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ORIGINAL RESEARCH

THE IMPACT OF WARM-UP ON YOUTH GOLFER CLUBHEAD SPEED AND SELF-REPORTED SHOT QUALITY

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ABSTRACT

Background/Purpose: Physical preparation in golf is now considered a key component of the game. With players becoming more athletic, warm-up has become an important area in a player's preparation for practice and competition. Much of the research to date has focused on the adult golfer, showing potential for improvements in clubhead speed, driving distance and shot quality, as well as reductions in injury risk. However, there is currently no work specifically investigating the impacts of warm-up in youth golf. The aim of this study was to examine the impact of a club only warm-up and a dynamic exercise routine followed by a club warm-up on club head speed and self-reported shot quality.

Methods: Using a counterbalanced repeated measures design, eight male and 13 female youth golfers completed a control (no warm-up), club only warm-up and an exercise based dynamic warm-up followed by club warm-up on three non-consecutive days. In each session, players were required to hit 10 maximal effort shots with a driver and clubhead speed (CHS) was recorded using a launch monitor alongside self-reported shot quality scores.

Results: Statistically significant improvements in clubhead speed and self-reported shot quality were seen in the dynamic warm-up combined with club warm-up. No significant differences were seen in the club-warm up only or control groups for either clubhead speed or self-reported shot quality.

Conclusion: A combined dynamic physical warm-up and club warm-up improves clubhead speed and self-reported shot quality in youth golfers. However, a club warm-up alone does not seem to be sufficient in eliciting these same improvements.

Level of Evidence: 3

Key words: Clubhead speed, golf, warm-up, performance, youth

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INTRODUCTION

Golf is commonly thought of as a technical sport focussing on strategy and skill,[1] however there is a growing recognition of the physical requirements of the game and a clear increase in the focus on physical preparation.[2] Past research has demonstrated strong relationships between clubhead speed (CHS) and proficiency in the sport,[3,4] with higher driving distance, as well as CHS showing strong associations with many athletic physical characteristics.[5,6] Thus, physical preparation, for purposes of maximizing driver ball distance is now an essential component of the modern golfer's routine.[7]

Carrying out a full physical warm-up is a commonly accepted process for enhancing performance and mitigating injury risk across a range of sports.[8-10] As such, golfers are employing these practices at the elite level, however there is currently no literature exploring the impact of warm-up on the youth golfer. In adult golfers, completing a warm-up in the form of preparatory dynamic exercises prior to competition has been shown as performance enhancing through demonstrable improvements in CHS.[11,12] Moreover, a golf warm-up has been shown to improve driving distance,[12,13] shot quality,[11,12] flexibility[13] and power,[13] as well as having a potential conditioning effect when completed regularly,[14] demonstrating the importance of these practices in golf. However, despite the evidence showing positive effects of warm-up in adult golfers, behaviors are often less than desirable, with many golfers completing inadequate warm-ups.[15,16]

Researchers have demonstrated a need for dynamic rather than static based stretching as part of the warm-up routine. Significant decreases in CHS, driving distance and shot quality have been shown as possible consequences of static stretching immediately prior to golf.[11,17,18] These findings are in line with those of other sports, where static stretching has been shown to acutely reduce explosive muscular performance.[19,20] Use of bodyweight exercises, bands, weights, whole-body vibration and club specific warm-ups have all be shown to have positive effects on golf performance.[11-13,17,18] Read et al[21] also suggest post activation potentiation (PAP) through the use of explosive jumps can have a positive impact on CHS and there may be use in incorporating these techniques prior to particularly long shots whilst on the course.

The completion of a warm-up in golf may also have potential benefits in terms of injury risk reduction.[22] Therefore, encouraging a player to successfully carry out a sufficient, well planned warm-up seems to be a desirable goal of any coach or therapist.

The effects of warm-up on youth athletes outside of golf is an area which has been researched extensively, often demonstrating positive effects on relevant performance measures[23-25] and a reduction in injury rates.[26] This clearly outlines a need for the inclusion of youth specific warm-up research within the sport of golf. Moreover, with evidence demonstrating poor warm-up habits in adult golfers,[15,16] the inclusion of appropriate warm-ups within a youth golfer's routine could be essential in creating positive behaviors related to warm-up at a young age. This could allow the golfer to enjoy all the proven benefits associated with this behavior when they progress to adulthood. Of note, many studies to date have required use of additional equipment for a warm-up,[12,13,17] which may be off-putting or impractical for the youth golfer and reduce compliance. Creation of an evidence base for the youth golfer, especially with regards to warm-up, is essential to inform youth development programs, coaches, therapists and other associated professionals, so they can best support these aspiring young athletes. Given the lack of research into warm-up in the youth golfer, the aim of this study was to examine the impact of a club only warm-up and a dynamic exercise routine followed by a club warm-up on CHS and self-reported shot quality.

METHODS

Subjects

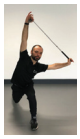
Eight male and 13 female youth golfers (handicap (HCP) 1.8 ± 2.8 strokes, age 16.6 ± 1.7 years) were recruited to take part in this study. At the time of testing, no golfers were suffering with injuries which impacted their ability to participate in golf. The players and guardians gave informed consent to take part in the study. They were also given a participant information sheet outlining the goals of the work. Ethical approval was granted by the University Ethics Committee.

Study Method

A counterbalanced repeated measures design was used, with subjects randomly assigned to

initial groups of either control, club only warm-up, dynamic and club warm-up. Testing was completed outdoors at several locations, using available driving range facilities. Each testing protocol was completed on separate, non-consecutive days. To obtain CHS values a TrackMan (ISG Company, Denmark) launch monitor was used. The system was calibrated per manufacturer instructions. On the control testing day, golfers were instructed to complete 10 maximal drives measured on the TrackMan system. Golfers could complete a self-defined number of practice swings and between maximal efforts golfers were required to take a one-minute rest. Golfers used their own drivers, and were blinded to their clubhead speed and other values from the launch monitor. Range balls were used for testing, in a variety of locations, and so only clubhead speeds were noted, and other metrics, such as ball speed, accuracy and driving distance were not considered due to the likely lack of reliability across testing locations. Clubhead speed was determined to be a more robust measure in varying conditions as it was less likely to be impacted upon by ball quality/type and weather conditions. On intervention days, golfers were required to complete either a club warm-up only or an exercise based dynamic warm-up which was immediately followed by the club warm-up (Table 1). Once the appropriate interventions had

Table 1. *Golf club and dynamic warm-up routines.*

Dynamic Warm-up	Start position	End position	Club Warm-up
10x overhead squats			4x shots for 3 different self-selected pitching distances
10x squat to overhead reach			4x full-swing shots with 8 iron
10x (5 on each leg) lunge and side bend			4x full-swing shots with 6 iron
10x (5 on each leg) lunge and rotate			4x full-swing shots with 4 iron
10x (5 on each leg) standing internal hip rotation			4x full-swing shots with 3 iron
10x (5 on each leg) single leg land and rotate			4x full-swing shots with rescue
10x (5 on each leg) lateral bound			4x full-swing shots with 3 wood
Complete all the above twice			4x full-swing shots with driver

been completed, the golfers were required to take 10 maximal effort shots, measured on the ball launch monitor as per control testing. Mean scores of the 10 shots were used when analysing the data. During all measured shots, golfers were also required to give a self-reported shot quality score (0-10), where 0 represented the golfers worst possible shot and 10 was representative of their best possible shot.[27] Both warm-up conditions were developed through modification of previous literature[12,17] in consultation with experienced national level golf coaches. The warm-up variations were also developed with no equipment beyond standard golf clubs to enhance the relevance to youth golfers.

STATISTICAL METHODS

Statistical analysis was performed using SPSS 23.0 software. A repeated measures ANOVA test using the three sets of mean CHS scores were used to look for differences between interventions for CHS values. For the shot quality scores, the Friedman test and Kendall's W test were carried out on three sets of median scores. These were then followed by a Wilcoxon signed ranks test.

RESULTS

The repeated measures ANOVA revealed statistically significant improvements in CHS ($p < 0.001$) following a dynamic warm-up combined with a club warm-up, showing a 1.1% increase when compared with control and 0.6% compared to club only warmup. No significant differences existed between the control and club only warm-up for CHS ($p = 0.877$) despite a 0.5% increase in CHS, nor between the club only warm-up and dynamic warm-up combined with a club warm-up for CHS ($p = 0.385$) despite increases of 0.6%. The Friedman test and subsequent Wilcoxon signed ranks test revealed significant improvements ($p < 0.001$) in shot quality scores for the dynamic warm-up combined with a club warm-up when compared with both club only warm-up and control, showing 40% improvements in scores, with no significant differences ($p = 0.46$) between club only and control. Effect size calculations showed moderate

Table 2. *Clubhead speed and self-reported shot quality following warm-up interventions.*

	Control	Club	Dynamic	Effect size	Power
Mean (mph) (mean +/- SD)	92.9±7.9	93.4±7.0	93.9±7.60**	0.63	0.998
Median Shot Quality (/10)	5	5	7**	0.52	-

**Indicates significant difference (p<0.001)

Table 3. *Mean % difference between different warm-up protocols on dependant variables .*

	Condition	% change	*p-value*	95% CI for mean lower-upper
CHS	Club vs. Control.	+0.5	0.877	-0.641 to 1.547
	Dynamic vs. Control**	+1.1	<0.001	0.545 to 1.520
	Dynamic vs. Club	+0.6	0.385	-0.375 to 1.535
Shot Quality	Control vs. Club	0	0.460	-
	Dynamic vs. Control**	+40	<0.001	-
	Club vs. Dynamic*	+40	0.002	-

*Indicates significant difference (p<0.05), **Indicates significant difference (p<0.001)

improvements in CHS (0.63) and shot quality (0.52) as a result of the combined club and dynamic warm-up intervention.

DISCUSSION

With no current literature available on the impacts of warm-up on youth golfers, this work is an essential step in expanding the knowledge base, and clearly demonstrates the utility of warm-up routines for youth golfers. However, despite statistically significant effects being demonstrated between the dynamic warm-up and control group, the 95% confidence interval was only 0.545 to 1.520mph. While demonstrating positive and non-harmful effects, these improvements in clubhead speed alone are unlikely to elicit meaningful changes in on-course performance. However, when combined with the large observed improvements in self-reported shot quality (40%), meaningful on-course performance improvements are likely.

Given the limited research on golf warm-up and especially in youth, female, skilful and low handicap players, this research makes a valuable contribution to the body of evidence on physical preparation in golf. With evidence already supporting the use of club warm-ups and exercise based dynamic warm-ups in golf,[11,12,17] this investigation looked to apply these principles to the youth golfer, using no equipment beyond golf clubs. The investigation specifically aimed to explore the impact of a club only warm-up and a dynamic exercise routine followed by a club warm-up on youth golf performance, demonstrated though changes in CHS and self-reported shot quality. The results showed a significant increase in CHS when golfers completed a dynamic exercise routine followed by a club warm-up against a control, with a moderate effect size improvement. This certainly demonstrates quantifiable improvements in performance, which may have further implications if continued over a longer period of time. [14] Significant improvements were also seen in self-reported shot quality from the dynamic exercise routine followed by a club warm-up when compared against the control and club only warm up. When combined with the improvements in CHS, meaningful real-world performance impacts on driving distance and shot accuracy are highly likely, despite not being directly measured. No significant improvements were seen between the club only warm-up and the control.

The findings from this investigation demonstrate some of the positive impacts of completing a dynamic exercise route prior to any club warm-ups or golf performance in youth golfers. While changes in CHS were low and likely to make minimal improvements to overall performance, there appear to be quite noticeable changes in self-reported shot quality. These improvements in shot quality are likely to result in increased performance confidence and while not measured within this study, may transfer to noticeable improvements in shot outcome. This research also outlines that while club only warm-ups show trends towards improved performance, they are unable to elicit significant CHS and shot quality improvements on their own. This is further supported by previous literature, where dynamic warm-ups have consistently shown enhanced results.[11,12,17]

Research in adult gofers has demonstrated a lack of positive warm-up behaviour[15,16] and reductions in injury risk through golf warm-up.[16] As such, the demonstration of positive and non-harmful warm-up effects in youth golfers should not only encourage them to participate in warm-ups as part of their preparation, but may also have the by-product of supporting positive warm-up behaviours in golfers from early on in their journey. In view of the significant and varied positive outcomes when golfers reach adulthood, and acknowledging current poor warm-up practices in golf, the implementation of warm-up routines in youth golf should be a desirable goal. This research should aid in encouraging warm-up practices and improving attitudes and behaviour to warm-up of youth golfers.

This study was not without limitations. While able to access high level players in ecologically valid environments, the pragmatic nature of this work limited a wider range of dependant variables which may have increased the acquired knowledge from this work. CHS was measured and improved, which, provided there was no reduction in shot quality, would lead to increased driving distance. However, driving was not directly measured due to the outdoor environment and mix of golf balls used. These environmental challenges would have negatively impacted on the reliability of a distance measure. Also, shot quality was taken through subjective questioning, without

quantifiable measurement, and while this method has previously been used,[27] it has not been validated against shot outcome. However, similar to measures of distance, a variable outdoor environment with a mix of golf balls would not have been conducive to direct measures of accuracy or launch monitor shot quality. As such, the resultant improvements in shot quality from this study are only inferences of what performance improvements might result.

Given the relative infancy of youth golf warm-up research, there are many areas which are worthy of future investigation. However, based on the current work, logical next steps should include evaluation ball speed, smash factor (CHS to ball speed ratio) and accuracy measures as a result of appropriate warm-ups. This will aid in determining whether players' perceptions of shot quality are comparable or consistent with actual shot quality. This was not possible within the current work due to the variable locations and balls used for the investigation. Given the large improvements in perceptions of shot quality within this study, the quantitative evaluation of this is an essential next step. While a golfers perception of their performance is important, and likely well informed, it does come with limitations. In golf, the player is measured on their shot outcome in terms of accuracy to a target, and therefore this may be a useful future addition. Moreover, work investigating the most efficient exercises for a warm-up, impacts of warm-up on injury risk reduction and whether regular warm-ups also have a potential conditioning effect for youth golfers would bring the literature more in-line with current adult golf research in preparation for continued expansion.

CONCLUSIONS

The results of this research indicate that significant improvements in CHS and shot quality occurred in youth golfers who participated in an exercise based and club golf warm up program. Therefore, the use of a dynamic exercise-based warm-up followed by a club warm-up may be advisable for youth golfers. This may have performance impacts and may also help to instill positive warm-up behaviors for the future. The program presented herein provides practical warm-up suggestions requiring no additional equipment that can accompany a club warm-up routine, which could be implemented immediately with youth golfers.

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