Static and Dynamic Postural Stability in Recreational Athletes with Chronic Ankle Instability

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Context: Time to Stabilization (TTS) is a relatively new measure, and is hoped to be more sensitive to subject differences in a dynamic setting, as compared to traditional sway measures. However, these collective measures have not been widely compared.
Objective: To determine whether traditional sway measures can differentiate between subjects in a dynamic setting, as to later determine whether TTS is more sensitive to mechanical ankle instability (MAI) and functional ankle instability (FAI) subject differences.
Design: A case control design was used to determine the postural stability of FAI subjects as compared with MAI, “coper” group, and a control group.
Setting: Biomechanics laboratory.
Participants: Eighteen subjects with MAI, 6 men (age = 19.500±.548 years, height = 176.417±5.864 cm, mass = 71.392±10.151 kg) and 12 women (age = 20.083±1.165 years, height = 168.642±5.699 cm, mass = 63.892±8.902 kg), twenty-three subjects with FAI, 11 men (age = 20.455±1.695 years, height = 179.818±7.799 cm, mass = 78.483±9.363 kg) and 12 women (age = 20.000±1.414 years, height = 168.642±6.615 cm, mass = 65.083±7.804 kg), twenty "coper" subjects, 8 men (age = 19.375±1.188 years, height = 181.6884.136 cm, mass = 77.988±6.634 kg) and 12 women (age = 20.3331.073 years, height = 165.675±6.649 cm, mass = 62.050±6.341 kg), and twenty-two control group subjects, 10 men (age = 25.480±16.672 years, height = 175.690±7.057 cm, mass = 68.730±7.835 kg) and 12 women (age = 20.167±1.030 years, height = 166.746±4.852 cm, mass = 61.158±9.726 kg).
Intervention(s): A jump protocol required subjects to perform a 2-legged jump to a height equivalent to 50% of their maximum vertical leap and land on a single leg.
Main Outcome Measure(s): The dynamic postural stability index, directional velocity, sway area, and displacement derived from the directional components (medial-lateral, anterior-posterior, and vertical), and vertical ground reaction force after a jump landing.
Results: No significant differences (P<.05) existed between testing groups in terms of directional velocity, sway area, and displacement.
Conclusions: Directional velocity, sway area, and displacement could not be used to differentiate between MAI, FAI, “coper,” and control groups.
Key Words: Ankle instability, jump landing, ground reaction force, displacement, sway area, velocity, time to stabilization

The ankle joint is the most frequently injured part of the body in many sports. Ankle injury itself has not been consistently proven to produce functional ankle instability (Tropp 185), but studies have suggested that the ligamentous and capsular tissues of the ankle are responsible for adjusting muscle tones to dynamic situations and that “damage to the receptors in ligamentous and capsular injuries will result in a proprioceptive defect” (Tropp 185).

Ankle problems, like sprains, are generally attributed either to functional ankle instability, mechanical ankle instability, or a combination of the two factors. Functional ankle instability of the ankle can be defined as “subjective ‘giving way’ or recurrent ankle sprains” (Tropp 185), as opposed to mechanical injuries that entail structural damage to the ankle ligaments (Nakagawa 255). An acute ankle injury may result in a defective ability to maintain postural equilibrium.

Although different measures of dynamic ankle stability have been formulated, and testing protocols, instrumentation specifications, and some other factors have been established, other traditional measurement issues, such as “validity, retest reliability, and sensitivity of different measures have not been addressed” (Goldie 510).

Time to Stabilization is a fairly new measure, and is embraced as more sensitive to subject differences in a dynamic setting, as opposed to traditional measurements including center of pressure (COP) and sway path length. TTS measurements entail the amount of time a subject requires to regain comparative stability after movement, while COP can be defined as “the center of the pressure distribution pattern on the surface of a force platform and represents the point of application of the resultant force” (Goldie 510), and sway path length simply as the complete length of movement of the center of pressure of a subject while regaining stability. The long-term goal of this project is to determine whether TTS is comparatively more sensitive to differences in subjects based on predetermined chronic ankle instability (CAI).

Specifically, this section of the study aims to analyze a testing group using traditional measures of ankle stability – directional velocity, sway area, and displacement – which can then be compared to analysis of the same group of subjects (by Dr. Cathleen Brown, Ph.D., ATC) made using Time-to-Stabilization measures, with the latter expected to show greater ability to differentiate between predetermined testing groups.

METHODS

Seventy recreational athletes – eighteen subjects with MAI, 6 men (age = 19.500±.548 years, height = 176.417±5.864 cm, mass = 71.392±10.151 kg) and 12 women (age = 20.083±1.165 years, height = 168.642±5.699 cm, mass = 63.892±8.902 kg), twenty-three subjects with FAI, 11 men (age = 20.455±1.695 years, height = 179.818±7.799 cm, mass = 78.483±9.363 kg) and 12 women (age = 20.000±1.414 years, height = 168.642±6.615 cm, mass = 65.083±7.804 kg), twenty "coper" subjects, 8 men (age = 19.375±1.188 years, height = 181.6884.136 cm, mass = 77.988±6.634 kg) and 12 women (age = 20.3331.073 years, height = 165.675±6.649 cm, mass = 62.050±6.341 kg), and twenty-two control group subjects, 10 men (age = 25.480±16.672 years, height = 175.690±7.057 cm, mass = 68.730±7.835 kg) and 12 women (age = 20.167±1.030 years, height = 166.746±4.852 cm, mass = 61.158±9.726 kg) – were selected from a group of volunteers who signed informed consent and underwent baseline testing for ankle injury status, ROM, mechanical laxity, height, weight, age, and limb dominance. CAI participants reported a history of multiple inversion ankle sprains and ≥2 episodes of the ankle "giving way" in the preceding year. Controls reported none. Subjects were separated into 4 testing groups: subjects with mechanical ankle instability (MAI), which entailed significant mechanical laxity of the ankle, subjects with functional ankle instability (FAI), which included subjects who met

Participants returned to the lab for a 1-hour testing session. They warmed up on a stationary bike and stretched and donned black spandex and a snug sleeveless shirt.

Subjects' maximum vertical jump height was then measured and anthropometric measures were recorded. 34 reflective markers were placed on the body (Figure 1) using double-sided tape.

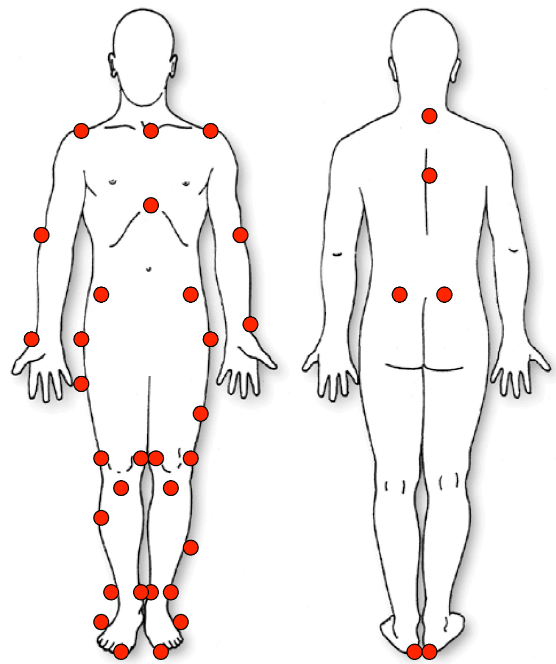

Figure 1

Studies were conducted at the University of Georgia Biomechanics Laboratory. Kinematic data was collected 7-camera Vicon Motion System (MX40TM Cameras, Vicon, Inc., Los Angeles, CA), coupled with Vicon Workstation software (v.5.2.4), which was used to capture the spatial location of reflective markers at a sampling frequency of 120 Hz and a shutter speed of 1/1000 s. An L-Frame (Ergacoal – 14 mm markers, Vicon, Inc., Los Angeles, CA) and a calibration wand (240 mm wand – 14 mm markers, Vicon, Inc., Los Angeles, CA) were used for static and dynamic calibration, respectively, to calibrate the capture space. An AMTITM force place (Model OR6-6, Advanced Mechanical Technology, Inc., Newton, MA) was used to collect ground reaction force data (GRF) at 1200 Hz. A conditioner-amplifier (Model SGA6-4, Advance Mechanical Technology, Inc., Newton, MA) was used to amplify (gain=1000) and low-pass filter (1050 Hz) the raw analog data.

Static stance trials were then taken for normalization. Subjects performed jump-landings, jumping off two legs, moving forward 70 cm to 50% of their maximum height, landing on the specified testing leg and balancing for approximately 10 seconds. Subjects jumped in 3 directions: forward (anterior), medial, and lateral. Direction order was randomized. Subjects performed at least 3 practice jumps, and then proceeded with jump-landings until they had completed 10 successful trials in which the landing foot did not leave the area of the forceplate.

Participants performed 10 medial and 10 lateral single-leg jump landings onto the unstable ankle side (CAI) or the matched side (controls).

GRFs were normalized to body weight (BW). Maximum magnitudes were identified in each GRF direction. Independent t-tests assessed group differences (α=0.05). Directional velocity, sway area, and displacement were found from the original testing data using MATLAB software (Version 7.0, The Math Works, Natick, MA). Participants were matched based on gender, age, height, and limb dominance. A 1-way ANOVA was used to compare the 4 testing groups on all dependent variables on Tukey post-hoc.

RESULTS

Displacement

The results are shown in Figure 2. The mean displacement in the anterior direction was 696.04±58.75 mm for MAI participants, 712.24±95.20 mm for FAI participants, 723.56±113.53 mm for "coper" group participants, and 741.27±112.81 mm for control subjects. The mean displacement in the lateral direction was 718.35±79.48 mm for MAI participants, 758.62±84.24 mm for FAI participants, 769.39±112.72 mm for "coper" group participants, and 790.64±90.6 mm for control subjects. The mean displacement in the medial direction was 706.70±60.97 mm for MAI participants, 731.75±75.27 mm for FAI participants, 747.26±97.25 mm for "coper" group participants, and 737.63±109.97 mm for control subjects. There were no significant differences (p<.05) in terms of displacement between MAI, FAI, "coper," or control groups in the anterior, lateral, or medial directions.

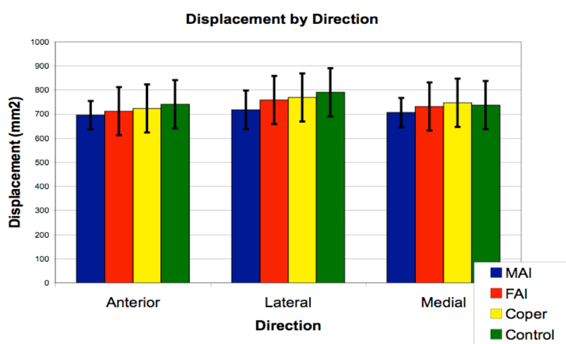

Figure 2

Sway Area

The results are shown in Figure 3. The mean sway area in the anterior direction was 6470.92±1077.45 mm^2 for MAI participants, 6911.45±1456.46 mm^2 for FAI participants, 6618.95±1738.29 mm^2 for "coper" group participants, and 7245.92±1925.17 mm^2 for control subjects. The mean sway area in the lateral direction was 6674.62±1219.71 mm^2 for MAI group participants, 7567.83±2110.99 mm^2 for FAI participants, 7361.97±2096.09 mm^2 for "coper" group participants, and 8121.88±2137.43 mm^2 for control subjects. The mean sway area in the medial direction was 7452.45±1461.48 mm^2 for MAI participants, 7730.26±1554.28 mm^2 for FAI participants, 7733.76±2523.58 mm^2 for "coper" group participants, and 7587.85±1886.72 mm^2 for control subjects. There were no significant differences (p<.05) in terms of sway area between MAI, FAI, "coper," or control groups in the anterior, lateral, or medial directions.

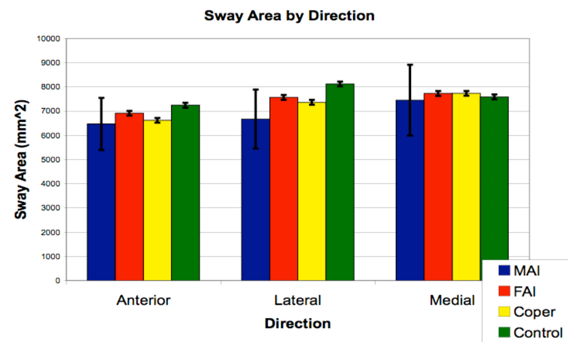

Figure 3

Velocity

The results are shown in Figure 4. The mean velocity in the anterior direction was 232.01±19.58 mm/s for MAI participants, 237.41±31.73 mm/s for FAI participants, 241.19±37.84 mm/s for "coper" group participants, and 247.09±37.60 mm/s for control subjects. The mean velocity in the lateral direction was 239.45±26.49 mm/s for MAI participants, 252.87±28.08 mm/s for FAI participants, 256.46±37.57 mm/s for "coper" group participants, and 263.54±30.20 mm/s for control subjects. The mean velocity in the medial direction was 235.56±20.32 mm/s for MAI participants, 243.91±25.09 mm/s for FAI participants, 249.09±32.42 mm/s for "coper" group participants, and 245.88±36.66 mm/s for control subjects. There were no significant differences (p<.05) in terms of velocity between MAI, FAI, "coper," or control groups in the anterior, lateral, or medial directions.

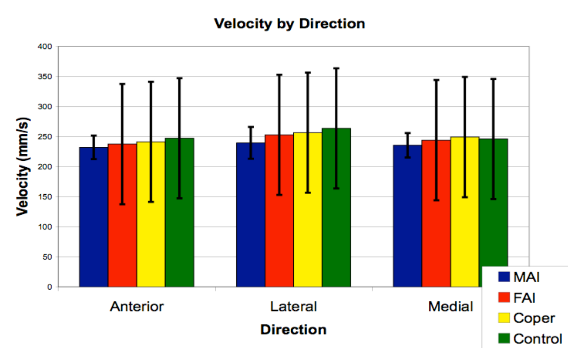

Figure 4

The results of the 1-way ANOVA used to compare the 4 testing groups are shown in the chart below. As previously shown, no significant differences existed between testing groups in any of the three testing directions for any of the three measurement methods.

Group	Significance
Anterior Displacement	.550
Anterior Velocity	.550
Anterior Sway Area	.461
Lateral Displacement	.126
Lateral Velocity	.126
Lateral Sway Area	.173
Medial Displacement	.605
Medial Velocity	.605
Medial Sway Area	.965

DISCUSSION

As hypothesized, the three traditional measures could not be used in this setting to easily differentiate between the predetermined testing groups. Based on these findings, in conjunction with any significant results found using DPSI values, it could be concluded that TTS was a more sensitive measure in this dynamic setting.

As TTS and DPSI values were designed with dynamic testing in mind, a lack of significant findings in this dynamic setting using traditional measures promotes the usefulness and requirement of the new measure, and as Dr. Cathleen Brown's simultaneous study did find significant differences between the group using TTS, the collective findings help support TTS as more resourceful in dynamic testing, and therefore more applicable for younger, more active populations.

REFERENCES

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