing more asymmetrical patterns (1). A similar study was done with stroke patients in the Journal of the American Heart Association (2). They demonstrated that damage to the posterolateral putamen in chronic stroke patients, caused a temporal gait asymmetry. Other researchers have looked at other factors of gait including, velocity, endurance, distance, and oxygen consumption, but few have looked at the asymmetry of marching as in the aforementioned studies (3-6). The OptoJump system, from which OptoGait was derived has proven to be a reliable optical assessment system, used for analyzing vertical jump, strength, speed, time, and asymmetry (7,8).

INTRODUCTION

The OptoGait system is an optical measurement system consisting of a transmitting and receiving bar. Each bar contains 100 LEDs that transmit continuously to each other. With a continuous connection between the two bars, any break in the connection can be measured and timed. Jumping, walking, and other movements can be analyzed to the 1/1000 of a second. This allows for a unique ability to pick up subtle differences in these movements that the naked eye may notice. These subtle differences can lead to muscle imbalance identification or even clearing an athlete for play post-injury. Many optical assessment systems are bulky and impractical. This system is portable and real-time data collection allows for immediate interpretation of testing. The portability also allows for utilization of the system for in-office or on-field use with ease (9).

The OptoGait, with its specificity in biomechanical analysis, can pick up the subtle differences in athletes' movement patterns. By establishing normative values and applying those values to an injury situation, the OptoGait aids in determining whethere or not an athlete has achieved full recovery of an injury.

MATERIALS & METHODS

This research project recruited subjects by verbally requesting for volunteers from the students of Logan College of Chiropractic. Included in the study were participants who are asymptomatic in the low back and lower extremities. Participants were male or female ages 18-50. Excluded from the study were applicants with current neck or low back pain with or without radicular symptoms extending below the knee or elbow, respectively, current foot and/or ankle pain, a history of neurological disease, history of severe lumbar trauma or surgery, and/or current use of muscle relaxants or analgesics. Excluded was also applicants with known degenerative joint disease (DJD), recent injury to lower extremity (within 6 months). Also, individuals currently pregnant or with diabetes, heart, kidney, thyroid disorders and chronic disease are not eligible for the study. There was no assignment of participants due to the need for only one group of subjects.

The tests were all executed at Logan College of Chiropractic in the Biofreeze® Sports & Rehabilitation Center. The test involved marching in place. The subject was instructed to stand with their feet shoulder width apart and asked to march in place at a self-chosen pace and to maintain the chosen pace for the duration of the test. The subject aligned his/her feet perpendicular to the OptoGait bars then marched in place three times for fifteen seconds each respectively with at least a thirty-second rest period in between marches. The subject was required to remove shoes/socks and wear shorts for the test. The height of the subject's march must have exceeded that of the sensor, which is approximately 1.25 inches from the ground. The OptoGait system can be were set up as far as six meters apart. During testing, they were six feet apart.

All measurements were done concurrently as the participant marches. The OptoGait software collected and calculated all equations as each foot exited and re-entered the OptoGait sensor area. Data gathered from this test included number of steps for taken for each leg bilateral measurement of contact time, flight time, and pace as well as the coefficient of variability bilaterally and for each leg.

The collection of data was to establish normative ranges for the coefficient of variability. The following parameters were collected: number of steps, contact time, flight time, pace (right foot duration to left foot), and cycle (time for one complete cycle i.e. right foot to right foot duration). Within these parameters values of minimum, maximum, average standard deviation, coefficient value, average left, average right, left-right percent difference, coefficient variable of left, and coefficient of right. Data collection occurred during a single visit. Expected duration of each session was no more than 5 minutes. Informed consent and inclusion/exclusion criteria were to be signed and determined.

RESULTS

579 tests were executed on 193 subjects. 4 tests were excluded from data analysis due to insufficient testing parameters and results. Those errors may have been due to the operator not properly queuing the instruction to the patient or the test having been halted before the proper time. 575 tests were examined and the coefficient of variability was examined for each of the four parameters. Data was gathered on four parameters. Overall coefficient of variability (CV), CV for the left foot, and CV for the right foot were analyzed for each parameter. The data analysis was done via Microsoft Excel 2007 spreadsheet, and the following values were calculated: mean, median, mode, maximum value, minimum value, and standard deviation. All calculations and Tables 1-4 were formulated using the Excel software.

Table 1. Contact Time (s)

	Coefficient of Variability (CV)	CV Right Foot Only	CV Left Foot Only
MEAN	4.36%	4.04%	3.23%
MEDIAN	3.8%	3.6%	2.8%
MODE	3.7%	3.6%	2.1%
MAXIMUM VALUE	84.6%	84.1%	83%
MINIMUM VALUE	0.942%	0.7%	0%
STANDARD DEV	4.97%	3.92%	4.27%

Table 2. Flight Time (s)

	Coefficient of Variability (CV)	CV Right Foot Only	CV Left Foot Only
MEAN	9.34%	9.20%	6.80%
MEDIAN	7.3%	6.8%	6%
MODE	4.9%	5.3%	4.7%

MAXIMUM VALUE	134.8%	148.5%	41.9%
MINIMUM VALUE	0.29%	1.4%	1.8%
STANDARD DEV	9.10%	10.86%	3.84%

Table 3. Pace (steps/s)

	Coefficient of Variability (CV)	CV Right Foot Only	CV Left Foot Only
MEAN	3.17%	3.26%	3.09%
MEDIAN	2.7%	2.8%	2.7%
MODE	2.4%	2.4%	2.2%
MAXIMUM VALUE	68.1%	77.8%	39.8%
MINIMUM VALUE	0.81%	0%	0%
STANDARD DEV	3.42%	3.525%	2.46%

Table 4. Cycle (s)

	Coefficient of Variability (CV)	CV Right Foot Only	CV Left Foot Only
MEAN	3.18%	3.10%	3.23%
MEDIAN	2.8%	2.8%	2.8%
MODE	2.5%	2.7%	2.1%
MAXIMUM VALUE	64.4%	24.65	83%
MINIMUM VALUE	0.8%	0%	0%
STANDARD DEV	3.37%	1.51%	4.27%

CONCLUSION

The results of this study show the variance found in non-injured, healthy individuals as they execute a marching-in-place test using the OptoGait system. Among the four parameters measured, the largest variability existed between flight time as compared with contact time, pace and cycle (CV=9.34%, 4.36%, 3.17%, and 3.18%, respectively). The lowest variability was found with pace, with cycle being similarly low also in comparison with contact time. Pace and cycle demonstrated nearly identical variability among all categories, as to be expected since they are not mutually exclusive. Within each of the four measured parameters, the flight time statistics show the most variability, and within that measurement, the right foot was shown to have more variability then the left (CV=9.20% and 6.80%, respectively). Comparisons of the remaining right to left CV's demonstrate less variability. The right foot had a higher variability versus the left foot in contact time (CV=4.04% and 3.23%, respectively) and pace (CV=3.26% and 3.09%, respectively). The left foot showed more variability in the cycle parameter than the right foot (CV=3.23% and 3.10%).

DISCUSSION

Limited research exists on establishing normative values and using the OptoGait system for asymmetrical evaluation (1-8). The goal of this study was to establish normal CV percentages for the different phases of the marching test parameters. The researchers involved in this study have determined to what degree of coefficient variability to expect in a population that is asymptomatic and has no history of serious injury. The values outlined in this study can serve as normative values for clinical use of the OptoGait system.

Clinical application of the OptoGait system's march test can include establishing whether or not a player has reached pre-injury baseline, by analyzing the symmetry in their gait. Having normative values is especially beneficial if that patient has no pre-injury data to compare post-injury recovery to. One of the hardest injuries for a physician or team trainer to manage is a concussion. When it comes to return to play from a concussion, the classification is vague and subjective. A checklist of symptoms is commonly employed and contains such criteria as "depression, dizziness, drowsiness, fatigue, feeling in a 'fog', sadness, nausea, and poor balance" (10). The problem with this system is that it is dependent on the patient to give accurate feedback. There are few dynamic or ballistic objective tests regarding return-to-play criteria post-concussion.

Within the data, some differences were found that were specifically thought-provoking to the research team. The difference between flight time and contact time may be caused by a compounding factor of marching. As the patient contact time differs it causes a compensation of the flight time to attempt to normalize gait cycle. This compensation can cause variability in the gait cycle while the body tries to normalize its own gait. Another striking difference is that the right foot demonstrated higher variability in all parameters besides cycle. This variability may have been caused by the right foot being the initial marching foot, or it could be due to a mechanical tendency to favor a dominant foot. Further research would need to be done to make a significant conclusion on such hypotheses.

This is valuable in the assessment of differences in both symptomatic and asymptomatic patients. With this information, in the opinion of the research team, the OptoGait marching protocol has clinical application with a central focus on obtaining symmetry throughout a treatment regimen. This could be done by using a better timing system to initiate the test or a louder initiating alert to begin the test. Increasing the ability of a practitioner to use technology to identify dysfunction and imbalance is of great value. Further outcome-based research involving the use of OptoGait as a clinical assessment tool is necessary. It is also recommended that further testing be done to establish pediatric, geriatric and gender specific CV normative data.

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