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## Elite Professional Golfers' Physical Preparation Practices and Perceptions

Authors:

**Sean R. White<sup>1</sup>, Daniel A. Coughlan<sup>2,3,5,6</sup>, Carly Wood<sup>1</sup>, Jack E. T. Wells<sup>2,3,4</sup>, Andrew Murray<sup>2,5,6,7</sup>, Simon L. Brearley<sup>2,3</sup>, Jason Moran<sup>1</sup>**

Affiliations:

- 1 School of Sport, Rehabilitation, and Exercise Sciences, University of Essex, Colchester, United Kingdom
- 2 European Tour Health and Performance Institute, European Tour Group, Virginia Water, UK
- 3 England Golf, Woodhall Spa, Lincolnshire, UK
- 4 Medical and Scientific Department, The R&A, St Andrews, UK
- 5 Cambridge Centre for Sport & Exercise Sciences, Anglia Ruskin University, Cambridge, UK
- 6 Health and Performance Institute, Ladies European Tour, Denham, UK
- 7 Medical and Scientific Department, The R&A, St Andrews, UK
- 8 UK Collaborating Centre for Illness and Injury Prevention (IOC Research Centre), University of Edinburgh, Edinburgh, UK.

## Abstract

Physical preparation for improving golf performance is a topic of rising interest. However, little is known of how advancements in empirical evidence have integrated with the practices and perceptions of elite professional golfers. To address this shortfall in knowledge, forty-nine (n = 32 European Tour, n = 17 Challenge Tour) professional golfers were surveyed on their physical preparation practices and perceptions. Additionally, golfers' in-tournament training practices were observed at the 148th Open Championship gym facility. The majority of surveyed golfers had experience of following a "structured resistance training plan" (89.8%). However, players face challenges to incorporate physical preparation throughout a tournament year. In-turn, the development of physical attributes including muscular strength, power and muscle mass known to underpin clubhead speed/driver distance, and the training methods typically required to stimulate such adaptations were often not prioritised during the in-season period. Limited engagement with heavy load and high velocity resistance training methods were observed at the Open Championship. However, in order to maximise their potential, players can enhance key physical qualities on a year-round basis (i.e. during the in-season). Consequently, further education and research on how to effectively organise and optimise resistance training within tournament constraints would be of value.

## Keywords

Golf, Strength & Conditioning, Periodisation, Clubhead Speed, Resistance Training

## Declaration of Interest Statement

The authors report there are no competing interests to declare. No external funding was received for this project, and there were no conflicts of interest relating to this study.

## Word Count

5538

## 1 1.1 Introduction

2 Recent advancements in empirical evidence have contributed to a greater acceptance of the role of  
3 physical preparation within the sport [1]. A considerable amount of research has now demonstrated  
4 that strength and conditioning (S&C) interventions can positively impact a golfers' clubhead speed  
5 (CHS) [2], and develop key physical attributes associated with high performance including muscular  
6 strength, power, impulse, and mass [2,3]. Likewise, various dynamic and resistance-based warm-up  
7 strategies have shown to significantly improve a golfers' short-term CHS and driver distance (DD)  
8 performances [4]. Anecdotally, many players now engage in physical preparation to improve their  
9 performance and reduce their risk of injury, which is supported by the philosophy implemented by  
10 the European Tour Health and Performance Institute (ETHPI) [5]. In support of this, a recent study  
11 investigated the sports science practices and perceptions of Professional Golfers' Association (PGA)  
12 Assistant Professionals (future-qualified coaches, n = 430). The authors reported some golfers  
13 perceived S&C as beneficial for performance and injury risk reduction, with most participants training  
14 year-round (75.81%) [6]. However, no empirical research has investigated how professionals  
15 competing at the highest level have integrated physical preparation strategies into their routines, and  
16 how they may navigate their training around extensive tournament schedules and throughout busy  
17 tournament weeks.

18 The season structure of a current touring professional golfer includes long competitive seasons. For  
19 example, the 2023 European Tour/DP World Tour season comprised 45 events, spanning five  
20 continents, and 26 separate countries, with tournaments being scheduled every month of the  
21 calendar year [7]. As a result, golfers are facing shorter off-season breaks in which to recuperate and  
22 establish physical goals for the subsequent competitive period, with the largest break between  
23 tournament scheduling for the DP World Tour often being less than one month. Currently, the typical  
24 touring professional will compete in 18 to 30 tournaments over the course of a year [8]. Each golfer's  
25 schedule is individually unique, with higher ranked players typically having greater choice in the events  
26 they play in, with more freedom to design their season structure [8]. In attempting to maintain their  
27 tour status or progress their ranking, lower ranked players may be required to play in more events  
28 and have more reactive schedules.

29 Tournament weeks are also intensive and depending on a player's level of success, they may compete  
30 on four consecutive days (Thursday to Sunday) with a minimum of two-tournament rounds if the  
31 player were to miss "the cut" (Thursday and Friday). Individual rounds span 4-6 hours of play, with tee  
32 off times which can range from 6.00 am to 3.00 pm. In the days preceding competition, golfers will  
33 need to familiarise themselves with the venue and engage in on and off course practice. Additionally,  
34 travel commitments and time zone changes between events are often significant. As such, the delivery

35 of optimal physical development strategies for a touring professional golfer is highly complex, and a  
36 greater understanding of how players may organise and approach their physical preparation  
37 throughout their annual training cycle is needed. Accordingly, the aims of this study were to  
38 investigate if physical preparation practices and perceptions of touring professionals align with  
39 scientific recommendations for the sport of golf and to explore how approaches and the barriers to  
40 engagement may vary between the in-season and off-season periods, as well as during tournament  
41 weeks within the in-season period.

## 42 1.2 Method

### 43 1.2.1 Survey Design

44 A survey was created using Qualtrics™ (Qualtrics, Provo, UT) and developed based on a review of the  
45 scientific literature pertaining to the use of physical preparation strategies for golf. Feedback was  
46 sought throughout the development of the survey from ETHPI S&C coaches with regards to the  
47 content, language used, and duration of the survey so as to maximise the content validity and ensure  
48 that the survey questions would be easily interpreted by players prior to distribution and data  
49 collection. Ethical approval was granted by the \*\*\*\*\* \*\* \*\*\*\*\* ethics Committee.

50 Survey questions followed three main topics relating to the golfers' 1) general physical preparation  
51 practices and perceptions, 2) practices and perceptions during the in-season and off-season periods,  
52 and 3) practices and perceptions during tournament weeks. All questions were either scaled multiple  
53 choice questions whereby a single response could be provided, or multiple-choice questions whereby  
54 more than one answer could be selected. Questions for which multiple answers could be selected also  
55 contained an 'other' response wherein participants could write an open text alternative response.  
56 Participants were directed to relevant follow-up questions based upon their responses to specific  
57 questions. The survey can be seen in the supplementary material section of this work with all  
58 questions and definitions written and distributed in English only.

### 59 1.2.2 Survey Questions

60 Questions related to players' general (Table 1), in-season and off-season (Table 2), and in-tournament  
61 physical preparation (Table 3) can be found in the respective tables. Each table details the specific  
62 questions asked, outlines the range of responses available to players, and describes the process by  
63 which players were prompted to provide follow-up answers. For all questions relating to training  
64 activities (questions 10, 11, 17 and 19), examples were provided for clarity. Examples included: heavy  
65 load/low volume (HL/LV) resistance training (RT) (e.g. 3x3 back squats at 85% 1RM), low load/high  
66 volume (LL/HV) RT (e.g. 3x10-15 lunges), weighted explosive training (e.g. weighted squat  
67 jumps/ballistic bench-press throws), bodyweight explosive training (e.g. box jumps / explosive press-  
68 ups), resistance-band exercise (e.g. shoulder rotations / crab walk), aerobic exercise (e.g. running /

69 cycling / swimming), proprioception (e.g. balance / co-ordination / movement quality), and mobility  
70 (e.g. range of motion exercise / stretching). Examples were constructed through pre-existing  
71 knowledge, and through consultation with ETHPI S&C coaches. For the purposes of this survey, RT was  
72 defined as any form of active exercise in which a muscular contraction is resisted by an external force,  
73 applied manually, mechanically, or by gravity [9].

#### 74 1.2.3 Survey Recruitment

75 The survey was primarily distributed online to all registered European Tour Players via direct email on  
76 the 24th June 2019. The email provided detail on the purpose of the survey and contained a unique  
77 link to the questions and was distributed via the Tour's player relations services. The survey was  
78 further promoted by ETHPI staff members to European Tour players throughout tournaments  
79 commencing between the 24th June 2019 to 20th July 2019, and to Challenge Tour players at  
80 tournaments between 2nd August 2019 to 3rd September 2019. During the tournaments, the survey  
81 was made available to all competing players. All survey responses were anonymised, and participants  
82 gave their informed consent after reading a survey information sheet. Partially completed surveys  
83 were also incorporated in the analysis.

#### 84 1.2.4 In-tournament Observation

85 Following ethical approval granted by the \*\*\*\*\* \*\* \*\*\*\*\* Ethics Committee, information was  
86 distributed regarding the onsite gym facility usage at the 148th Open Championship at Royal Portrush,  
87 Northern Ireland 2019. The tournament took place between the 18th and 21st July 2019, with 156  
88 players entered to compete [10]. Data were collected with the use of observational records completed  
89 by ETHPI staff members at the championships fully equipped gym. The gym was exclusively accessible  
90 to Open Championship players, with no other facilities available at the venue. The observational  
91 records were split between staff observing players' training habits from 6am-1pm and 1pm-9pm on  
92 Wednesday 17th and Thursday 18th July 2019. Data were anonymised with staff members recording  
93 each entry to the gym. Staff members also observed the nature of gym usage, with each exercise  
94 recorded to the most appropriate exercise modality from a pre-determined list. The pre-determined  
95 list included both exercise modality names and examples for reference and was constructed through  
96 pre-existing knowledge and through consultation with ETHPI S&C coaches. The observational record  
97 sheet can be seen in the Supplementary material.

### 98 1.3 Statistical Analysis

#### 99 1.3.1 Survey

100 Descriptive and frequency analysis for each question were conducted and analysed using SPSS  
101 statistics (Version 28.0, SPSS Inc. Chicago, IL, USA) for Microsoft windows. Results are presented as  
102 the absolute volume of responses and as percentages. Median response and standard deviation are

103 provided for scaled responses, with individual tables highlighting the range of each scale. The mean,  
104 median, and standard deviation are reported for the number of answers selected, for multiple-choice  
105 questions wherein multiple answers could be selected. Direct comparisons between in-season and  
106 off-season practices and perceptions were made with descriptive and frequency analysis. Partially  
107 completed responses wherein answers were not recorded for both in-season and off-season questions  
108 were removed from the analysis so as to draw direct comparisons. A Wilcoxon Signed Ranked test was  
109 used to compare in-season and off-season practices and perceptions. Specifically, the median number  
110 of weekly RT sessions reported between the in-season and off-season, and the number of multiple-  
111 choice answers selected for questions pertaining to participants' key training goals during the in-  
112 season/off-season, and participants self-regarded prioritised training modalities in-season and off-  
113 season. The Alpha level was set at 0.05.

#### 114 1.3.2 In-tournament Observation

115 The results are presented as the absolute number of gym entries each day, and were expressed as a  
116 percentage of the number of players entered to compete in the tournament (n = 156) [10]. The volume  
117 of engagement in categorised training modalities was also recorded and expressed as a percentage in  
118 relation to the number of players entering the gym.

### 119 1.4 Results

120 A total of forty-nine survey responses were collected, with forty-five full responses and four partially  
121 completed responses (13-84% completion). Twenty-nine full responses were obtained from European  
122 Tour professionals, with three partially completed responses. Sixteen full responses were recorded  
123 from Challenge Tour professionals, with one partially completed response. Eleven participants started  
124 but did not submit a response for any question.

#### 125 1.4.1 General Physical Preparation

126 Participant responses to questions relating to their general physical preparation practices and  
127 perceptions are shown in Table 1. Descriptive statistics indicated that the majority of surveyed golfers  
128 had historically followed a structured RT plan, with the median response being "4+ years" (57.1%).  
129 The most frequently reported reasons for having not had experience (n = 5, 10.2%) were due to: "time  
130 constraints" (60.0%), "fatigue"(40.0%), "fear of injury" (40.0%) and they "would rather practice golf"  
131 (40%). The most commonly selected reasons for engaging with RT were to: "improve strength"  
132 (93.0%), "stay healthy" (83.7%), and "improve power" (81.4%).

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**Table 1.**  
Surveyed Golfers General Physical Preparation Practices and Perceptions.

Question	Choice Selection	Responses (n)	%	Number of Responses Selected (mean ± SD)
<i>Q1</i>	<i>Single Choice</i>	<i>49 Total</i>		
How many years have you followed a structured RT plan for?	I haven't	5	10.2%	1.0 ± 0.0
	0-1 year	4	8.2%	
	1-2 years'	2	4.1%	
	2-3 years'	5	10.2%	
	3-4 years'	5	10.2%	
	4+ years'	28	57.1%*	
<i>Q2</i>	<i>Multiple Choice</i>	<i>5 Total</i>		
Why do you not follow a RT plan? (Follow-up Q1, if "I haven't" was selected)	Time constraints	3	60.0%	2.2 ± 0.8
	Fatigue	2	40.0%	
	Would rather practice golf	2	40.0%	
	Fear of injury	2	40.0%	
	RT will not improve golf performance	1	20.0%	
	Lack of facilities	1	20.0%	
	RT will worsen golf performance	0	0.0%	
	Other	0	0.0%	
<i>Q3</i>	<i>Multiple Choice</i>	<i>44 Total</i>		
Why do you resistance train? (Follow-up Q1, If "I haven't was not selected)	Improve strength	40	93.0%	6.4 ± 2.2
	Stay healthy	36	83.7%	
	Improve power	35	81.4%	
	Improve flexibility	30	69.8%	
	Improve balance/co-ordination	29	67.4%	
	Improve swing technique	28	65.1%	
	Improve CHS/DD	27	62.8%	
	Improve cardiovascular fitness	20	46.5%	
	Increase muscle mass	19	44.2%	
	Decrease body fat	9	20.9%	
	Other	0	0.0%	

*%= Percentage of participants responses, \*= Indicates the median response, RT= resistance training, CHS = clubhead speed, DD= Driver distance*

136 1.4.2 In-season and Off-season Physical Preparation

137 Participant responses to questions relating to their in-season and off-season physical preparation  
 138 practices and perceptions are shown in Table 2. Descriptive statistics indicated that surveyed golfers  
 139 were more likely to resistance train in the off-season (89.4%) compared to in-season (76.1%). Golfers  
 140 would only "sometimes" resistance train in the off-season (n = 11; 23.9%) due to: "time constraints"  
 141 (72.7%), "fatigue" (63.6%), "lack of facilities" (63.6%), and because they "would rather practice golf"  
 142 (54.4%). Comparatively, during the off-season golfers would only "sometimes" (n = 5, 10.6%)  
 143 resistance train due to "time constraints" (60.0%), and "fear of injury" (60.0%). Results of the Wilcoxon  
 144 Signed Ranked test revealed a significant difference between participants weekly RT frequencies (Z =  
 145 -5.647, p < 0.001), with a median training frequency of "4 times" per week (43.5%) during the off-  
 146 season and only "2 times" per week (39.1%) in-season.

147 No statistically significant difference between the volume of answers selected detailing players  
 148 prioritised training activities during the in-season and off-season periods were observed (Z = -1.342, p  
 149 < 0.180). However, the most commonly selected training modalities varied. For example, "heavy



150 load/low volume” (HL/LV) RT was commonly perceived to be a training priority in the off-season  
 151 (67.4%), but not during the in-season (32.6%). Other training modalities including “low load/high  
 152 volume” (LL/HV) RT, “weighted explosive training” and “aerobic exercise” were also more commonly  
 153 perceived as a priority during the off-season, whereas “resistance-band exercise”, “proprioception”,  
 154 and “mobility” were more frequently perceived to be training priorities in-season. The results of the  
 155 Wilcoxon signed ranked test revealed that golfers selected a significantly greater number of key  
 156 training goals during the off-season compared to the in-season ( $Z = -4.060$ ,  $p < 0.001$ ). Players most  
 157 commonly reported improving “strength” (91.3%), “power” (78.3%), and to “stay healthy” (71.3%) as  
 158 their key training goals in the off-season, whereas “maintenance” (84.4%) of condition, and to “stay  
 159 healthy” (80.4%) were most commonly selected for the in-season. Fewer participants regarded  
 160 increasing “muscle mass” (13.0%; 54.4%) and improving “strength” (52.2%; 91.3%), “CHS/DD” (23.9%;  
 161 60.9%), “power” (50.0%; 78.3%) and “cardiovascular fitness” (23.9%; 37.0%) as key training goals  
 162 during the in-season period when compared to the off-season.

**Table 2.**  
 In-season and off-season physical preparation practices and perceptions

Question	Choice selection	Off-season			In-season		
		Responses (n)	%	Number of Responses Selected (mean ± SD)	Responses (n)	%	Number of Responses Selected (mean ± SD)
<i>Q4 &amp; 5</i>		<i>47 Total</i>			<i>46 Total</i>		
Do you resistance train during the off-season/in-season?	Yes	42	89.4%*	1.0 ± 0.0	35	76.1%*	1.0 ± 0.0
	Sometimes	5	10.6%		11	23.9%	
	No	0	0.0%		0	0.0%	
<i>Q6 &amp; 7</i>		<i>5 Total</i>			<i>11 Total</i>		
Why would you not train during the off-season/in-season? (Follow-up Q4 & 5 if “yes” was not selected)	Time constraints	3	60.0%	2.6 ± 1.1	8	72.7%	2.9 ± 1.4
	Fatigue	2	40.0%		7	63.6%	
	Lack of facilities	2	40.0%		7	63.6%	
	Would rather practice golf	2	40.0%		6	54.5%	
	Fear of injury	3	60.0%		3	27.3%	
	Won’t improve performance	1	20.0%		1	9.1%	
	Will worsen Performance	0	0.0%		0	0.0%	
Only train during the in-season/off-season	0	0.0%		0	0.0%		
Other	0	0.0%		0	0.0%		
<i>Q8 &amp; 9</i>		<i>46 Total</i>			<i>46 Total</i>		
How many times do you resistance train per week during the off-season/in-season?	1 time	1	2.2%	1.0 ± 0.0	8	17.4%	1.0 ± 0.0
	2 times	3	6.5%		18	39.1%*	
	3 times	10	21.7%		12	26.1%	
	4 times	20	43.5%*		6	13.0%	
	5 times	5	10.9%		1	2.2%	
	6 times	7	15.2%		1	2.2%	
	7+ times	0	0.0%		0	0.0%	

(Follow-up Q4 & 5 if “no” was not selected)

Q10 & 11	Multiple choice	46 Total			46 Total		
Which of the following fitness activities do you prioritise during off-season/in-season training? (Follow-up Q4 & 5 if “no” was not selected)	HL/LV RT	31	67.4%	4.2 ± 1.9	15	32.6%	3.8 ± 1.6
	LL/HV RT	23	50.0%		19	41.3%	
	Resistance-band exercise	18	39.1%		23	50.0%	
	Weighted explosive training	29	63.0%		25	54.4%	
	Bodyweight explosive training	24	52.2%		22	47.8%	
	Mobility	29	63.0%		33	71.7%	
	Proprioception	18	39.1%		23	50.0%	
	Aerobic exercise	18	39.1%		14	30.4%	
	Other	1	2.2%		0	0.0%	
Q12 & 13	Multiple Choice	46 Total			46 Total		
What are your key goals for training during the off-season/in-season? (Follow-up Q4 & 5 if “no” was not selected)	Improve strength	42	91.3%	6.3 ± 2.3	24	52.2%	5.0 ± 2.4
	Improve power	36	78.3%		23	50.0%	
	Improve flexibility	26	56.5%		27	58.7%	
	Improve balance/co-ordination	22	47.8%		20	43.5%	
	Improve cardiovascular Fitness	17	37.0%		11	23.9%	
	Improve swing technique	27	58.7%		24	52.2%	
	Improve CHS/DD	28	60.9%		11	23.9%	
	Increase muscle mass	25	54.4%		6	13.0%	
	Decrease body fat	11	23.9%		10	21.7%	
	Stay healthy	33	71.7%		37	80.4%	
	Maintenance	24	52.2%		39	84.4%	
Other	0	0.0%		0	0.0%		

*%= Percentage of participants responses, \*= Indicates the median response, HL/LV = heavy load/low volume, LL/HV = low load/high volume, RT= resistance training, CHS = clubhead speed, DD= Driver distance*

163 1.4.3 In-Tournament Physical Preparation

164 Participant responses to questions relating to their in-tournament physical preparation practices and  
 165 perceptions are shown in Table 3. Descriptive statistics revealed that 93.5% of players (n = 46)  
 166 reported that they would resistance train during their current tournament week. Monday to  
 167 Wednesday were the most commonly selected training days (50.0 – 58.7%), and Thursday (23.7%)  
 168 and Sunday (8.7%) were the least common. Players reported mixed perceptions, when asked whether  
 169 they would partake in a morning training session prior to an afternoon (1pm) tournament round, with  
 170 the median response being “might or might not” (23.9%). The most commonly selected justification  
 171 for not wanting to train was due to “fatigue” (66.7%), because they “will train another time” (43.6%),  
 172 due to “time constraints” (28.2%), and due to a “lack of facilities” (23.1%). When asked what activities  
 173 golfers would include in this session, mixed perceptions were reported with each of the proposed  
 174 training modalities being selected by at least 25.0% of players.

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**Table 3.**  
Self-reported in-tournament physical preparation training practices and perceptions.

		Responses (n)	%	Number of Responses Selected (mean ± SD)
<i>Q14</i>	<i>Multiple Choice</i>	<i>46 Total</i>		
Which days will you resistance train this week? (At current Tournament)	I Won't Train	3	6.5%	1.0 ± 0.0
	Monday	27	58.7%	
	Tuesday	26	56.5%	
	Wednesday	23	50.0%	
	Thursday	10	21.7%	
	Friday	19	41.3%	
	Saturday	19	41.3%	
Sunday	4	8.7%		
<i>Q15</i>	<i>Single Choice</i>	<i>46 Total</i>		
If you had a 1 pm tee time, would you train on the morning of the first round of golf?	Definitely yes	7	15.2%	1.0 ± 0.0
	Probably yes	8	17.4%	
	Might or might not	11	23.9%*	
	Probably not	14	14.0%	
	Definitely not	6	13.0%	
<i>Q16</i>	<i>Multiple Choice</i>	<i>39 Total</i>		
Why would you not train on the morning of the first round of golf? (Follow-up Q15 if "definitely yes" was not selected)	Fatigue	26	66.7%	2.3 ± 1.1
	Will train another time	17	43.6%	
	Time constraints	11	28.2%	
	Lack of facilities	9	23.1%	
	Will have a negative impact on performance	7	17.9%	
	Would rather practice golf	7	17.9%	
	Fear of injury	6	15.4%	
	Will not improve golf performance	4	10.3%	
	Only RT off-season	2	5.1%	
Other	1	2.6%		
<i>Q17</i>	<i>Multiple Choice</i>	<i>40 Total</i>		
Which of the following fitness activities would you include in this training session? (Follow-up Q15 if "definitely not" was not selected)	Mobility	29	72.5%	3.7 ± 1.5
	Resistance-band exercise	23	57.5%	
	Proprioception	21	52.5%	
	Body-weight explosive training	20	50.0%	
	Weighted explosive training	17	42.5%	
	LL/HV RT	14	35.0%	
	Aerobic exercise	11	27.5%	
	HL/LV RT	10	25.0%	
	Other	1	2.5%	

*%= Percentage of participants responses, \*= Indicates the median responses, HL/LV = heavy load/low volume, LL/HV = low load/high volume, RT= resistance training, CHS = clubhead speed, DD= Driver distance*

179 Participant responses to questions relating to their in-tournament warm-up practices and perceptions  
 180 are shown in Table 4. Descriptive statistics indicated that the majority of players would “definitely”  
 181 warm-up prior to the first round of golf at their current tournament. An average of  $3.7 \pm 1.2$  separate  
 182 exercise activities would be included in this warm-up, with the most commonly selected being:  
 183 “Hitting golf balls” and “mobility” (91.1%), followed by “proprioception” and “resistance-band  
 184 exercise” activities (60.0%). Only one (2.2%) player indicated that they would exclusively “hit golf  
 185 balls” during their warm-up.

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**Table 4.**

Self-reported in-tournament warm-up practices

Question	Choice Selection	Responses (n)	%	Answer selection (mean ± SD)
<i>Q18</i>	<i>Single choice</i>	<i>46 Total</i>		
Will you warm-up before the first round of golf? (At current tournament)	Definitely yes	43	93.5%*	1.0 ± 0.0
	Probably yes	3	6.5%	
	Might or might not	0	0.0%	
	Probably not	0	0.0%	
	Definitely not	0	0.0%	
<i>Q19</i>	<i>Multiple Choice</i>	<i>46 Total</i>		
Which of the following fitness activities will you include in this warm-up? (Follow-up Q18)	Hitting golf balls	41	91.1%	3.7 ± 1.2
	Mobility	41	91.1%	
	Resistance-band exercise	27	60.0%	
	Proprioception	27	60.0%	
	Body-weight explosive training	11	24.4%	
	Aerobic exercise	9	20.0%	
	Weighted explosive training	4	8.9%	
	LL/HV RT	4	8.9%	
	Other	2	4.4%	
	HL/LV RT	1	2.2%	

*%= Percentage of participants responses, \*= Indicates the median response, HL/LV = heavy load/low volume, LL/HV = low load/high volume, RT= resistance training, CHS = clubhead speed, DD= Driver distance*

187 1.4.4 In-Tournament Observation

188 A total of 72 gym entries were recorded on Wednesday accounting for 46.2% of the total players who  
 189 competed in the tournament (n = 156). Comparatively fewer entries were observed on the Thursday  
 190 in-line with the start of the tournament (20.5%). On the Wednesday, the most commonly observed  
 191 training activities from players observed to enter the gym were “mobility” (100.0%), “resistance-band”  
 192 (58.3%), “proprioception” (55.6%), and “LL/HV RT” (47.2%) exercises. Comparatively, fewer golfers  
 193 partook in all observed training modalities on the Thursday. Limited engagement was observed for  
 194 “HL/LV RT” (6.9%, 3.1%), “weighted explosive” (22.2%, 0.0%), and “bodyweight explosive” (22.2%,  
 195 0.0%) training activities on both the Wednesday and Thursday.

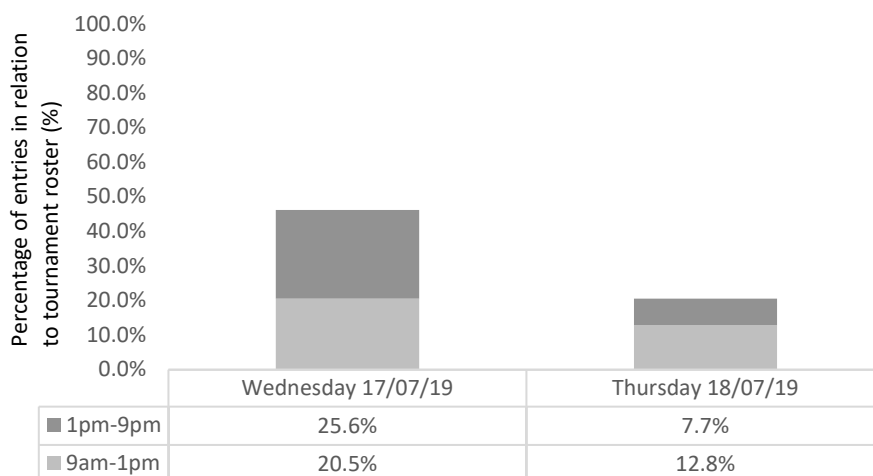


Figure 1. Recorded gym entries at the 148<sup>th</sup> Open Championship

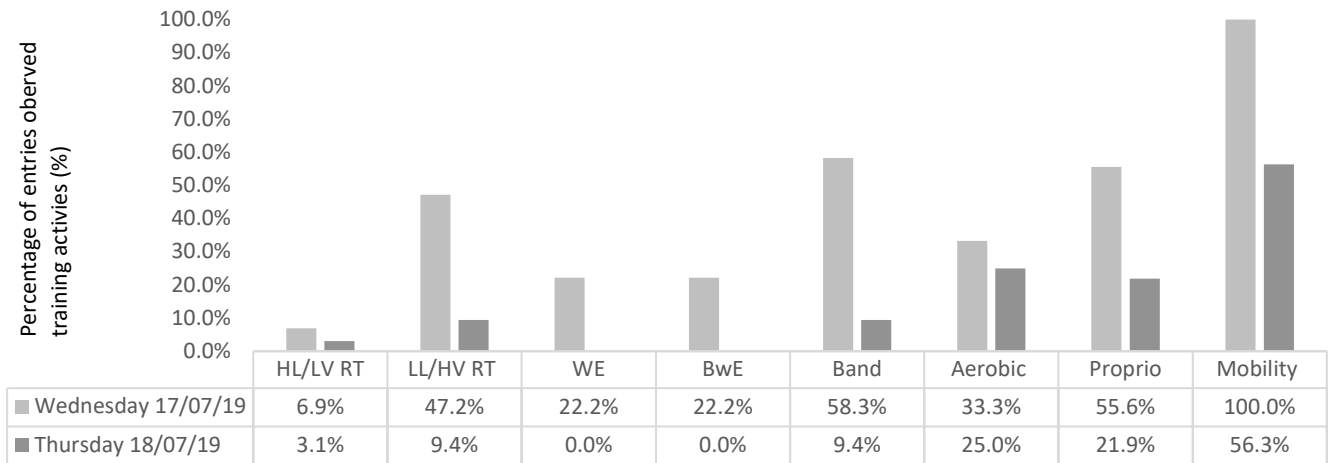


Figure 2. Recorded training activities at the 148th Open Championship gym facility

HL/LV RT = heavy load/low volume resistance training, LL/HV RT = Low load/high volume resistance training, Band = Resistance-band, WE = Weighted explosive BwE = bodyweight explosive, Proprio = proprioception.

196 1.5 Discussion

197 The aims of this study were to investigate whether elite professional golfers’ physical preparation  
 198 practices and perceptions aligned with scientific best practice within the sport and to explore players  
 199 approaches to physical preparation during the in-season and off-season periods, in-addition to during  
 200 tournament weeks.

201 1.5.1 General Physical Preparation

202 Physical preparation appears to be part of many elite professional golfers’ routines, with the majority  
 203 of players reporting having had experience following a structured RT plan (89.8%), RT both during the  
 204 in-season and off-season periods, warming-up prior to tournament rounds, and making use of gym  
 205 facilities during events. For the most part, players reasoning for engaging with RT also comply with  
 206 scientific recommendations. For example, the majority of players resistance train to “stay healthy”  
 207 (83.7%), complying with the principal recommendations from the ETHPI S&C service, whose primary  
 208 goal is to assist players in avoiding injury [5]. In their ‘probability of performance-impact model’  
 209 Brearley et al. [5] stated that the avoidance of injury (and illness) is likely to have the largest impact  
 210 on a golfers’ performance in allowing them to train and compete as frequently as they like, thus  
 211 resulting in a positive and indirect long-term performance effect. In keeping with scientific  
 212 recommendations, the majority of players also acknowledged the importance of RT for developing  
 213 muscular “strength” (93.0%) and “power” (81.4%). Muscular strength, impulse, and power qualities  
 214 have been shown to be the physical attributes with the strongest correlations with CHS [3], and  
 215 improvements in golfers CHS, distance, and associated strength and power qualities have been  
 216 observed to improve following RT interventions [11–14].

217 Currently, improving CHS and DD are the clearest and most researched means through which physical  
218 development may directly impact a golfers' performance [6]. Indeed, PGA Tour players' who drive the  
219 ball further are significantly more likely to achieve lower scores on par-4 and par-5 holes [15]. The  
220 importance of DD was also reported by Brodie [16], who showed that PGA Tour professionals who  
221 could drive the ball 20-yards further should save 0.75 strokes per round, equalling a reduction of three  
222 shots over the course of a typical four-day tournament. However, over a third of golfers did not regard  
223 improving "CHS/DD" as a reason for engaging in RT, and only 23.9% of players considered this to be a  
224 key training goal during the in-season period. Given the fine margins of success at the elite level of  
225 sport, it would however appear important for players to focus on their physical development to  
226 generate greater speed and distance in attempting to gain a competitive advantage over their  
227 opposition. Further player education may therefore be of value.

228 It has been suggested that physical preparation may play a key role in assisting a golfer to make a  
229 change in their swing technique [2]. This perception is common amongst surveyed golfers, with over  
230 two thirds of players engaging in RT to improve their "swing technique". While there is some evidence  
231 to support that changes in swing kinematics can amount from longitudinal S&C training interventions,  
232 this evidence is currently limited [5,17–19]. Considering the findings of this study, this highlights the  
233 need for further research in this area, particularly with regards to the kinematic and kinetic changes  
234 which may underpin developments in players CHS. A common perception among golfers, while not  
235 directly examined in this review, is that RT exercises performed in the gym should replicate the golf  
236 swing, perhaps to elicit a change in technique. Indeed, Wells et al. [6] reported that 63.25% of  
237 surveyed PGA Assistant Professional golfers agreed to some extent, with the statement that S&C  
238 training needs to replicate the golf swing under load. However, it has been recommended that the  
239 gym is likely not to be an optimal environment for rehearsing golf specific swing movements [5]. The  
240 primary focus, instead should likely be on enhancing physical capacities [5], such as muscular  
241 force expression, which have been identified through both associative analysis and S&C interventions  
242 as key to improving golf performance outcomes such as CHS/DD [2,20]. This may be particularly  
243 relevant, given that "time constraints" were commonly reported as a barrier to engagement in RT.  
244 However, adaptations in muscular force expression gained from such training may need to be coupled  
245 with technical training outside the gym environment to refine this capacity and apply it to the golf  
246 swing. For example, a golfer who improves their vertical force producing capacity in the lower limb,  
247 may also require technical refinement to effectively and efficiently transfer that force through the  
248 kinetic chain during the golf swing, to elicit increases in CHS [21].

249 The results of this study indicate that many golfers prioritise "proprioception" and "mobility" in their  
250 training and warm-ups, and train to improve "balance/co-ordination" and "flexibility" qualities. This is

251 not well supported by current empirical evidence, with poor relationships between balance and  
252 flexibility characteristics and golfers CHS having been observed [3,20,22], and a current lack of  
253 research demonstrating that development of such qualities in isolation can lead to improved golf  
254 performance outcomes [2]. For example, Ehlert. [20] reported in a systematic review with quantitative  
255 analysis that flexibility characteristics as a whole demonstrated only trivial correlations with CHS ( $r =$   
256  $0.03$ ; 95CI:  $-0.08, 0.14$ ), and in a sub-category analysis only small correlations were found for trunk  
257 rotation flexibility ( $r = 0.17$ ; 95CI:  $-0.26, 0.60$ ). This may partly be explained in that measures of passive  
258 flexibility appear to not adequately reflect the dynamic and fluent movement of the golf swing [20].  
259 With that being said, the importance of rotational ability should not be overlooked entirely, with the  
260 degree of separation between the hips and thoracic spine at the top of the backswing (i.e. X-factor),  
261 and the maximal X-factor that occurs as the hips rotate back towards to lead leg (X-factor stretch)  
262 recognised as important factors for generating CHS [21,23]. Comparatively, single leg balance ability  
263 has shown to be poorly related to measures of golf performance [22], likely as this does not reflect  
264 the specific balance demands of the golf swing. Indeed, given the task-specific nature of balance  
265 adaptations [133], it is questionable whether generalised balance or unstable surface training can  
266 effectively translate to improved golf performance outcomes.

#### 267 1.5.2 In-season and Off-season Physical Preparation

268 The results of this study indicate that there are large differences between golfers' approach to in-  
269 season and off-season physical preparation. Notably, it appears that while players consistently engage  
270 with physical preparation strategies, physical development is often not prioritised on a year-round  
271 basis. For example, the development of muscular "strength", "power", "muscle mass", and "CHS/DD"  
272 were commonly perceived as key training goals in the off-season, but not during the in-season.  
273 Instead, "maintenance" of condition was commonly prioritised in-season (84.4%). In accordance with  
274 other professional sports with long in-season periods such as rugby and soccer, it is common practice  
275 for athletes to aim to achieve a peak in their physical condition during their off-season preparation  
276 [24]. They will then subsequently aim to maintain their physical fitness during competition periods of  
277 up to 35 weeks duration [24]. However, with the limited time available for most touring golfers to  
278 develop upon key physical qualities aside from competitive commitments, the aspiration of  
279 maintenance of condition could be argued to be a poor in-season training goal. In order to maximise  
280 their potential, players can also focus on their physical development during the in-season period by  
281 maximising adaptations and reducing fatigue through the strategic programming of RT during  
282 tournament weeks.

283 Players prioritising their physical development solely in the off-season may indicate a misconception  
284 on the time course required for certain training adaptations to occur. For example, developing

285 “CHS/DD” and increasing “muscle mass” were commonly prioritised in the off-season (54.4%-60.9%),  
286 but not during the in-season (13.0%-23.9%). However, highly skilled golfers may require training of a  
287 longer duration, greater frequency, higher volume, and/or higher intensity to elicit increases in their  
288 physical capacities to contribute to CHS/DD [2]. For instance, Alvarez et al. [11] investigated the effects  
289 of a periodised RT intervention within a cohort of skilled golfers. The initial six-week strength phase  
290 was sufficient to elicit improvements in participants’ strength and power, but a further six-weeks of  
291 power training was required to enhance their driver performance. Likewise, muscle hypertrophy is  
292 often stated to take several weeks or months to develop [25]. Contributions to muscular force  
293 producing capabilities resulting from hypertrophy will often occur after eight-weeks of training  
294 [26,27], approximately twice the duration typically afforded for a break in DP World Tour players  
295 tournament scheduling. This further highlights the importance of physical development during the in-  
296 season period, or at least during strategically planned periods, to ensure that long-term training  
297 adaptations are achieved, and the risk of de-training is minimised. Players' reluctance may be partly  
298 attributed to the challenges of incorporating development strategies alongside their in-season  
299 commitments. As such, this issue will be explored in subsequent sections, with potential solutions  
300 proposed.

301 RT frequencies of 2-3 weekly sessions as performed by the majority of surveyed players (67.4%), have  
302 shown to be sufficient to develop a golfer’s CHS/DD and associated physical qualities [11,12,14,28],  
303 and may therefore enable players to progress their physical development during the in-season.  
304 However, this speaks nothing of the specific training methods being used, with the high intensity and  
305 velocity training methods required to elicit such adaptations often not being prioritised. Further to  
306 this, contradictions between players reported training goals and their prioritised training activities  
307 were evident. For example, It is generally accepted that improvements in strength are best achieved  
308 with lower repetition ranges of 1-5 repetition maximal (RM) exercises (HL/LV RT) [29,30]. While  
309 players acknowledged the importance of “HL/LV RT” methods in the off-season (67.4%), conflicting  
310 perceptions were reported in-season (32.6%) despite 52.2% of players seeking to develop their  
311 “strength”. Similarly, many players reported to not prioritise the high-velocity “explosive” training  
312 modalities (45.6% - 52.2%) during the in-season, which are typically required to develop an athletes’  
313 ballistic capabilities [31,32]. In-turn, even if a golfer were to enhance their muscular strength and  
314 power in the off-season, a lack of strength and power training during the in-season can result in de-  
315 training [33]. For instance, Ronnestad et al. [34] reported that a frequency of once weekly strength  
316 training was sufficient to maintain improvements obtained by professional soccer players during pre-  
317 season up to 12-weeks after. Comparatively, training only once every two weeks resulted in an  
318 average loss of 10% in participants 1RM strength.



319 1.5.3 In-tournament Physical Preparation

320 The significant barriers faced by touring professionals during tournaments may in-part account for the  
321 differences between player approaches to in-season and off-season physical development. For  
322 instance, players reported facing significant “time constraints” during the in-season period (72.7%)  
323 and consequently may benefit from education on how to effectively organise and adapt their RT  
324 throughout busy tournament weeks and dense schedules. A “lack of facilities” was also commonly  
325 considered as a barrier to engagement in RT. However, even when players had access to fully equipped  
326 facilities at the Open Championship, they were reluctant to engage with high-intensity and high-  
327 velocity training methods. Players’ reluctance to engage with such activities may therefore be  
328 attributed to the potential for reduced competitive performance levels resulting from neuromuscular  
329 “fatigue” [29], and increased muscle soreness and passive tension resulting from exercise-induced  
330 muscle damage (EIMD) [35]. As such, in professional sports it is common practice for S&C coaches to  
331 ensure adequate recovery between strength and power development sessions and competition is  
332 provided, with sessions typically being separated by 48 hours [36]. RT should therefore in most cases  
333 be prioritised earlier in the week to allow sufficient recovery before the first round of golf. Players are  
334 also advised to consider the nature and timing of their training sessions during the week, as research  
335 indicates that the most EIMD occurs when an exercise is novel, eccentrically oriented, and/or of a  
336 higher volume [35,37]. In-line with these recommendations, many players already report scheduling  
337 RT sessions between Monday and Wednesday (50.0% - 58.7%), however it remains unclear as to what  
338 training activities are commonly performed during these sessions.

339 Opportunities to resistance train later in the week may also present if the golfer were to miss “the  
340 cut”, which may in-part account for why players reported to train on a Friday/Saturday (41.3%).  
341 However, with travel, practice, and other lifestyle factors this is not always possible, and the more  
342 successful golfer will have less obvious opportunities to train during a tournament week. In such  
343 circumstances, players may benefit from scheduling short duration RT sessions around tournament  
344 play. Evidence suggests that high-intensity strength and power training interventions can be safely  
345 administered without resulting in lasting deficits in mechanical performance markers and metabolic  
346 measures of fatigue, provided that low-volume sessions (i.e., reduced sets, repetitions, or exercises)  
347 are employed [38–40]. Pragmatically, players may be able to resistance train on the morning of, or in  
348 the day(s) preceding competition and minimise the potential for adverse effects on competitive  
349 performance levels by maximising adaptations and reducing fatigue through strategic programming  
350 of sets, repetitions, and exercises. Shorter sessions may also encourage greater compliance  
351 throughout busy competitive periods whilst also enabling players to make continued physical  
352 development via a ‘micro-dosing’ training effect [41,42], recently defined in S&C literature as “the

353 division of total volume within a micro-cycle across frequent, short duration, repeated bouts” [43]. Of  
354 further interest, emerging research indicates that neuromuscular performance outcomes can be  
355 maintained, and even in some cases, enhanced several hours (1-48 hrs) after low volume, high  
356 intensity strength or externally loaded ballistic ‘resistance priming’ training sessions [44], although it  
357 is currently unclear how this may affect a golfer’s performance. Survey results indicate that some  
358 golfers already perform “explosive” (42.5% - 50.0%) and “HL/LV RT” (25.0%) activities on the morning  
359 prior to an afternoon tournament round. Consequently, further research would be of value to  
360 determine the potential effects of performing short duration RT session on golf performance  
361 outcomes and recovery on the day of and in the day(s) preceding competition.

362 Surveyed golfers’ warm-up practices appear for the most part to align with conventional  
363 recommendations, with various dynamic stretching activities, dynamic exercises, light RT activities,  
364 and golf practice having been shown to contribute to immediate improvements in golfers’ CHS and  
365 shot distance outcomes [45–47]. Warm-ups also provide an opportunity to include a range of training  
366 stimuli to contribute to longer-term training effects [48], and for the time poor golfer may present an  
367 ideal occasion to contribute to developing or maintaining key physical attributes. For example, high  
368 velocity jumps and throws as an extension of a golfer’s regular warm-up could contribute to  
369 developing a golfer’s long-term ballistic capabilities [31], without excessive additional time  
370 commitments or equipment demands. Some evidence has also shown ballistic jump exercises to elicit  
371 immediate short term improvements in golfers’ CHS over that of performing regular warm-ups  
372 [49,50]. However, only a small percentage of golfers appear to currently be utilising such activities.  
373 This may in-part be explained in that the benefits accrued from such strategies will typically dissipate  
374 within minutes of the applied stimulus [49–51], which may limit the potential benefits to performance  
375 over an entire tournament round which will typically span over several hours of play, unless re-applied  
376 on course. Further research and education on the potential longer-term training effects which may  
377 occur through warm-up training interventions may encourage the use of more diverse training  
378 activities to be performed during a golfer’s warm-up.

#### 379 1.5.4 Strengths and limitations

380 This study provides a unique and previously unexplored insight to the physical preparation approaches  
381 of golfers’ competing at the elite professional level on the European/Challenge Tour and competitors  
382 at the Open Championship. However, the results of this study may not be representative of other  
383 professional golfers competing for example on other tours such as the PGA Tour. It is also possible  
384 that surveyed players who responded were more interested in physical preparation than those that  
385 did not. This potential bias could indicate that the results obtained from this survey may not represent  
386 the perceptions of all players, especially those less interested in physical preparation. The survey was

387 constructed in a manner whereby questions and terminology would be easy to understand, and  
388 examples were provided as technical terminology could have hindered understanding of the survey  
389 questions. While the observational records at The Open Championship offer a unique insight to one  
390 of the most prestigious events in golf, it is possible that there were omissions to the data, with players  
391 training outside of the observed facility. It is however likely that most training requiring specialised  
392 equipment would be performed at the tournament's fully equipped gym facility. The Wednesday and  
393 Thursday were the days specifically chosen for observation due to these being the most likely days  
394 that the entire tournament field would have access to use the gym facilities, with players arriving  
395 sporadically to the event and players being "cut" after Friday's round (n= 83). The days that data were  
396 collected may therefore not be representative of other days and may miss players training for example  
397 in hotels. Finally, since data collection was anonymised, it is possible that multiple gym entries were  
398 recorded for a player in a single day (e.g. warming up in the morning and RT in the evening).

#### 399 1.6 Conclusion

400 The results of this study indicate that physical preparation is a regular part of elite professional golfers'  
401 routines, with most golfers perceiving that RT can be beneficial for reducing injury risk and improving  
402 striking distance/swing technique. Current scientific literature indicates that measures of muscular  
403 strength and power have the strongest correlations with CHS, and longitudinal S&C interventions have  
404 demonstrated that specific strength and power training can enhance CHS and subsequent shot  
405 outcomes. In-line with this, many players appear to acknowledge the value in developing these  
406 attributes. However, training approaches vary considerably between the in-season and off-season  
407 periods, with physical development seemingly being prioritised by many in the off-season. Given that  
408 the in-season period accounts for the majority of most players annual training cycle, there is however  
409 limited time available to develop key physical attributes aside from competitive commitments.  
410 Consequently, in order to maximise their potential players should prioritise their physical  
411 development during the in-season period. As a result, further education and research on the key  
412 physical qualities associated with high performance, the necessary training methods required to  
413 develop such qualities, and how to organise and effectively implement training strategies during the  
414 in-season period would be of value. Due to players limited availability to train around tournament  
415 commitments, future research should look to identify methods for optimising RT within the  
416 constraints imposed by tournament play.

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