Reliability and Concurrent Validation of TRAZER® to 3D Motion Capture

Mason W. Briles, MS, ATC; Alyssa H. Johnson, MS, ATC; Jennifer A. Hogg, PhD, ATC; Gary B. Wilkerson, EdD, ATC

THE UNIVERSITY of TENNESSEE CHATTANOOGA

BACKGROUND AND PURPOSE

- Efficient neural processing of visuospatial and proprioceptive input appears to be crucial for avoidance of sport injury[1]
  - Clinical tests are needed to identify deficiencies found by advanced neuroimaging and electrophysiological tests
    - Virtual reality visual stimuli with body motion tracking may provide an affordable means to acquire relevant data[2,3]
- 3D motion capture (MoCap) in a laboratory is the gold standard for measurement of human movement parameters
  - A single analysis of only 2 subjects related TRAZER® Sport Simulator metrics to 3D motion capture data[4]
    - Independent evidence of the validity and reliability of metrics derived from this system is currently lacking
- The purposes of this study were to assess concurrent validity of TRAZER® single-camera data with 3D motion capture system data and to assess test-retest reliability of its whole-body reactive agility (WBRA) metrics

METHODS

- Two cohorts of healthy college-aged individuals were recruited to assess validity and reliability of TRAZER® metrics
  - 13 individuals (24.8 ±3.1 yrs, 170.0 ±7.7 cm, 70.0 ±14.2 kg) participated in the validation study
  - 18 individuals (23.3 ±2.5 yrs, 168.2 ±11.2 cm, 78.2 ±17.8 kg) participated in the reliability study
- Assessments utilized randomized linear and diagonal movements; 5 repetitions in each of 8 directions (Figures 1-2)
  - Participants performed within 1.75 m x 1.75 m area, facing 40" monitor at a distance of 2.7 m from monitor
    - Proper movement directions guided by random appearance of targets on monitor in front of athlete
      - Movements of 0.88 (linear) to 1.24 m (diagonal) required to deactivate targets; same distances return to center
- Validation assessed by simultaneous collection of TRAZER® data and Vicon® 3D MoCap (Denver, CO)
  - Total Distance, Speed Maximum (Max) and Acceleration (Acc) Max were acquired
    - Vicon® 3D MoCap collected at 60 Hz, double the 30 Hz capture rate of the TRAZER® system
      - Reflective adhesive markers placed on S2 spinous process, bilateral heels, and bilateral hallux
        - 3D digital skeleton created using Vicon® Nexus software; only S2 marker used for MoCap tracking
- Paired t-tests compared means (α=.05); validity assessed by interclass (r) and intraclass correlation coefficient (ICC)
  - Standard error of measurement (SEM) calculated from ICC (2,1) for Total Distance, Speed Max, and Acc Max
- Reliability (test-retest consistency) of WBRA metrics assessed over 3 testing sessions separated by at least 24 hours
  - Total Distance, Speed Max & Avg, Acc Max & Avg, Deceleration (Dec) Max & Avg, and Reaction Time (RT) Avg
    - Repeated measures ANOVA used to assess differences among days; post-hoc paired t-tests if needed (α=.05)
  - ICC (2,1) for Total Distance and Max values (Speed, Acc, Dec) and ICC (2,K) for Avg values (Speed, Acc, Dec, RT)

RESULTS

- Measures of Total Distance, Max Speed, and Max Acc lack absolute agreement between systems (Table 1)
  - Total Distance (t_{12} = 16.26; P < 0.001); Max Speed (t_{12} = 12.38; P < 0.001); Max Acc (t_{12} = 7.80; P < 0.001)
- Agreement between TRAZER® and Vicon® measures analyzed for Left-Front and Left-Back quadrants (Figure 3)
  - Left SD = 9.5 cm; Back SD = 15.0 cm; Diagonal-Front SD = 8.7 cm; Diagonal-Back SD = 10.9 cm
    - Exceptionally strong correlation between measures for Total Distance covered over 40 movements (Figure 4)
- Bland-Altman Plots illustrate mean difference and 95% limits of agreement with Vicon® as criterion (Figures 5-7)
  - Systematic (middle line) and random error for Total Distance, Max Speed, and Max Acc; 95% CI (dashed lines)
- 3-day test-retest ICC values indicated good to excellent agreement, with exception of RT Avg (Table 2)
  - ICC values classified as follows: Excellent ≥ .75; Good .60 - .74; Fair .40 - .59; Poor < .40[5]
    - 2-day test-retest ICCs (1-2, 1-3, 2-3) good to excellent, with exceptions of RT Avg, Acc Max, and Dec Max

Figure 1

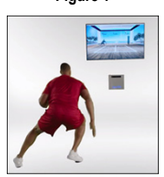

Figure 2

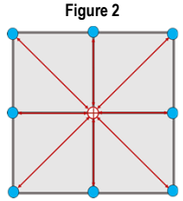

Figure 3

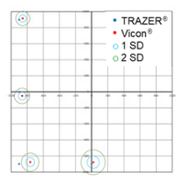

Figure 4

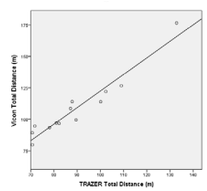

Table 1	TRAZER® Mean (±SD)	Vicon® Mean (±SD)	Difference Mean (±SD)	r	ICC (SEM)
Total Distance (m)	89.46 (±17.85)	108.59 (±24.47)	19.13 (±8.85)	.961	.793 (11.13)
Speed Max (m/s)	1.00 (±0.12)	2.46 (±0.52)	1.46 (±0.43)	.808	.079 (0.50)
Acc Max (m/s²)	4.32 (±0.47)	1.34 (±0.42)	2.98 (±0.66)	-.090	-.008 (0.48)

Figure 5

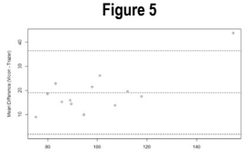

Figure 6

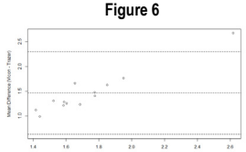

Figure 7

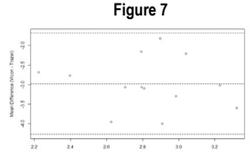

Table 2	Mean (±SD)	Days 1-2-3 ICC (SEM)	Days 1-2 ICC (SEM)	Days 2-3 ICC (SEM)	Days 1-3 ICC (SEM)
Total Distance (m)	81.06 (±6.65)	.745 (3.36)	.794 (3.02)	.761 (3.25)	.683 (3.74)
Speed Avg (m/s)	0.68 (±0.08)	.847 (0.03)	.819 (0.03)	.864 (0.03)	.677 (0.05)
Acc Avg (m/s²)	2.12 (±0.47)	.919 (0.13)	.852 (0.03)	.957 (0.10)	.825 (0.20)
Dec Avg (m/s²)	1.79 (±0.31)	.948 (0.07)	.927 (0.08)	.907 (0.09)	.937 (0.08)
RT Avg (ms)	320 (±50)	.536 (31)	.447 (40)	.493 (40)	.409 (40)
Speed Max (m/s)	0.84 (±0.10)	.654 (0.06)	.665 (0.06)	.559 (0.07)	.725 (0.05)
Acc Max (m/s²)	3.00 (±0.56)	.171 (0.51)	.067 (0.54)	.032 (0.55)	.824 (0.23)
Dec Max* (m/s²)	2.39 (±0.32)	.416 (0.24)	.581 (0.21)	.139 (0.30)	.495 (0.23)

* 1 outlier case omitted (>3 SD from mean)

CLINICAL RELEVANCE

- Lack of close agreement of maximum instantaneous measures acquired at any point of testing is not surprising
  - Differences in Speed Max and Acc Max measures may be due to differing capture rates (Hz) of the two systems
  - Greater precision of Vicon® 8-camera system for 3D quantification of spatial points likely contributed to differences
- Test-retest reliability of averaged TRAZER® measures were substantially greater than that of maximum measures
  - Excellent consistency among 3-day measures of Speed Avg, Acc Avg, and Dec Avg, but only fair for RT Avg
  - High RT Avg SEM makes day-to-day change assessment impractical; possibly due to brief data collection phase
- Lack of strong concurrent validity between measures from different systems does not adversely affect the clinical utility of repeated TRAZER® measures for documentation of change in an individual's performance capabilities

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