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**ORIGINAL ARTICLE**

# Effect of Backstroke Swimming on Pelvic Tilt in females

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**ABSTRACT**
*The aim of the present study was to determine the effect of 8 weeks of backstroke swimming on pelvic tilt in non-athlete girls. For this purpose, 67 non-athlete, female university students willing to participate in this program were selected and divided into two groups. The experimental group (mean height, 159.78 cm; weight, 61.32kg; age, 19.3 years) included 20 subjects and the control group (mean height,163 cm; weight, 62.8 kg; age, 19.5 years) included 23 subjects. The experimental group performed backstroke swimming exercises for 24 sessions while the control group had no specific sport exercise during the 8-weeks of this study. Pelvic tilt rate was measured in the subjects before and after the 8-week period using a caliper, a metal meter, and a marker. The COANOVA test was used for data analysis at a significance level of P<0/05. The results revealed the meaningful effect of backstroke swimming exercise on pelvic tilt in the subjects (P<0/05, F=7/801).The results of this study indicate that the eight-week backstroke swimming exercise had a meaningful effect on decreasing the subjects' pelvic tilt. This is probably due to the improved performance of the posterior rotator muscles of pelvis and the increased flexibility of iliopsoas.*
***Key Words**: Pelvic tilt, Backstroke swimming, Non-athlete girls*

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## INTRODUCTION

Pelvis consists of the junction of the two pelvic bones (each made up the three parts of Ilium, Ischium, and Pubis) with sacrum and coccyx[1].At this junction, there exist 22 muscles which make different movements in the frontal, saggital, and vertical planes[2].Researchers maintain that increased pelvic anterior tilt is usually related to the following abnormalities: 1) inflexibility of lumbar muscles, 2) weak abdominal muscles, 3) inflexibility of the hip flexor muscles, and 4) weak hamstring[3]. Physiotherapists generally try to cure patients with backache by surveying and measuring their pelvic tilt rate. Scientists have found that lumbar lordosis increases as a result of voluntary increase of pelvic anterior tilt but decreases with voluntary increase of pelvic posterior tilt [4]. They also believe that pelvic tilt affects head position and other parts of the body[5].Generally, pelvic tilt is defined in terms of pelvic tendency toward the horizontal plane[6].

In the pelvic part, the iliopsoas muscle has the role of stabilizing the lumbar vertebrae. The contraction of Psoas major is accompanied by pelvic flexion while iliac or iliacus also helps pelvic bending. In kinematics, these two muscles are collectively known as iliopsoas muscles. They can make strong flexion in pelvis[7].The psoas, when it is strong or tight, contributes to the excessive extension of the upper lumbar spine while also causing flexion of the lower lumbar spine[8]. The gluteus maximizes the most effective muscle in the buttocks part and the hamstring muscle at the back of the converse thigh of iliopsoas and rectus femur is responsible for the rotation of the thigh posterior muscle [9]. Although some scientists believe that pelvic anterior rotation is due to the weakness of abdominal muscles and leg extensors, others have shown that the weakness of the posterior rotator muscles of pelvis leads to imbalance[10].

Bellew [9] claims that reduced hamstring flexibility is related to a slight rotation of pelvis during bending to the front side, which limits the bending of the body to the front. She has also shown that hamstring flexibility affects pelvic rotation. Levine et al (2011) studied the effects of abdominal muscles 'power on pelvic tilt and lumbar lordosis and found that performing 8 weeks of power exercise led to a meaningful

increase in the power of abdominal muscles in their experimental group, but they observed no effects on lordosis and pelvic tilt [3]. Carpes et al [11] found that body power and balance programs during 20 session's decreased backache, advanced the motion range of spines and pelvis, and improved the stability of posture in women during walking. Kaneda (2008) surveyed the rate of motion range of pelvic jointing three motion activities: walking in water depth, walking on the ground, and walking in water. After measuring the electromyography activity (EMG) of the muscles involved, he found that the motion range of pelvis was greater in walking in water depth than in walking on the ground or walking in water[12]. Phrompaet *et al* (2011) investigated the effects of Pilates' exercise on the stability and inflexion of lumbar-pelvic. They found that 68% and 85% of their subjects were able to pass the tests related to stability and inflexion successfully after 4 and 8 weeks, respectively, while none of the subjects in the control group was able to pass the tests[13].

The aim of the present study was to investigate the effect of backstroke swimming exercises on pelvic tilt in non-athlete girls.

## METHODOLOGY

For the purposes of this study, 67 volunteer female university students willing to participate in this test were selected. Subjects were non-athlete girls with no special disease or backache history, but they seemed to have weak muscles. From among the volunteers, 23 were placed in the control group and 20 in the experimental group. The subjects filled out physical health questionnaires and signed a disclaimer form approved by the IUT University Office of Human Research Ethics Committee. The remaining ones were excluded from the test duo to their irregular participation in the exercises. The experimental group was instructed to perform special backstroke swimming exercises while the control group was banned from participating in this exercise. The selection criteria of for being assigned to the control or the experimental group included familiarity with backstroke swimming and ability to attend 3 sessions of the exercises per week.

Different methods including radiography, filming, spondyolometry, anthropometry, and goniometry have been suggested for measuring body movements around the saggital plane. Radiography can measure pelvic movements more distinctly than the other methods; however,it is not commonly used due to such disadvantages as possible harms to subjects, high expenses, and unavailability in most academic centers. A technical method suggested by Sanders and Strvrakas for measuring pelvic tilt involves measuring the pelvic angle relative to a horizontal line by using trigonometric functions[1]. In this method, pelvic tilt is defined as the angle formed bythe line between the posterior superior iliac spine (PSIS) and the anterior superior iliac spine (ASIS), on the one hand, and the horizontal line, on the other[1].Gajdosiket al (1985) studied different movements of the pelvis at different levels and found the method proposed by Sanders and Strvrakas more reliable for measuring anterior and posterior tilts of the pelvis [14]. In another study, Alviso *et al* (1998) measured the pelvic rotation angle using a caliper, a meter, and a marker and showed the high reliability of this method for measuring pelvic tilt [1].

The pelvic rotation angle in standing position consists of the angle formed by the line drawn between the posterior superior iliac spine (PSIS) and the anterior superior iliac spine (ASIS) and the horizontal line[1].This same method is also employed in the radiography method[15]. In the normal standing position and in the pelvic anterior rotation, ASIS moves inferiorly and PSIS moves superiorly so that the angle is usually increased. In the pelvic posterior rotation, ASIS moves superiorly and PSIS moves inferiorly such that the angle is decreased[1].

Pelvic tilt measurement in the method suggested by Sanders and Strvrakas is performed as follows. First, the subjects are asked to stand in an upright and comfortable position. For this purpose, the position of the subject's feet is traced on a sheet of paper on which all the subjects are asked to stand. Then, measurement is performed on the right side of the subject as in the following steps. Initially, the ASIS point found by palpating is marked by a marker. Next, the PSIS point is marked in the same way. By placing the caliper on these points, the distance from ASIS to PSIS is recorded. Then, the distance of ASIS and PSIS from the floor is measured and recorded. Finally, the following formula is used to compute pelvic tilt in the standing position based on the data thus obtained:

$$sin\theta = \frac{\text{side opposite}}{\text{hypotenuse}} orsin\theta = \frac{\text{A} - \text{B}}{\text{C}}$$

where, A-B is the distance of ASIS and PSIS from the floor and C is the distance between ASIS and PSIS measured by the caliper[1].

Using the above procedure, pelvic tilt was measured in each of the subjects in both the experimental and control groups. The subjects then participated in their relevant group programs. The exercise program for the experimental group is described in Table (1). After 8 weeks, the two groups were tested again by measuring pelvic anterior tilt.

Table (1): The exercise program for the experimental group

| Week | Exercise program | | |
|---|---|---|---|
| First & second | Heating (walking ) | 2*200 | Returning to original position (walking or backstroke) |
| Third & forth | Heating (walking ) | 3*200 | Returning to original position (walking or backstroke) |
| Fifth & sixth | Heating (walking ) | 4*200 | Returning to original position (walking or backstroke) |
| Seventh & eighth | Heating (walking ) | 5*200 | Returning to original position (walking or backstroke) |

Swimmers took a 5-minute rest in each set. Subjects who were absent for one session had to participate in a compensating session to complete their swimming program so that the end of the study period, each subject had attended 24 sessions of increasing backstroke exercise. After 24 sessions of exercise, the subjects were measured for their weights and the pelvic tilt test was repeated using the caliper, the meter, and the marker. The same post-test measurements were also performed for the control group although they had not taken part in any regular exercise program. The descriptive statistics was used for gathering data and the SPSS software and COANAVA test were used for comparing pre-test and post-test data.

**RESULTS**

Based on the Kalmogroph-Smirnoff test, the data thus collected were found to be normal. The results are presented in Table (2). Given the fact that the significance level was P>0/05 for the pre-test and post-test, it is clear that the normality of the pelvic tilt data is confirmed and the parametric tests such as co-variance analysis can be used to analyze the data. Also, standardization of variances was performed using the Levine's test and the significance level was determined at P>0/05. Pelvic tilt rate was assigned as the dependant variable in the post-test. A high correlation was observed between the pre-test post-test pelvic tilt rates duo to the unique characteristics of the subjects. Using the co-variance analytical model, the effects of pre-test were adjusted and by eliminating the effect of this variable from the dependent variable, the post-test pelvic tilt rate was observed in both groups Table (2).

Table 2Results of co-variance analysis of pelvic balance (determining the effects of exercise and pre-test on pelvic tilt)

| Source of change | Squares sum | Degree of Freedom | Squares mean | F | Significance level | Effect factor | Test exponent |
|---|---|---|---|---|---|---|---|
| Fixed value | 0/002 | 1 | 0/002 | 0/172 | 0/680 | 0/004 | 0/069 |
| Pre-test pelvic tilt | 0/852 | 1 | 0/852 | 72/880 | 0/000 | 0/646 | 1/000 |
| Exercise effect | 0/091 | 1 | 0/091 | 7/801 | 0/008 | 0/163 | 0/778 |
| Error | 0/468 | 40 | 0/012 | | | | |
| Total | 1/320 | 42 | | | | | |

It is clear from Table 2 that the individual exercise had a significant effect on pelvic tilt (P<0/05, F=7/801). The mean values of pelvic tilt in both control and experimental groups show a meaningful difference, indicating that backstroke exercise had a meaningful effect on decreasing pelvic tilt. The level of significance for the pre-test scores equals zero (i.e., P>0/05).Based on the co-variance analytical method, it can, therefore, be concluded that the exercise has a meaningful effect on decreasing pelvic tilt.

**DISCUSSION**

It has been suggested that weak abdominal musculature can increase pelvic anterior tilt[1].It is also believed that hamstring contraction or stretching can affect pelvic posture due to its connection to the pelvis[16]. Although several studies have been conducted on the effect of the length of abdominal musculature, hamstring, and pelvic flexor on pelvic tilt, few have been conducted to determine the effect of exercise on pelvic tilt. The present study is novel in that it investigates the effect of 8 weeks of backstroke swimming exercise on pelvic tilt.

Swimming is a favorite sport among people as an amusing sport and among therapists for its invigoratingly active nature that involves many muscles. In backstroke swimming, the main group of muscles involved includes biceps, triceps, gluteal, hamstring, quadriceps, leg, spinal curves, shoulder, neck, thoracic, and breathing muscles[17]. The backstroke leg involves the group of gluteal, rumps, quadriceps, and leg muscles. Compared with other kinds of swimming, backstroke swimming creates a greater flexibility in the ankle muscles (in torsion) and pelvic rotator muscles due to numerous foot strokes [18], and strengthens the operative muscles because of the water condition.

In the saggital plane, four muscles preserve the normal pelvic posture: pelvic flexors, pelvic extensors (gluteal and hamstring), body extensors (lumbar muscles), and body flexors (abdominal wall muscles)[19]. Pelvic flexors and body extensors give raise to the anterior tilt while pelvic extensors and body flexors are responsible for the posterior tilt. Balance in this part depends on the stretching of the musculature counteracting each other, which determines the pelvic posture in the saggital plane[19].

The aim of the present study was to examine the effect of 8 weeks of backstroke swimming exercise on pelvic tilt in non-athlete girls. It was found that escalating backstroke swimming exercises decreased the pelvic anterior tilt with at a confidence level of P<0/05. Swimming, especially backstroke swimming, can, therefore, improve the pelvic posture and return the pelvic anterior tilt to its normal posture.

These results are somehow consistent with findings of previous studies. Bellew (2010) found a relationship between hamstring flexibility and pelvic tilt[9]. Because the hamstring is active in backstroke leg strokes, it may be possible to justify the results of this research with regard to hamstring inflexion and consider these results in agreement with Bellew's. Levine et al (1997) investigated the effect of abdominal power exercises on lordosis and pelvic tilt and found that these exercises had no effect on pelvic tilt [3]. The results obtained for back stroke exercises do not agree with those reportedfor abdominal power exercises probably because the effect of back stroke exercises on other muscle groups. In a test, Walker et al (1987) showed that a negligible relationship between abdominal muscles performance and pelvic tilt and lumbar lordosis. However, they mentioned that muscles other than the abdominal musculature may be involved in pelvic tilt and lumbar curvature[20].In the present study, the backstroke exercises led to improved pelvic tilt probably because numerous muscles are involved in this type of exercise. Also, Carpes' exercise program was effective in his subjects and improved the motion range of the pelvis[18], confirming the results of the present study concerning the effect of backstroke exercises on pelvic posture. Kaneda (2008) reported that walking in water depth had a better effect on pelvic muscles than walking on the ground; this also confirms the present results regarding the positive effect of backstroke exercises on pelvic posture. Finally, the present results are in agreement with those of Pilates' exercises conducted by Phrompaet [13].

## CONCLUSION

As already mentioned, a large number of muscles are connected to the pelvis whose weakness or inflexibility may directly affect the iliacus pelvic posture. Hamstring is one important muscle affecting pelvic stability which is especially involved in a broad range of human activities[21].Previous studies have shown that exercises that give rise to greater flexibility of hamstring have better effects on pelvic stability[13]. Although some studies show no effect of abdominal muscle power on pelvic tilt, others indicate that this lack of effect might be restricted only to a specific group of muscles while others may have positive effects [20].It has been recommended that performing exercises is necessary for strengthening the pelvic posterior rotators in order to maintain/restore balance in the pelvic part [10]. Therefore, exercises that involve a larger number of muscles and strengthen and/or enhance their flexibility exercise positive effects on pelvic posture. Backstroke leg is one such exercise which employs big and deep muscles leading to their strengthening and enhanced flexibility. The most important muscles in this exercise are hamstring, iliopsoas, abdominal, and quadriceps muscles. Hence, the results of the present study are validated by the fact that performing backstroke swimming has a meaningful effect on pelvic posture and improves the pelvic anterior rotation at probability of P<0/05.

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