

Chapter 2

Golf Putting

Abstract This chapter introduces golf putting by describing its movement phases and all other relevant details. As such, we describe how we can learn this skill of driving in different conditions of practice variability, thus showing the ‘science’ behind this action. To do this, we will use the area of motor control and explain how players can optimize their learning performance and address the constraints that emerge from the task and environment.

Keywords Golf putting • Variability • Constraints • Performance

2.1 Description of the Movement

Golf is one of the most well-known short games in sport, where competing players need to introduce the ball into the hole with the fewest number of strokes. According to Pelz, the putting technique, or simply putting, is defined as a light golf stroke made on the green in an effort to place the ball into the hole (Pelz 2000). Note that this movement represents approximately 43 % of the strokes in a golf game (Alexander and Kern 2005).

Authors such as Pelz (2000), Hume et al. (2005), Couceiro et al. (2013) and Dias et al. (2013) divide the execution of the golf putting movement into four phases (Fig. 2.1):

- (1) *Backswing* movement of the putter upwards and backwards in relation to the ball. This phase is necessary to position and align the golfer’s hub center and the club head.
- (2) *Downswing* movement of the putter downwards and forwards in relation to the ball. This phase starts where the backswing phase ends, and finishes immediately before the club head strikes the ball in the correct plane under maximum velocity.
- (3) *Contact/ball impact* time instant in which the club head strikes the ball.

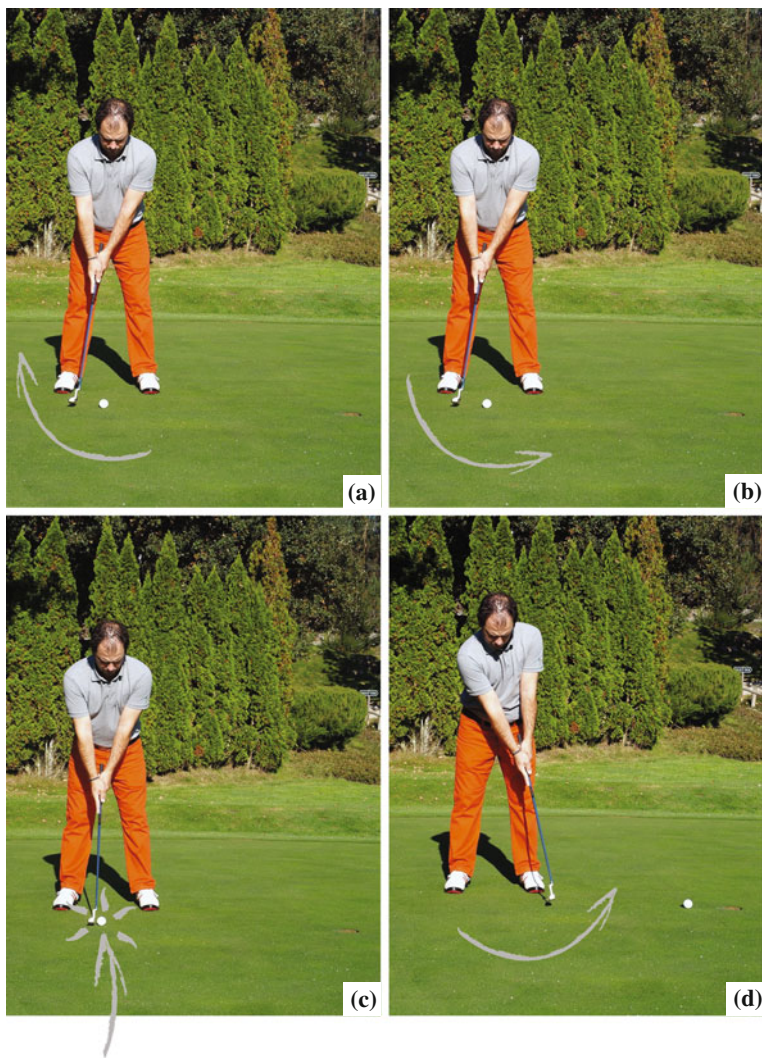


Fig. 2.1 Phases of golf putting: **a** backswing; **b** downswing; **c** ball impact; and **d** follow-through. Sequence executed by the European Champion of *pitch* and *putting*: Hugo Espirito Santo

- (4) *Follow-through* starts immediately after the ball impact and consists of the deceleration phase by benefiting from eccentric muscular actions, i.e., an inertial phenomenon inherent in golf putting (Hume et al. 2005).

Pelz (2000) shows that this pendulum movement is described by a simplistic and yet efficient model, thus being easy to learn when compared to ballistic actions, such as the tennis serve (Mendes et al. 2012). The configuration behind putting has

been commonly described by a triangle, formed by an imaginary line that connects the shoulders of the golfer with his/her hands: ‘The Putting Bible’.

Supported by *Newton’s Universal Law of Gravitation*, Pelz (2000) proves that the force of gravity seems to create, on its own, an adequate optimal velocity for the execution of putting, without any incremental velocity or force applied by the golfer.

By means of this pendulum technique, golfers can adopt a rhythm similar to the cadence of a pendulum clock or a metronome,¹ maintaining a constant velocity during the process of motor execution. However, it should be noted that the golf putting performance substantially varies from player to player, depending on their morphological and functional features (Schöllhorn et al. 2008; Karlsen et al. 2008). For instance, as stated in Chap. 1, the length of the rod, which in this case is related to the length of the golfer’s arms and club, influences the pendulum’s maximum velocity. Besides this morphological feature, the golfer’s reasoning and cognition also affect the end result. For example, the golfer needs to adapt the initial angular displacement (initial position of the downswing) based on the distance to the hole. As a rule of thumb, the larger the angular displacement, the larger the maximum velocity when the putter hits the ball (see Chap. 1).

Although Pelz (2000) states that golf putting is a simplistic movement with little or no struggle regarding its motor execution, he also emphasizes that within such deceptive simplicity, one needs to take into account a wide range of variables that can make this quite a complex movement.

Confused with this description? Well, let us then explain to what extent the simplicity of golf putting can be actually quite complex!

2.2 Learn How to Putt

This section describes the learning process behind golf putting, covering its basis by following the work of Pelz. The authors decided upon this choice since this researcher made a remarkable contribution within the laboratory context. Please refer to ‘The Putting Bible’ for a deeper understanding of the teaching and learning of golf putting (Pelz 2000).

2.2.1 The ‘Science’ Behind the Learning

Golf putting can be learned in many different ways and with many different methods. However, the individual *variability* underlying human motor behavior makes this

¹ According to Merriam-Webster dictionary, a metronome is ‘a device that makes a regular, repeated sound to show a musician how fast a piece of music should be played’.

movement different from player to player, since the morphological and functional characteristics are distinct. Therefore, to better understand the concept of biological and functional variability, let us introduce some preliminaries around this subject.

Variability is a key feature of any biological system and plays a key role in human motor behavior (Newell and Corcos 1993). When we talk about the variability that underlies the human body, we have to realize that the interaction established between the various bones comprising our skeleton results in 244 degrees of freedom (DOF)—the movement of a human arm requires 7 DOF and, if analyzed in terms of muscles, the number of DOF can segment into up to 26 possible combinations (Rose 1997; Magill 2011).

With regard to golf putting performance, the variability may be associated with how the task or the golfer is ‘disturbed’. For example, if we change the mass of the putter head, we may increase the ‘noise’ in the putting performance, which, by itself, is already quite complex to analyze. Under those conditions, we can identify two types of human variability—*intra-individual variability* and *inter-individual variability*. Intra-individual variability is related to the morphological, physiological or psychological features (profiles) that depict a particular golfer. The inter-individual variability depicts performance trends among several golfers during the execution of the same movement under the same conditions (Dias et al. 2011).

With this in mind, Pelz (2000) states that there are several strategies to learn how to putt under several conditions of variability, including:

1. hitting the ball at different distances to the hole, contemplating various paths (linear or curvilinear) and slopes (ascending or descending);
2. executing the putting under different atmospheric conditions (e.g., sun, rain, wind, snow and cold);
3. training to putt under different green and practice conditions (green with short grass, long grass or mishandled grass, with holes, squashed by the spikes of golf shoes, with sand, etc.);
4. executing putting with different types of balls (‘soft’ and ‘stiff’), using clubs of different lengths (small, average, large).

Given these arguments, the reader should be wondering if all this variability does not work as a ‘negative constraint’ for the golfer during the execution of golf putting. However, as we will see through the model of Karl Newell, by ‘constraining’ the action of the athlete we may positively influence his/her action system, thus providing new mechanisms of motor adaptation and self-regulation in the course of his/her learning.

2.2.2 ‘Constrain’ to Learn

Newell’s model (1986) shows that the constraints contribute to the regulation of human movement dynamics. These constraints are related to the connectivity between each component, establishing a particular form of self-organization. As

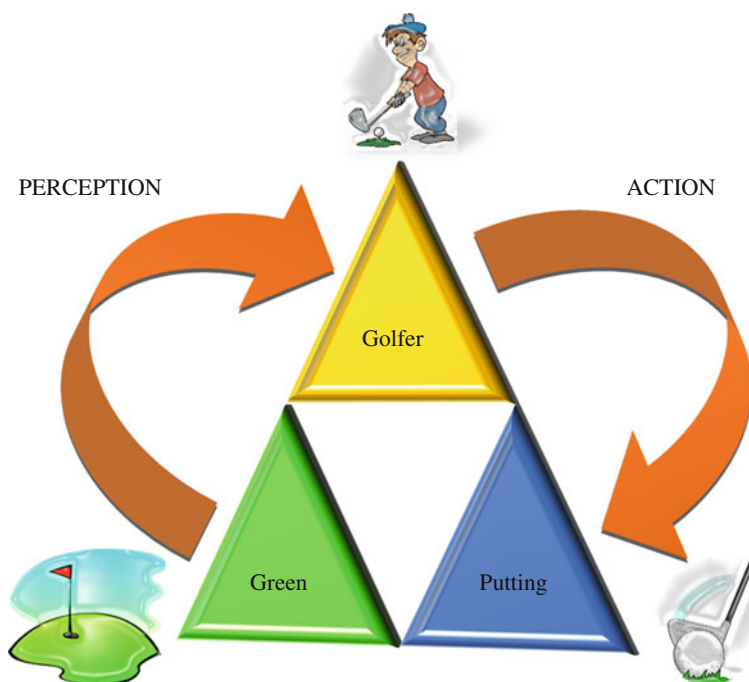


Fig. 2.2 Constraint model—adapted from Newell (1986)

such, they should not be seen as a negative influence on behavior, but rather as a set of limitations that may influence the action system (Davids et al. 2008). After validating that the constraints influence the dynamic response of the human movement, Newell (1986) introduced the *constraints-based approach* by classifying them into three different categories—the athlete, the environment, and the task. This model shows that both learning and motor performance emerge from the interaction that occurs between these three categories (Fig. 2.2). Therefore, the dynamics established between the constraints is a factor that needs to be taken into account during the performance of this movement.

By bridging a relationship between Newell’s constraints and the learning of golf putting, one can easily argue that both the morphological (height, weight and height) and functional (motivation, fatigue, etc.) characteristics of the players may influence the angular displacement applied to the putting and, as a consequence, to the force, acceleration and velocity of the movement throughout the putting performance. These aspects relate to the characteristics and profiles that distinguish each individual practitioner in the motor execution process. On the other hand, the

Table 2.1 Newell’s constraint model (1986) adapted to the putting performance

Player	Environment	Task
Morphological characteristics: height, weight and height	Weather: wind, rain and morning dew	Irregularities of the green: slopes and texture of the grass
Functional characteristics: motivation, fatigue, among others		

irregularities of the green (slopes and texture of the grass) may also compel the golfer to adjust his/her technique to overcome the restrictions imposed on the task, thus inevitably influencing the putting performance (Table 2.1). Finally, the atmospheric conditions (wind and rain) may also constrain the displacement of the ball on the green, thus forcing the player to adapt to different situations during the game (Pelz 2000).

Within the three types of constraints presented by Newell (1986), the ones that shows a higher degree of manipulability and that have been more studied in the literature are the ones provided by the task.

2.2.3 Practice Tips

In line with the previous sections, this section summarizes some practice tips so as to foster the learning of golf putting. Let us start by the perception of the task. Pelz (2000) highlights the need to ‘read’ the green and confirm its main characteristics (e.g., slopes). This ‘routine’ is very important in the decision-making of the player and can influence the outcome. It is often common to watch expert players on the PGA Tour kneeling on the green and carefully visualize the state of the grass. All these factors have a decisive influence on how the golfer will hit the ball and adjust its action, i.e., the angular displacement of the putter and all other related process variables of motor execution. Naturally, this will also have repercussions on the final location of the ball (see the concept of the radial error described in the next section).

As well as the green, the shape and size of the putter is also worthy of appreciation since it should ‘fit’ the athlete’s morphological features, namely the size of his arms and hands. A good grip is the one that best suits both the morphological and functional characteristics of the golfer, offering the highest probability of succeeding in the task (Pelz 2000). In that sense, from an instrumental point-of-view, one can verify that the putter plays a crucial role in the motor performance of this action (Karlsen et al. 2008; Mackenzie and Evans 2010). Hence, researchers such as Gwyn et al. (1996) state that the range of putters available on the market is quite

diversified and broad, and one can find almost all possible sizes and materials (e.g., titanium, graphite, steel). This aspect is different from the choice of golf balls, whereby a different material may result in a completely different outcome.

Karlsen et al. (2008) and Karlsen (2010) state that the market trend over the last decade depicts an increasing number of putter designs. Their survey shows that some researchers compared putting performance using different putter designs. However, Gwyn et al. (1996) found no statistically significant differences in the putting accuracy when comparing a traditional blade-putter and a cylindrically formed putter head. Karlsen and Smith (2007), Karlsen et al. (2008) and Karlsen (2010) devoted their studies to understanding the influence of putter length on performance. With this in mind, Pelz (1990) also compared putting performance using long and conventional putters, confirming that a long putter was best on short putts (0.9 m), equally good on medium putts (2.7 m) and worse on long putts (6.1 m). However, Gwyn and Patch (1993) did not find any significant differences regarding the length of the putter. Alternatively, Brouliette and Valade (2008) compared grooved and milled putter faces with different loft for skid distance; however, skid distance did not seem to be reduced by grooves, suggesting that the design of the putter head can also affect putting performance (cf. Karlsen et al. 2008; Karlsen 2010). Nilsson and Karlsen (2006) found that a specially designed wing-shaped putter performed better than a blade and a mallet putter, both in distance and direction on horizontal miss hits.

In spite of this, Pelz (2000), Karlsen et al. (2008) and Mackenzie and Evans (2010) showed that golf club manufacturers are starting to exploit the possibility of having ‘adaptive’ putters. However, little information is provided on how this may be accomplished, especially considering the variable weight and height of golfers, and how they may achieve an ‘optimum putter’ using the same putter. This evidence allows us to conclude that it is necessary to deepen the research around putter design and further assess its influence on putting performance.

Besides the perception of the task and the putter, the execution of motor skills needs some special care per se. Motor stability is of crucial importance, in such a way that the golfer can evolve while learning putting.

As such, it is once again recommended to follow the physics of a simple pendulum governed by Newton’s Universal Law of Gravitation. One way to promote this is to film the motor performance and to analyze it later to identify and correct any technical inconsistencies.

Given the evidence presented above, the *5-Step Routine* by Pelz (2000) is strongly recommended to foster the learning of golf putting (Fig. 2.3).

After the basis of how to execute golf putting, now comes the time to understand how we may evaluate it. Note that such insights presented in the next section may be used not only in the research perspective, but also for training purposes.

Imagine your ball-track starting on Aimline

- Stand behind ball on Aimline
- Use binocular vision (eyes horizontal)
- Three preliminary practice swings (for touch)

Walk to your ball

- Internalize Aimline direction in mind and body
- Feel slope of ground under feet

Set up to imaginary ball 4 inches inside real ball

- Flow-lines parallel-left of Aimline

Practice swings: create and commit to "preview" stroke

- 3 strokes minimum—6 strokes maximum
- Imagine ball rolling 17 inches past left edge of hole
- Commit to feel and vision of preview stroke

Move in and set up to real putt

- Eyes over Aimline (exact toe-to-ball distance)
- One look to verify proper alignment to Aimline
- Pull "trigger" to initiate putting ritual

Fig. 2.3 Five-step routine—adapted from Pelz (2000)

2.3 Evaluating Golf Putting Performance

State-of-the-art research shows that golf putting is focused on performance analysis, thus confirming its relevance towards evaluating a complex motor ability which differs from player to player. In that sense, many authors such as Beilock and Carr (2001), Singer (2002), Beilock and Gonso (2008) etc., indicate that the best golfers in the world train their psychological skills and new strategies of mental visualization (i.e., mental imagery). This kind of reasoning allows control of anxiety and pressure, which are crucial during competitions. Pelz (2000) shows that expert golfers can be distinguished from inexperienced golfers because, among other conditions, they are able to successfully follow these strategies:

- (1) control both pressure and anxiety states with greater ease, often using imagery and mental visualization of the action and the outcome beforehand;
- (2) obtain high levels of concentration and intrinsic motivation, adopting behavioral routines during the task;
- (3) perform golf putting in an autonomous and involuntary way, without allocating too much time thinking of its execution.

Golf putting also encompasses other relevant variables within the performance context, such as stability, routine,² attitude and rhythm (Pelz 2000), as well as other aspects of personality, learning ability and motivation in the execution of this movement (Jonassen and Grabowski 1993; Orliaguet and Coello 1998; Vickers 2004).

When we analyze golf putting, it is important to consider the largest amount of variables that may influence its performance. Therefore, it is common in the field of motor control to consider both product and process variables to accurately describe a particular problem related to the learning or motor coordination of players. Product variables are directly related to the performance measure of the final product or outcome (distance between the final position of the ball to the hole). On the other hand, process variables are related with the implementation and operation of the motor execution (acceleration of the putter when hitting the ball). Most of the research around golf putting proposes or re-evaluates metrics within these two domains. Chapters 4 and 5 will describe most of the metrics proposed to date in the evaluation of both product and process variables.

2.4 Practical Implications

In our conceptual framework, we assume that research around putting is rather scarce from a perspective that constraints emerging from learning and training may be beneficial to a golfer's performance. In that sense, this chapter gives the first steps to help understand the most adequate way to analyze putting in a laboratory and real-life context. Although golfers and coaches are aware that there is a number of 'ecological' variables that are inevitably present on the green, it is not known how to take them into consideration in order to win. Furthermore, we know that process variables inherent in motor execution, and how these influence putting, can be decisive in the final outcome, i.e., what we describe as 'product'. Thus, in terms of practical implications, there is little research that portrays how a certain player (novice/expert) can, or cannot, properly 'read' the constraints of the green and clearly perceive the trajectory that the ball may take over the hole. Yet, this can be the difference between winning or losing a game at the highest level!

The above-mentioned considerations are still practical implications for coaches and players, as they allow better understanding of how a seemingly simple pendulum action, as in the case of putting, can be rather complex and include a large set of variables of a physical and cognitive nature. We propose that putting learning and training are enhanced depending on the characteristics of the players and their

² The routine in golf can be characterized by a sequence of programmed actions to prepare for the performance of the golf putt. For example, there are golfers who walk the green and 'read' it from several places; they simulate the performance of the putt without hitting the ball (putting preparation); they examine the hole from several viewpoints; they close their eyes to mentally visualize the movement and imagine the trajectory of the ball, etc.

morphological and functional profile. Furthermore, we also suggest that putting must be analyzed rigorously and that the player and the coach are aware that there is indeed a science behind this pendulum motion, and that such ‘science’ can help to optimize the learning process and workout. Therefore, it is suggested that both coach and athlete act as a ‘dynamic system’, whereby multilateral work emerges that goes beyond the purely analytical learning and training.

2.5 Summary

This chapter presented a brief overview of one of the most well-known short games ever—*golf putting*. It did so by first describing the pendulum movement and the basis surrounding the learning process associated with it. The first part of the chapter was necessary not only to describe the problem that will be addressed throughout this book, but also to provide the necessary sensitivity to the problems that may arise from this and other similar pendulum-like movements in sport.

We then provided a brief revision of the literature on the evaluation of golf putting. The contributions presented throughout this book are sustained in the state-of-the-art research referred to in Sect. 2.3, especially regarding the proposal of new performance metrics for both the product and process of golf putting.

Nevertheless, before introducing those new mathematical concepts, the next chapter presents the typical experimental setup and all the underlying issues one should consider before starting a research project around golf putting, or any other similar topic.

References

- Alexander DL, Kern W (2005) Drive for show and putting for dough? *J Sports Econ* 6(1):46–60. doi:[10.1177/1527002503260797](https://doi.org/10.1177/1527002503260797)
- Beilock SL, Carr TH (2001) On the fragility of skilled performance: what governs choking under pressure? *J Exp Psychol* 130(4):701–725. doi:[10.1110.1037//0096-3445.130.4.701](https://doi.org/10.1110.1037//0096-3445.130.4.701)
- Beilock SL, Gonso S (2008) Putting in the mind versus putting on the green: expertise, performance time, and the linking of imagery and action. *Q J Exp Psychol* 61(6):920–932. doi:[10.1080/17470210701625626](https://doi.org/10.1080/17470210701625626)
- Brouliette M, Valade G (2008) The effect of putter face grooves on the incipient rolling motion of a golf ball. In D Crews, R. Lutz (eds.) *Science and golf V: proceedings of the world scientific congress of golf*: 363–368
- Couceiro MS, Dias G, Mendes R, Araújo D (2013) Accuracy of pattern detection methods in the performance of golf putting. *J Mot Behav* 45(1):37–53. doi:[10.1080/00222895.2012.740100](https://doi.org/10.1080/00222895.2012.740100)
- Dauids K, Button C, Bennett SJ (2008) *Dynamics of skill acquisition—a constraints-led approach*. Human Kinetics Publishers, Champaign
- Dias G, Figueiredo C, Couceiro MS, Luz M, Mendes R (2011) Análise Cinemática do Putt em Jogadores Inexperientes. In: Roseiro L, Neto A (eds) *Actas do Congresso. 4.º Congresso Nacional de Biomecânica*. Quinta das lágrimas, Portugal

- Dias G, Mendes R, Couceiro MS, Figueiredo C, Luz JMA (2013) “On a ball’s trajectory model for putting’s evaluation”, computational intelligence and decision making—trends and applications, from intelligent systems, control and automation: science and engineering bookseries. Springer, London
- Gwyn RG, Patch CE (1993) Comparing two putting styles for putting accuracy. *Percept Mot Skills* 76:387–390. doi:[10.2466/pms.1993.76.2.387](https://doi.org/10.2466/pms.1993.76.2.387)
- Gwyn RG, Ormond F, Patch CE (1996) Comparing putters with a conventional blade and cylindrically shaped club head. *Percept Mot Skills* 82:31–34. doi:[10.2466/pms.1996.82.1.31](https://doi.org/10.2466/pms.1996.82.1.31)
- Hume PA, Keogh J, Reid D (2005) The role of biomechanics in maximising distance and accuracy of golf shots. *Sports Med* 35(5):429–449. doi:[10.2165/00007256-200535050-00005](https://doi.org/10.2165/00007256-200535050-00005)
- Jonassen DH, Grabowski BL, Hillsdale NJ (1993) *Handbook of individual differences, learning and instruction*. Lawrence Erlbaum
- Karlsen J (2010) *Performance in golf putting*. Dissertation from the Norwegian School of Sport Sciences
- Karlsen J, Smith G (2007) Club shaft weight in putting accuracy and perception of swing parameters in golf putting. *Percept Mot Skills* 105(1):29–38. doi:[10.1016/j.proeng.2010.04.044](https://doi.org/10.1016/j.proeng.2010.04.044)
- Karlsen J, Smith G, Nilsson J (2008) The stroke has only a minor influence on direction consistency in golf putting among elite players. *J Sports Sci* 26(3):243–250. doi:[10.1080/02640410701530902](https://doi.org/10.1080/02640410701530902)
- Mackenzie SJ, Evans DB (2010) Validity and reliability of a new method for measuring putting stroke kinematics using the TOMII system. *J Sports Sci* 28(8):1–9. doi:[10.1080/02640411003792711](https://doi.org/10.1080/02640411003792711)
- Magill RA (2011) *Motor learning and control: concepts and applications*. McGraw-Hill, New York
- Mendes PC, Dias G, Mendes R, Martins F, Couceiro MS, Araújo D (2012) The effect of artificial side wind on the serve of competitive tennis players. *Int J Perform Anal Sport* 12(17):546–562. ISSN 1474-8185 (online)
- Newell KM (1986) Constraints on the development of coordination. In: Wade MG, Whiting HTA (eds) *Motor development in children: aspects of coordination and control*. martinus nijhoff, Boston
- Newell KM, Corcos DM (1993) Issues in variability and motor control. In: Newell KM, Corcos DM (eds) *variability and motor control*. Human Kinetics Publishers, Champaign
- Nilsson J, Karlsen J (2006) A new device for evaluating distance and directional performance of golf putters. *J Sports Sci* 24(2):143–147. doi:[10.1080/02640410500131225](https://doi.org/10.1080/02640410500131225)
- Orliaguet JP, Coello Y (1998) Differences between actual and imagined putting movements in golf: a chronometric analysis. *Int J Sport Psychol* 29:157–169. ISSN 0047-0767
- Pelz D (1990) The long putter. *The Pelz Report* 1:3
- Pelz D (2000) *Putting bible: the complete guide to mastering the green*. Publication Doubleday, New York
- Rose D (1997) *A multilevel approach to the study of motor learning and control*. Allyn & Bacon, Boston
- Schöllhorn W, Mayer-Kress G, Newell KM, Michelbrink M (2008) Time scales of adaptive behavior and motor learning in the presence of stochastic perturbations. *Hum Mov Sci* 28(3):319–333. doi:[10.1016/j.humov.2008.10.005](https://doi.org/10.1016/j.humov.2008.10.005)
- Singer R (2002) Pre-performance state, routines, and automaticity: what does it take to realize expertise in self-paced events? *J Appl Sport Psychol* 24(4):359–375. ISSN 1543–2904 (online)
- Vickers JN (2004) The quiet eye: it’s the difference between a good putter and a poor one. *Golf Digest* 96:32–44. ISSN 0017-176X

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