ASSOCIATION BETWEEN 3-D MOTION ANALYSIS OF GOLF MECHANICS, ABDOMINAL STRENGTH AND PAIN IN RECREATIONAL GOLF PLAYERS: A CROSS-SECTIONAL CORRELATION STUDY

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ABSTRACT:

Purpose: Golf is a High impact sport that helps in increasing muscular endurance and physical performance in the elderly which further prevents the risk of injury and improves neuromuscular coordination. Optimum biomechanics and core stability are assumed to be two vital requirements for better performance. The objective of the study is to find the correlation between abdominal strength, pain, and golf mechanics in recreational golf players.

Methods: Eight recreational golfers aged above 50 years were recruited by the convenience non-random sampling to participate in this cross-sectional correlational study. Correlation between pain at shoulder and elbow measured through McGill pain questionnaire, playing technique measured through BIOVAL® motion analyser system, and abdominal strength by 7-stage abdominal strength test were reported.

Result: A negative correlation between pain and abdominal strength and a positive correlation between abdominal strength and playing technique was revealed from the cross-sectional correlational study.

INTRODUCTION

According to the National Golf Foundation, it is estimated that 50 to 60 million golfers play worldwide. Along with physical benefits the game also renders social benefits for players, which is much needed at any stage of life.¹ Reduced strength, flexibility, co-ordination, and balance affect golf performance as well as increases the potential for injuries. The low impact exercise part in this game plays an important role in the reduction of falls in older adults, axial mobility, weight shifts, coordination, and focus on visual-motor integration. Additionally, golf offers the potential to improve axial rigidity, motor training, bradykinesia, coordination, gait, postural instability leading to improvement in golf swing and performance.²

Overuse and poor swing mechanism can also be the cause of recurrent elbow and wrist injuries. Around 40% of injuries can mimic strain on the back with tenderness on the posterior thigh and over the hip joint.³ An excessive backswing may contribute to injuries of the trunk and also increase the stress on the thumb and wrist. Excessive shoulder elevation can impinge the subacromial bursa or compress the rotator cuff muscles. Excessive rotation of the trunk during forward swing leads to muscular strain in the thoracic segment and compressive forces on the leg which results in knee osteoarthritis. Overextended elbows along with tight gripping may cause golfer’s elbow and further incorrect posture or poor balance can lead to injury of hand and wrist in players.⁴ Compressive forces and repetition of weight transfer during late follow-through can provoke a risk of injury or discomfort to the hip joint particularly for some old players affected by degenerative changes.⁵ Hence most of the low back injuries are sustained during the swing phase.⁶

The biomechanics of golf consists of kinetics, kinematics, and muscle activity.⁷ By examining the muscle activity in recreational golfers further insight can be gained to how controlled skilled movement can be initiated to improve performance and prevent injuries in elderly players.⁸ The core stability and core strength exercises will enable more functional training which results in improvement of sports performance.⁹ Transverse abdominis muscle plays important role in trunk stability and protects the vertebra and joints from injury in older adults.¹⁰
Core strength and stability are important for ADLs, better performance, and fall prevention in older golf players. The combination of core and non-dominant arm strength exercises program for recreational golfers proves to be an effective improvement of the drive distance.

Despite the knowledge of various factors affecting performance in recreational golf players, there is a dearth of studies portraying clarity on the correlation between abdominal strength, pain, and playing techniques among recreational golf players. Hence, this study focused on the correlation between abdominal strength, pain and playing technique in recreational golf players.

II. MATERIALS AND METHODS

Recruitment

The study was executed between March 2020 and February 2021. A total of eight recreational golfers aged above 50 years were recruited by the convenience non-random sampling to participate in this cross-sectional correlational study from the recognized golf club, Chandigarh. Both male and female recreational golfers playing golf 2-3 times/weeks were recruited in the study. Recreational golfers who were overweight, history of disc prolapse, known case of hypertension and suffering from known cardiac illness, chronic low back pain, and any other condition which prevent them from taking part in the study were excluded. Signed informed consent was obtained from all the recruited recreational golfers before the study commencement.

Study procedure

The basic demographic information like height, weight, occupation, age, date of the last practice session/match played, address, etc were recorded from the participants. The whole procedure of the study was explained in detail by the therapist. Initially the abdominal strength of the players was recorded through a 7-stage abdominal strength test in which the players were asked to lie down in supine position with the knee at right angle and feet flat on the floor. Started at level 1, the participant attempted to perform one complete sit-up for each of the levels. Out of eight levels attempted, the level achieved by the participant was marked accordingly. Pain experienced by the players in the bilateral upper limb was interviewed through McGill Pain Questionnaire.

After this, the players were moved to the drive range area where the golf mechanics were recorded with the players on the club head. The range of motion (ROM) of the trunk and upper limb (UL) were measured through the motion sensors of the 3-D BIOVAL® motion analyser system, Figure 1.
The yellow, green, blue, and red sensors were placed over the spinous process of T7 vertebrae for the trunk, shoulder (greater tuberosity), elbow (lateral epicondyle), and wrist joint (lower end of radius) respectively. After the sensor placement, the players were asked to take the position and on the command of the therapist, they were asked to hit the ball by their usual swing mechanics as displayed in Figure 2. This playing technique was analysed by motion analyser software from the information obtained through the motion sensor placed on the anatomical bony landmarks. All the data were documented in MS Excel format and imported to the statistical software for further analysis.

**Figure 1:** 3-D BIOVAL® motion analyser system
Data analysis

The collected demographic and outcome measures which included, abdominal strength through 7-stage abdominal strength test, pain in bilateral upper limb through McGill Pain Questionnaire (McGP-Q), and ROM of the trunk and UL measured through BIOVAL® motion analyser system were assessed for their normality using Shapiro-Wilk test. As the demographic dimensions data follow a normal distribution, all the descriptive were expressed in mean ± standard deviation. While the outcome measures were expressed in mean with interquartile range (IQR) and range as they do not follow the normal distribution. Spearman rank correlation coefficient was used to report the bivariate correlation between McGP-Q -shoulder and elbow with abdominal strength. A scatter plot with an intercept line was used to report the degree of correlation graphically. Similarly, a bivariate correlation was used to report the degree of correlation between ROM of the trunk and UL measured through BIOVAL® motion analyser system with abdominal strength. Correlation of various independent variables such as sensors used in BIOVAL® motion analyser system with abdominal strength was expressed as multiple regression equations. All the data were analysed using statistical software, statistical package for the social science (SPSS), IBM SPSS version 20.0 (Armonk, NY: IBM Corp.). The p-value ≤0.05 was considered to be statistically significant.

III. RESULTS

Demographic dimensions and outcome measures of the eight recreational golfers recruited were tabulated in Table 1 and Table 2 respectively.

Table 1: Demographic dimensions of the eight recreational golfers recruited

<table>
<thead>
<tr>
<th>Demographic dimensions</th>
<th>Mean±SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>63.1±10.2</td>
<td>51 to 78</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.3±8.1</td>
<td>168 to 185</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81.8±9.7</td>
<td>75 to 105</td>
</tr>
<tr>
<td>BMI (kg/cm²)</td>
<td>26.9±2.5</td>
<td>23 to 30.5</td>
</tr>
</tbody>
</table>

Table 2: Descriptive statistics of years of experience, McGill pain on shoulder and elbow with abdominal strength

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Median (IQR)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of experience</td>
<td>7 (5.25,8)</td>
<td>4 to 8</td>
</tr>
<tr>
<td>McGP-Q – Shoulder</td>
<td>0 (0, 3)</td>
<td>0 to 5</td>
</tr>
<tr>
<td>McGP-Q - Elbow</td>
<td>3 (0.5, 4)</td>
<td>0 to 5</td>
</tr>
<tr>
<td>Abdominal strength</td>
<td>3 (3, 4)</td>
<td>2 to 5</td>
</tr>
</tbody>
</table>
Correlation between abdominal strength and McGill pain on shoulder and elbow was tabulated in Table 3 with their graphical representation in Figure 3 and Figure 4.

**Table 3: Correlation between abdominal strength and McGill pain on shoulder and elbow.**

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Spearman rank correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>McGP-Q - Shoulder</td>
<td>- 0.268</td>
<td>0.522</td>
</tr>
<tr>
<td>Abdominal strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McGP-Q - Elbow</td>
<td>0.318</td>
<td>0.443</td>
</tr>
<tr>
<td>Abdominal strength</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** McGP-Q - McGill Pain Questionnaire

**Figure 3:** The above graph relates the reduced abdominal strength of the players with increased pain in the shoulder recorded on McGill questionnaire scale.

**Figure 4:** The above graph relates the abdominal strength with pain in elbow recorded on McGill pain questionnaire.

**Table 4: Correlation between ROM of trunk and UL measured through BIOVAL® motion analyser system with abdominal strength**

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Abdominal strength</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Green-Yaw</td>
<td>0.236</td>
<td>0.574</td>
</tr>
<tr>
<td>Sensor Green-Pitch</td>
<td>-0.013</td>
<td>0.976</td>
</tr>
</tbody>
</table>

**Abbreviations:** McGP-Q - McGill Pain Questionnaire
The multiple regression equation describing the correlation between ROM of trunk and UL measured through BIOVAL® motion analyser system with abdominal strength is:

\[ 2.019 - 0.006 \times \text{Sensor Green-Yaw} + 0.011 \times \text{Sensor Green-Pitch} + 0.005 \times \text{Sensor Blue-Yaw} + 0.017 \times \text{Sensor Red-Yaw} + 0.040 \times \text{Sensor Red-Pitch} - 0.022 \times \text{Sensor Red-Roll} + 0.0 \times \text{Sensor Yellow-Roll}; F (7,0) = 0; p=0, R^2=1, R=1. \]

There exists strong association (R^2 = 1) between abdominal strength and performance measured through motion analysis.

**IV. DISCUSSION**

Golf has established itself as one of the most popular sports around the world which demands moderate reasonable effort and good fitness. It is also characterised by intermittent bouts of walking, henceforth permitting aged players (50 years or above) to participate safely. The common injuries were increased in recreational golf players. The study conducted by McHardy in 2005 also illustrated common sites of injuries in the shoulder, elbow leading golfer’s elbow, and wrist due to absence of warm-up or insufficient physical condition and poor technique.4

This study intended to find out the factors which contribute to musculoskeletal injuries in recreational golf players and their specific correlation between each factor. Eight male golfers with mean age 63.1±10.2 participated in this study. All the participants were asked to perform golf swing action and the movement of the golf mechanics was objectively recorded by a bioval 3-D motion analyser. Simultaneously, the abdominal strength was recorded by a 7-stage abdominal strength test by the researcher and pain was analysed by McGill pain questionnaire especially for the commonest site such as the shoulder, elbow, and wrist joint.

Results proved a negative correlation between abdominal strength and shoulder pain and however, there was not much correlation found between abdominal strength and elbow pain which is close to the proximal Trunk segment. The motion mechanics monitored through bioval system, showed positive correlation with the abdominal strength displaying low abdominal strength lead to poor golf swing mechanics. In other words, insufficient abdominal strength lead to increased range of motion in shoulder, elbow, and wrist joint in vertical and longitudinal axis showing poor controlled mobility of distal joints over insufficient proximal stability of the trunk, hence as a compensation mechanism the muscles and soft tissue around the shoulder, elbow, and wrist joint over work for their increased range of motion and results in repetitive strain injury and recurrent pain at these common sites. The results synchronise with the motor control theories where deficient in Proxi mal trunk stability will lead to a lack of controlled mobility in distal segments showing an increased uncontrolled compensatory range of motion.

Hence the probability of more recurrent trauma and pain in the shoulder, wrist, and elbow will be reported because of poor abdominal strength in golf players. Similar studies conducted by Justin W.L et al reviewed that studies on biomechanics have emphasised understanding of the variables that characterise a successful golf swing in older golfers and also highlighted the importance of motor learning theories which have improved focus, structure, and feedback that potentially increases golf performance.10 Kwang-Jun Kimet et al after 12 weeks of the study found that core muscle training had positive effects on flexibility and strength of core muscle. Moreover, it was effective in enhancing driver shot performance in female professional golfers.11

This suggests that the application of specific and scientific core muscle training should be done continuously in female professional golfers. Jae-Yoon Song et al had described in their study that asymmetry while performing swing mechanisms may cause side-to-side imbalances in rotations, strength as well as in endurance in golfers.12

In a Contrast view the results of the study also displayed a positive correlation between the abdominal strength and the motion mechanics in Trunk which goes in synchronisation with motor control theories explaining the
abdominal strength had contributed for better Trunk controlled stability and mobility in this Proximal zone however the abdominal strength according to the results explained above was insufficient to bring out controlled mobility in distal segments like shoulder, elbow and wrist over the proximal trunk stability proposing a threat factor for pain and recurrent injuries in recreational players.

Hence through this study, we strongly recommend core strength training protocol should be emphasised for recreational golf players to prevent repeated trauma and pain in the commonest sites.

V. CONCLUSION

The study concluded that existing core control was sufficient for trunk stability whereas insufficient for providing controlled mobility in distal joints such as shoulder, elbow, and wrist proving a negative correlation. This study recommends the need to focus on the core training protocol for recreational golf player.

REFERENCES

2. Bliss RR, Church FC. Golf as a Physical Activity to Potentially Reduce the Risk of Falls in Older Adults with Parkinson’s Disease. Sport (Basel, Switzerland). 2021 May;9(6):72.