Chapter 4: Warming-up for Golf

Abstract

Over recent years, there has been a growing body of evidence highlighting the significant benefits warming-up can have on physiological mechanisms, physical performance, impact factors and ball flight characteristics. In this chapter, the warm-up habits of highly skilled and elite players are compared to less skilled amateur golfers with discussion highlighting the barriers to engagement in a warm-up. This chapter also discusses the effects of dynamic and static stretching and the contrasting effects these modalities can have on impact factors and ball flight characteristic. It is proposed that a raise, activate, mobilise and potentiate (RAMP) warm-up protocol is followed where possible and that while there may be barriers to engaging in each phase, applied solutions are available. A number of practical recommendations are offered to the reader, which includes a warm-up template, a validation protocol to assess the effectiveness of a warm-up and numerous methods in which a strength and conditioning (S&C) coach or golf coach can facilitate engagements in a warm-up.

Introduction

The Impact of Warm-ups on Golf Performance

Within many sports, a well-designed warm-up is seen as a fundamental part of an athlete's routine to prime themself both physically and mentally for performance (Jeffreys, 2007). Benefits include a decrease in muscle and joint stiffness, alterations in the force-velocity relationship, increased transition rates of nerve impulses and improved energy production and processing of fuels for performance (Bishop, 2003). From a mechanical standpoint, these physiological responses can increase the rate of force development, strength, power and jump height (Jeffreys, 2007; Perrier et al., 2011). A successful warm-up within golf could be determined from the effects it has on the desired ball flight (i.e. increased distance, and control over direction and curvature). However, this is directly determined by optimising the impact

conditions between the clubhead and the ball. Whilst clubhead speed (CHS) accounts for 75% of the variance in determining ball speed (Sweeney et al., 2013), there are several other impact factors, namely centredness of strike, clubface alignment, dynamic loft, club path and angle of attack, that act together to determine the outcome of the shot (Betzler et al., 2014). Golf specific research has evidenced that engaging in a warm-up can lead to a significant improvement in centredness of strike (Moran et al., 2009), straighter swing-paths (in-square-in) (Moran et al., 2009), increased CHS (Bliss et al., 2021; Fradkin et al., 2004; Hébert-Losier & Wardell, 2021; Moran et al., 2009), ball speed (Langdown et al., 2019; Moran et al., 2009) and drive distance (Sorbie et al., 2016; Tilley & Macfarlane, 2012). When considering these findings collectively, a golfer can improve their impact conditions, ball flight, and thus scoring potential simply through engaging in a warm-up.

It is not uncommon for golfers to set goals to achieve '*increased distance and accuracy'* and given the aforementioned benefits of warming-up, this presents an opportunity to coaches. With the achievement of these goals possible from a warm-up protocol, it can present golfers with an easier approach shot to the green, given that a shorter, more lofted club can be used, providing additional control over the ball flight. Research assessing PGA Tour professionals has indicated that golfers who hit the ball further tend to also be straighter hitters (Broadie, 2014). Aside from dispersion, there are also several other noteworthy advantages to increasing driving distance such as navigating the course more effectively. For instance, increasing distance may mean that a golfer can benefit from additional tactical variations. For example, reducing the distance of holes where a dog leg is present by selecting a target line over the corner, or carrying a hazard as opposed to 'laying-up' short. Further still, this could have positive psychological outcomes with regards to increased confidence and advantages in both stroke- and match-play situations when outdriving an opponent.

Despite these benefits, research has highlighted only 29.4% of golfers perform a warm-up (Fradkin et al., 2003). Indeed, 81% of 703 golfers have been observed to spend less than 10 minutes warming-up (Gosheger et al., 2003). Further research, however, indicated that 79.6%

of 1040 golfers reported performing a warm-up (Fradkin et al., 2001). Upon further analysis, these warm-ups consisted predominately of air swings on the tee (60.5%) or before the tee (24.0%). This is of great concern given that a warm-up has no associated cost, whereas a golfer will likely invest in the latest driver amidst advertising claims that it will improve drive distance.

Despite suggestions that warming-up is an important factor in reducing the risk of injury, there is currently insufficient evidence to substantiate these claims (Fradkin et al., 2006). In contrast to lesser skilled golfers, better players appear to recognise the importance of warming up, with 86.51% of highly skilled golfers either agreeing or strongly agreeing that engaging in a warm-up protocol will improve their performance (Wells & Langdown, 2020). However, the authors anecdotal experiences would suggest that most golfers either avoid warming-up or adopt a strategy that may not provide the required stimuli to enhance performance. As such, the purpose of this chapter is to 1) highlight the body of evidence advocating the benefits of warming-up, 2) compare highly skilled and low skilled golfers' perceptions and practices on warming-up and 3) propose effective practical recommendations that can be implemented prior to both play and practice.

Highly Skilled and Elite Golfers

Research has evidenced that PGA Tour players who can increase drive distance by 20-yards are able to save 0.75 strokes per round (Broadie, 2014). In a tournament setting, this could make the difference between making or missing the cut (1.5 shots over two days) or winning or losing an event (3 shots over four days). From applied experience, in recent years there appears to be a far greater demand from golfers to hit the ball further. However, previous research indicates that highly skilled and elite golfers may have not always fully utilise a warm-up to benefit their performance. Bridge et al., (2008) conducted a 2-day observational study assessing the warm-ups of Ladies European Tour (LET) players prior to tournament rounds.

Observations indicated that, on average, the LET players spent just 73 and 84 seconds conducting static stretches on day one and two respectively. Additionally, the LET players spent just 27 and 29 seconds performing dynamic stretches on day one and two respectively. These dynamic stretches were only comprised of shoulder rotations and air swings. The study concluded that these golfers spent very little time engaging in a warm-up on the practice range, with their modalities typically focussed on static stretching. However, as the observations were solely conducted on the range, the findings omit any warm-up protocols being undertaken elsewhere (e.g. the locker room). This may, therefore, misrepresent what constituted a warm-up for LET golfers at the time of the research. Organisations such as the European Tour often provide designated areas for players to warm-up (such as the European Tour Performance Institute Unit or gym facilities), which means that the golfers can prepare for an event away from the range area and the public eye.

From the authors' collective experiences of working within the industry, an ever-increasing number of highly skilled and elite players recognise the value in warming-up and are engaging in these as part of their pre-performance preparation. This was reported in a recent survey by Wells & Langdown, (2020) which assessed 430 (males n = 386, females n = 44) highly skilled golfers' (handicap = 0.42 ± 2.81 strokes) perceptions and practices of warming-up prior to a range session, practice round and tournament round. Of these 430 golfers, only eight failed to conduct a warm-up prior to play or practice. The main anatomical foci for the golfers' warm-up were the shoulders (83.0%), quadriceps (74.3%) and hamstrings (71.7%). Less emphasis was placed on the ankles (28.1%) and lower legs (45.8%), which would be a cause for concern given that the downswing is initiated from the ground-up (Nesbit & Serrano, 2005). When comparing the warm-up durations (combined physical and golf protocols) for these highly skilled golfers, Wells & Langdown, (2020) reported that there were significant differences between a tournament round warm-up (37 minutes 50 seconds) compared to a practice round warm-up (26 minutes 16 seconds). The findings highlighted that highly skilled golfers may not be performing a thorough warm-up in practice conditions where there is 'little consequence'

and may place greater emphasis on warming-up for a round of golf that 'matters' (i.e. tournament rounds). The repetition of a warm-up allows the acute adaptations to be validated during practice conditions. Should a golfer decide to engage in this for the first time prior to an important event, they may suffer from significant detrimental impact on performance and therefore scoring. Consequences may include, fatigue going into the round following an inappropriate warm-up intensity or reduced force generating capacity where inadequate preparation or inappropriate static stretching has been employed.

Less Skilled Golfers

Broadie (2014), highlighted that as the skill level of the golfer reduces, the value of hitting the ball 20-yards further exponentially increases (Table 1).

Table 1: The skill level of the golfer and the strokes each category of player would save if they were to increase their drive distance by 20-yards (Broadie, 2014).

Strokes per round (i.e. indicator of skill level)	Strokes saved
PGA Tour average	0.75
80	1.30
90	1.60
100	2.30
115	2.70

Broadie's (2014) work highlights that perhaps there are additional benefits to encouraging lower skilled golfers to warm-up. This presents a valuable opportunity to the S&C practitioner, given that the majority of golfers in the industry would be of a lower skill level (e.g. average handicap for club golfers in England: males = 16.4 strokes, females = 26.9 strokes; England Golf, 2021). Gosheger et al., (2003) reported that golfers who warmed-up for >10 minutes had a lower average handicap (14.3 strokes) than golfers who spent <10 minutes warming-up (22.0 strokes). However, it is important to recognise that these differences in warm-up duration

could be due to a number of different factors (e.g. the golfer's individual perceptions and understanding of the benefits of a warm-up, level of knowledge and confidence to perform the exercises, and the environment in which they are warming-up etc.) Fradkin et al., (2003) indicated that of 1040 golfers surveyed, a large proportion either 'never' (48.3%) or 'seldom' (22.3%) warmed-up. This was based on the golfers' perceptions that they 'don't need to' (38.7%), 'don't have enough time' (36.4%), and 'can't be bothered' (33.7%). Fradkin et al., (2001) reported that the number of muscles stretched by the 1040 golfers was as little as three. The primary areas were the shoulders (73.2%), the torso (21.3%) and lower back (5.2%). Given the findings, it appears prudent that practitioners publicise and share the shots saved statistics (Table 1) to encourage their golfers to warm-up and to ensure that the protocols employed target the whole body in an appropriate manner.

Static and Dynamic Stretching for Golf

The choice of warm-up modality used is of great importance. Prior to a practice round and tournament round, Wells & Langdown, (2020) reported that highly skilled golfers commonly utilised both dynamic (54.65% (practice round) to 61.63% (tournament round)) and static stretches (46.98% (practice round) to 54.42% (tournament round)). With a growing amount of supporting evidence being published in academic research, there are now substantiated performance benefits to encourage golfers to conduct a warm-up that includes dynamic stretching. Therefore, it is important that practitioners and golfers understand the impact that both dynamic and static stretching can have on performance. Research from other domains has highlighted the negative effects static stretching can have on vertical jump performance. For instance, static stretching of the hamstrings, quadriceps and soleus over various intensities (100% [the point of discomfort], 75% and 50%) were all shown to reduce jump height by 2.4 to 8.0% (Behm & Kibele, 2007). Additionally, Haddad et al., (2014) reported a significantly reduced length in 'five jump distance' when comparing the static stretch to the dynamic stretch condition 24 hours post stretch. Given the ground reaction forces required for

jumping, the negative impact of static stretching is of concern, especially as all three principal components (anterior to posterior, medial to lateral and vertical force vectors) are significantly related to clubhead speed (Han et al., 2019). Additionally, research has highlighted that countermovement jump positive impulse can predict 39.7% of the variance in CHS (Wells et al., 2019). It is therefore plausible to suggest that static stretching may negatively impact a golfer's performance if conducted within the 24-hour period prior to play and practice.

Golf specific research has compared the differences in performance between a control condition using a golf club warm-up (i.e. hitting shots) and the combination of this warm-up with static stretches (Gergley, 2009). When compared to the control condition, the combined static and golf club warm-up resulted in a significant reduction in CHS (-4.19%), distance (-5.62%), accuracy (-31.04%) and perceived ball contact (-16.34%). Given that both warm-up groups utilised the same golf club warm-up, this evidence highlights the negative effects static stretching can have on drive performance. Furthermore, Moran et al., (2009) reported that when compared to both static stretching and no stretching, dynamic stretching resulted in a significant increase in CHS (no stretch = 88.58 mph, static = 88.14 mph, dynamic = 92.39 mph), ball speed (no stretch = 124.37 mph, static = 123.93 mph, dynamic = 131.76 mph), and a straighter swing path (no stretch = 4˚, static = 3.9˚, dynamic = 3.3˚). Straightening a swing path (assuming clubface alignment is square to the target line) will help to reduce the curvature of the ball flight. When the clubface alignment and swing path are square to the target line at impact, this reduces the tilt of the spin axis on the ball, thus reducing the curvature during the flight. Moran et al., (2009) also reported that dynamic stretching resulted in significantly more centred strikes than static stretching (no stretch = -0.5 cm, static = -0.7 cm, dynamic = 0.0 cm), however there were no statistical differences when comparing dynamic stretching with no stretching.

Gergley, (2010) compared the acute (0 mins post warm-up) and latent (i.e. 15, 30, 45, and 60 mins post warm-up) effects of an active dynamic warm-up and static stretching warm-up.

Following the static stretch protocol, prolonged and significant impairments to drive performance were observed (Table 2).

Table 2: The effects of static stretching on drive performance over prolonged periods of time (Gergley, 2010).

Time post stretching (mins)	Speed (%)	Distance (%)	Accuracy (%)	Perceived ball contact (%)
0	-4.92*	-7.26*	61.99*	-31.29*
15	-2.59*	-5.19*	58.78*	-31.29*
30	-2.19*	-5.47*	59.46*	-23.56*
45	-0.95	-3.30*	61.32*	-27.49*
60	-0.99	-3.53*	36.82	-15.70*

N.b. * indicates statistical significance at $p \leq 0.05$. The greater the value for accuracy, the further the ball is from the target line.

Table 2 highlights that static stretching can negatively impact performance for at least 60 minutes, which, in the context of a tournament round, could mean that drive performance and scoring is impacted for up to 6 holes. The collective evidence presented within this section demonstrates that static stretching can have detrimental effects on both distance and accuracy. Recent research has, however, suggested that if static stretches are followed by a comprehensive high intensity dynamic warm-up, there are no detrimental effects on performance (Blazevich et al., 2018). It is worth noting that there is currently no evidence supporting this for golf.

Further research has compared static and dynamic stretching protocols to increase the understanding of the warm-up methods golfers should employ. Sorbie et al., (2016) compared the impact of both dynamic and static stretching on carry distance, accuracy, and perceived ball contact. The dynamic stretching group achieved a statistically significant increase of 4.05 yards in carry distance compared to the static stretch group. Additionally, driving accuracy was significantly better in the dynamic stretch group compared to the static stretch group:

dispersion of 6.14 yards and 6.98 yards respectively. There were no statistically significant differences in perceived ball contact between the groups, however the dynamic stretching group tended to have an improved ball contact (78% vs. 70%). Despite a lack of statistical significance, these marginal differences in perceived ball contact may have contributed to the improved accuracy and distance in the dynamic stretch group. The impact between the club and the ball is fundamental to determine the ball flight characteristics. For instance, a one degree change in club path or a 1 cm change in horizontal impact location on the clubface will alter the initial start direction by 0.269˚ and 0.494˚ respectively (Betzler et al., 2014). This has subsequent consequences on drive distance and distance away from the intended target. Furthermore, when combined with club face alignment, swing path and horizontal impact location account for 87.9% of the variance in initial start direction (Betzler et al., 2014). Additionally, the further away from a centred strike, the greater the reduction in ball speed. Specifically, for every cm^2 that impact occurs away from the centre of the clubface, there is a reduction of 1.32 mph (0.59 $m \cdot s^{-1}$) in ball speed (Betzler et al., 2014). Therefore, a shot hit 1 cm from the centre of gravity reduces ball speed by 1.32 mph, whereas a shot hit 2 cm away from the centre of gravity reduces ball speed by 4 times this amount, i.e. 5.28 mph (2.36 $m \cdot s^{-1}$). Warming up appropriately provides the golfer with an ideal opportunity to optimise impact conditions and potentially reduce the likelihood of off-centred strikes.

Practical recommendations

Before every practice session, workout or competition it is important to prepare the body for the specific activity ahead and to optimise subsequent performance by warming-up. Jeffreys, (2007) comments that a needs analysis must consider the physiological, biomechanical and technical requirements of the activity in order for a coach to provide a specific and effective warm-up protocol that will prepare the body for the physical activity ahead (see Chapter 2). The warm-up should gradually raise the temperature of the body, activate and increase blood flow to the working muscles, mobilise the joints and get the body primed and ready (i.e.

potentiate) for the sport specific actions of the golf swing. This process can be termed RAMP: Raise, Activate, Mobilise, and Potentiate. The RAMP warm-up protocol has been accepted as a valid method of achieving the acute adaptations that are possible to improve performance. RAMP is a method that follows:

Raise – preparing the systems of the body for performance, resulting in raised heart rate, respiration rate, blood flow and joint fluid viscosity (influencing range of movement available at the joints) via low intensity activities.

Barriers to engagement: This phase, may present a barrier to engagement in golf club contexts. With many golfers lacking access to a gym environment in which to perform a warm-up, it may feel out of place to complete a jog or other aerobic activity (e.g. rope skipping) around the practice facilities at their golf club. For many golfers a brisk walk (e.g. from the car park to the driving range) would act as a suitable activity here. Alternatively, combining the 'raise' element into the 'activate and mobilise' phase of the warm-up protocol may equally work to increase engagement in warming-up for subsequent golf performance. We also believe that the (sometimes strict) regulations around wearing smart golfing attire can contribute to the disengagement as some club golfers may not associate a warm-up with this culture or dress. In contrast when athletes go to play a team sport such as hockey, netball, football, etc. they will be in sports kit and a warm-up will be commonplace and completed as a team prior to any training or match situation. This practice is embedded into the culture of team sports. Spectators also see players physically warming-up in these sports. If a warm-up for golf is done away from public view (e.g. in the locker room) then it will not be seen and therefore not be associated with the game of golf. As previously noted, the lack of warm-up engagement from the golfers surveyed in Fradkin et al., (2003) supports our conclusions here.

Activate and mobilise – Ensuring that the muscles used in performance are activated, ready to produce maximal force, and to mobilise the joints that are to be used in the swing. Specific exercises can be used to target muscle groups that have been identified as important to golf performance based upon a prior needs analysis (see Figure 1). Dynamic stretching (activation and mobility exercises) can target an individual's specific limitations to allow acute increases in range of movement of these joints. As Jeffreys (2007) states, this requires a shift from traditional approaches of static stretching or targeting individual muscles towards a movement based warm-up. He continues to state that the advantages to this approach are that 1) the 'raise' element of the warm-up is maintained through this dynamic stage, 2) it focuses on the movements that golfers will use in their sport, and 3) it is time efficient. With the typical poor engagement in golf warm-ups the time efficiency of a RAMP warm-up protocol potentially assists in overcoming one of the barriers, in this regard. Strength and conditioning coaches working with golfers should look to design warm-ups that suit and benefit each individual while keeping in mind the need to address the key biomechanical and physiological requirements of the sport. For instance, there is an inherent importance in mobilising the hips and the thoracic spine due to the rotational requirements of the backswing and follow through (Chu et al., 2010). It is important to consider the muscle activity that is typical in the golf swing and to target movements that will both activate the musculature involved and mobilise the joints that have been cited as important for allowing increased time over which force can act. McHardy & Pollard, (2005) highlighted the activation of muscle groups during the swing (Figure 1) and practitioners should consider these when designing warm-up protocols. McHardy & Pollard's (2005) report stated that the gluteals on the trail side are 98-100% active and 58% active on the lead side at the point between mid-downswing (club horizontal to the floor) to impact. As such, exercises that include either squat or lunge movement patterns, either in a dynamic bodyweight or resisted form are useful examples here.

Barriers to engagement: The most likely issue with this phase is a lack of understanding around what exercises constitute an activation and mobilisation protocol. There is often a disconnect between academic research (in this case showcasing the benefits to golf warm-up protocols) and applied practice (Bishop, 2008; Eisenmann, 2017; Finch, 2011). This chapter aims to further reduce any disconnect by providing practical recommendations and solutions to barriers to engagement. With Fradkin et al.'s (2003) survey results suggesting an increased likelihood of warming-up would occur when golfers knew how to conduct a suitable protocol, it is clear that further education is required to ensure club golfers have an increased awareness of not only the protocols but also the performance benefits. While this is being addressed within golf coaching education (e.g. through The Professional Golfers' Association's higher education programmes), it is important that these messages are disseminated to golfers of all abilities.

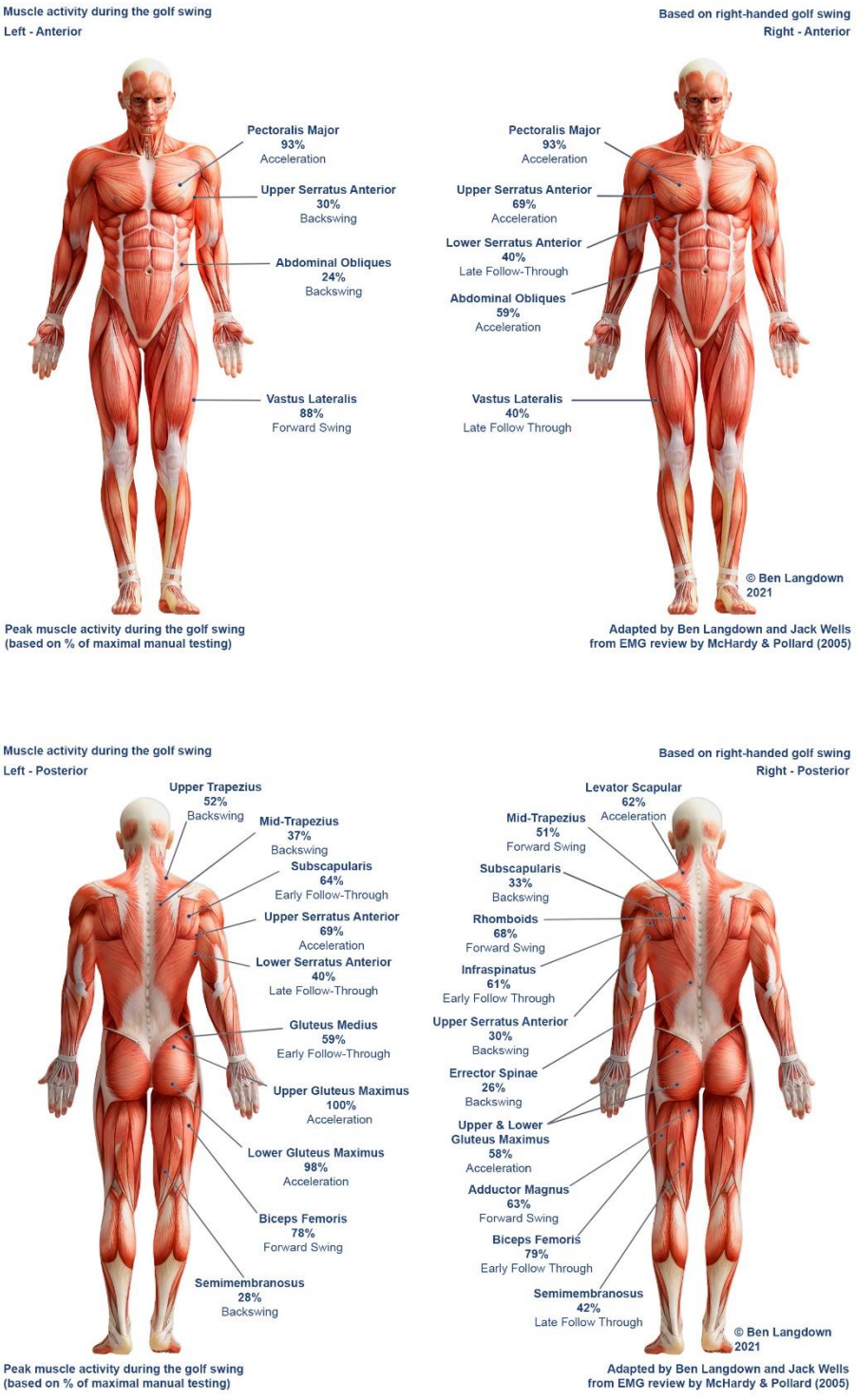

Figure 1: Activation levels of muscles based on electromyography analysis of the golf swing (adapted from McHardy & Pollard, 2005)

Potentiate – This phase requires the athlete to perform activities that will improve the effectiveness of subsequent performance (Jeffreys, 2007). For golfers, this may simply mean performing their golf swing – building towards full speed drives. However, alternative methods have been proposed, for example, post activation potentiation (PAP) research by Read et al., (2013). Their protocol employed a dynamic warm-up prior to three countermovement jumps (CMJ), where the CMJ acted as a potentiation exercise, prior to hitting any golf shots. This protocol led to a 2.2% increase in CHS vs. a control condition of just the dynamic stretching warm-up. As an aside, this also leads to the possibility of using CMJs throughout the round prior to tee shots where distance is of increased importance. Acute potentiation responses may benefit in these circumstances. Recent golf specific research has investigated the effects of overspeed protocols on performance. Hébert-Losier & Wardell, (2021) reported that a SuperSpeed Golf™ warm-up acutely increased CHS (2.6 mph) when compared to a control condition (golf swing warm-up using a selection of clubs from sand-wedge to driver). Although SuperSpeed Golf™ claim enhanced performance for 30 mins post warm-up, the results here showed that, following 400m of walking (6 mins), the CHS changes were reduced to trivial levels from a statistical standpoint (range 1.5 – 1.7 mph). Although statistically, this is considered 'trivial', these 1.5 – 1.7 mph increases may still be important to the golfer, thus providing merit to including potentiation in their warm-up protocol. A note of caution: It is important to recognise that although there were increases in CHS, these failed to transfer to improved ball speed suggesting that centeredness of strike was likely compromised. Further research in this area observed that a bodyweight potentiation protocol (3x10 CMJs and 2x10 plyometric press-ups) elicited similar significant increases in CHS when compared to the use of an overspeed protocol where light, medium and heavy speed sticks where swung at maximal speed (40 reps in total) (Bliss et al., 2021). The addition of CMJs and overspeed training (such as weighted clubs) on top of a dynamic stretching condition can significantly increase CHS. However, the need for overspeed training is questionable since it offers no additional benefits in golf performance when compared to bodyweight exercises. If maximal intent swings are recommended, then it would appear wise to utilise equipment that the golfer

will use (i.e. their own driver) as opposed to an implement that may vary in mass and length and therefore presents a different moment of inertia and ultimately 'feel'. At the time of writing, golf research has shown some positive gains from potentiation exercises (Bliss et al., 2021; Hébert-Losier & Wardell, 2021; Read et al., 2013) but further research is required to fully understand the mechanisms, the most effective protocols, and recovery periods required for maximal CHS gains.

Research from sports such as rugby have provided alternative approaches, for example, the use of an 80% 1RM loading in a high hang pull exercise (one set of three reps) (Parr et al., 2017). The authors stated that a gluteal specific, 'activation warm-up may facilitate recruitment of the gluteal musculature by potentiating the glutes in such a way that a smaller neural drive evokes the same or greater force production during movement' (Parr et al., 2017; p1). It is clear that only a minority of golfers will have both the access to a gym facility at their golf club, and the technical competence to complete a warm-up protocol using an exercise like the high hang pull at 80% 1RM (Parr et al., 2017). In the sport of rugby, this may be feasible as the higher skilled athletes may well be engaged in both S&C and regular warm-up protocols prior to training and matches. Strength and conditioning coaches should therefore consider the most relevant protocol for each individual golfer, their access to facilities and equipment, views on / willingness to engage in warm-up protocols and ensure their competency levels are sufficient that they can demonstrate each exercise safely for use on their own in their golf specific context.

A note of caution: Research highlights that PAP research is not yet complete or conclusive due to many projects failing to confirm the presence of PAP or fatigue (see MacIntosh et al., 2012), and indeed, minimal evidence has been presented that PAP plays a significant role where 'multiple physiological processes have already been upregulated by a preceding,

comprehensive, active muscle warm-up' (Blazevich & Babault, 2019; p1). As such, the effects of potentiation during a warm-up should be viewed with caution. Research suggests that beneficial, potentiating effects are only applicable within one to five minutes of completing the potentiating exercises (see MacIntosh et al., 2012), which poses issues for those golfers who are warming-up prior to hitting balls, and then putting before approaching the first tee. It may be necessary to repeat potentiating exercises prior to the first tee shot, and again throughout the round to maximise the acute adaptations and benefits to drive performance. Golfers should also be aware of ensuring reps and sets are kept low (i.e. ~3 reps at >80% 1RM if using loaded activities) and allowing sufficient recovery time prior to maximal effort golf swings after the exercise stimulus (Kilduff et al., 2011; MacIntosh et al., 2012).

Barriers to engagement: Due to the potential low engagement of club level golfers in this phase, it's important for coaches to consider which protocols represent the most viable option that will engage golfers in warming-up. The use of three CMJs, albeit in golf attire, presents an effective means of achieving some potentiating practises in a golfer's routine, without the need for resisted exercises to be undertaken. Performing plyometric push-ups (as in the bodyweight potentiation protocol in Bliss et al., (2021)) on a range or beside the first tee is likely to discourage many club golfers from engaging with the warm-up. However, the potential use of overspeed protocols perhaps offers a more inconspicuous route to potentiation. This may be because the overspeed protocol looks like a golf swing, whereas the jumping and press-ups, despite the benefits they provide, look increasingly alien to the sport. However, with 27 and 40 reps being performed in the Hébert-Losier & Wardell, (2021) and Bliss et al., (2021) protocols respectively, it is important that golfers adapt their own warm-up to account for fatigue and recovery times to optimise their own drive performance. It is not uncommon for some professional golfers to hit over 300 balls, plus perform practice swings, during each range session (Thériault & Lachance, 1998). Adding a further 27-40 maximal swings through

a warm-up substantially increases the volume of shots per session. The additional cumulative load across a week that included 3+ range sessions, not to mention gym-based sessions, means that they will be exposing their body to a potential spike in training volumes. With excessive and rapid increases in training load linked to greater risk of injury (Gabbett, 2016), we would suggest that, to mitigate risks, a golfer should perform 3-5 maximum air swings with their own driver. This should suffice as a potentiation protocol to elicit the required acute adaptations.

To guide the reader towards an example of a suitable warm-up protocol, a template has been provided (Table 3). Please note, this represents an example guide and this protocol should be adapted for individuals based on their training status, fitness levels, physical requirements and following the completion of a physical activity readiness questionnaire (PAR-Q).

Table 3: Example of a warm-up based on the RAMP protocol

Phase	Modality	Links to research
Raise	Brisk walk or jog	
Activate and Mobilise	Clock lunges (4 reps each leg: Forwards, lateral, reverse, crossed reverse lunge) Overhead squats (10 reps) Scapula wall slides (2 x 30 seconds) Thoracic rotation (6 reps each side) Hip openers (i.e. open and close the gate exercises) (6 reps in each direction on each side)	(Langdown et al., 2019)
Potentiate	Vertical jump (3 reps) Max. intent air swing with a driver (3-5 reps)*	(Bliss et al., 2021; Hébert-Losier & Wardell, 2021; Read et al., 2013)

*SuperSpeed warm-ups involved 40 swings in total. Given that there are already other modalities utilised within this warm-up template, the authors feel that 3-5 reps should suffice. Warm-up validation should take place to appropriate amend this warm-up.

Fostering an environment to encourage a warm-up

With the potentially significant barriers to conducting a warm-up identified, it is crucial that coaches foster an environment that is conducive to encourage warm-ups. Golfers need to appreciate that a time efficient protocol can be implemented that may add distance to their drives. Indeed, this may play a significant role in helping them achieve their performance / outcome goals for the year and that, like purchasing a new driver, it is worth investing in an individualised protocol. Of course, there is not a one-size-fits-all protocol that coaches can apply to every golfer. Golf coaches and S&C coaches must liaise to establish what is feasible given the underpinning health and training status of each individual, the facilities available and the perceptions and current behaviours of the golfer. Warm-up protocols should, therefore, be adapted to the individual and the environment in which their warm-up is likely to take place.

Demonstrating the benefits through dissemination of relevant warm-up research

As Jeffreys, (2007) suggested, it is useful for athletes, in this case golfers, to consider a warm-up as 'Performance Preparation'. By encouraging a shift in attitudes, towards warming-up for performance, a golfer's engagement levels may increase to achieve the acute physiological adaptations that bring about maximal CHS and drive distances. An established protocol should be tried and tested in order to ensure an optimal effect on performance.

In our experience, the act of validating a warm-up protocol provides golfers with an affirmation that performance can be significantly impacted within a short period of time (see Figure 3). Validating the protocol through the use of a launch monitor or distance markers can facilitate engagement and provides insight into the "low-hanging fruit" that a warm-up can provide. Specifically, a launch monitor will provide data into drive performance measures such as CHS, ball speed, carry distance, swing path, centredness of strike etc.

Ratings of perceived exertion and subjective ratings of performance

When considering the individual response to a warm-up Langdown et al., (2019) stated that it is important to note that each protocol would need to be adapted to the physical capabilities of each golfer. This can be achieved with a Borg scale (Figure 2) to establish the level of physical exertion during each protocol (Borg, 1998). Golfers need to feel that they have completed an effective warm-up and not increased the intensity to an extent that it becomes a training session for them, resulting in undue fatigue on the first tee. Equally, the protocol needs to be of a level that elicits the physiological (and possible psychological) benefits that will lead to enhanced performance. We recommend the application of a Borg scale rating of perceived exertion – aiming for a rating of three (moderate) – four (somewhat hard). It is also recommended that this perception rating is taken 15 minutes after the completion of the warm-up to collect a rating that is not influenced by the last exercise performed.

Rating	Descriptor
0	Nothing at all
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

Figure 2: Modified category rating of perceived exertion (RPE) scale (Foster et al., 2001).

With a validated protocol and appropriate exertion achieved it is possible for significant gains to be made in drive performance. Langdown et al., (2019) reported that one individual in their study gained 40 yards following a resistance band protocol compared to a control condition and 34 yards when completing a dynamic stretching warm-up protocol. Not every golfer will be fortunate to achieve distance gains to this extent but with every ~ten yards gained comes a reduction in the club required to play an approach shot to the green. As previously stated, this allows a variety of tactical advantages and greater control.

Additional coaching benefits from a golfer's warm-up

In addition to the benefits seen by individual golfers when undertaking a warm-up, there are opportunities for the S&C coach to gain a valuable insight into movement patterns and increased understanding of the golfer's movement competence. The use of dynamic exercises in a warm-up, such as squats, lunges, scapula wall slides and rotation based dynamic stretches, allows coach observations and assessment of full body mobility, posture, stability through single-leg or split stance exercises, strength in specific areas and the ability to cope with resistance (where bands / weights are incorporated). This can offer an opening to discuss S&C and the impact upon the individual's golf swing or overall performance. If the golfer is already engaged in S&C it offers the opportunity to assess the effectiveness of any systematic interventions and to make amendments as required.

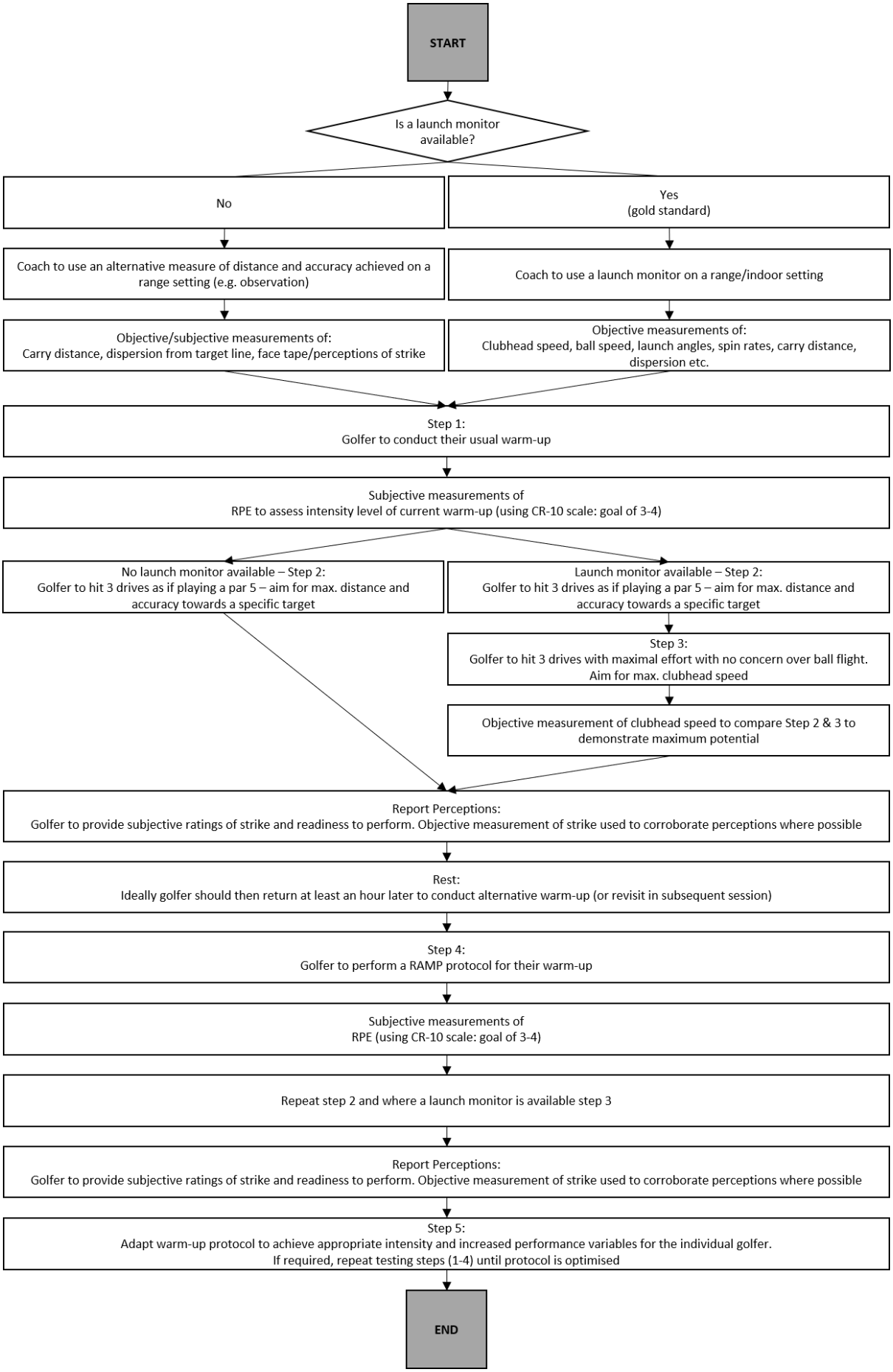
START
Is a launch monitor available?
No
Yes (gold standard)
Coach to use an alternative measure of distance and accuracy achieved on a range setting (e.g. observation)
Coach to use a launch monitor on a range/indoor setting
Objective/subjective measurements of: Carry distance, dispersion from target line, face tape/perceptions of strike
Objective measurements of: Clubhead speed, ball speed, launch angles, spin rates, carry distance, dispersion etc.
Step 1: Golfer to conduct their usual warm-up
Subjective measurements of RPE to assess intensity level of current warm-up (using CR-10 scale: goal of 3-4)
No launch monitor available – Step 2: Golfer to hit 3 drives as if playing a par 5 – aim for max. distance and accuracy towards a specific target
Launch monitor available – Step 2: Golfer to hit 3 drives as if playing a par 5 – aim for max. distance and accuracy towards a specific target
Step 3: Golfer to hit 3 drives with maximal effort with no concern over ball flight. Aim for max. clubhead speed
Objective measurement of clubhead speed to compare Step 2 & 3 to demonstrate maximum potential
Report Perceptions: Golfer to provide subjective ratings of strike and readiness to perform. Objective measurement of strike used to corroborate perceptions where possible
Rest: Ideally golfer should then return at least an hour later to conduct alternative warm-up (or revisit in subsequent session)
Step 4: Golfer to perform a RAMP protocol for their warm-up
Subjective measurements of RPE (using CR-10 scale: goal of 3-4)
Repeat step 2 and where a launch monitor is available step 3
Report Perceptions: Golfer to provide subjective ratings of strike and readiness to perform. Objective measurement of strike used to corroborate perceptions where possible
Step 5: Adapt warm-up protocol to achieve appropriate intensity and increased performance variables for the individual golfer. If required, repeat testing steps (1-4) until protocol is optimised
END

Figure 3 Warm-up validation process with and without a launch monitor

Coaches' perspectives

Our applied experience provides other methods and practical recommendations / considerations that have supported golfers' engagement in warm-up protocols:

- Sharing high-profile examples of warm-up – these can be high performing golfers within the club, region or highlighting professional golfers' protocols.
- Create and share programme goals – Within regional and national level programmes there are expectations that young golfers will be competent at performing their own warm-up and be able to adapt this to the context in which they find themselves at tournaments. Club based programmes can also set warm-up goals for all golfers to achieve.
- Data to prove benefits – an individual validation process is the most effective method of providing evidence on the benefits of a warm-up. However, creating and disseminating case studies may also raise curiosity and motivation to engage in the process.
- Practice what you preach – Coaches are often role models too. It is important that when training or playing golf they are seen to engage in a RAMP protocol and are able to discuss the benefits to golf performance.
- Encourage warm-ups as an expected standard – Coaching the golfer to be autonomous in their warm-up protocol affords them the opportunity to adapt their warm-up to any physical limitations they may experience prior to competing or prior to training and practicing. Discussing and coaching them through various alternatives they can use, given varying contexts, will allow them to utilise the most effective warm-up in each condition (e.g. when away at a tournament with no gym facilities, training in a gym / at home etc.).
- Promote warm-ups using research data and posters around the facilities – Golf manufacturers use promotional materials for the sales strategy of new drivers.

In the same way, warm-up benefits can be promoted at your facility / online to raise awareness of the benefits and to upskill golfers through increased understanding of warm-up exercises.

- Stock mini-bands / resistance bands in the gym / pro shop – Making it easy for golfers to apply principles of resisted exercise in their warm-up is critical to engagement. While many golfers will benefit from dynamic stretching in their warm-up, others will want the benefits of resisted exercises that they can do on the range or in the locker room. If coaches are able to competently demonstrate a range of resisted exercises and to provide access to purchase bands, it will allow easy access to engagement. The use of imagery / videos together with the bands will serve as a reminder of how to develop competency in the exercises.
- Insurance - Consideration should be given to making it mandatory to perform a warm-up prior to attending a golf coaching session. This not only benefits the performance of the golfer from the start of their session it also allows the golf coach to assess the movements of the golf swing from a physically prepared condition. From an insurance perspective this may also be a condition of all golf coaching sessions (coaches should check with suppliers of insurance).
- Changing the coaching session culture – Golf coaches would be wise to check that the golfer has warmed-up prior to the lesson (as highlighted above). If the golfer has not engaged in a warm-up, it would be advisable to spend time taking the golfer through a full warm-up protocol. Golfers will most likely want to spend their lesson time refining technical / performance aspects of their game. In this regard, encouragement to conduct the warm-up prior to the lesson will highlight the saving of time for technical and performance coaching. Furthermore, this will help to facilitate a culture shift that will encourage warm-up engagement.

Conclusion

Research has highlighted that warming-up for golf can significantly improve impact factors and ball flight characteristics. However, golfers are yet to fully embrace the benefits that warming-up can bring to their performance. Strength and conditioning practitioners can support golfers and coaches by devising bespoke warm-up routines to enhance performance. It is recommended that a R.A.M.P protocol is followed where possible, however, to support engagement, phases can be combined and manipulated to suit each individual and their specific context. To further encourage golfers' engagement, validation of the warm-up protocols can be undertaken to provide evidence of impact on performance. The inclusion of a launch monitor in this process increases validity and can support the coach to highlight the acute adaptations following a warm-up protocol. While physiological gains are important to clubhead speed, the use of RPE and perceptions of strike can also be critical to the psychological aspects of performance. The application of the evidence presented in this chapter offers both S&C and golf coaches valuable opportunities to encourage a culture shift and increased engagement in warming-up for golf.

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