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THE RELATIONSHIP BETWEEN LUMBAR LORDOSIS AND ANTERIOR PELVIC TILT AFTER 8 WEEKS OF BACKSTROKE EXERCISE

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ABSTRACT
Pelvis is the skeletal part lying between the spinal columnand the lower extremities. Researchers believe that any kind of change in the position of pelvis has a direct effect on posture (MuscolinJoe, 2012). The purpose of this study wasto determine the relationship between lumbar lordosis (LL) and pelvic tilt (PT) before and after 8 weeks of backstroke exercise in non-athlete females with lowlumber lordosis. The Participants were divided into two experimental and control groups based on their interest in swimming and their floating skills. The experimental group included 44 Participants (age: 19/25 years, weight: 35/62kg, and height: 52/163 cm) while the control group consisted of 23 Participants (age: 3/19 years, weight: 35/61kg, and height: 52/163 cm). The experimental group performed the backstroke exercise for 8 weeks while the control group had no specific sports exercise. LL was measured using a flexible ruler and PT was measured with a caliper and a metal meter before and after the eight weeks of backstroke program in both the control and experimental groups. The data thus obtained were analyzed using the Pearson correlation ($p<0.05$). No meaningful relationship was found between LL and PT before and after the eight-week exercise in either the experimental or the control group.

KEY WORDS: Backstroke swimming, Lordosis, Lumbar, Pelvic tilt, Relationship.

INTRODUCTION

Pelvis is located between the spinal column and the lower extremities and is connected to the sacrum and the coccyx. The lumbar spine sits on the sacrum. Hence, any change in the posture of the pelvis, and thereby in that of the sacrum, directly changes the posture of the lumbar spine (MuscolinJoe, 2012). Intensified lumbar lordshis disease has a close relationship with the structure of the lumbar and sacroiliac spines; lumbar muscles; the extensor, lumbar fascia, and the abdominal muscles; hip flexor; and the hamstring muscle group (Alizadeh., 2006). Since 1960s, incidence rates of disabling low back pain have increased faster than any other disabling conditions (Kroll Penny., 2000). Alterations in the normal relationships between the alignment of the spine, the position of the pelvis, and the length of the muscles attaching to the spine and pelvis have been implicated as contributory factors to the development of low back pain (Toppenberg Rowena., 1986). Little is known about the relation of lumber lords and pelvic tilt. Toppenberg (1986) studied the interrelations of spinal curves, pelvic tilt, and muscle lengths in adolescent females. He found no muscle length index was found to be significantly correlated with pelvic tilt (Toppenberg Rowena., 1986).

Sitting for a long time and immobility of hip flexor lead to the development of short hips (Toppenberg Rowena M., 1986). The posterior rotation of pelvis and the convenient sacral angle let lordosis to return to its normal state (MuscolinJoe, 2012) which is generally considered to be a position of anterior tilt such that the sacral base angle measures approximately 30 degrees. The sacral base angle is determined by measuring the angle formed between a line drawn along the base (top) of the sacrum and a horizontal line (MuscolinJoe, 2012). Some researchers have documented that the voluntary increase of the anterior pelvic tilt increases lordosis and that the voluntary extension of the posterior pelvic tilt decreases the lordosis angle (Levine D, 1996). The standing pelvic tilt angle is the angle formed by a line drawn through the posterior superior iliac spine (PSIS) and the anterior superior iliac spine (ASIS) and the line of the horizontal plane (Alviso Debra, 1988). In an anterior pelvic tilt, the ASIS moves inferiorly, the PSIS moves superiorly, and the angle is usually increased from that of relaxed standing. In a posterior pelvic tilt, the ASIS moves superiorly, the PSIS moves inferiorly, and the angle is decreased (Alviso Debra, 1988). Walker *et al* (1987) studied the relationship among lumber lordosis, pelvic tilt, and abdominal muscle performance. They found no relationships between the performance of abdominal muscles and lumber lordosis orpelvic tilt in the standing position(Walker Martha L 1987)

Lopez *et al* (2012) studied the effect of hamstring stretching protocol on spinal curve lordosis and pelvic tilt. They concluded that stretching produced no significant changes in the spinal curvatures or in the pelvic tilt on standing. Static stretching of the hamstring is associated with an immediate change in the saggital spinal curvatures and pelvic position when performing trunk flexion with knees extended (López Pedro A.-Miñarro, 2012). Naseri *et al* (2010) studied the relationship of pelvic tilt and lumbar lordosis with muscle tightness, BMI, and age among 75 healthy women in the standing position. The found a poor relationship between each of these variables with muscle strengthening, BMI, and age. Muscle tightness and muscle strength had no significant effects on pelvic tilt or lumbar lordosis (Naseri, 2010). Levine *et al* (1997) conducted a study to determine the effects of abdominal muscle strengthening on lumbar lordosis and pelvic tilt. They observed that exercise increased abdominal muscle strengthening but found no meaningful difference between pelvic tilt test and lumbar lordosis in the standing position among the different groups tested (Levine David, 1997). Kroll *et al* (2000) studied the relationship between lumbar lordosis and pelvic tilt angle among 3 groups who had normal, decreased, or increased lumber lordosis in the standing position. They found a poor relationship between pelvic-tilt state and pelvic tilt classification. Moreover, they observed a meaningful difference between pelvic tilt and decreased or increased lumbar lordosis but no meaningful relationship between pelvic movable domain and lordosis in their groups (Kroll Penny G., 2000). Yasukochi (1995) studied the low back curve with pelvic tilt among 20 men in one standing position and 3 sitting positions.The related was significantly between trunk tight angle of 120 degrees (Yasukouchi, 1995).

While previous studies have focused on the relationship between lordosis and pelvic tilt in the standing position, the purpose of this study was to study the relationship between lumbar lordosis and pelvic tilt before and after 8 weeks of backstroke swimming exercise. The results show that lumbar lordosis improved after the exercise but no effects were observed on anterior pelvic tilt.

MATERIALS AND METHODS

For the purposes of this study, 156 female university students were screened, 98 of whom had been detected with lordosis in the primary test of standing against the wall. The selection criteriato be included in the study were eagerness to participate in the experiment, having no special disease or backache history, and having weak muscles. The Participants filled out physical health questionnaires and signed a disclaimer form approved by the IUT University Office of Human Research Ethics Committee. The selected Participants were divided into two experimental (68 Participants) and control (30 Participants) groups based on skills in backstroke swimming and interest in participating in the exercises three times a week. The protocol approved by the IUT University Office of Research. The experimental group was instructed to perform a special backstroke swimming exercise, while the control group received no especially designed exercise.

Lumbar lordosis and pelvic tilt were determined for each Participant using a flexible ruler and a caliper strip meter (both approved by University of Tehran), respectively. A modified meter metal (Japan) was used for measuring height
A variety of methods can be used for measuring pelvic rotation angle in the sagittal plane. Radiography is one such method used to measure pelvic movements. The disadvantage, however, is that it is harmful to Participants. Furthermore, it is almost impractical for research purposes due to the high cost associated.

The clinical Sanders and Stavarkez method employed in the present study uses trigonometric functions to calculate the angle of pelvic tilt rotation relativity the horizontal plane (Alviso Debra, 1988). Alviso *et al* (1988) measured the pelvic angle distinctly by making use of a caliper, a marker, and a meter stick and found it more reliable. Gajdosik *et al* also confirmed the validity and reliability of this method (Gajdosik Richard, 1985). Intra-tester reliability (Pearson) of 88 has been reported for the test and re-tests standing pelvic tilt angle measurements. According to this method, the Participants should, initially, stand in a direct and comfortable position. For this purpose, the condition of the individual's feet was traced on a sheet of paper on which she stood. Measurement was then performed on the right side of the Participant as in the following steps. All the PSIS points were initially found by palpating followed by tracing. Next, the ASIS point was touched and traced. The caliper was subsequently placed on these marks and the distance from ASIS to PSIS was recorded. In the next step, the ASIS and PSIS distance from the floor was measured using a meter and recorded. The following formula was used for computing the pelvic tilt in the standing position:

$$\sin\theta = \frac{sideopposite}{hypotenure} or \sin\theta = \frac{AB}{C}$$

Where. A represents the PSIS distance from the floor, B designates the ASIS distance from the floor, and C is the distance measured by the caliper. Thus, A-B expresses the difference between ASIS and PSIS heights and C will be the distance between ASIS and PSIS (Alviso Debra, 1988).
In a second stage of the experiment, the Participants were examined for lumbar lordosis using a flexible ruler. The flexible ruler has been used and confirmed by a number of researchers (Lovell , 1989 ; Sydi, 2009). Height and weight were also measured for each Participant.

In some studies, lordosis has been measured from L_3 toS_2 while in others, it has been measured from L_1 to S_1 (Danshmandi, 2006; Sydi, 2009). In the present study, lordosis was recorded with a flexible ruler between L_1 and S_1. According to the following formula, the arc angle was measured to be Ø =4Arctg (2H/L). The Participants were then accepted into the plan. L is distance between L1 and S1, H is the distance between the midline of L and the deepest part of the curve

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

Swimmers took a 5-minute rest in each set. Participants who were absent for one session had to participate in a compensating session in order to complete the exercise program as planned. At the end of the study period, each Participant had performed 24 sessions of the backstroke exercise when they were weighed again and their lumbar lordosis was measured using a flexible ruler. Pretest measurements were also performed for the control group although they did not take part in any regular exercise program. At the end of the study period, 44 Participants from the experimental group and 23 Participants from the control group participated in the post-test because some from the experimental group did not participate in the exercises on a regular basis and some from the control group did not participate in the post-test. The SPSS and Pearson correlations were used in the pretest and post-test for determining the relationship between lumbar lordosis angle and pelvic tilt in the Participants.

RESULTS

Tables 2 to 4 present the data revealing the relationship between lumbar lordosis and pelvic tilt. Clearly, eight weeks of exercise had a meaningful effect on lumbar lordosis in the control group; however, the specifically designed exercise did not have any meaningful effect on the 44 Participants with pelvic tilt. The information also indicates that the correlation between lordosis and pelvic tilt is not meaningful (p>5%).

Table 2 Correlation in the experimental group's pre-test

		Tilt 1	Tilt 2	Lordosis1	Lordosis 2
Tilt 1	Pearson Correlation	1	1	0.016	-0.152
	Sig. (2-tailed)			0.920	0.325
	N	44	44	44	44
Lordosis 1	Pearson Correlation	0.016	-0.152	1	1
	Sig. (2-tailed)	0.920	0.325		
	N	44	44	44	44
a.group = 2.00					

Table 3 Correlation in the control group's pre-test

		Tilt 1	Tilt 2	Lordosis 1	Lordosis 2
Tilt 1	Pearson Correlation	1	1	0.365	0.238
	Sig. (2-tailed)			0.086	.274
	N	23	23	23	23
Lordosis 1	Pearson Correlation	0.365	.238	1	1
	Sig. (2-tailed)	0.086	.274		
	N	23	23	23	23
a. group = 1.00					

Comparison of the post-test and pre-test pelvic tilts between the two experimental groups reveals that the dependent variable is post-test pelvic tilt. Due to the unique characteristics of the Participants, the pre-test pelvic tilt exhibits a high correlation with the post-test one. Pre-test effects were cancelled out by using the co-variance analysis. The pre-test pelvic tilt scores in the two study groups were determined by eliminating the effect of this dependent variable.

Table 4 Results of co-variance analysis on pelvic tilt

Source of change	Squares sum	Degree of Freedom	Squares mean	F	Significance level	Atha Correlation
Pelvic balance pre-test	0.457	1	0.457	24.272	000	0.275
Exercise effect	0.12	1	0.12	0.621	0.434	0.10
Error	1-205	64	0.019			
Total	1.704	66				

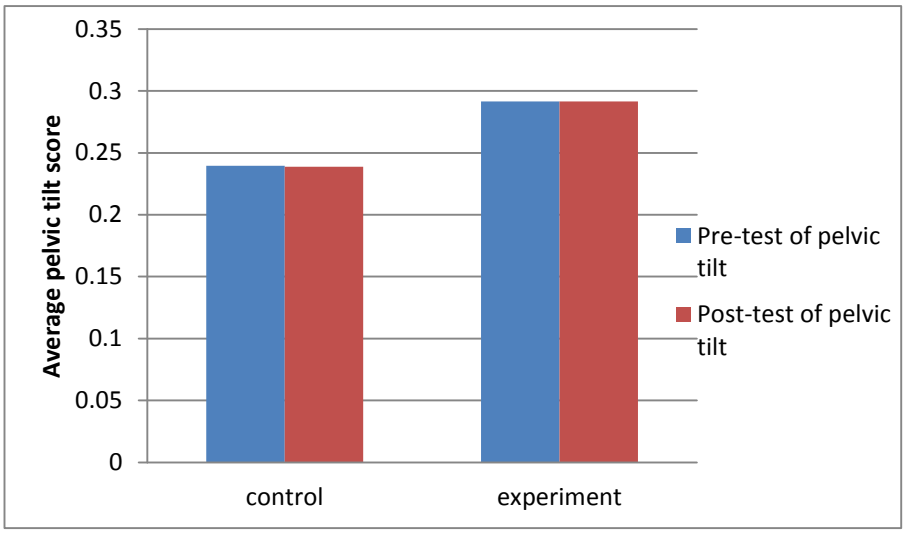

Diagram 1. Pre- and post-test pelvic tilt scores for both control and experimental groups

It is clear from the above Table that individual exercise had no significant effects on pelvic tilt (f=0/62; p>0/05). Therefore, the average pelvic tilt scores in the experimental and control groups exhibit a meaningful difference. These findings indicate that treatment had no effect on decreasing pelvic tilt.

The level of significance for the pre-test scores equals zero (i.e., P>0/05). Therefore, pre-test has a meaningful effect on pelvic tilt. This means that pelvic tilt in post-test is influenced by the pelvic tilt in the pre-test. Based on the co-variance analytical method, it may, therefore, be concluded that exercise does not have any meaningful effect on decreasing pelvic tilt. Diagram 1 shows the mean post-test and pre-test pelvic tilt scores for the control and experimental groups independently.

DISCUSSION

The relationship between pelvic posture and lordosis with backache is not yet established; neither is the relationship between pelvic tilt and lordosis. This failure to identifya relationship may be because of the limitations in the measurement of the pelvic tilt angle and its position as well as the lack of proper method for lordosis gradation (Kroll Penny., 2000). Scholars believe that the sacrum is not placed at a proper level due to anterior pelvic rotation, which leads to a compensatory lordosis on lumbar spines in order to balance the gravity center. Therefore, lumbar spines lordosis is a direct result of anterior pelvic rotation in the sagittal plane (MuscolinJoe, 2012). Habibi *et al* (2011) maintain that the relative weakness of anterior pelvic muscles in men causes an increase in lumbar lordosis. Complementary exercise prescriptions for balancing muscular strengthening in the lumbar-pelvic belt, thus, improves lumbar abnormality (Habibi Abdolhamid, 2011).

The source of hamstring muscles is connected to the pelvisischial tuberosityexcept the short head of Biceps Femoris. Therefore, hamstring contraction affects pelvis posture. Pelvis is located perpendicular to the spinal curve and its posterior inclination affects the spinal curve lordosis in the sagittal plane. Changing the hamstring length can influence the position of pelvis and spinal curves, especially when hamstring has high or medium contractions (López Pedro A.-Miñarro, 2012). Armpit (2010) has shown that Pilates exercise leads to meaningful improvements in flexibility during exercises so that 65 to 85 percent of the Pilates Participants able to perform the test exhibited improved pelvic lumbar constancy (Phrompaet sureeporn, 2011). Other researchers believe that one group of muscles is more flexible in each type of sport than others. They conclude that it is essential to design exercises that involve all the muscles in order to prevent sport injuries (Nasiri Mohammad, 2011).

Swimming is a favorite sport among therapists due to its invigoratingly active nature that its simultaneous involvement of all the muscles in the exercise. In backstroke swimming, the main group of muscles involved are biceps, triceps, gluteal, hamstring, quadriceps, spinal curves, shoulder, neck, thoracic, and breathing muscles (eHow, 2013). In the backstroke leg swimming, the muscle group including the gluteal, rumps, quadriceps, and leg muscles gets involved. Compared with other kinds of swimming, backstroke swimming is more flexible because of the numerous strokes of foot, ankle, and pelvic rotation muscles (Troup, 1999). Moreover, the operative muscles are strengthened because of the water condition. Studies have shown that one hamstring stretching protocol affects the spinal curve lordosis and pelvic tilt (López Pedro A.-Miñarro, 2012).

CONCLUSIONS

The purpose of this study was to investigate the relationship between lumber lordosis and pelvic tilt before and after eight weeks of backstroke exercise. Findings indicate that there is no meaningful relationship between lumber lordosis and pelvic tilt. Walker *et al* (1987) found a poor relationship between lumber lordosis and pelvic tilt (Walker Martha L 1987). Lopez *et al* showed that stretching protocols had no meaningful effects on lumber lordosis or pelvic tilt in the standing position (López Pedro A.-Miñarro, 2012). Naseri *et al* reported that the relationship between pelvic tilt and lordosis was too weak among their 75-year-old Participants (Naseri N, 2010).Levine *et al* found that powerful abdominal exercise did not have any meaningful effects on lordosis or pelvic tilt (Levine David, 1997). Kroll *et al* maintain that a relationship can be established between pelvic tilt and decreased or increased lumber lordosis but that no such relationship may exist in natural lordosis (Kroll Penny., 2000). In the present study, there was no meaningful relationship between pelvic tilt and lumbar lordosis among the two groups in the pre-test and neither was any meaningful relationship found after 8 weeks of backstroke exercise in the post-test. Previous studies had reported either no meaningful relationship among these variables or only a weak relationship in the comfortable standing positions without any decrease or increase in lumbar lordosis. In this paper, exercise was found to lead to improvements in lumbar lordosis although no meaningful effect was discovered on the pelvic tilt. It may, therefore, be concluded that considering the involvement of muscles and the improvement of Participants' lumbar lordosis in the experimental

group as a result of the backstroke exercise, no meaningful relationship can be established between lumbar lordosis and pelvic tilt. For future studies, it is suggested that more convenient exercises be investigated that involve other muscles since spinal curve abnormalities resulting in backache is an important problem in industrial societies that warrants study of the factors involved in pelvic tilt and spinal curve abnormalities.

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