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SPORTS PERFORMANCE

Sports science for golf: A survey of high-skilled golfers' "perceptions" and "practices"

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ABSTRACT

Despite a growing body of evidence on the positive impact of sports science for golf, there is still a paucity of research investigating the "perceptions" and "practices" of high-skilled golfers. Professional Golfers' Association Assistant Professionals (future-qualified coaches; n = 430) were surveyed on their "perceptions" and "practices" of "sports science", "warm-ups", "cool-downs" and "strength and conditioning" for golf. Participants perceived the discipline of sports science as beneficial to golfers but lacked implementation in coaching settings. Warm-up protocols were also perceived to be beneficial to all aspects of golf performance; however, the duration of tournament-based (37.84 ± 20.05 min), warm-ups was significantly greater (p < 0.001) than practice rounds (26.26 ± 18.63 min) and range sessions (13.00 ± 13.38 min). Education continues to be required to raise the understanding of warm-ups for golf. There were mixed perceptions regarding the benefits of a cool-down, with 62.1% of the high-skilled golfers omitting a cool-down following tournament play and practice. Strength and conditioning was perceived as beneficial, with 78.51% engaging in some form of training throughout the year. Results confirm, however, that certain misconceptions around surveyed sports science practices still exist and it is imperative that education disseminates research findings and validated applied practices to coaches and golfers alike.

ARTICLE HISTORY
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KEYWORDS
PGA Professionals'; golf; warm-up; cool-down; strength and conditioning

Introduction

In their review of Golf Science at the beginning of the twenty-first Century, Farrally et al. (2003), highlighted that golf has benefited and will continue to do so from improved knowledge of physiological parameters linked to performance. Since then, a number of studies have assessed the impact that warm-ups (Langdown et al., 2019; Tilley & Macfarlane, 2012) and strength and conditioning (S&C) (Doan et al., 2006; Fletcher & Hartwell, 2004; Oranchuk et al., 2018) have upon elements of golf performance. As such, this has helped to develop understanding as to the mechanisms associated with generating greater clubhead velocity (CHV), ball velocity (BV), and carry distance (CD) (Hume et al., 2005). Whilst the aforementioned research indicates the positive effects these strategies can have on golfers' performances, it is imperative that research is disseminated in ways that can positively shape the perceptions and practices of the wider golf community.

Warm-up for golf

A warm-up can be defined as preparatory exercises conducted to enhance performance in competition or training (Hedrick, 1992). Fradkin et al. (2001) conducted an observational analysis of golfers (n = 1040) warming-up prior to a round of golf and a driving range session. Of the sample, 565 golfers performed "some form" of warm-up, however, this mainly comprised air swings prior to arriving at the tee (n = 199) or when on the tee prior to playing a shot (n = 501). Very few golfers performed static stretches (n = 31) with only three regions targeted: the shoulder (73.7% of the 31 golfers), the wrists (21.1%), and the hamstrings (5.2%). More golfers performed dynamic stretching (n = 97), however, again with only three muscle groups targeted: the shoulder (73.2% of the 97 golfers), the trunk (21.3%), and lower back (5.5%). No golfers were observed undertaking any aerobic activity. Most golfers who warmed-up performed only one type of activity (77.0%) with 17.8% and 0.4% of golfers performing two or all four of the warm-up activities, respectively.

In a separate study, Fradkin et al. (2003) indicated that 70% of the golfers surveyed (n = 1040) reported that they "never or seldom warmed-up", due to 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%). It is important to recognise that only 5.8% of the golfers within their survey had a handicap between 0 and 10. Given that the group were predominantly low-skilled golfers, it is plausible to suggest that high-skilled golfers may adopt different warm-up habits. A study by Bridge et al. (2008), observed the warm-up habits of Ladies' European Tour golfers prior to tournament rounds over 2 consecutive days. Findings indicated that dynamic stretches (air swings and shoulder rotations) lasted only 27 and 28 s, and static stretching lasted 73 and 84 s on days 1 and 2, respectively. Although observational studies provide valuable insights, it is possible that there will be omissions in the data due to golfers warming-up out of sight.

Strength and conditioning for golf

A survey-based study assessed the perceptions and practices of golf coaches towards S&C for golf (n = 251; 15.2% response

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rate; Evans & Thomas, 2012). Results indicated that only 54% of the coaches agreed that their clients should be physically fit to play golf. Further analysis indicated that the 46% of coaches who "disagreed" or were "unsure" had coached for more years ($p = 0.01$), believed that it was more important for elite/professional golfers to engage in S&C ($p = 0.01$) and attempted to correct swing mechanics before referring clients with pain and injury to a health professional ($p = 0.01$). It is important to recognise, however, that despite these apparent negative perceptions of S&C for golf, there is a growing body of evidence advocating the benefits to golfers' CHV and drive distance following a S&C programme (e.g., Doan et al., 2006; Fletcher & Hartwell, 2004; Oranchuk et al., 2018). Further research is required to highlight the practices of high skilled golfers in this area.

Cool-downs for golf

Whilst previous research highlighted the warm-up practices of golfers, to date, there is currently no evidence regarding golfers' cool-down practices. A recent review highlighted that cool-downs offer little meaningful benefit to performance (Van Hooren & Peake, 2018), citing no significant reduction in muscle soreness and muscle damage or improvement in neuromuscular contractile properties. Increases in lactate concentrations are also of little concern to the golfer and therefore a cool-down protocol to reduce concentrations are irrelevant in the context of this sport (Unverdorben et al., 2000). As such, it is important to understand golfers' current practices and perceptions of a cool-down to compare this with literature findings.

The aims of this study were to address the paucity of data assessing the "perceptions" and "practices" of high-skilled golfers towards the use of "Sports Science for Golf" (where sports science is viewed as the overarching discipline), and "S&C for Golf". In addition, the study also aims to assess the "perceptions" and "practices" towards "Warming-up for Golf", and "Cool-downs for Golf" in range session, practice round and tournament round contexts.

Methods

A mixed methods survey, developed using Qualtrics™, assessed the "perceptions" and "practices" of Professional Golfers' Association (PGA) Assistant Professionals. Ethical approval was granted by the University's Research Ethics committee.

The survey was distributed to 834 PGA Assistant Professionals (referred to as high-skilled golfers hereafter), with 430 (males $n = 386$, females $n = 44$) completed returns (51.6% response rate).

Self-reported participants' characteristics

Combined age = 24.65 ± 5.57 years (males = 24.66 ± 5.60, females = 24.59 ± 5.35 years); Combined height = 1.78 ± 0.12 m (males = 1.80 ± 0.11 m, females 1.66 ± 0.07 m); Combined mass = 79.92 ± 17.67 kg (males = 81.59 ± 17.37 kg, females 65.32 ± 12.98); Handicap = 0.42 ± 2.81 strokes (males = 0.33 ± 2.59 strokes, females 1.20 ± 4.11 strokes); Launch-monitor data: Combined CHV = 48.48 ± 4.37 m/s (males = 49.41 ± 10.80 m/s, females 38.47 ± 16.92 m/s); Combined driver CD = 262.30 ± 25.42 yards (males 268.09 ± 18.78 yards, females 211.48 ± 18.59). Participants reported completing the following number of in- or off-season golf sessions within each context: Range session (RS): in-season = 3.74 ± 2.45 sessions per week and off-season = 2.97 ± 2.36 sessions per week, Practice round (PR): in-season = 3.00 ± 1.88 sessions per week and off-season = 1.68 ± 1.41 session per week and Tournament rounds (TR): 18.30 ± 14.88 rounds per year.

Modality questions

Golfers responded to questions assessing their individual warm-up, cool-down, and S&C practices. This allowed for the assessment of the most common modalities selected within each context.

Scaled questions

Various Likert scales using the median value assessed the "perceptions" towards sports science for golf (Figure 1), warm-up (Figure 2), cool-down (Figure 5) and S&C (Figure 8). Individual figures highlight the range of each Likert scale used.

Statistical analysis

A repeated measures ANOVA with Bonferroni post hoc analysis were used to analyse warm-up and cool-down durations across the three contexts. Normality of distribution were met through visual inspections of histograms. Where Mauchly's test of sphericity was violated a Greenhouse-Geisser correction was employed. For all other data, descriptive statistics are presented.

Results

Sports science for golf

Perceptions

Findings indicated that participants "agreed" that the use of sports science as a discipline helps to enhance performance (median = "agree" 40.93%) and reduce the risk of injury (median = "agree" 40.00%). In comparison, there was a reduced perception that sports science was being used at their clubs (median = "somewhat agree" 34.88%) (Figure 1).

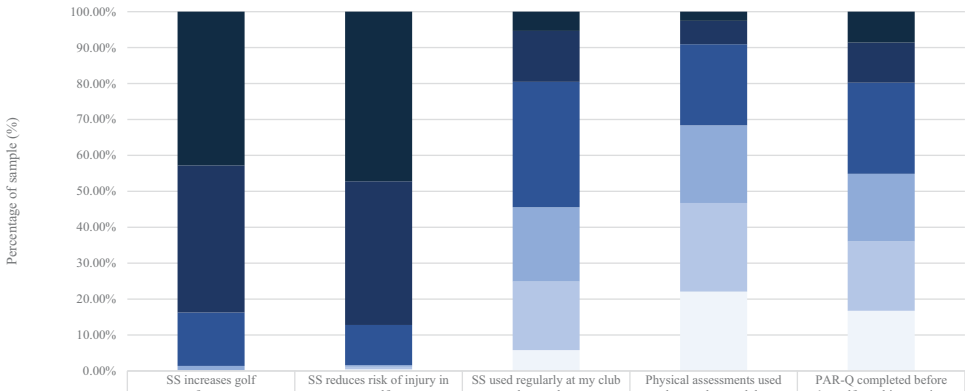
Warm-ups

Perceptions

The application of a warm-up was perceived to be beneficial to all aspects of golf performance from CHV and ball flight characteristics (e.g., carry distance) to putting and the mental side of the game. There was a median "disagreement" that warm-ups were more important for highly skilled/professional golfers as opposed to amateurs (median = 21.86%) (Figure 2).

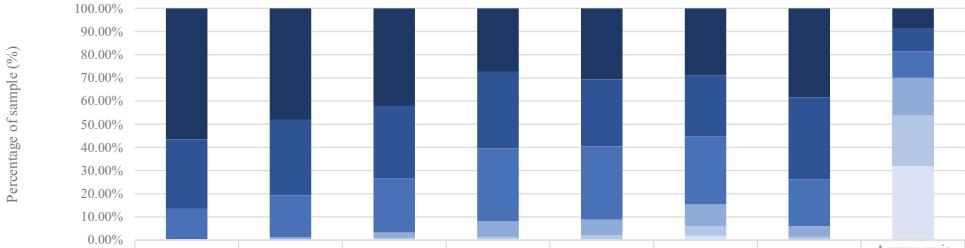
Practices

In-line with the positive perceptions of the benefits of a warm-up, descriptive statistics indicated that a slightly greater



	SS increases golf performance	SS reduces risk of injury in golf	SS used regularly at my club by coaches	Physical assessments used by coaches at club	PAR-Q completed before 1st golf coaching session
Strongly agree	42.79%	47.21%	5.35%	2.56%	8.60%
Agree	40.93% *	40.00% *	14.19%	6.51%	11.16%
Somewhat agree	14.88%	11.16%	34.88% *	22.56%	25.35%
Somewhat disagree	1.16%	0.47%	20.70%	21.63% *	18.84% *
Disagree	0.23%	0.70%	19.07%	24.65%	19.30%
Strongly disagree	0.00%	0.47%	5.81%	22.09%	16.74%

Figure 1. Perceptions of sports science (SS) for golf.
N.b. * = median for each item on Likert scale



	A warm-up can help to increase golf performance	A warm-up can help increase CHV	A warm-up can help increase maximum CD	A warm-up can help with distance control	A warm-up can help with ball flight control	A warm-up can help with putting performance	A warm-up can help with the mental aspects of performance	A warm-up is more important for highly skilled, elite or professional players as opposed to amateurs or regular club golfers
Strongly agree	56.51%*	48.14%	42.09%	27.44%	30.70%	28.84%	38.37%	8.84%
Agree	30.00%	32.56%*	31.16%*	33.02%*	28.84%*	26.51%*	35.35%*	9.77%
Somewhat agree	13.02%	18.14%	23.49%	31.40%	31.63%	29.30%	20.23%	11.40%
Somewhat disagree	0.23%	0.93%	2.33%	6.74%	6.74%	9.30%	4.65%	16.05%
Disagree	0.23%	0.23%	0.70%	0.93%	1.63%	4.19%	1.40%	21.86%*
Strongly disagree	0.00%	0.00%	0.23%	0.47%	0.47%	1.86%	0.00%	32.09%

Figure 2. Perceptions of warming-up for golf.
N.b. * = median for each item on Likert scale

percentage of golfers undertake a warm-up prior to playing a TR (96.74%) compared to both an RS (94.65%) and a PR (91.86%). A Greenhouse-Geisser correction indicated that the duration of warm-up was significantly affected by the type of condition (RS, PR, TR), (F (1.82, 681.05) = 318.07, $p < 0.001$, $\eta p2 = 0.459$). Bonferroni post-hoc analysis revealed a significant increase in warm-up duration from the RS (13.00 ± 13.38 min) to both the PR (26.26 ± 18.63 min, $p < 0.001$) and TR (37.84 ± 20.05 min, $p < 0.001$) and from the PR to TR ($p < 0.001$).

In an RS context the most frequently utilised warm-up component was "Shots with reduced power" (85.58%), for a PR context this was "Putting" (82.09%) and for TR contexts both "Hitting full shots" and "Putting" were most commonly utilised (91.16%) (Figure 3). Within each context, there is a greater emphasis on technical components being selected as part of a warm-up protocol when compared to physical components.

Targeted muscles

These high-skilled golfers indicated that the three most common muscles/regions of the body targeted during warm-ups were the shoulders (82.97%), the quadriceps (74.34%) and the hamstrings (71.70%) (Figure 4).

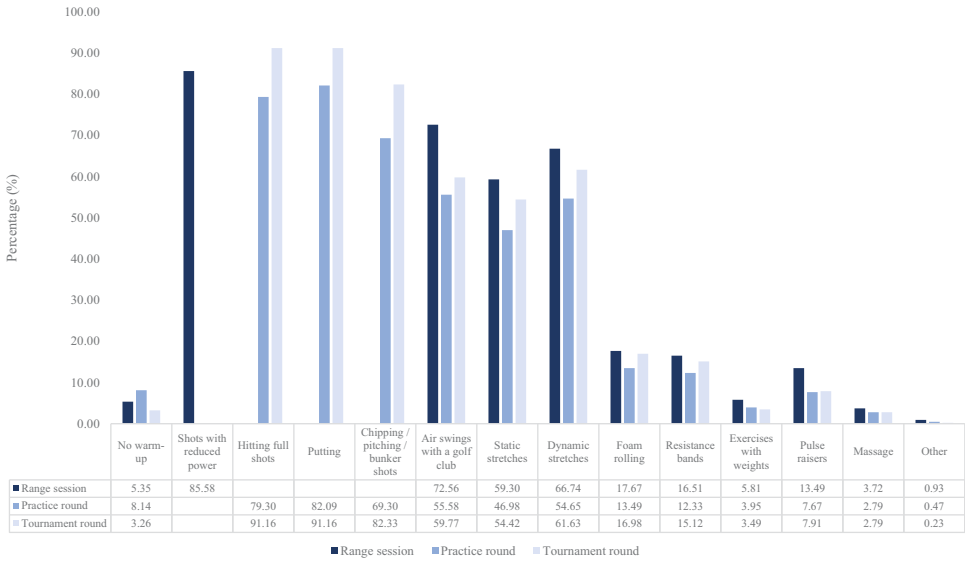
Cool-downs

Perceptions

Median statistics revealed that participants "somewhat agreed" that cool-downs are beneficial for performance (median = 37.21%) and "somewhat disagreed" that a cool-down was more important for highly skilled/professional players (median = 21.16%) (Figure 5).

Practices

Descriptive statistics indicated that a slightly increased percentage of golfers "don't cool-down" following an RS (70.47%) and a PR



	No warm-up	Shots with reduced power	Hitting full shots	Putting	Chipping / pitching / bunker shots	Air swings with a golf club	Static stretches	Dynamic stretches	Foam rolling	Resistance bands	Exercises with weights	Pulse raisers	Massage	Other
Range session	5.35	85.58				72.56	59.30	66.74	17.67	16.51	5.81	13.49	3.72	0.93
Practice round	8.14		79.30	82.09	69.30	55.58	46.98	54.65	13.49	12.33	3.95	7.67	2.79	0.47
Tournament round	3.26		91.16	91.16	82.33	59.77	54.42	61.63	16.98	15.12	3.49	7.91	2.79	0.23

Figure 3. Warm-up practices for golf during RS, PR and TR contexts.

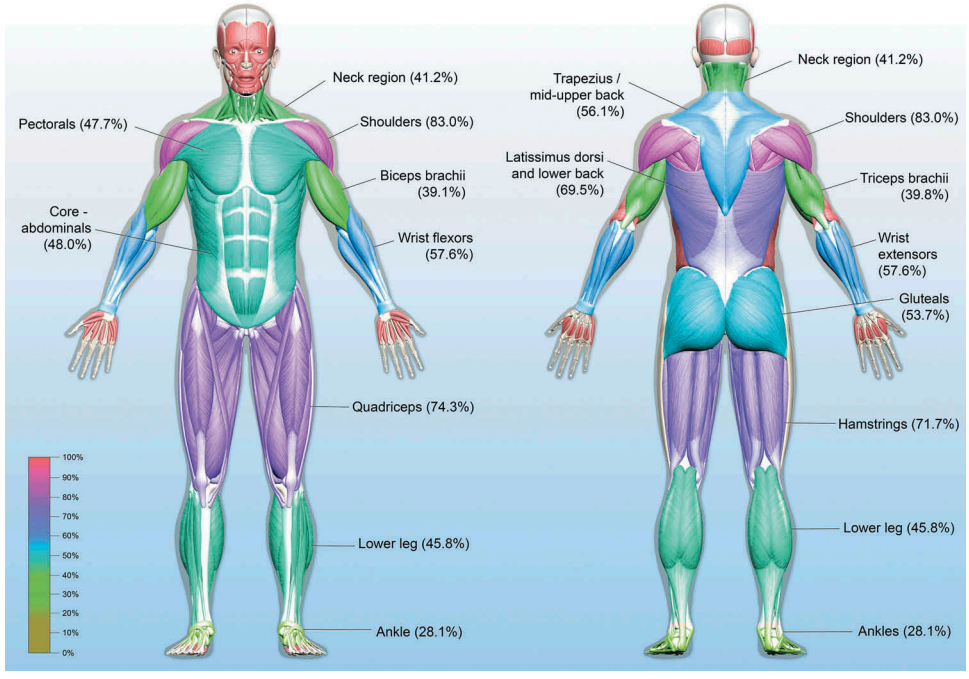


Figure 4. The percentage of high-skilled golfers (n = 422) targeting each body segment within their warm-up protocol.

(72.79%) when compared to playing a TR (65.58%) (Figure 6). Within each context, golfers favoured "Static stretches" over any other cool-down protocol (RS = 19.53%; PR = 15.12%; TR = 19.53%). A Greenhouse-Geisser correction showed no significant main effect for cool-down duration between the three contexts.

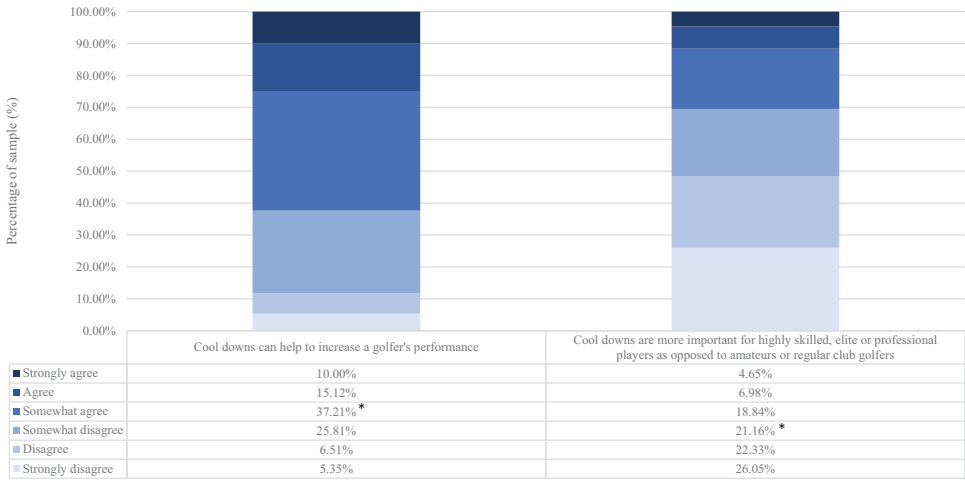
Targeted muscles

These high-skilled golfers indicated that the three most common muscles/regions of the body targeted during cool-downs were the quadriceps (73.08%) the hamstrings (71.79%) and the latissimus dorsi/lower back (67.95%) (Figure 7).

Strength & conditioning

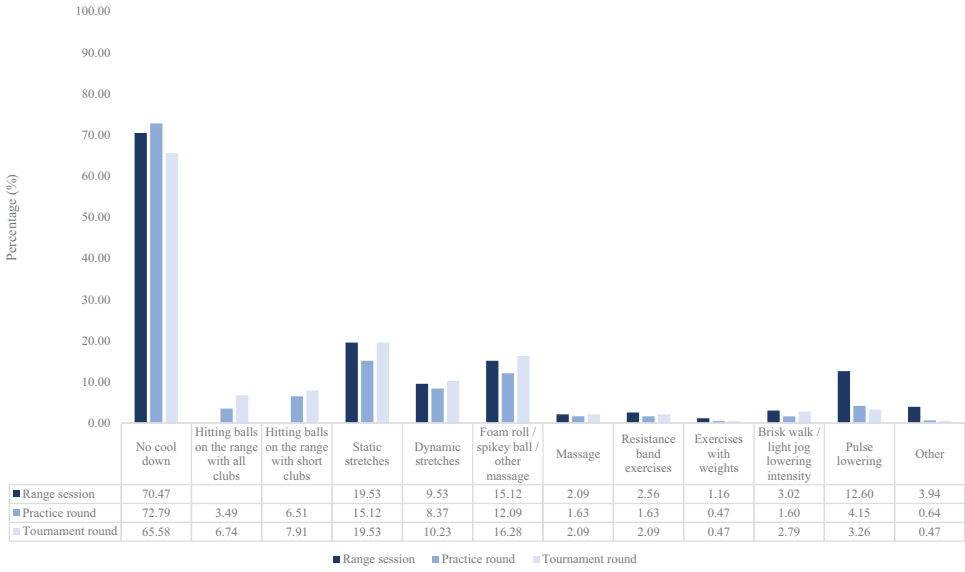
Perceptions

Median statistics revealed that participants "disagreed" that "golfers should avoid resistance training as it can reduce flexibility" (median = 29.53%). Participants "somewhat agreed" that "training in the gym should replicate the movements of the golf swing as closely as possible" (median = 35.58%); however, they "disagreed" that training in the gym should be asymmetrical to reflect the golf swing (median = 24.65%). Golfers also "somewhat disagreed" that both "resistance training can increase the risk of injury to the golfer" (median = 25.35%) and gym-based training is



	Cool downs can help to increase a golfer's performance	Cool downs are more important for highly skilled, elite or professional players as opposed to amateurs or regular club golfers
Strongly agree	10.00%	4.65%
Agree	15.12%	6.98%
Somewhat agree	37.21% *	18.84%
Somewhat disagree	25.81%	21.16% *
Disagree	6.51%	22.33%
Strongly disagree	5.35%	26.05%

Figure 5. Perceptions of cool downs for golf.
N.b. * = median for each item on Likert scale



	No cool down	Hitting balls on the range with all clubs	Hitting balls on the range with short clubs	Static stretches	Dynamic stretches	Foam roll / spikey ball / other massage	Massage	Resistance band exercises	Exercises with weights	Brisk walk / light jog lowering intensity	Pulse lowering	Other
Range session	70.47			19.53	9.53	15.12	2.09	2.56	1.16	3.02	12.60	3.94
Practice round	72.79	3.49	6.51	15.12	8.37	12.09	1.63	1.63	0.47	1.60	4.15	0.64
Tournament round	65.58	6.74	7.91	19.53	10.23	16.28	2.09	2.09	0.47	2.79	3.26	0.47

Figure 6. Cool-down practices for golf following RS, PR and TR contexts.

more important for highly skilled/professional golfers as opposed to amateurs (median = 19.77%) (Figure 8).

Practices

Of the 430 golfers, 326 (75.81%) were engaging in S&C all year round, an additional 30 (6.98%) solely train in the off-season and 9 (2.09%) solely train in the tournament season. Of those engaging in S&C, an average of 3.38 ± 1.52 sessions were conducted per week during the off-season and 2.47 ± 1.37 during the tournament season. During these sessions, golfers reported using between 8 and 12 reps most commonly (n = 239; 73.31%), followed by 1–5 reps (n = 68; 20.86%), 15+ reps (n = 30; 9.20%), "I usually lift until I can't perform any more repetitions" (n = 13; 3.99%), "I usually lift the same resistance for the same amount of repetitions as the last session" (n = 4; 1.23%). The most common S&C modalities employed by these high-skilled golfers varied across the year; "flexibility and stretching" was reported as the most commonly used modality during the "in-season" (*n* = 43) and "all year" (*n* = 227) periods, and "fitness training – but not for golf" the most commonly used modality during the "off-season" period (Figure 9).

Of the 326 golfers engaging in S&C, 299 have had a session with an S&C coach/fitness instructor. The most frequently reported qualifications of these S&C coaches/fitness instructors comprised a degree in a relevant field (*n* = 150), followed by a gym instructors' certificate (*n* = 107), an S&C certificate (*n* = 97), Titleist Performance Institute certification (*n* = 82), with some of the golfers unsure of the S&C coaches' qualifications (*n* = 62).

Results indicated that the reason golfers were most attracted to work with the S&C coach/fitness instructor were

(1) They have previously worked with golfers (22.86%)
(2) Their understanding of the golf swing (18.10%)

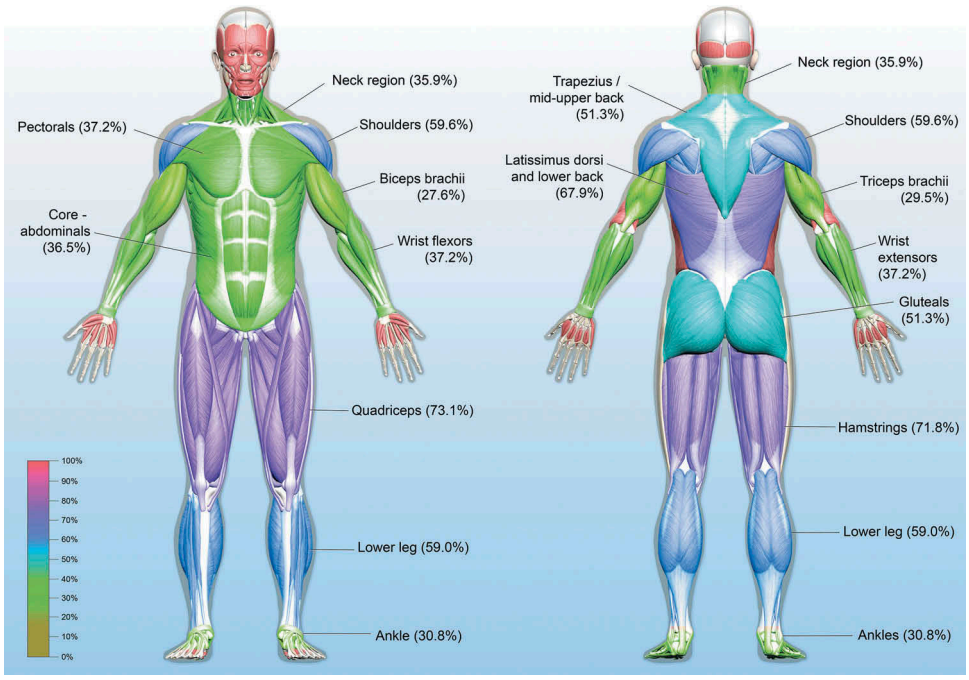
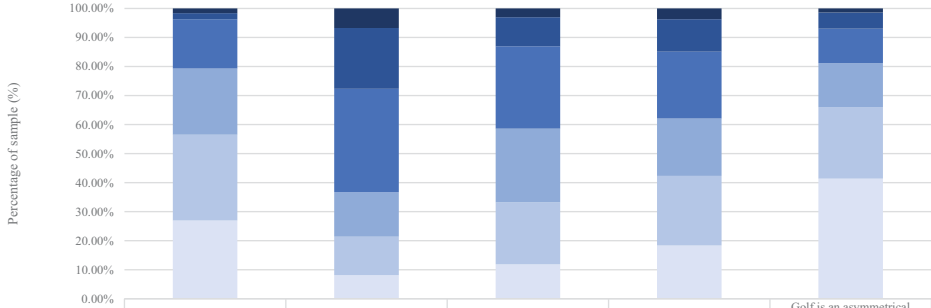


Figure 7. The percentage of high-skilled golfers (n = 163) targeting each body segment within their cool-down protocol.



	Golfers should avoid resistance training (e.g. exercises with weights) as it can reduce the flexibility needed for golf	Training in the gym should replicate the movements of the golf swing as closely as possible (i.e. exercises look like parts of the golf swing)	Resistance training can increase the risk of injury to the golfer	Gym based training is more important for highly skilled, elite or professional players as opposed to amateurs or regular club golfers	Golf is an asymmetrical sport (only hitting one-way i.e. played left or right handed), therefore gym based training should also be asymmetrical
Strongly agree	1.63%	6.74%	3.02%	3.72%	1.40%
Agree	2.09%	20.93%	10.00%	11.16%	5.58%
Somewhat agree	16.98%	35.58% *	28.37%	23.02%	11.86%
Somewhat disagree	22.79%	15.35%	25.35% *	19.77% *	15.12%
Disagree	29.53% *	13.26%	21.40%	23.95%	24.65% *
Strongly disagree	26.98%	8.14%	11.86%	18.37%	41.40%

Figure 8. Perceptions of S&C for golf.

N.b. * = median for each item on Likert scale

(3) Their qualifications (16.51%)
(4) They're based at my gym/club (14.29%)
(5) They're a friend of mine (10.79%)
(6) My swing coach recommended that I see them (10.79%)
(7) Another reason (5.08%)
(8) They are also my golf coach (1.59%).

Targeted muscles

During their S&C training, these high-skilled golfers indicated that the three most common muscles/regions targeted were the quadriceps (88.22%), the abdominals (83.84%) and the hamstrings (81.10%) (Figure 10).

Discussion

The aim of this study was to survey high-skilled golfers' "perceptions" and "practices" towards "Sports Science for Golf", "Warming-up for Golf", "Golf Cool-down" and "Strength and Conditioning for Golf".

Sports science for golf

The findings of this study indicated that these high-skilled golfers perceive that the use of sports science (as an overarching discipline) helps to both improve golf performance and reduce the risk of injuries (Figure 1). Despite this, the

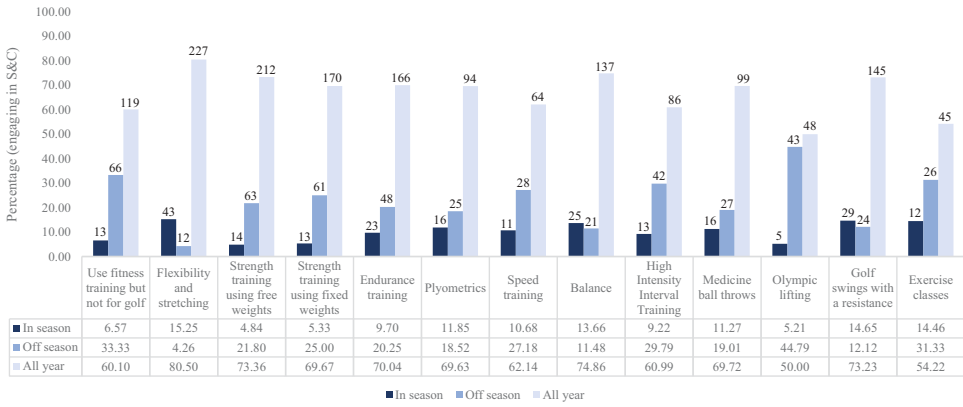


Figure 9. The different S&C modalities performed by participants in-season, off-season and all year round.

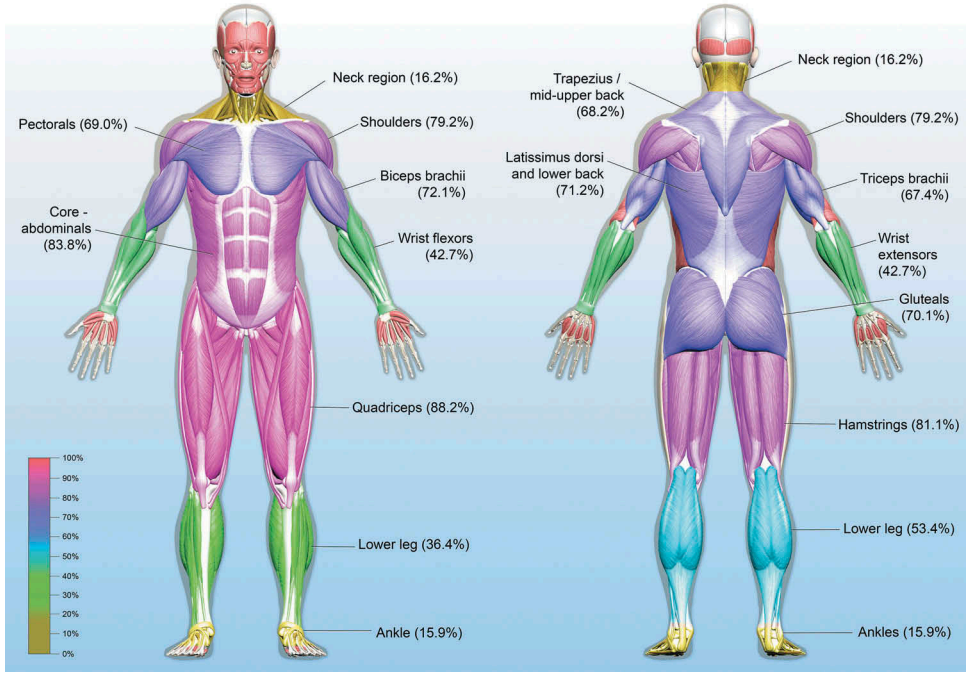


Figure 10. The percentage of high-skilled golfers (n = 326) targeting each body segment within their strength and conditioning programme.

high-skilled golfers indicated that they only "somewhat agree" that sports science is being used in their golf club settings. However, it is plausible to suggest that they do not yet fully comprehend where aspects of sports science are being used, or that they do not have influence over the implementation of specific sports science disciplines at their golf club. In addition, there appears to be a greater tendency for golf coaches to omit physical assessment during their lessons which, if undertaken, could aid their understanding of golfers' physical limitations. Results also show that a PAR-Q is not being completed by every golfer who attends coaching sessions. On a practical level, this not only has potential implications for insurance, it could also limit the benefit golfers are receiving from coaching sessions. In this situation, coaches may be unable to plan effectively to meet the needs of the golfer without taking account of any physical or medical constraints each individual may have. Having an understanding of a golfer's injury history and physical limitations will allow a golf coach to address those swing characteristics/faults that are within the physical capabilities of the golfer to amend (Langdown, 2015). This would suggest that there is an inherent need for researchers to carefully consider the practical applications of sports science to the end user. Furthermore, coach education for PGA Assistant Professionals can, and is, addressing these issues through The PGA's education programmes. This will allow coaches and supporting professionals to understand when and where they may implement sports science within their coaching setting.

Warming-up for golf

The median rating of "strongly agree" suggests that there is a general perception from these high-skilled golfers that warming-up brings about performance benefits (Figure 2). This perception is supported by the high-skilled golfers practices given that a low percentage of the sample indicated that they performed "no-warm-up" prior to the RS (5.35%), PR (8.14%) and TR (3.26%). These findings are in contrast to Fradkin et al. (2003) who suggested that 70% of the golfers surveyed reported that they "never or seldom warmed-up". This is part could be due to their sample were of alower skill (with only 5.8% between 0 and 10 handicap) when compared to the current study, or this could be due to a possible cultural shift due to the practices of elite players and the findings of empirical evidence since 2003. Indeed, experimental research has highlighted significant improvements in CHV (Moran et al., 2009), BV (Langdown et al., 2019; Moran et al., 2009) and drive distance (Tilley & Macfarlane, 2012) following dynamic stretches. However, to the authors' knowledge, there is currently no evidence supporting or refuting the effects a warm-up has on putting performance and the mental aspects for golf, and as such, further research is required.

A theoretical framework was proposed by Jeffreys (2007) providing guidance for optimising performance. The "RAMP" protocol outlines the benefits of "raising" heart rates, "activating" key muscles, "mobilising" joints and to "potentiate" prior to engaging in the sport. Although there was a wide variety of warm-up protocols conducted across each of the golfing contexts, the high-skilled golfers' warm-ups were mainly based on technical components (i.e., the use of a club). Dynamic stretches were the most utilised single component during the RS (66.74%), PR (54.65%) and TR (61.63%). It is also important to recognise that static stretching was commonly utilised by these high-skilled golfers within their RS (59.30%), PR (46.98%) and TR (54.42%) protocols suggesting that further education is required. Static stretching has been evidenced to significantly reduce CHV, CD, shot accuracy and consistent club-ball contact (Gergley, 2009). Based on these results, it is plausible that high-skilled golfers perceive static stretching to be beneficial for their game, which is not a notion supported by research. High-skilled golfers spent a significantly greater mean duration warming-up prior to a TR compared to the PR and RS. This is plausible given that there is likely a perception that tournament rounds are "more important" than both a PR and RS. It should also be noted that the RS omitted any golf shots played as part of the warm-up as this is the purpose of the session. This therefore explains the significant difference here. During the warm-ups, the shoulders were the most targeted region (82.97%), which matches the findings of Fradkin et al. (2001) (73.2%).

Athlete monitoring protocols, such as RPE scales, should be used to ensure warm-up durations and intensity do not impact upon levels of fatigue. The discrepancies in duration observed in this study (especially between PR and TR), along with the exercise selection highlight the importance of coaches collaborating with an S&C coach to design an appropriate and validated (e.g., with a launch monitor) warm-up protocol to utilise prior to both play and practice. With a number of golfers indicating that they perform no warm-up in the three contexts, a launch monitor or performance validation may facilitate further buy in from golfers to subsequently engage in warm-up protocols. Further still, education bodies should endeavour to help coaches immerse themselves in, and apply the research findings from studies validating preferential warm-up protocols.

Cool-down following golf

Professional tournaments can last up to 4 days, and amateurs sometimes compete over 36 holes on consecutive days. Despite a slightly greater percentage of the high-skilled golfers performing some form of cool-down during TR, these high-skilled golfers tended to "somewhat disagree" that cool-downs were beneficial for performance. However, participants generally disagreed that it is more important for Professionals or Elite players to engage in a cool-down (as opposed to amateurs). This, in part, could be due to the perception that a cool-down provides little benefit to performance, or that they do not feel the amateurs should be seen as "different" to professional/elite players. There were no significant differences in the time golfers spend cooling down between RS, PR and TR. This is likely due to the fact that a vast majority of golfers do not perform a cool-down following each of these contexts (Figure 6). Lactate responses of 0.8–1.1 mmol/L have been reported following an 18 hole round which are the equivalent to those observed during resting (Unverdorben et al., 2000). Additionally, a recent review questioned the benefits of performing a cool-down, with little evidence supporting the notion that cool-downs positively impact muscle damage, contractile properties, musculotendinous stiffness and range of movements following a cool-down (Van Hooren & Peake, 2018). Whether a conscious decision in response to research findings or due to a general omission of a cool-down, the practices of the high-skilled golfers appear appropriate.

S&C for golf

The authors presented a number of commonly held misconceptions within the golf industry. As such, the 'ideal' response would be to be 0 (strongly disagree) for all of these statements, therefore, anything greater than this would indicate that these misconceptions still exist. Whilst there is evidence that some participants appreciate these as misconceptions, education continues to be required in the area of S&C for golf to ensure research findings are disseminated widely to the golf coaches and subsequently the golfers playing and training for the sport. Previous research has indicated that 46% of 251 golf coaches "disagreed" or were unsure whether golfers need to be fit to play golf (Evans & Thomas, 2012). In contrast, 78.51% of the current sample (many of whom will be future PGA Professional golf coaches) engaged in some form of S&C. It is interesting to note that there appeared to be a pattern regarding the muscles targeted during the high-skilled golfers S&C sessions. Specifically, there was a greater emphasis on targeting the more proximal muscles/regions in the body (quadriceps = 88.22%, abdominals = 83.84%), hamstrings = 81.10%, latissimus dorsi and lower back = 71.23%),

with reduced emphasis on the more distal muscles/regions (wrist flexors and extensors = 42.74%, lower legs = 36.44%, neck = 16.16%, ankles = 15.89%). Evidence has suggested that the thoracic (20.6% of the sample) and lumbar (21.1%) were amongst the most common site of injury within elite level golfers (Smith & Hillman, 2012). As such, it may be that these high skilled golfers are targeting these muscles/regions in order to provide protection against injury risk. However, it is also evident that the cervical (24.9% of the sample; Smith & Hillman, 2012) and the wrists (30% of the sample; Hawkes et al., 2013) are also exposed to a high incidence of injury within elite golfers. As such it is important that distal muscles/regions aren't neglected when engaging in S&C.

Research within golf has demonstrated that engaging in S&C can increase flexibility rather than decrease it (Hetu et al., 1998) as perceived by 20.70% of this current study's participants. A common misconception in golf is that S&C training needs to replicate the golf swing under load, this was evident in this study with 63.25% of participants agreeing with this misconception to some extent (Figure 8). To date, there is no evidence that supports the suggestion that interventions that mimic the golf swing provide greater enhancements to drive performance (e.g., CHV and CD), or indeed other aspects of performance, than exercises that do not replicate the swing. In this regard, significant improvements have been observed in CHV and/or CD from engaging in an 8-week S&C programme (Doan et al., 2006; Fletcher & Hartwell, 2004; Oranchuk et al., 2018). These studies all incorporated "traditional" resistance training (e.g., squat and deadlift variations, bench press and bent over row), therefore, until further research suggests otherwise, the need to replicate the golf swing in a S&C programme would appear to be an unsubstantiated misconception. When engaging in an S&C session, these high-skilled golfers indicated that they usually work between a repetition range of 8–12 reps, which is representative of a hypertrophy loading zone (depending on the % of repetition maximum lifted). Whilst it is important to recognise that golfers may utilise varying repetition ranges depending on the design of their programme, it would be inherently beneficial to liaise with S&C coaches to ensure that a well suited and individualised programme is structured to meet the needs of the golfer. Further still, during the off season, the most commonly selected training modality was "fitness training – but not for golf". Again, this advocates forming links with S&C coaches in order to carefully consider a periodised training programme to facilitate golfers' performance during the in-season.

Another well held misconception is that "Resistance training can increase the risk of injury to the golfer". It can be argued that the opposite is true with the aim of S&C to increase resilience/resistance to injury. Lauersen et al. (2014) evidenced that strength training reduced sports injuries to less than 1/3, with overuse injuries nearly halved. The high-skilled golfers "somewhat disagreed" that resistance training can increase the risk of injury. It is important to recognise, however, that concerns remain given that 28.37% "somewhat agree", 10.00% "agree" and 3.02% "strongly agree" that resistance training can increase the risk of injury. This provides further support around the importance of education in supporting golf coaches and golfers. Of the 299 golfers engaging in S&C, the most commonly utilised exercises were flexibility, resistance training with free weights and resistance training with fixed weights (Figure 9). As such, there is a potential missmatch between the perception (41.39% selected "somewhat agree", "agree" or "strongly agree" with the injury misconception) and practices of the current sample. Therefore, it is important for evidenced-based education to be continued around the use of pertinent S&C modalities that have been evidenced to improve aspects of golfers' performances. This is reflected in other research where 84% of 251 golf coaches reported wanting to know more about physical fitness for golf (Evans & Thomas, 2012). Addressing this need for further education around S&C for golf may also help to alter the perception of S&C being more important for highly skilled, elite or professional golfers rather than regular club golfers. With 37.9% of the participants agreeing to this statement to some extent it is critical that education reinforces and disseminates findings that anyone can benefit from S&C.

Results from the 299 high-skilled golfers that reported to having a session with an S&C coach highlighted that the three most common reasons for working with an that coach were 1 = "they have previously worked with golfers", 2 = "their understanding of the golf swing", and 3 = "their qualifications". Therefore, it would be advisable for S&C coaches seeking to work with golfers, to conduct/understand a needs analysis of the game of golf, with a specific focus towards the mechanics of the swing and the demands of performance across the golfing year to allow successful periodised programming. Working in partnership with PGA Professionals not only facilitates opportunities for collaborative, multidisciplinary development of golfers, but raises the education experience of all parties concerned. Understanding the performance demands and how these can be influenced by ball flight, swing mechanics, a golfer's physiology and other variables can provide ultimate benefits to those being coached. Additionally, shadowing another S&C coach with experience of working with golfers may offer insights with regards the nuances of programming to meet the wants, needs, and motivations of golfers and continue to alter perceptions and practices of golfers in both gym and golf environments.

It is important to recognise that these findings are representative of high-skilled golfers' who are engaging in the PGA education programme. Given that the discipline of sports science is part of the education programme, these individuals perceptions and practices may differ to other high skilled golfers who are not exposed to this educational material. The sample is, however, reflective of individuals who are, most likely, going to coach and influence golfers' perceptions and practices in the future. As a result, the findings presented are inherently important given that these high skilled golfers are fundamental in the future implementation of sports science within the game of golf, and indeed, influencing other high skilled golfers' practices and perceptions.

Conclusion

The results of this study suggest that PGA Assistant Professionals (high-skilled golfers) perceived that the overarching discipline of sports science is beneficial for performance

whilst also reducing the risk of injury. However, there is the perception that the discipline of sports science is not being utilised within the coaching at every golf club. Whilst there also appears to be the perception that warm-ups are beneficial to various elements of golf performance, static stretches are a commonly utilised physical preparation strategy utilised by the golfers in this investigation. Based on the current evidence, it is recommended that dynamic stretching is used as part of a validated warm-up prior to both play and practice to increase buy in from golfers. Finally, despite over two-thirds of these high-skilled golfers engaging in S&C, some general misconceptions still exist that resistance training may lead to an increased risk of injury along with reduced flexibility. Given the results of this study, it is recommended that researchers and coach education providers collaborate to clearly emphasise and widely disseminate the true practical applications and benefits of the many facets of sports science to the individuals involved in both coaching and playing the sport of golf.

Disclosure Statement

The authors report no conflict of interest.

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