Concussion Screening Evaluation: BESS vs SWAY

Zachariah Hatoum1, Aidan Neustadtl2, Jeremy Altman2 Aurash Zarrinbakhsh2, David Milzman, MD

1The George Washington School of Medicine and Health Sciences, 2Georgetown University School of Medicine

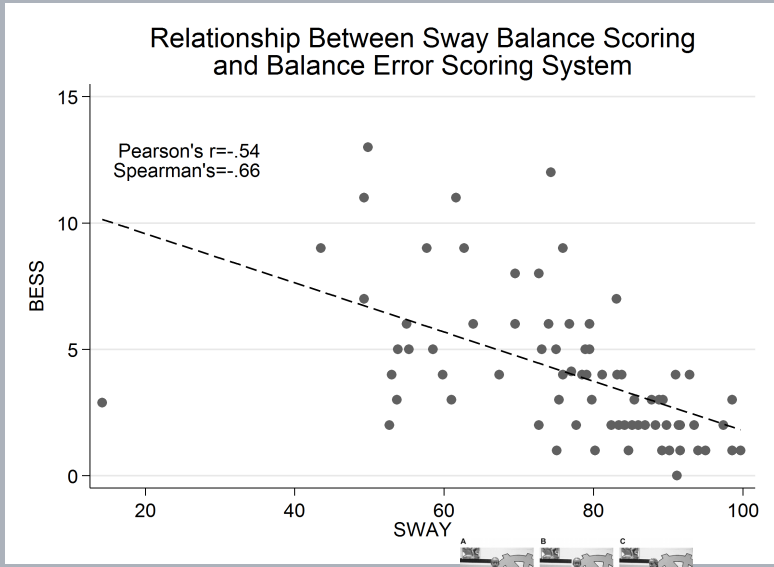
Background

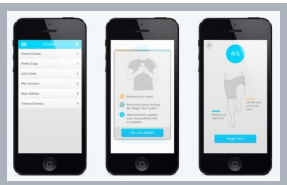
In the pre-hospital setting as well as the Emergency Department, rapid decision on concussion screening and diagnosis is important, as too often concussive injuries go unnoticed and undertreated. Concussive injuries are associated with worsening postural stability. This postural instability compared to baseline is apparent immediately after the concussive injury and persists for up to 5 days (1). The Balance Error Scoring System (BESS) is a commonly used tool by clinicians and researchers to assess postural stability. Previous studies have demonstrated the utility of BESS in serving as a diagnostic tool in concussion evaluation and return to play decisions for athletes (2). SWAY, a new gyroscope based iPhone application, is being proposed as a more sensitive and objective test of postural stability. Our study aims to determine a correlation between Sway and BESS scores, as an initial step in evaluating the utility of SWAY as a substitute to BESS.

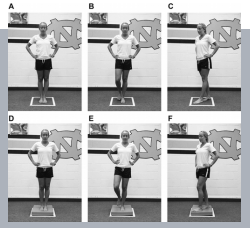
Materials and Methods

The Balance Error Scoring System (BESS), developed by Kevin Guskiewicz and colleagues at UNC is a portable, cost-effective, objective method of assessing postural stability. BESS consists of 3 stances performed on two surfaces. Subjects undergo a double-leg stance, single-leg stance, and tandem stance with heel placed to toe. Subjects were assessed one point for each of the following errors: opening the eyes, stepping, stumbling, or falling, remaining out of the test position for five seconds, moving the hip into more than 30° of hip flexion or abduction, or lifting the forefoot or heel. Increasing points indicate increasing postural instability. SWAY balance test uses a smartphone gyroscope, provides the user with prompts and instructions, and is graded out of 100 points with 100 indicating perfect postural stability. Our subject sample consisted of 74 male highschool and junior-college hockey athletes, with age range of 17-21 years old. Previously excluded from the study were any athletes with recent musculoskeletal or concussive injury. As part of concussion baseline testing, the athletes underwent BESS testing by a trained administrator. Subjects in the study were then tested with SWAY after an appropriate rest period. A correlational analysis was then performed comparing scores from BESS to SWAY.

Results and Data







SWAY is scored on a scale from 0-100 with 100 indicating maximum postural stability. BESS is scored as a tally of the number or errors during test administration, with more errors indicating higher degree of postural instability. Our study found an average BESS score of 4.1 (+/- 2.9) and range of 1-13. SWAY average score was found to be 77.1 (+/-14.2) with range of 49.8- 99.7. In regards to the BESS mean of 4.1, previous studies on BESS normative data for pediatric athletes ages 17-18 have shown mean of 3.34 (+/-2.47) for firm surface totals (3). While our population had overlap with the previous study population, our population was on average older and our mean results fall within this range. Other studies on non-athletes have shown 4-6 is considered in the 76-90th percentile for individuals ages 20-39, indicating a subset of our population falls into the "above average" category based on normative data (4). **In performing a regression analysis between the SWAY and BESS scores, a moderate to strong negative correlation with Pearson's r= -0.54 was seen between the data sets**.

Discussion and Conclusions

In analysis of results, we have demonstrated a moderate to strong negative correlation of r= -0.54 between SWAY scores compared to BESS scores. The negative correlation reflects the difference in scoring as a decreasing BESS score and increasing SWAY score reflect increased postural stability and was expected in our study design. **We conclude that SWAY has moderate utility in serving as a substitute for BESS**. Previous studies have proven the utility of BESS in serving as a diagnostic tool in concussion and return to play decisions for athletes (2). SWAY has promise in being used in scenarios where BESS administration is impractical or a trained BESS scorer is not available such as in athletic sideline or ED testing.

The advantage of SWAY lies in its administration using pre-determined algorithm and standardized gyroscopes leaving little room for human error, making it a more objective measure of balance. Previous studies have indicated that total BESS scores are subject to significant inter-rater reliability (5), bringing its utility into question when administered by those of different levels of training.

Future Directions and Limitations

1) Our study aimed to establish a correlation between SWAY and BESS scores. Further research will be needed to determine effectiveness of SWAY in direct clinical assessment of mTBI and concussion in the ED. This study did not independently asses the validity of SWAY as a clinical tool for concussion.
2) Our subject population was a specific subset and findings may not be generalizable to other populations
3) Revisions in SWAY firmware and hardware may alter future results

References

1. McCrea M, Guskiewicz KM, Marshall SW, Barr W, Randolph C, Cantu RC, Onate JA, Yang J, Kelly JP. Acute Effects and Recovery Time Following Concussion in Collegiate Football PlayersThe NCAA Concussion Study. *JAMA*. 2003;290(19):2556-2563.
2. Riemann, B. L. and K. M. Guskiewicz . *Effects of mild head injury on postural stability as measured through clinical balance testing*. Journal of Athletic Training. 2000
3. Olson,B. *Balance Error Scoring System Normative Values in an Athletic Pediatric*. Canadian Athletic Therapist Association. 2012.
4. G.L. Iverson, M.L. Kaarto, and M.S. Koehle. *Normative Data for Balance Error Scoring System in Adults*. Rehabilitation Research and Practice. 2013.
5. J. Finnoff, DO, V. Peterson ATC, J. Hollman, PhD, J. Smith, MD. *Intrarater and Interrater Reliability of the Balance Error Scoring System (BESS)*. PM&R Journal. 2009.