EFFECTS OF CORRECTION PROGRAM ON BACK MUSCLE FUNCTIONAL ASYMMETRY AMONG SQUASH PLAYERS

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ABSTRACT

Back muscle functional asymmetry is most common among squash players by their regular unilateral movement while playing. This study analyzed the effect of the body alignment correction program on asymmetry (left-right) developed squash players. Twenty eight asymmetry developed squash players were considered. All of them were male, right-handed and more than four years of experience in playing squash. Electromyography of back muscles (erector spinae and trapezius) and moiré topography of back were statistically compared before and after the twelve week alignment correction program that include various training. Results showed that the scapular inclination was decreased ($p < 0.05$) and resulting scapular in anatomically straight. To alignment, a decrease was observed in right side inclination and increase in left side inclination, which result in decreased ($p < 0.05$) left-right asymmetry rate and increased left-right balance. Significant ($p < 0.01$) decrease in right-side erector spinae muscle activity was observed and identified that erector spinae muscle contributed more on left-right asymmetry than the trapezius muscle. It was witnessed that training program decreased the muscle activity of the stronger side rather than increasing the weaker side. To conclude, the body alignment correction program was effective in reducing stronger side muscle activity and assisting to maintain left-right symmetry.

Key words: Muscle asymmetry, electromyography, Moiré topography, unilateral play.
1. INTRODUCTION

Athletes/Players are physically challenged as they are forced to engage in continuous, repetitive training and frequent participation in the game to improve their fitness and skills [1]. Due to wrong exercise habit and regular unilateral movement while playing causes back muscle functional asymmetry among athletes/players [2]. Unilateral movement in sport is kind of an asymmetrical exercise which uses one side of the muscle extremely depends on the nature of the sport [3]. In a unilateral sport, a unilateral movement/pattern of movement, biased to improve the performance, however, resulting in development of asymmetric in muscle behavior, morphological deformation and pain. The pain limit range of motion in joints and control active movements that result in reduced performance and lead to additional sports injuries. It was reported that unilateral sports such as pitching, balling, table tennis, etc., requires heavy torque from dominate side of the players that cause physical asymmetry [4]. In addition, squash, golf, tennis, and badminton mainly increases development of left-right asymmetry in muscle behavior and changes in body shape i.e., body alignment [5].

The left-right asymmetry inversely correlate with health and fitness of an individual. This asymmetry cause back pain and related disorders [6]. A simple muscle strain lead to moderate to severe pain while doing physical activity in sports. Low back pain patients would have lesser stability than healthy one due to weak and asymmetric core muscles [7]. Danneels et al., [8] reported decreased muscle area for patient with chronic lumbar pain and also confirmed it through computerized tomography. Pain due to asymmetry lead to severe injuries either in lower /upper back. Yu et al., [9, 10] reported the increased spinal deformity due to continuous functional asymmetric forces. This spine deformity will affect the muscle characteristics (i.e., thickening of the unilateral muscles) around spine [11], and cause instability in the upright posture [12].

Vertebral deformities are largely classified as lordosis, kyphosis, and scoliosis. Scoliosis is one of spinal deformation associated with exercise, Omey et al., [13] reported that scoliosis was found in 33.5% of 571 top players in the sports. The sports-related vertebral deformity is not only scoliosis but also the spina bifida, the reduction of the disk spacing between the vertebrae, abnormality of spinal epiphyseal plate, and crystallization of schmorl [14]. Vertebral deformity cause back pain due to the asymmetry of the muscles around the vertebrae to sports players and the general public, and act as a major cause for decreased performance and the activity disorder.

Correction exercise model for people with vertebral deformity been proposed by many researchers [13]. Kim et al., [15] reported that reduction of scoliosis angle after a 12-week yoga exercise program. In addition, chiropractic exercise program [16], swiss ball exercise & chiropractic exercise program [17], ballet exercise program [18] reported the same. There are many previous studies related to yoga exercises and correction programs that can prevent spinal deformity. In Korea, most of the studies been about correction exercise treatments related to yoga and gymnastics, however, agreed findings are limited [19]. On the other hand, resistance exercise, gymnastic exercise, aerobic exercise, isotonic exercise, etc. have also been reported to be effective in improving lumbar function [20]. It has been reported that the combined treatment of chuna manual therapy and spinal stabilization exercise improved the body stability positively for the patients with a chronic back pain [21]. Kim [22] and Moon...
[23] reported that performing posture correction exercises, spine stretching exercise, and muscle strengthening exercises were effective for scoliosis.

This study reporting the effect of the body alignment correction program on asymmetry (left-right) developed squash players. Back muscles electromyography and moiré topography of back were statistically compared before and after the twelve week alignment correction program that included various training.

2. METHODS

2.1. Participants

This study considered 28 asymmetry developed squash players. All the players were male and right-handed players. All are having more than 4 years of squash play experience. All are carefully selected based on moiré topography measurement, where players asymmetry (left-right) was 4 degree/above [24] as shown in Figure 1. As mentioned this alignment correction program for 12 weeks. Hence, the study purpose clearly explained to all the selected players and received signed consent form from them. The demographic characteristics of the players are shown in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=28</td>
<td>24.25±4.23</td>
<td>175.51±7.26</td>
<td>67.75±5.62</td>
</tr>
</tbody>
</table>

Figure 1 Moiré topography image

2.2. Equipments used

To measure the electrical activity of erector spinae and trapezius muscles, a surface electromyography system was used. To measure EMG signals, pairs of disposable Ag/AgCl surface electrodes were utilized. To measure body alignment (i.e., moiré topography), a Contour equipment was used.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Model</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMG</td>
<td>ME-6000T</td>
<td>Megaelectronic, Finland</td>
</tr>
<tr>
<td>Electronic maker</td>
<td>2223 Monitoring</td>
<td>3M</td>
</tr>
<tr>
<td>Contour</td>
<td>Moiré Topography 5.0</td>
<td>Mac System</td>
</tr>
</tbody>
</table>
2.3. Correction (Exercise) Program

Twelve week alignment correction program include muscle strengthening program for asymmetry developed squash players. Asymmetry of the trapezius muscle, rhomboid muscle, serratus anterior muscle affect postural balance and cause instability of whole shoulder girdle. To improve functionality of shoulder girdle, Bae et al., [25] and Beeton [26] suggested isotonic contraction exercise for restoring the scapula to ideal posture. This study correction program: dumbbell row in one arm as a trapezius strengthening exercise, Romanian deadlift as erector spinae strengthening exercise. Meghan et al., [27] reported that the linear relationship and correlation between the exercise intensity and the Borg Scale. Hence, this study also considered Borg Scale rating. In exercise intensity, by considering the participants unilaterality, the load on both hand was kept different, 20 Rep / 3 sets with a load corresponding to the individual Borg Scale RPE 14-16 on right hand, and 20 Rep / 3 sets of with a load corresponding to the individual Borg Scale RPE 15-17 on left hand were performed 3 times per week for a total of 12 weeks. Before starting the main correction exercise, a 30 seconds warm-up exercise were performed. The warm-up exercises included static [28], Half-Twist, Side-inclination, Supine Twist, Standing Left-right Inclination, Standing Left-right Bending. These static stretching exercises for the shoulder joint, hip joint, knee joint, and lumbar. In the case of relaxation of the left arm muscle and warm-up of the main exercise, the left smash swing movement were composed of opposite movements and performed for 10 minutes each. Overall, we set 5 minutes for warm-up before the main exercise, 15 minutes for opposite movement, 15 minutes for resistance exercise, 5 minutes for warm-down, 30 seconds for break time between the sets, and 3 minutes for break time between the exercises.

2.4. Experimental Procedures and Methods

First, the back moiré topography was captured in a relaxed, and after resting for 5 minutes. Second, 2 minutes muscle activity were recorded by attaching surface EMG electrodes to the erector spinae and the trapezius muscle and then rest for 5 minutes.

2.4.1. Moiré topography

In general vertebrae deformation involves three-dimensional deformation, i.e., coronal plane, sagittal plane, and transverse plane deformation. In this study, the participants stood on the footboard of Moire's topography with their tops removed, backs pointing toward the camera, underwear’s lowered so that the rear tailbone could be seen, making the sacrum-point visible. At that time, the subjects were photographed with fully attaching both feet to the footboard while watching the marker on the front, relaxing the whole body, and letting the arm down smoothly and maintaining a comfortable posture. For the photographing, the horizontal line for figuring out the balance of the body is aligned with the left and right acromion and the vertical line is aligned with the center of the cervical vertebrae and the center of the coccygeal vertebrae [29]. In the case of moiré, for quantitative analysis, the inclination angles between the left and right horizontal lines of R01 (R : right side) and L02 (L : left side), and the cervical C3, and the inclination angles between the left and right horizontal lines of R03 and L04 and the lumbar were measured with connecting horizontal and vertical line with a line connecting the four points, C3 vertebrae, L5 vertebrae, and the acromion’s of both shoulder, to judge the left-right asymmetry. The angle of slope of the scapula was calculated from the inclination angle (I0, inclined angle) between the horizontal line and the line connecting the protrusion of both scapula’s Figure 1.

To determine the degree of asymmetric development of the left and right muscles, the R01+R03 and L02+L04 values were compared, and the asymmetry ratio of left and right muscle development was obtained by the following formula (Equation 1).
Left-Right Asymmetry Ratio \( r = \frac{(R01+R03)}{(L02+L04)} \) \hspace{1cm} (1)

**2.4.2. Electromyogram (EMG)**

To compare the status of asymmetry developed on the left and right side back muscles, the electrical activity of erector spinae and trapezius muscles were recorded using a surface electromyography system (ME-6000T Megaelectronic, Finland) was used. Pairs of disposable Ag/AgCl surface electrodes were affixed to the skin over the selected muscles with a sticky gel. The skin was abraded and cleansed with alcohol before the electrodes were placed using standard placement procedures in Figure 2. The muscle activities were observed constantly on a monitor and stored digitally in raw form for further analysis using software at 1000 Hz sampling frequency. To normalize EMG signals, rest EMG was measured in the prone position and work EMG was measured in standing position. The EMG normalization calculated by considering rest and work muscle activity (Equation 2). Both work and rest EMG were measured at no-load state.

\[
\text{Normalized RMS EMG} = \frac{(\text{RMS at work} - \text{RMS at rest})}{\text{RMS at rest}} \hspace{1cm} (2)
\]

![Figure 2 Muscle and EMG maker position](image)

**2.5. Statistical analysis**

Electromyography of back muscles (erector spinae and trapezius) and moiré topography of back were statistically compared before and after the twelve week alignment correction program. The variables compared were inclined scapula angle, inclined back muscle angle, left-right asymmetry angle of the back muscle, left-right asymmetry ratio of the back muscle, and left-right muscular activity of the back muscle. Statistical analyses were performed using SPSS (release 18, SPSS Inc., Chicago) and Paired T-test was adopted. The confidence level for statistical significance was set at alpha equal to 0.05.

**3. RESULTS AND DISCUSSION**

**3.1. Moiré Topography**

**3.1.1. Comparison of the inclined scapula angle**

The result of scapula inclination angle before and after the correction program presented in Table 3. A sample Moiré topography image comparing scapula inclination angle before and after correction program are given in Figure 3. The results showed that the scapula inclination angle significantly \((p < 0.05)\) decreased from 6.75 deg to 5.54 deg after correction program. The left and right contour lines after the strengthening exercise were more balanced when observed with the naked eye. The scapula inclination was significantly decreased by 0.87 deg after the correction program, which is in line with result reported [30]. They have achieved scapula to the anatomical position after certain exercise program. Similarly, this study also achieved scapula to the anatomical position after the 12 weeks correction program.
### Table 3: Comparison of Scapula inclination angle before and after correction program (in deg)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre (Mean ± SD)</th>
<th>Post (Mean ± SD)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iθ</td>
<td>6.75 ± 3.52</td>
<td>5.54 ± 2.67</td>
<td>2.206</td>
<td>.011*</td>
</tr>
</tbody>
</table>

Iθ : Inclined Scapula Angle

*: p < 0.05

### Figure 3: Comparison of Moiré Topography of a subject pre & post correction program

![Figure 3](image)

**3.1.2. Comparison of inclination of back muscle area**

The result of angle of back muscle inclination before and after the correction program presented in Table 4. The results showed that the L04 was improved from 64.26 deg to 66.83 deg with significant (p < 0.05) increment of 1.87 deg. After the correction program, there was decrease in R01 by 0.19 deg, increase in L02 by 0.39 deg, and decrease in R03 by 0.77 deg. However, there was no significant changes in R01, L02, and R03. Kim et al., [15] and Yu, [10], reported that yoga was helpful for correction of left-right asymmetry by decreasing the angle of the scoliosis. In another study, Gorton and Masso [31], reported that after undergoing the exercise program to the adolescent with scoliosis, the protrusion of the cross-section of the right shoulder, centered on the pelvis, decreased from 6±4 ° to 2±3 °, getting closer to neutrality in the coronal plane.

### Table 4: Comparison of angle of back muscle inclination (in deg)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre (Mean±SD)</th>
<th>Post (Mean±SD)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>31.46±3.48</td>
<td>31.27±2.97</td>
<td>-.639</td>
<td>.432</td>
</tr>
<tr>
<td>L02</td>
<td>32.32±1.43</td>
<td>32.71±1.21</td>
<td>.782</td>
<td>.345</td>
</tr>
<tr>
<td>R03</td>
<td>66.64±1.72</td>
<td>65.87±1.83</td>
<td>-.193</td>
<td>.758</td>
</tr>
<tr>
<td>L04</td>
<td>64.96±2.57</td>
<td>66.83±1.49</td>
<td>1.446</td>
<td>.022*</td>
</tr>
</tbody>
</table>

R : Right Side, L : Left Side

*: p < 0.05
Effects of Correction Program on Back Muscle Functional Asymmetry among Squash Players

3.1.3. Comparison of angle of asymmetry between left-right back muscle

The result of angle of back muscle asymmetry before and after the correction program presented in Table 5. The $R_{02}+R_{04}$ angle was significantly ($p < 0.05$) decreased from 99.10 deg to 97.14 deg. In $L_{01}+L_{03}$, it was increased from 95.58 deg to 97.54 deg with increment of 1.96 deg. However, there was no significant difference observed.

Table 5 Comparison of angle of back muscle asymmetry

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre (Mean±SD)</th>
<th>Post (Mean±SD)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{01}+R_{03}$</td>
<td>99.10±3.94</td>
<td>97.14±1.43</td>
<td>-510</td>
<td>.532</td>
</tr>
<tr>
<td>$L_{02}+L_{04}$</td>
<td>95.58±4.57</td>
<td>97.54±1.64</td>
<td>1.410</td>
<td>.012*</td>
</tr>
</tbody>
</table>

R : Right Side, L : Left Side

*: $p < 0.05$

3.1.4. Comparison of left-right asymmetry ratio

The result of left-right asymmetry ratio before and after the correction program presented in Table 6. The results showed that the ratio decreased from 1.04 % to 0.1 % with no significant difference. Though there was no significant difference found, the balance ratio got better. Kim [28] reported that if normally unused muscles trained means, it helps to improve body balance.

Table 6 Comparison of Left-right asymmetry ratio

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Lθ:Rθ$</td>
<td>49.48 : 50.52</td>
<td>49.95 : 50.05</td>
<td>6.282</td>
<td>.062</td>
</tr>
</tbody>
</table>

$Lθ$: $L_{01}+L_{03}$, $Rθ$: $R_{02}+R_{04}$

3.1.5. Comparison of coefficient of variation (CV) of the inclination and the angle of the back muscle

CV is the value obtained by dividing the deviation of the measured value when the same individual or sample is repeatedly measured under the same conditions, by the average value. The smaller the CV value is, the higher the repeatability. The result of CV value ratio of the inclination and the angle of the back muscle before and after the correction program presented in Table 7. The results showed that the CV value was about 1.6% smaller in the back muscle inclination angle, and 0.56 % smaller in the change of asymmetry angle.

Table 7 Comparison of CV values Back muscle CV Value %

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient of Variation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>$R_{01}$</td>
<td>7.57</td>
<td>6.78</td>
</tr>
<tr>
<td>$L_{02}$</td>
<td>4.47</td>
<td>4.35</td>
</tr>
<tr>
<td>$R_{03}$</td>
<td>2.44</td>
<td>2.41</td>
</tr>
<tr>
<td>$L_{04}$</td>
<td>4.17</td>
<td>2.84</td>
</tr>
<tr>
<td>$L_{01}+L_{03}$</td>
<td>2.22</td>
<td>1.94</td>
</tr>
<tr>
<td>$R_{02}+R_{04}$</td>
<td>2.19</td>
<td>1.62</td>
</tr>
</tbody>
</table>

R : Right Side, L : Left Side

*: $p < 0.05$
3.2. Electromyogram (EMG)

3.2.1. Comparison of back muscle activity

The result of muscle activity before and after the correction program presented in Table 8. The results showed that the right side erector spinae muscle activity was significantly \( p < 0.01 \) decreased from 22.36% to 20.22 % by 2.14%. Muscle activity of left side erector spinae was decreased by 0.10%, left side trapezius by 0.71%, and trapezius right by 0.38%. However, there was no significant difference in these muscle activities. The activity of overall left and right muscle activity (Left side of erector spinae and trapezius, right side of erector spinae and trapezius) showed that significant \( p < 0.05 \) decrease in right side muscles (by 1.39 %) were observed. However, there was no significant difference observed in the left side muscles, it only showed 0.80 % decrease. In addition, it was observed that greater decrease in trapezius muscle activity than the erector spinae. Hence, it was clear that erector spinae muscle contributing more to the spinal movement. Overall, it was observed that decreased activities in erector spinae and trapezes muscles only rather increasing the weaker muscles activity. However, this claim should be verified by measuring those muscle activities in future.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre (Mean±SD)</th>
<th>Post (Mean±SD)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL</td>
<td>18.36±4.73</td>
<td>18.26±5.62</td>
<td>.445</td>
<td>.684</td>
</tr>
<tr>
<td>ER</td>
<td>22.36±3.72</td>
<td>20.22±3.28</td>
<td>3.041</td>
<td>.005**</td>
</tr>
<tr>
<td>TL</td>
<td>12.45±2.69</td>
<td>11.74±2.92</td>
<td>1.957</td>
<td>.060</td>
</tr>
<tr>
<td>TR</td>
<td>14.28±3.52</td>
<td>13.90±3.23</td>
<td>1.286</td>
<td>.293</td>
</tr>
<tr>
<td>EL+TL</td>
<td>15.72±3.53</td>
<td>14.92±3.56</td>
<td>1.06</td>
<td>.255</td>
</tr>
<tr>
<td>ER+TR</td>
<td>18.62±3.64</td>
<td>17.23±3.27</td>
<td>2.54</td>
<td>.013*</td>
</tr>
</tbody>
</table>

E: Erector Spinae(left, right), T: Trapezius (left, right) \* p < 0.05, \*\* p < 0.01

4. CONCLUSIONS

This study reported the effect of the body alignment correction program on asymmetry (left-right) developed squash players. Body alignment i.e., postural deviations and muscle activities were analyzed during pre and post training program. Moiré topography was captured to analysis postural deviations and surface EMG was recorded to analysis muscle activities. This study conclusion as follows: achieved scapula to the anatomical position, back muscle asymmetry and its ratio reduced and regained balance, erector spinae muscle contributed more to spinal movement, decreased activities in erector spinae and trapezes muscles than increase in weaker muscles. Hence, the 12 week body alignment correction program was effective for asymmetry developed squash players.

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REFERENCES

Effects of Correction Program on Back Muscle Functional Asymmetry among Squash Players


Gorton G, Masso P. Assessment of the standing posture of patients with scoliosis using optoelectronic measurement techniques. In Pediatric Gait: A New Millennium in Clinical Care and Motion Analysis Technology 2000 (pp. 78-83). IEEE.