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TECHNICAL STUDIES OF BOOSTERS IN "GOLF": A REVIEW

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ABSTRACT

This research paper gives an insight on the recent researches undergoing in the various research areas of golf. The major research includes effect of skill level of golfer on variability of EGG measures under different pressure settings, Golfers brain activities during the preparation phase of a full swing, effect of confirming grooves as shown by measured spin rates in skilled golfers, Effect of polymetric exercise on golf swing kinematics, perceptual and biomechanical conflicts in putting, Accuracy of reading putts as a function of skill level and direction of break and viewing position. At the end of the research paper scope of further research based on current research is suggested in the paper.

Keywords: Golf Performance, EGG Measures, Polymetric Exercise and Swing Kinematics

I. INTRODUCTION

Golf fitness has been discussed informally in golf magazines, on television, and at the range. Effects of fitness, strengthening, and stretching exercises have been formally researched by kinesiologists and biomechanists; and their research has been published. But up to the point of the execution of this study, there had been no research studies directly linking golf fitness to changes in the body directly linked to the accuracy, carry, and distance of the drive. There had been extrapolations of increased power which would increase distance, but the drive had not been tested directly. Because of existing and emerging opinions and the practice of golf fitness intervention with respect to a golfer's game, and because of the gap in the literature showing direct links of changes in the body from specific golf fitness to the actual outcome of a drive, this study is important. There were no studies looking at the specific physical needs of the individual golfer. Other studies showed responses to general exercises. Previous authors requested more studies looking at the individual golfer and his or her specific needs. This study filled that gap in the research with a research design sensitive to the individual's needs but with a methodology which could be generalized to all golfers.

II. REVIEW ON RECENT RESEACH AND DISCUSSION

Previous research [Ref 1] has shown that the brain electrical activity of golf experts shows distinct differences relative to non-experts and facilitates an understanding of the neuro physiological mechanisms that underscore the performance differences between elite and amateur. Compared to novice golfers, experts demonstrate higher frontal theta power values during task performance and an increased stability (decreased variability) in electroencephalograph (EEG) rhythms. The frontal theta is related to working memory, is an indicator of increased attention and is associated with higher skill level during a complex task such as a golf putt. To evaluate the amounts of theta produced during task along with the variability of EEG rhythms, three different levels of golfers were recruited to go through varying pressure settings under golf putt task. The experiment was conducted at Medalist Golf Course in Hobe Sound, Florida. Participants included a professional baseball player but novice golfer, a professional golfer not on PGA listings and an expert golfer. Low-pressure consisted of 18 putts at predetermined locations. Moderate-pressure involved the same putt scenario except this trial would be filmed and an announcer would be describing their actions and putt results so that this footage could be used for a show on the Golf Channel. The high-pressure setting had predetermined putt positions, announcer and cameras, but in addition, each golfer worked as a team with the other golfers and for every putt made, money could be won or lost that would ultimately be donated to a charity. Multiple physiological measures were recorded including electroencephalograph (EEG), heart rate (HR), respiration rate (RR), heart rate variability (HRV), electromyography (EMG), skin conductance, and hand temperature.

This study specifically looked at the EEG data and focused on theta but also included the frequency bands: delta, alpha and beta. EEG data was collected during each pressure scenario at Fz and P_Z for the different skill level athletes under the three different pressure settings. Artifact was removed from the EEG recordings and the variance of EEG amplitude within each task was calculated. The variance and standard deviation were calculated and plotted for each subject across each condition for comparison. Results indicated trends between the skill levels of golfer as having an interaction with the variability in EEG. The findings indicate the novice and elite golfer demonstrated low variability across multiple pressure settings while the professional, non-elite golfer demonstrated highest variability between settings. Additionally, as had been previously reported (Babiloni, 2008), The expert participant demonstrated increased levels of frontal theta during the putting task.

Neurophysiological studies have been conducted using and electrophysiological approach (EEG) before and during the golf putt to examine changes related to EEG spectral power during the preparation phase directly before the execution of the full swing in conjunction with the activation of the fronto-parietal network. Ten male, right-handed expert golfers with golf handicap volunteered in this study were screened with a health questionnaire and had no history of neurological, cardiovascular or other major disorders, no current use of medications or drugs. The participants were asked to execute 15 golf shots with a full swing to reach a 100m target with high precision at their own pace. After this execution block (M1) they rest for two minutes in sitting position with eyes open (R1). This procedure was repeated six times (M1/R1-M7/R7). The precision of the shots was measured by the percentage of shots reaching the target within a 10m circle. EEG activity was recorded continuously using only 6 Ag/AgCl electrodes (F3, FZ, F4, P3, PZ, P4) out of 32 embedded in an elastic cap (QuickCapTM, Neuroscan, USA) in accordance with the international 10:20 system. The signals were sampled at 1000 Hz / 32 bit amplified and filtered. An impedance test (< 5 kI) ensured a sufficient signal to noise ratio before each measurement. The EEG recordings were bandbass filtered (0.5 – 40 Hz) and visually inspected for artifacts. Only artifact free 2 s epochs (2048 sample Cosine windows) before the start of the movement were used for analysis. Power spectra were calculated for each epoch and divided into Theta (4.75 – 6.75 Hz) and Alpha-2 (9.75-12.5 Hz) frequencies. For statistical analysis (ANOVA TIME x CONDITION) the average power

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values were log-transformed. Spectral power in each frequency was computed in each block (M1/R1-M7/R7) in each subject. The participants reached the 100m target very precisely with 85.4 % of all balls lying within a 10m distance circle. The statistical analysis demonstrated a CONDITION effect with higher Theta values in frontal brain areas during the preparation phase compared to rest in all three frontal electrode positions (F3: p=0.017; part. eta2=0.579; Fz: p=0.031; part. eta2=0.509; F4: p=0.026; part. eta2=0.529). Parietal Alpha-2 spectral power show significant lower values in the preparation phase 2 s before execution in P3 (p=0.043; part. eta2=0.523) compared to the resting condition.

A study is conducted recently [ref 2] to quantify the spin rates of skilled golfers with 2 different wedges (56° and 60°) with conforming versus non-conforming grooves. Eight university-level golfers (mean handicap 1.1) were asked to hit a series of golf shots with each wedge in an indoor laboratory setting from a launch monitor that measured impact characteristics. The results of the study showed that the skilled players in our study were actually putting greater spin on shots using wedges with conforming grooves. These somewhat puzzling results were explained, at least partially, by supporting evidence that showed that the players were swinging the newer wedges at greater velocities. It was concluded that, for yet unknown reasons, skilled players were delivering the conforming wedge to the ball with greater club head speeds, thereby imparting significantly greater backspin to the golf ball. The implications of these data are discussed from both skill acquisition and applied (i.e., club fitting) perspectives.

A study [ref] to examine how plyometric training can influence golf swing kinematics is conducted recently. Sixteen male golfers who were plyometric naive participated in the study. Participants were randomly assigned to either the control group (n=8; hcp 3.3 ▯} 1.6; 24.4 ▯} 8.8 yrs) or experimental group (n=8; hcp 3.8 ▯} 1.6 [2 professionals excluded]; 21.5 ▯} 5.5 yrs). The control group continued with any existing exercise programme that they were performing, whilst the experimental group followed an 8-week plyometric exercise program. Training consisted of two plyometric sessions a week for eight weeks. Sessions contained the following exercises: Multi-directional Hops, Bounding, Lateral hops, Squat Jumps, Overhead Throws, Squat Ball rotational throws, Kneeling lunge Rotations, Frontal rotation throws. All swing kinematic analysis took place on a driving range and after completion of their normal warm up routine each participant hit five 6 iron shots from a driving range mat at full speed toward a designated target at a distance on the range using a full compression ball. Three-dimensional kinematic data was collected using a Polhemus Liberty electromagnetic tracking system (Polhemus Inc., Colchester, VT, USA), sampling at 240 Hz. The target was located so that a line drawn between it and the position of the ball on the driving range mat was parallel to the x-axis of the global frame. Kinematic variables were calculated for each shot and included: maximum rate of X-factor stretch (MROS), maximum rate of X-factor recoil (MROR), maximum X-factor (mXF), X-factor stretch (XFs), peak pelvis speed (pelvispeak), peak upper torso speed (torsopeak), peak lead arm speed (armpeak), peak hand speed (handpeak). A between groups repeated measures design approved by the University Ethics Committee was used **to assess the impact of an 8-week plyometric exercise programme on golf swing kinematics**. The effects of the intervention on swing kinematics were analysed using mixed factorial MANOVAs with a repeated factor of test (pre-test, post-test) and a between-groups factor of group (control, experimental). Where significant effects were found follow-up mixed factorial ANOVAs were performed to identify significant effects within individual variables along with pairwise comparisons. All data and reported as mean (95% CI) unless otherwise stated.

Table 1. Kinematic variables pre and post intervention. *significant change between pre and post testing, $p<0.05$)

	Power training		Control	
	Pre	Post	Pre	Post
mXF (°)	61 (56-67)*	68 (60-76)*	57 (51-63)	56 (48-64)
XFs (°)	14.9 (9.8-20.0)	17.0 (12.4-21.6)	15.5 (10.4-20.5)	13.4 (8.7-18.0)
MROS ($°s^{-1}$)	91 (63-119)	99 (81-117)	72 (44-100)	67 (49-84)
MROR ($°s^{-1}$)	771 (652-889)*	929 (769-1090)*	651 (533-770)	651 (490-812)
$Pelvis_{peak}$ ($°s^{-1}$)	490 (430-550)	513 (465-561)	443 (383-503)	457 (408-505)
$Torso_{peak}$ ($°s^{-1}$)	745 (688-802)	770 (725-815)	718 (661-774)	734 (689-779)
Arm_{peak} ($°s^{-1}$)	868 (766-970)*	930 (840-1020)*	905 (803-1007)	908 (819-998)
$Hand_{peak}$ ($°s^{-1}$)	1483 (1401-1565)*	1562 (1473-1651)*	1438 (1356-1520)	1404 (1315-1493)

There was a significant interaction effect between test and group for MROR, MROS, mXF, XFs (Wilk's $\lambda=0.32$ $F4=5.9$, $p=0.009$). Follow-up ANOVAs showed the interaction to be present for MROR ($F1=5.0$, $p=0.04$), XFs ($F1=7.2$, $p=0.02$) and mXF ($F1=7.0$, $p=0.02$) with pairwise comparisons showing significant increases in MROR and mXF for the experimental group post training (Table 1). There was a significant interaction effect between test and group for peak segmental speeds (Wilk's $\lambda=0.45$ $F4=3.4$, $p=0.049$). Follow-up ANOVAs showed the interaction to be present for armpeak ($F1=5.5$, $p=0.03$) and handpeak ($F1=13.5$, $p=0.003$) with pairwise comparisons showing significant increases in armpeak and handpeak for the experimental group post training (Table 1).

A study [ref] is conducted on to quantitatively analyze how golfers couple versus uncouple their feet from their putting actions on right-to-left (RTL) and left-to-right (LTR) breaking putts, to relate these actions to their estimation of break, and to propose a partial explanation for why LTR putts are considered more difficult than RTL putts, for right–handed golfers. Twenty-one proficient male golfers (ages: 20-25, USGA HCPs: 0-7) participated in the study. Each golfer performed three straight putts 6.1 m (20 ft) in length in a swing laboratory. An overhead camera captured foot placement relative to the ball-to-hole direction. Average baseline toe-line angles (TLAs) were determined for each golfer. Each golfer then putted three times each to two different holes on a putting green. These putts were also 6.1 m (20 ft) in length, incorporating moderate RTL and LTR breaks. Prior to each attempt, golfers provided an estimate of total break (EST), defined as the distance from the hole to the putt's starting velocity vector, measured at the hole perpendicular to the original ball-to-hole line. To control for putting pace, putts were considered valid if the ball reached the hole, or stopped within 0.46 m (18 in) beyond the hole. An overhead, boom-mounted video camera captured ball motion and foot placement relative to the original ball-to-hole line. EST and attempt outcomes (make, miss high, miss low) were recorded, and TLAs and initial ball projection angles (BPAs) were calculated by analyzing the overhead videos. TLAs for each golfer during breaking putts were corrected based on their straight putt TLAs. The putt's actual breaks were determined trigonometrically based on the average BPAs of the made putts. ANOVA was used to analyze differences between TLA, BPA, and EST for each putt, and ANOVA with repeated measures evaluated learning effects across the three attempts. The actual breaks of the 6.1 m (20 ft) RTL and LTR putts were 1.14 m (44.8 in) and 0.98 m (38.7 in), respectively. Perfectly struck putts were thus struck with the ball initially travelling 9.3 and 10.8 degrees above the original ball-to-hole line for RTL and LTR breaking putts, respectively. EST averaged 76.4% of the actual break for the RTL putts, and only 64% of the actual break for the LTR putts. These estimates did not statistically improve across attempts. Only 9% of RTL putts were made; 24% were missed on the high side, and 67% were missed low. For LTR putts, 19.7% of the putts were made,were missed high and 59% were missed low. With LTR putts, TLA and BPA were nearly equal (averaging 9.8 and 9.7 degrees, respectively); one degree lower than the actual break. Thus, on average, golfers struck LTR putts parallel to how their toes were aligned and below the required break. TLA and BPA were statistically greater than EST, differing by 2.8 deg. For RTL putts, TLA and BPA were remarkably disparate (averaging 2.8 and 8.8 degrees, respectively). On average, these RTL putts were struck half a degree lower than needed to

make the putt, while the feet were aimed 6 degrees more open than the ball's starting direction. TLAs were statistically different (less) than both estimated break (EST) and BPA. Cluster analysis exposed differences in technique. It appears many proficient golfers uncouple their feet from their putting stroke on RTL breaking putts, prioritizing ball starting direction with less regard to foot placement. The putter is swung dramatically away from the toe line, well above the estimated break and TLA. By contrast, the feet are placed parallel to the starting direction of the ball on LTR putts, but aligned below the required break. To make a LTR putt, the putter must be swung toward the toe-line (out to in); a potentially more difficult/uncomfortable action than the outward (in to out) swing path of the RTL putt. These findings alter our understanding of putting mechanics and should be considered in instructional settings.

2.1 Assessing Golfer Performance Using Golfmetrics

Objective and quantitative analysis of the game of golf is greatly facilitated by golfer shot data collected under real golf conditions. Standard statistics, such as number of putts and greens hit in regulation, have at least two drawbacks. First, most statistics measure the effect of a combination of shots and do not isolate the quality of individual shots. For example, if a golfer misses a green and then chips in, the number of putts recorded will be smaller not because of good putting, but because of an exceptional chip shot. Fewer putts may be an indication of good putting, good chipping, or poor iron play. A second drawback is that most statistics involve counting (e.g., number of fairways hit) and do not distinguish between large and small errors (e.g., whether a fairway is missed by 1 yd or 30 yds). Starting and ending position information of individual shots allows the quality of each stroke to be measured directly and in isolation from other shots. Cochran and Stobbs (1968) pioneered the idea of collecting and analyzing golf shot data. However, they collected a relatively small amount of data, the analysis was done prior to modern computer technology, and their results pertain to golf in another era, when equipment and course conditions were very different than today. Soley (1977) collected and analyzed putting data with similar limitations. Riccio (1990) applied statistical analysis to professional and amateur data, but did not have shot position or distance information. The PGA tour's excellent shot link system is used to record shots of golfers at PGA tournaments. This system contains extensive data, but is limited to the very best professional golfers and does not allow custom analyses to be performed

2.2 Description of the Golfmetrics Program and Database

Golfmetrics allows golfer, round and shot information to be entered into a computer, stored in a database and analyzed. A map of each hole is created using an accurate rendering of the hole (e.g.,a satellite image from Google Earth) and a separate hole editor program. Hole maps can be developed for any course with accurate hole information, but the Golfmetrics program is currently limited to six courses. Using the program's graphical interface, a user can, for example, click near a 150-yd marker and then click in the middle of a greenside bunker to indicate the starting and ending positions of a shot. The program stores this information and then computes the shot distance, the error relative to the hole position, and using the hole map it can determine that the shot started in the fairway and ended in a bunker. This design allows detailed information to be entered relatively quickly, easily and accurately. The Golfmetrics database currently contains almost 40,000 shots representing about 500 rounds of golf from over 130 golfers on six courses in tournament and casual play primarily during 2005-2007. Golfer ages in the database range from 9 to 70 years and the scores range from 64 to 120. PGA and LPGA tour pros, club professionals, and amateur golfers are included. PGA tour shot information was transferred from shot link into Golfmetrics. The data were divided into five groups for analysis: Pro1 (PGA tour players scoring in the range 64-71), Pro2 (PGA tour players scoring in the range 72-79), Am1 (low-handicap amateurs scoring in the range 70-83), Am2 (middle-handicap amateurs scoring in the range 84-97) and Am3 (high-handicap amateurs scoring in the range 98-120). The Pro1 and Pro2 groups were sometimes combined into a single

III. CONCLUSION

We have variety of research undergoing in the above field but a research design sensitive to the individual's needs but with a methodology which could be generalized to all golfers is still in need. A lot of fields including golf injuries, Epidemiology of female golfers, coach's perspective on fitness, relation between injuries and golf playing surfaces, drag on the golf ball drops, Reduction on body load during swing and impact and optimal kinetic sequencing need more attention.

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