INVESTIGATING THE RELATIONSHIP BETWEEN BALANCE ASSESSMENT AND CENTRE OF PRESSURE EXCURSION DURING GOLF PUTTING

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The aim of this study was to investigate the relationship between balance assessment and centre of pressure (COP) excursion during golf putting between recreational and novice female golfers. Five novice golfers (age: 28.0±15.8 years) and six recreational golfers (age: 29.0 ± 19.2 years; handicap: 21.4 ± 10.9 strokes) participated in the study. All participants performed the Star Excursion Balance Test (SEBT) and had their COP measured on a force plate while putting a ball towards targets. Significant differences were found between recreational and novice conditions for the COP displacement and velocity excursions ($p<0.05$) but no significant differences were observed in SEBT ($p>0.05$). Models for predictors of the COP excursions were identified mainly in the anteroposterior direction for the first 50% of the time to complete the putting stroke. The results suggest that SEBT may complement balance assessment for coaches in golf putting.

KEYWORDS: Balance, Star Excursion Balance Test, Centre of Pressure, Perception, Golf Putting.

INTRODUCTION: Balance is an important component in golf putting (Chauvel, Orr, & Wulf, 2017). Weight distribution and centre of pressure (COP) excursion are associated with balance (Smith, Roberts, Kong, & Forrester, 2017). Currently, the gold standard for measuring balance requires expensive and not easily portable computerized tests that are time consuming. The Star Excursion Balance Test (SEBT) is an inexpensive, quick method of measuring balance that has good reported reliability (Plisky, Rauh, Kaminski, & Underwood, 2006). Performance on the SEBT may differ between sexes and levels of competition, though the results of previous studies have been inconsistent. The investigation of performance and asymmetry differences between different types of sports is limited. Sex- and sport-specific reference values likely need to be determined to best assess SEBT performance.
Proprioception is one of the most important functions of the human nervous system and strongly influences the maintenance of balance during movement (Poltavski, 2015). Thus far, very few studies are associated with balance tests to improve balance during putting.
Therefore, the aim of this study was to investigate the relationship between SEBT assessments and COP excursions during golf putting. We hypothesized that there would be a high correlation between the SEBT assessment and the COP excursion in all directions.

METHODS: A total of eleven female participants, five novice and six recreational golfers volunteered to take part in the study. The recreational golfers had established handicaps while the novice golfers did not. The average age and handicap of the recreational golfers were 29.0 ± 19.2 years with a 21.4 ± 10.9 handicap. The average age of the novice golfers were 28±15.8 years. All eleven golfers were right handed and were free of injury at the time of testing. Ethical clearance was obtained from Republic Polytechnic Internal Ethics Review Board of Republic Polytechnic and written informed consent was obtained from all the participants.
The participants had to perform a balance test on the Star Excursion Balance Test (SEBT) equipment (see Hatton et al., 2015) in all the eight directions namely: anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral for both the right and left limbs. Additionally, they had to stand on a Kistler forceplate (Kistler, 9281CA) during the putting performance. The force plate's orthogonal axes were associated with the ground plane are defined as the Medial/Lateral (ML) and Anterior/Posterior (AP) axes. Each golfer faced the anterior direction with both feet within the force plate to putt the golf ball ten times

towards the target hole placed 3m away. The participants had 30 s rest in between the attempts.
The parameters used for analyses were the mass, age, height, COP excursion displacement and velocity in the anterior/posterior and medial/lateral directions, SEBT's normalised excursion (based on limb length) in the anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral directions. The standard deviations (SDs) of the COP kinematics were computed in quarters associated with the normalised putting time.
We tested the difference between novice and recreational participants in all parameters using a t-test ($\alpha = 0.05$). Pearson product moment correlations (Dixon et al., 2014) were used to test the relationship between balance and COP excursions. Stepwise regression analysis was used to determine a regression model predicting balance excursion from the COP excursions.

RESULTS: We found differences between the novice and recreational golfers for the displacement and velocity excursion of the COP and between the SEBT excursions ($p < 0.05$). For the Pearson product moment correlations, we found moderate correlations (i.e. $0.63 < r < 0.77$) associated with the lateral SEBT and the AP and ML excursion of the COP. Figure 1 illustrates the standard deviations of the displacement and velocity of the COP.

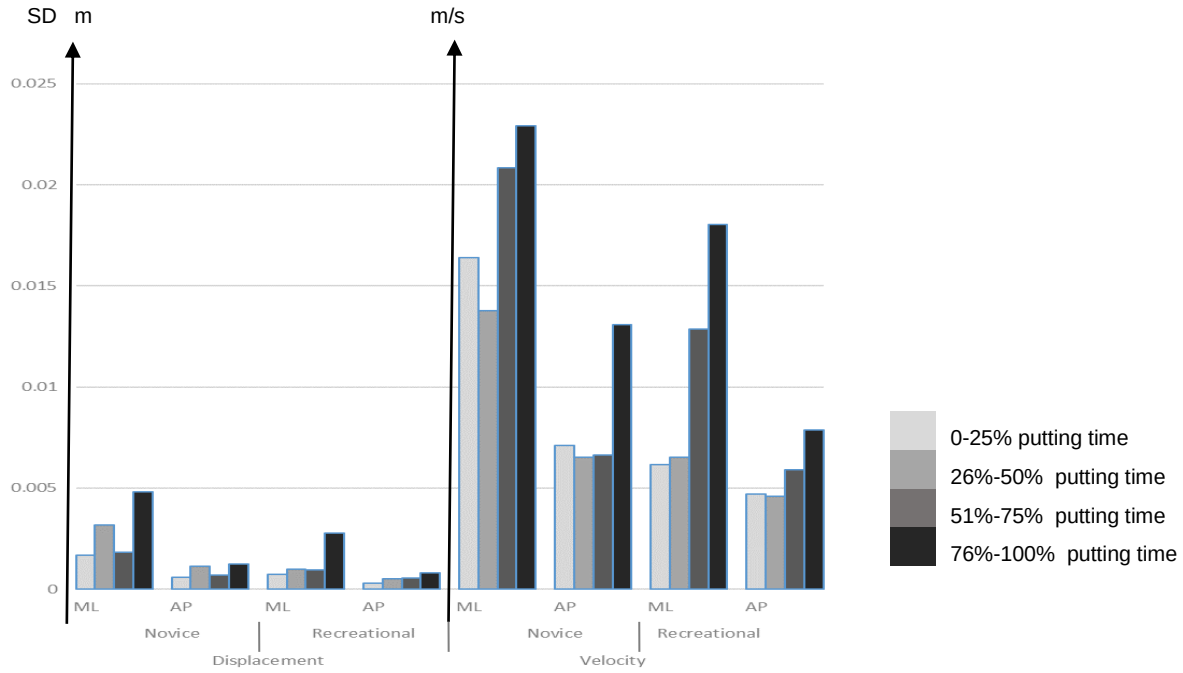

Figure 1. Standard Deviation (SD) of AP/ML COP displacements and velocities within the 0-25%, 26%-50%, 51%-75% and 76%-100% putting time intervals for novice and recreational group.

Table 1 presents the most parsimonious regression equations predicting the COP excursions during each quarter of the putting stroke time from the SEBT excursions. The R^2 values (i.e. the variance explained) for these equations ranged from 0.33 to 0.99.

Table 1. Multiple regression results for the quarter SDs and predictors from the SEBT assessments in the Anterior (A, RA), anteromedial, medial (AM, RMA), posteromedial (PM, RPM), posterior (P, RP), posterolateral (PL, RPL), lateral (L, RL) and anterolateral (AL, RAL) directions for the left and right limbs respectively.

SDs	Equation	R^2	SEE
$SD25_{ML}$	$7.814x10^{-5}$ L - $6.010x10^{-3}$	0.595	$7.678x10^{-4}$
$SD50_{ML}$	$1.163x\ 10^{-4}$L -$8.003x10^{-3}$	0.331	$1.698x10^{-3}$
$SD50_{AP}$	$8.646x10^{-5}$ L - $6.902x10^{-5}$ AM - $3.6x10^{-5}$ PL + $1.223x10^{-5}$ PM + $1.001x10^{-2}$	0.996	$5.9x10^{-5}$
$SD75_{AP}$	$2.012x10^{-5}$ L - $1.094x10^{-3}$	0.482	$2.477x10^{-4}$
$SD25V_{ML}$	$4.522x10^{-4}$ L - $2.801x10^{-2}$	0.406	$6.505x10^{-3}$
$SD25V_{AP}$	0.5001xAge - $4.422x10^{-6}$ Mass + $1.583x10^{-4}$ A - $1.345x10^{-4}$ M +$2.264x10^{-4}$ L - $1.368x10^{-4}$ AL - $1.461x10^{-4}$ RAM + $3.398x10^{-5}$ RM - $1.483x10^{-4}$ RPM - $1.144x10^{-4}$ RAL + $2.292x10^{-2}$	0.999	$1.232x10^{-6}$
$SD50V_{AP}$	$1.012x10^{-3}$Age - $5.011x10^{-6}$ Mass + $9.038x10^{-5}$ A - $3.461x10^{-4}$ M + $7.109x10^{-5}$ L -$2.951x10^{-4}$ AL + $3.500x10^{-5}$ RAM + $1.243x10^{-4}$ RM + $6.001x10^{-5}$ RPM + $4.113x10^{-5}$RAL + $1.591x10^{-2}$	0.999	$3.123x10^{-6}$

SEE: standard error of the estimate. $SD25_{ML}$/$SD50_{ML}$: medial/lateral displacement SD during 0-25% and 26%-50% putting time; $SD50_{AP}$/$SD75_{AP}$: anterior/posterior displacement SD during 26%-50% and 51%-75% putting time; $SD25V_{ML}$: medial/lateral velocity SD during 0-25% putting time; $SD25V_{AP}$/$SD50V_{AP}$: anterior/posterior velocity SD during 0-25% and 26%-50% putting time respectively.

DISCUSSION: The purpose of this study was to investigate the relationship between balance assessment and COP excursions in golf putting. In this study, differences have been observed between recreational and novice groups. This is similar to other studies where low handicap golfers demonstrated lower COP excursions along the anteroposterior axis in comparison to high handicap golfers (Richardson, 2016).

The results suggest that anterior/posterior COP excursions can be predicted by components of the SEBT assessments. Models with R^2>0.3 occurred mostly in the 0-50% swing time where the highest R^2 value was close to 1.0 for predicting COP anteroposterior velocities for 0-25% and 26%-50% putting time and displacement for 26%-50% putting time.

CONCLUSION: The study suggests that SEBT assessment can be associated with COP excursions particularly in the sagittal plane during the early phases of the putting stroke. This potentially facilitates the coaching team in the evaluation of balance during putting and potentially can improve putting results in novice and lower handicap golfers.

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