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BACKSWING LENGTH AND SWING PATH TENDENCIES FROM AMATEUR GOLFERS

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The purpose of this study was to identify if shorter backswings off the tee influence the 'outside-in' ball impact (i.e. tendency to slice, fade or pull). Participants motion data were obtained on a reduced-size driving range, using a SmartSwing driver club (3D data sampling at 1000 Hz). Findings from a representative sample of the amateur golfers' population (N=13, 531 swings) indicate a pattern where a shorter backswing reduced the tendency for 'outside-in' (-17.8%) while increasing 'parallel' (+6.9%) and 'inside-out' ball impacts by (+10.8%). For golfers who suffer from repetitive overuse or ageing-related reduced range movement or back pain, shortening the backswing is a viable option when considering safety and risk of injury. The findings can help golf swing coaching, as well as competitive/strategic and recreational aspects of self-management.

KEYWORDS: augmented coaching, swing technique, X-factor, back pain, inertial sensors.

INTRODUCTION: In golf, a shortened swing (or abbreviated backswing with pendulum motion follow-through) is a common part of the *short game*.[1] Selecting a shortened swing is common for *approach shots* to the *green* and is dictated by a ball position where a golfer has to overcome natural or man-made obstacles e.g. trees, water hazards, and sand bunkers. In contrast, when attempting to generate swing power and gain distance, from of the *tee* position, amateur players sometimes over rotate or overextend their regular backswing at the top of the swing. Contemporary research shows that overextending stretch-shortening cycle (SSC) and over rotating and maximising *X-factor* (a degree of separation between shoulders and hips rotation) are linked to inconsistencies and injuries (Walker, Uribe, & Porter, 2019). For example, during introductory golf lessons or when coaching those experiencing discomforts associated with back or shoulder pain, immediate feedback aiming to achieve full backswing (parallel to the target line at the top of the swing) should not be a priority. Regarding the qualitative nature of coaching, it is known that feedback on knowledge of performance (KP) can have a greater impact on the outcome of the movement produced than just knowledge of results (KR) as discovered by Hatze (1976) and elaborated further in broader multidisciplinary contexts by Knudson (2013). The importance of KP could help us understand why coaches prefer to work on swing technique while learners tend to prefer to focus on improving the outcome i.e. to 'improve the distance' by 'hitting harder' or exaggerating their typical range of motion (ROM). The relationship between over-rotated backswing (as the club position at top of the swing across the intended target line) and the natural tendency to *slice, fade* or *pull* is not well investigated yet, hence the focus of this paper is to report a selection of safety and performance implications associated with the length of the backswing from data collected from a representative group of amateur golfers, who attended golf lessons.

The study presented here was based on two prior studies sharing data-driven insights: (1) the use of AI to produce computer models that can predict golf ball trajectories from a swing plane, and (2) discovery of natural tendency to slice, fade or pull (Bačić 2014; Bačić 2016). As in the past two studies, swing parameters were obtained by developing a datamining software tool that could process extracted text feedback from the SmartSwing system (www.smartswinggolf.com), extract measured parameters it into '`name=value`' pairs and store

[1] For reading convenience, first occurrence of golf-specific terminology is *italicised*.

numeric data into a CSV tabular format. The purpose of this study was to identify if shorter backswings off the tee influence the 'outside-in' ball impact (i.e. tendency to slice, fade or pull).

METHODS: Golf swing data collection was conducted on a reduced-size driving range, which prevents golfers from seeing KR i.e. the full ball trajectory representing the outcome of a swing movement. The recorded golf swing data used to provide KP feedback include two video sources (front and rear sagittal views) combined with biomechanical swing parameters (Bačić, 2016) obtained from a standard size and shaft flex driver equipped with the SmartSwing inertial sensor (3D sampling at 1000 Hz). The approval from AUT University's Ethics Committee (AUTEC No. 06/105) was obtained prior to data collection. The participants (N=13) were a of diverse age groups of amateur golfers (17 – 55+ years). All participants have received analytical feedback related to KP only, which did not include X-factor or how to extend or over rotate top of their backswing beyond the target line (Table 1). All participants developed their backswing during their regular practice between golf sessions.

Table 1: Golf lessons plan with suppressed knowledge of results (Bačić, 2014).

Lesson	Introduced concept and focus	Remarks
1.	Introduction lesson: Grip, ball addressing and stance basics information. Basic swing information.	Information pre-session included general and local driving range routine information, biometrics measurement for club initialisation Making sense of basic technique.
2.	Stance focus: Posture and ball addressing. Hand and arms 'softness feel' Back swing (right knee and coil resistance) information.	Upper body and knees corrections, technique corrections. Importance of activating large muscles (consistency) over small muscles (variability).
3.	Basic swing motion and dynamic posture stability: Focus on 'steady knees', hips, trunk and head.	Introduced wrist release, length of the swing, head, upper body, and knees corrections. Achieving a 'comfort zone'.
4.	Ball impact and swing features.	Introduced concept of swing parameters related to ball flight.

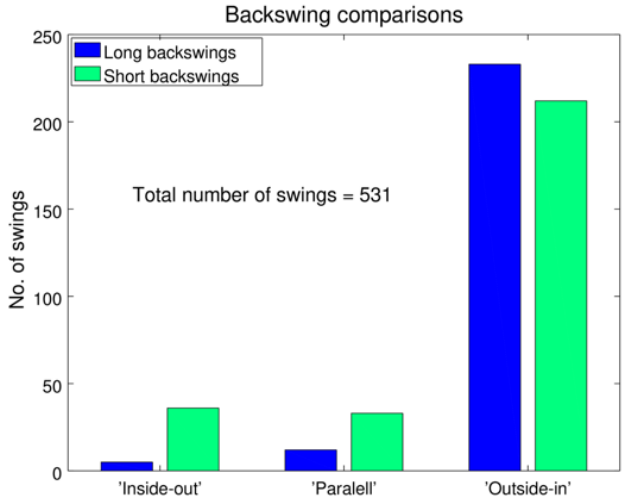
RESULTS: Data analysis (Table 2 and Figure 1) shows that golfers with a longer backswing (LB) extending across the target line at the top of their swing, had a greater tendency to produce 'outside-in" swing path. Results clearly show that, 'outside in' was the most frequent (over 93%) compared to the other two categories of impact (Table 2) when executing a long backswing (LB).

Table 2: Collected dataset separated into longer and shorter backswing.

Criteria and categories	'Inside-out' ≤ 2° Percentage (count)	'Parallel' Percentage (count)	'Outside In' ≥2.1° Percentage (count)	Total (count)
Dataset swing count	7.72% (41)	8.47% (45)	83.80% (445)	(531)
LB > parallel to target line	2.00% (5)	4.80% (12)	93.20% (233)	(250)
SB < parallel to target line	12.81% (36)	11.74% (33)	75.44% (212)	(281)
Δ (SB – LB)	**10.81%**	**6.94%**	**-17.76%**	

Note: LB … Longer backswing; SB … Shorter backswing. Criteria and categories are defined by the SmartSwing system. No 'ideal' backswings, parallel to the target line were found in the collected dataset.

For participants executing shorter backswings, the distribution of ball impacts changed, with significantly more 'inside-out' (leading to draw, push or hook) and 'parallel' (i.e. straight) shots performed. Table 1 shows an increase of 10.81% of 'inside-out' and 6.91% more 'parallel' ball impacts with shorter backswings (SB) compared to when hitting with longer backswings (LB). The dominance of outside-in ball impacts is significantly reduced by 17.76% when a shorter backswing was employed. Increased standard deviations for shorter backswings (Figure 1), provides evidence of coaching practice focused on naturally developing backswing towards the top of the swing parallel to the target line.



Standard deviations:

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'Outside in' ball impact:
  Short backswing = 17.955
  Long backswing  = 14.259

'Parallel' ball impact:
  Short backswing = 25.860
  Long backswing  = 13.503

'Inside-out' ball impact:
  Short backswing = 22.769
  Long backswing  =   9.198
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Figure 1: Comparisons of backswing lengths with natural tendency for swing path at impact.

DISCUSSION:

During the course of the data collection coaching sessions, participants receiving KP-related information and feedback were developing and adjusting the length of their backswing; while they were unable to see the produced ball distance as KR. Findings from data are aligned with published coaching views (Proudman & Ward, 2018; Ward & Proudman, 2017) and in agreement with a study that investigated expert-level shots variability and ball placements at PGA tournaments, including the short game (Stöckl & Lamb, 2018). One of the limitations of this preliminary study was that the findings reflect a snapshot in time based on accumulated data from a relatively small number of participants with different learning progress, backgrounds and abilities. However, this study is not intended to promote exclusively short or long backswings but to draw attention to possible performance and safety implications (e.g. injury, instability and inconsistency) for golf coaches and players including those who may experience reduced spine mobility, shoulder or back pain. We support the view, that as we progress through skill level, swing technique becomes more individual. Therefore, it is possible that one group of golfers would benefit from slightly reduced backswing producing more straight shots, while for others it may increase variability of ball placement. When changing technique or style, we expect that there will be a temporary loss of distance and consistency regardless whether a golfer is learning a short or long backing before drawing conclusions on how this new swing style works or whether fine adjustments of the regular swing technique are beneficial.

The authors' swing-agnostic view is to encourage golfers to try (at a full-length driving range): (1) fine adjustments to their usual backswing technique to improve consistency including ball flights video logging to provide evidence that can be used for personalised analysis, aligned with this study; (2) to base their individual swing style on solid scientific foundations and what 'feels right' for the body rather than just mimicking their ideal golf pro's swing technique; and (3) learning abbreviated swing style with technique adaptation including different *tempo* e.g. (Ingham, 2015) with the purpose of adding another shot to their skill set. Learning an abbreviated swing might be useful in the future or when experiencing back pain, or the ball is in a difficult, fairway positioning. For competing preparations, intermediate and advanced golfers can determine new swing distances for each club and include the '*club up*' practice combined with a shorter backswing.

In contrast, for players aiming to increase their shoulder turn, from a biomechanical perspective, our advice is that instead of bilateral hand balance or right arm and shoulder puling during the back swing (for right-handed player), they should try more left arm pushing and examine the difference using video replay analysis, or a golf club sensor.

One of the purposes of sport technology is to report biomechanical parameters associated with activity or sport-specific movements. Therefore, the end users are informed with various

statistics associated with KP and KR should also gain biomechanical knowledge relevant to an activity or sport-specific parameters. However, sport technology without adequate coaching knowledge, parameters such as velocity and range of movements may lead to open interpretations that can be broad and not necessarily resulting in improved sport-specific technique. On the other hand, it is possible for end users of golf club sensors to collect swings' statistics to establish whether they have less tendency to slice and subsequently apply this knowledge to increase the percentage of straight shots by implementing minor adjustments of their personalised backswing. As an alternative to the use of sensors attached to a golf club, a low-cost data collection solution is using a mobile or other camera at the driving range while fine tuning the backswing. Video analysis of the recorded swings would allow to keep track of typical distance lost, variability and golf ball trajectory for each club (e.g. by using a mobile app for swing analysis or a similar augmented video coaching solution).

CONCLUSION: For the representative sample of amateur golfers' population in this study, one of the causes for the 'outside-in' impact (tendency to slice, fade or pull) for tee-off golf swings (93.20%) is linked to over-rotated extended backswings. Furthermore, shorter swings distribution pattern indicates decrease the 'outside-in' tendency by 17.76% while increasing a percentage of straight shots by 6.94% and 'inside-out' impact (tendency to hook, draw or push trajectories) by 10.81%. In expert-skill level context, a study based on ball placement in PGA competitions (Stöckl & Lamb, 2018), has also found the increased variations in the tee shots and in the short game (approach to the green). Adopting a short swing style may be beneficial for those golf players prone to back pain or experiencing a reduced range of motion and may offer a solution to reducing the risk of injuries. Whether it is a case of fine adjustments of the individual backswing or learning a new style of swing (with a different tempo), it can be a worthwhile commitment to self-management when returning to the game from injury or playing competitively (e.g. Stableford scoring format in social events), where using the 'club up' combined with a shorter backswing may help to regain confidence and get into the zone.
Future work will include additional performance and safety parameters and investigate transferability of the presented findings to other sport disciplines and sport equipment.

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