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10	"To Hit, or Not to Hit?" Examining the Similarity between Practice and Real Swings in
11	Golf
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## Abstract

30	Practice swings are commonly employed among golfers, presumably based on the tacit
31	assumption that they share common psychomotor processes with real swings; however, this
32	has not been verified by empirical research. Therefore, this study aimed to examine whether
33	practice swings shared equivalent levels of control to real golf swings, when attempting the
34	same target behavior. Three PGA Professional golf coaches and six amateurs (mean
35	handicap = $2.7$ , SD = $2.2$ ) each executed 20 swings under two quasirandom conditions; 10
36	real swings when striking a ball and 10 practice swings without. Underpinned by the
37	theoretical suggestions of the UnControlled Manifold (UCM) approach (Scholz & Schöner,
38	1999), motor control was assessed using intraindividual movement variability. Results
39	showed the level of equivalence to be inconsistent on both an inter and intraindividual basis.
40	Coaches should, therefore, recognize that practice swings do not share the same effect for
41	every golfer. Optimal coaching needs to consider individual responses before committing to
42	specific training designs if counterproductive training is to be avoided.
43	Keywords: Coaching practice, movement variability, focus of attention, motor control,
44	individual differences, imagery.
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55 "To Hit, or Not to Hit?" Examining the Similarity between Practice and Real Swings in Golf For coaches seeking to optimize the practice design of their pupils, many different 56 factors need to be addressed. From a psychomotor perspective, previous research has shown 57 58 how differences in the sequencing (blocked vs. random) and temporal distribution (massed vs. distributed) of practice (Goode & Magill, 1986; Lee & Genovese, 1988), feedback 59 provision (Lee & Carnahan, 1990), and model characteristics conveyed within a 60 demonstration (Ste-Marie et al., 2012), can be controlled by coaches to enhance performance 61 and the *acquisition* of motor skills over either short- or long-term timescales (Schmidt & 62 Bjork, 1992). Underpinning these coaching practices, or "tools," is the influence on 63 performers' attentional control, which serves a critical role in the organization and efficiency 64 of technique execution (Eysenck, Derakshan, Santos, & Calvo, 2007). With this knowledge, 65 66 coaches should be able to apply these tools when implementing, for instance, systems of skill acquisition (Fitts & Posner, 1967) or refinement (Carson & Collins, 2011); which are 67 theoretically underpinned by the dynamic nature of attention. Crucially, therefore, not only 68 69 must coaches be able to select appropriate tools at certain times within these systems, they must also be able to evaluate the resultant effect on performers' levels of attention and motor 70 control. Unfortunately, this process is rarely "black and white" when designing individually-71 tailored practices; due to even subtle individual differences, one size does not always fit all 72 73 (cf. MacPherson, Collins, Graham-Smith, & Turner, 2013; Newell, Liu, & Mayer-Kress, 74 2005). If, however, the effects of coaching tools were evaluated on an individual-basis and data provided pertained to psychomotor processes, coaches would be better able to plan, 75 implement, reinforce, and/or modify their interventions for optimal effectiveness. 76 77 Despite this recognized requirement for individualized practice design, there is one

79 the practice swing, an overt physical simulation of an often impending movement: a full

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tool which appears as almost ubiquitously employed by coaches and their golfers; namely,

power swing without a ball. Within the literature, practice swings have been reported
amongst golfers when performing a warm up (Fradkin, Finch, & Sherman, 2001), attempting
to make technical refinements (Carson, 2014), and as part of a preperformance routine
intended to optimize skill execution (Cotterill, Sanders, & Collins, 2010). Within
professional coach education, practice swings have explicitly been promoted; as
demonstrated by the following extract from a coaching manual of The Professional Golfers'
Association of Great Britain and Ireland:

When you consider that a golf swing lasts less than 2 seconds, hitting 100 balls with
this method [blocked practice] constitutes less than 3mins 40's worth of actual
practice. With this in mind it is a good idea to carry out blocked practice without a
ball as well as with a ball. Carrying out practice swings is as effective as hitting golf
balls when using blocked practice. (PGA, 2008, p. 61)

In consideration of this common behavior, there is a tacit assumption that it shares common psychomotor processes as a real swing, otherwise why do it? Unfortunately, however, there is no scientific literature, to the best of our knowledge, which specifically addresses the similarity between these two versions of execution. Accordingly, the implementation of practice swings must be confirmed as equivalent by empirical investigation if consistency of a particular technique is the task goal (i.e., practice intended for a positive perturbation).

Assessing the equivalence between practice and real golf swings can be undertaken on a number of different levels of system (i.e., performer) organization (cf. Newell, Liu, & Mayer-Kress, 2001). Since this paper concerns the level of motor control, measures should relate to the processes through which execution depends; what Newell et al. term "microphenomena" (p. 63). Reflecting recent advances from dynamical systems theory, intertrial movement covariability has been shown to reveal the functional role of mechanical degrees of freedom (DoFs) which contribute to the control of technique. Scholz and Schöner

105 (1999) proposed the UCM concept, that an abundance of DoFs within the motor system results in some being controlled (stable) and others uncontrolled (flexible; cf. Bernstein, 106 1967). Stable DoFs are identified by low levels of intertrial variability, whereas flexible 107 108 DoFs demonstrate much high levels; crucially, however, the low level variability variables seem to be those most crucial to effective executions of the target task. By employing this 109 method, Scholz and Schöner demonstrated that the center of mass position in the sagittal 110 plane was more stable when compared to either hand or head position when executing a sit-111 to-stand task. Consequently, this approach is able to attribute a level of importance given to 112 113 individual technical components by the central nervous system towards achieving a desired task goal. The combination of stable and flexible components ensures reproduction of 114 movement form (characterized by stable DoFs) while accommodating for unplanned 115 116 perturbations imposed during execution (involving the flexible DoFs). Accordingly, once a skill is learned, intertrial movement variability should "settle down" to a consistent and 117 functional, although individually-specific, level across the different DoFs and be maintained 118 from session-to-session, with more "important" factors displaying lower levels of variability. 119 As a novel extension of the UCM approach, Carson, Collins, and Richards (2014) 120 suggested that the same nonlinear pattern of movement covariability could result from the 121 manipulation of performers' attentional focus. This would, therefore, provide an informative 122 measure of dynamic attentional control during the process of skill refinement (cf. Carson & 123 Collins, 2011). Specifically, it was hypothesized that when a ". . . performer decides to work 124 on a particular aspect of that movement by exerting increased conscious control, that 125 particular part becomes more consistent (with even lower variability) whilst the variability of 126 other nonassociated parts increases" (p. 330). Supporting this hypothesis, data were 127 presented to demonstrate this effect when PGA Professional Golf Coaches made conscious 128 short-term refinements to their techniques within a single session. Interpreting these findings 129

against the theoretical percepts of the UCM approach, increased conscious control over a
single DoF serves to increase its relative importance and lessen that of other technical
components. In summary, the studies by Scholz and Schöner (1999) and Carson et al. (2014)
reveal intertrial movement variability to reflect the functional organization of motor control,
but which is also related to both conscious and subconscious cognitive processes.

Crucially, application of this concept under differing task constraints (Newell, 1986) 135 could be employed as a coaching tool to augment a coach's understanding of, and ability to 136 evaluate, different methods of practice. Accordingly, practices designed to elicit equivalent 137 138 psychomotor processes should reveal the same measure of intertrial movement variability across mechanical DoFs; for instance, when performing practice and real golf swings. 139 Indeed, such checks would seem essential if counterproductive (dysfunctional perturbation) 140 141 training methods are to be avoided. Therefore, the aim of this study was to examine whether practice swings shared equivalent levels of control to real golf swings, when attempting the 142 same target behavior. To reduce the chance of between condition differences, executions 143 were performed by skilled golfers with already well-established techniques. We should stress 144 that some level of variability within each condition is acceptable, perhaps even functional, 145 but that excessive variability is clearly dysfunctional (cf. Gentile, 1972). 146

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#### Method

148 **Participants** 

149 Reflecting the need for advanced skill status, participant eligibility required no current 150 injury (assessed through self-report) and a handicap of less than five. Accordingly, nine 151 right-handed male golfers (A–I) between the ages of 17 and 44 years (M = 26.1, SD = 8) were 152 recruited for this study. Playing ability included PGA Professional Golf Coaches (n = 3; no 153 handicap however all held a maximum handicap of 4 upon turning professional) and amateur 154 golfers (n = 6; mean average handicap = 2.7, SD = 2.2).

#### 155 **Procedure**

Preceding data collection, participants were required to read an information sheet and provide signed informed consent. Ethical approval was granted from the University's Ethics Committee prior to data collection. Participants were randomly assigned the order of conditions; execution by striking a ball, the "ball condition", followed by practice swings, the "practice swing condition", or vice versa.

To minimise the potential for any warm up effect, participants were allocated as much time as required to warm up. Accordingly, the warm up period ceased when each participant conveyed verbally that they were ready to commence with the testing. Warm ups were typified by the use of self-conducted stretching exercises, practice swings, and shots using participants' own 7-iron and legally conforming golf balls. A 7-iron was selected for use during this study because it is a commonly used club during play and practice conditions; consequently, it would likely represent a skill that was well-established.

Participants' body dimensions were measured, including; body height, arm span 168 (distal end of the right hand's middle finger to the distal end of the left hand's middle finger 169 when adopting a "T" pose), hip height (ground to the most lateral bony prominence of the 170 greater trochanter) and width (right to left anterior superior iliac spine), and shoulder width 171 (right to left distal tip of acromion). Following, participants were fitted with an inertial-172 sensor motion capture suit (MVN Biomech Suit, Xsens<sup>®</sup> Technologies B.V., The 173 174 Netherlands). Sensors were affixed to segment landmarks on the pelvis (flat on the sacrum), shoulders (scapulae), and sternum (proximal end) using Velcro strapping, the hands using 175 fitted gloves (above the metacarpals), and the head using a head band (superior and posterior 176 to the right ear) in accordance with the manufacturer's guidelines. Following, a second warm 177 up phase provided familiarity and comfort in wearing the suit, and allow any necessary 178 adjustments to the strapping to be made. The motion capture suit was then calibrated to 179

determine joint centers of each participant, incorporating the earlier measured body 180 dimensions. This was performed by employing a "neutral" static, followed by dynamic hand-181 touch calibration process whereby, the sensor to segment alignment and segment lengths are 182 estimated by solving the closed kinematic chain for each pose. In addition, a single trial was 183 captured when adopting the anatomical position to allow an anatomical model to be created. 184 Depending on the randomly assigned test condition order, participants executed 10 full 185 swings using their own 7-iron in either the ball or practice swing condition; followed by 186 another 10 swings to satisfy the alternative condition. To increase levels of adherence 187 188 towards executing the same target behavior, participants were reminded following Trials 3, 6, and 9 of each condition to try and achieve a typical technique and distance that they would 189 normally perform during play. Given the likelihood of each participant's target behavior 190 191 being idiosyncratic; it was inappropriate to provide a specific technical or mental instruction which would, of course, have a differential level of impact. As such, in order to assess any 192 mentally induced differences in movement variability for the same target behavior, it was 193 important to allow a natural and individually preferred response to the task. Executions were 194 conducted from an artificial golf mat into an indoor net 15 m away, aiming for the same 195 target each time—a vertical line running the entire height of the net. Maintaining a consistent 196 hitting surface provided an enhanced level of experimental control. All kinematic data were 197 collected using a sampling rate of 120 Hz. 198

### 199 Data Processing and Analysis

Raw data from the MVN Studio software (Xsens<sup>®</sup> Technologies B.V., The
Netherlands) were exported into c3d file format and analyzed with Visual3D<sup>™</sup> v4.89.0
software (C-Motion<sup>®</sup> Inc., Germantown, MD, USA) using six DoFs modeling. Three events
were automatically identified and used to divide the swing into two phases, the backswing
and downswing. The first event, "swing onset," was defined as the frame when the left

205 hand's center of gravity linear velocity crossed a threshold value of 0.2 m/s in the local medial-lateral axis relative to the pelvis. The second event, "top of swing," was defined as 206 the frame when the right hand distal end position reached its maximum value in the global 207 vertical axis prior to the third event occurring. The third event, "bottom of swing," was 208 defined as the frame when the distal end position of the right hand reached its minimum 209 position in the global vertical axis. Accordingly, bottom of swing represented the "end 210 event"; no data were included for the remainder of the swing. Following, the time between 211 each event was normalized to 101 points. 212

213 In consideration of the study's aim, an analysis of every kinematic variable was not possible. As such, the left hand position was referenced to the local co-ordinate system of the 214 215 sternum in three-dimensions (3D) as a representative variable. This variable was selected 216 because it was believed to provide a good reflection of the swing principle width of arc, which is defined by professional golf coaching texts in terms of the relationship between the 217 lead (left in right handed golfers) hand and center of golf swing rotation. According to 218 Nesbit and McGinnis (2009), the radius path of the hand during the swing influences the 219 kinetic loading on the golfer and therefore the transfer of kinetic energy to the club. 220 Optimizing the hand path was thus shown to demonstrate increases in club head velocity; a 221 factor which is primarily associated with increased shot distance (Sweeney, Mills, Alderson, 222 & Elliott, 2013). Figure 1 represents the width of arc using a two-dimensional (2D) image in 223 224 the global coronal plane—the referenced standard for golf coaching practice. Accordingly, in this study, the medial-lateral, anterior-posterior, and superior-inferior hand position relative 225 to the sternum were exported to Microsoft Excel<sup>®</sup> 2010 and standard deviations for all 101 226 227 points between each event during the two conditions were plotted for each participant (cf. Carson et al., 2014). 228

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#### Results

230 Data are shown in Figures 2, 3, and 4 which represent the intertrial movement variability of the medial-lateral, anterior-posterior, and superior-inferior position of the left 231 hand to sternum position for participants across the two different conditions. Visual 232 inspection of these graphs reveal the highly individual-nature of effect between the ball and 233 practice swing conditions; executing practice swings did not have the same influence on all 234 participants. Therefore, findings pertaining to the level of equivalence between conditions on 235 an intraindividual basis are reported below. Note however, that the themes within the 236 findings are also applicable as interindividual comparisons. For clarity and to highlight 237 238 specific aspects of the analyses, exemplar participant graphs are referred to throughout, with individual qualitative summaries provided in Table 1. 239

Results reveal a number of findings with regards to the equivalence between 240 241 conditions; clearly data are highly complex. Firstly, data show temporal inconsistencies within the swing for many participants. For instance, Participant F (Figure 2) demonstrates 242 three moments during the swing where variability levels are noticeably separated: at the 243 swing onset, 50% during the backswing, and 90% during the downswing. Participant E 244 (Figure 3) shows a consistent discrepancy for most of the swing up until 70% during the 245 downswing. Whereas, Participant D (Figure 4) shows greater equivalence for the downswing 246 compared to the backswing. 247

In addition, individuals showed differences in the level of equivalence between the planes of motion. As exemplified by Participant G, showing what we would consider to be a consistent and reasonably good level of equivalence for the majority of the swing in the medial–lateral (Figure 2) and anterior–posterior (Figure 3) planes of motion; however, this is less well-reflected in the superior–inferior (Figure 4) plane. Likewise, Participant A shows a similar effect across the same planes of motion. For Participant E, data in the medial–lateral

(Figure 2) and superior-inferior (Figure 4) planes of motion show a largely equivalent 254 amount of variability, which is not shared by the anterior-posterior (Figure 3) plane data. 255 Finally, the disparity of variability between the two conditions was not always 256 consistent in its "direction" across the planes of motion. That is, sometimes the practice 257 swing condition demonstrated a higher level of variability compared to the ball condition. 258 For example, Participant I shows a consistently increased level of variability for the ball 259 condition in the medial-lateral (Figure 2) and superior-inferior (Figure 4) planes of motion, 260 but the opposite effect in the anterior-posterior (Figure 3) plane. Whereas, Participants D 261 262 and H showed a predominantly increased amount of variability in the ball condition compared to the practice swing condition in all three planes of motion. 263

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### Discussion

265 The aim of this study was to examine whether practice swings shared equivalent levels of control to real golf swings, when attempting the same target behavior. The overall 266 result showing differences in effect between participants is perhaps unsurprising, since 267 interventions are dependent on each performer's "dynamic state" (Newell et al., 2005, p. 46): 268 a reference to the developed control processes underpinning the skill of each performer. 269 From an applied perspective, the important implication for coaches, at least when working 270 with low handicap golfers, is that employing practice swings will not impact on every golfer 271 in the same way. Data from this study reveal the subtle interparticipant differences that exist 272 273 between the two conditions; the answer to knowing whether or not to employ practice swings is certainly not black or white. Indeed, this finding supports several other intraindividual 274 analyses in sport which have questioned the veracity of "received wisdom" when coaching 275 high-level athletes. For example, MacPherson et al. (2013) demonstrated four out of six 276 elite-level horizontal jumpers to perform their upper quartile performances when the pattern 277 of footfall variation was consistently lower for 15 strides prior to contact with the takeoff 278

279 board, when compared to the lower quartile performance which were much higher in variability across the 15 strides. This is in contrast to received wisdom suggesting that 280 variability should reduce from only five strides prior to takeoff (cf. Lee, Lishman, & 281 282 Thomson, 1982). Likewise, in archery and many target-oriented sports, it is commonly assumed that heart rate deceleration immediately prior to arrow release is predictive of 283 optimal performance (Tremayne & Barry, 2001). However, on inspection of individual data 284 from elite-level archers, this pattern was not apparent across all (Collins, 2002). 285 Consequently, at present, we suggest caution towards the ubiquitous employment of practice 286 287 swings if the aim is to enhance subsequent execution and avoid a negative transfer effect where, for some golfers, the latter would seem to be a genuine possibility. Therefore, optimal 288 coaching practice should be viewed as that which attends to the response of each performer 289 290 on an individual-basis, prior to committing to specific training designs.

From the perspective of the UCM approach (cf. Scholz and Schöner, 1999), the 291 variability graphs (Figures 2–4) imply that movement was differentially organized both 292 293 between and within the two conditions; the central nervous system dynamically altered the amount of importance allocated to each of the DoFs. Furthermore, reflecting the findings of 294 Carson et al. (2014), differences between conditions could have resulted from inconsistent 295 patterns of cognition. We present no data in this paper to demonstrate such a cause; however, 296 our initial speculation is that this might have been an underlying and influential factor to 297 298 explaining the results. On the basis that Carson et al. showed a consistent change in the amount of movement variability under contrasting conditions of attentional focus, such 299 speculation should be considered as supported by reasoned evidence. 300

If practice swing effectiveness as a preperformance prime is dependent on a
 performer's cognitions, it is worth addressing possible tools that might help "equip"
 performers to optimize their practice design. Previous applied and theoretical research has

304 strongly supported the beneficial employment of multimodal imagery as a tool for accurately activating neural networks involved in movement execution (e.g., Collins, Morriss, & 305 Trower, 1999; Holmes & Collins, 2001; MacPherson, Collins, & Obhi, 2009); what cognitive 306 psychologists would refer to as memory *retrieval*. As such, those participants who were 307 better able to execute under both conditions by attending to the same sensory stimuli, would 308 be more likely to demonstrate equivalent levels of control. Adopting a similar attentional 309 strategy could also be interpreted as a reflection on participants' levels of *intent* during 310 movement organization and execution; therefore suggesting the requirement for a sufficient 311 312 level of psychological skill in order to benefit from employing practice swings. If this were to be the case, the mixed results in this study would be supported by the inconsistent use of 313 psychological skills previously reported by golfers (Carson, Collins, & MacNamara, 2013). 314 315 Clearly future work is required to verify this possible link. Were this research to find strong causality however, it would present a robust case for the implementation of psychological 316 skills training in parallel with executing practice swings, for those performers showing low 317 levels of equivalence between the two conditions. 318

Notwithstanding the advances that have been made to understanding the optimization 319 of practice, this study was not without limitation. For instance, psychometric data pertaining 320 to imagery ability were not collected. Completion of the Vividness of Movement Imagery 321 Ouestionnaire-2 (VMIO-2; Roberts, Callow, Hardy, Markland, & Bringer, 2008) or Sport 322 Imagery Ability Questionnaire (SIAQ; Williams & Cummings, 2011) could have validated 323 our speculation that imagery ability is a causative factor of equivalence between practice and 324 real swings. Another limitation of this study relates to the ecological validity of test 325 conditions, although it should be recognised that it is not uncommon for golfers to practice in 326 front of a net. It is also not known whether our findings are valid across different skill levels 327

of golfer, or indeed other swing variables that are unrelated to the left hand relative to thesternum position.

To overcome limitations within this study, we propose several directions for future 330 research. Firstly, the suggestion that imagery might moderate the similarity between practice 331 and real swings could be explored using supplementary psychometric assessment. Secondly, 332 the differences between blocked and interleaved trials of real and practice swings should be 333 explored, as it is not known whether our blocked approach could have influenced the 334 findings. Thirdly, collecting data in more ecologically valid environments could offer further 335 336 insight. Indeed, such inclusion would be supported by theory (Lang, 1979), since greater congruence between stimulus propositions would be apparent, and recommended guidelines 337 for practicing mental imagery (Holmes & Collins, 2001). For research purposes, this might 338 339 consist of hitting shots and performing practice swings in front of a golf simulator. Finally, research should seek to explore whether genuine improvements in imagery ability, following 340 theoretically grounded intervention, are better able to reduce the discrepancy between 341 practice swings and real swings and assess the impact on subsequent performance (both 342 outcome and consistency), that is, skill level. 343

In conclusion, by employing intraindividual movement variability as a tool for assessing motor control, this study showed practice swings to share different amounts of equivalence with real swings, despite similarity of skill status between golfers. As such, we hope to have raised awareness amongst golf coaches against the implementation of a "one size fits all" approach when designing optimal training tasks. While much research is required to develop a more complete understanding of how best to employ practice swings, this study represents an initial step to being able to ask fundamental questions about their use.

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	Qualitative Comparison			
Participant	Figure 2	Figure 3	Figure 4	
A	Consistently higher variability in the practice swing condition between 70% backswing and 80% downswing.	Inconsistently higher variability in the practice swing condition from 70% downswing.	Inconsistently higher variability in the practice swing condition from 65% backswing.	
В	Distinct fluctuation in variability at 40% backswing. Higher variability in the practice swing condition between 90% backswing and 45% downswing, then again from 90% downswing.	Generally consistent throughout, slightly lower variability in the practice swings condition until 50% backswing, slightly higher variability in the practice swing condition between 70% backswing and 55% downswing.	Inconsistently higher variability in the practice swing condition between 75% backswing and 25% downswing, then again between 45–80% and from 90% downswing.	
С	Inconsistently higher variability in the ball condition until 30% backswing. Inconsistently higher variability in the practice swing condition from 50% downswing.	Inconsistently higher variability in the practice swing condition from 25% backswing.	Consistently higher variability in ball condition from 50% backswing.	
D	Inconsistently higher variability in the ball condition until 80% backswing.	Inconsistently higher variability in the ball condition.	Inconsistently higher variability in the ball condition until 85% backswing and between 50–90% downswing.	

## 448 Table 1. *Qualitative Comparison between Ball and Practice Swing Conditions.*

Ε	Consistently higher variability in the ball condition between 0–60% and 70–90% downswing.	Inconsistently higher variability in the practice swing condition.	Consistently higher variability in the ball condition between 85% backswing and 55% downswing. Inconsistently higher variability in the practice swing condition from 60% downswing.
F	Distinct fluctuation in variability at 60% backswing. Inconsistently higher variability in the ball condition from 80% downswing.	Inconsistently higher variability in the ball condition from 40% backswing.	Inconsistently higher variability in the practice swing condition between 40% backswing and 40% downswing.
G	Very similar amounts of variability between ball and practice swing conditions.	Slight increase in variability in the practice swing condition between 55%–75% of backswing. Small and fluctuating changes in variability during the downswing.	Inconsistently higher variability in the ball condition between 60% backswing and 25% downswing. Inconsistently higher variability in the practice swing condition between 30–85% downswing, the relationship reverses from 85% downswing.
Н	Inconsistently higher variability in the practice swing condition until 65% backswing and 60–75% downswing. Inconsistently higher variability in the ball condition between 90% backswing and 55% downswing and from 75% downswing.	Inconsistently higher variability in the ball condition until 55% backswing, between 70% backswing and 70% downswing, the reverse occurred following 70% downswing.	Inconsistently higher variability in the ball condition 85% backswing.

Ι	Inconsistently higher variability in	Inconsistently higher variability in the	Inconsistently higher variability in the ball
	the ball condition between 35–80%	ball condition until 70% backswing,	condition between 20% backswing and
	backswing and 40–70%	inconsistently lower variability	90% downswing.
	downswing.	following 70% backswing.	



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*Figure 1.* Width of arc defined by the distance between the hand and swing center, viewed at451 swing address (left) and at the top of swing (right).



*Figure 2.* Intraindividual variability of left hand's medial-lateral position to the sternum for ball (solid line) and practice swing (dashed line)
 479 conditions.



*Figure 3*. Intraindividual variability of left hand's anterior-posterior position to the sternum for ball (solid line) and practice swing (dashed line) 511 conditions.



*Figure 4.* Intraindividual variability of left hand's superior-inferior position to the sternum for ball (solid line) and practice swing (dashed line)
 conditions.