The Effect of Positive, Negative and Zero Inclinations on Lumbosacral Biomechanical Angles

Morteza Saeb [1], Somayeh Nemati [2], Naser Behpour [3], Kamran Ghoreishi [3], Tayebeh Mahvar [1*]

[1.] Department of education, Ayatollah Taleghani hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran
[2.] Kermanshah faculty of physical education and sports sciences, Kermanshah, Iran
[3.] Razi University, Kermanshah, Iran
mandanamahvar@yahoo.com

Abstract: Poor movement and lack of physical mobility in children and teenagers are the major causes of physical weakness and major factors in retarding the growth process. Corrective movements are intended to balance the body and decrease the pressure on different organs. The present study compared the effects of different heel inclinations, while doing corrective movements, on the changes of lumbosacral biomechanical angles in students with lumbar hyperlordosis. This quasi-experimental study was conducted on 15 girls diagnosed with hyperlordosis with the mean age of 10.93. They were divided into 3 groups (n=5) and carried out corrective movements on positive, negative and zero inclinations for 8 weeks. Then, the sacral inclination angle (SIA), sacral lordosis angle L1-L3 (SLA L1-S3), sacral lordosis angle L3-S1 (SLA L3-S1), and the effects of inclinations on these angles were determined. Data were analyzed by SPSS 16 software using Kruskal-Wallis statistical test. The findings indicated no significant difference in terms of angle changes in different groups ($P \geq 0.05$). However, there was very little difference between the three groups in terms of angle L3-S1. Despite the insignificant differences, there were more changes in the group standing on negative inclination compared to the other groups. Based on the findings, it can be argued that since the corrective movements were the same for all groups and the only difference was observed between groups regarding the inclination used under the individuals' feet, the differences between groups can be attributed to the differences in the heel inclinations.

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1. Introduction

Poor movement and insufficient physical activities during childhood and teens are major causes of physical weakness and main threatening factors in postponing the growth process. Corrective movements with the aim of removing various physical weaknesses balance the body posture and consequently reduce the pressure on different parts of the body. Weak physical conditions, due to the pressures on different organs, create an imbalance in the body posture and this regular pressure creates non-anatomic adaptability. Imbalance in the body posture occurs over time (Swinkels & Dolan, 2000). Position changes exert abnormal stretching posture on ligaments and muscles that indirectly affect lumbar and pelvic inclination (Knight, et al., 2007). Also, establishing normal lumbar lordosis is essential in the treatment of spinal disorders. The attributes of lumbar lordosis are highly dependent on sacral and pelvic inclinations. Further, the amount of lumbar lordosis inclination is associated with lumbosacral angles (NakipogIu & Karagoz, 2008). The analysis of lordosis or any other disorder associated with spines is part of the issue, another part of the issue includes questions such as, how much are these disorders changeable? How can these changes be done? etc. Shoes and especially, heel height are factors influencing the posture, which in the case of being improper, can help create abnormal posture (Knight, et al., 2007). Heel is a major factor in changing the power in shoes (Van & Hobley, 2001). Many studies have indicated that different heel inclinations have various effects on lumbar lordosis. Some studies have shown that positive heel inclination has no effect on lumbar lordosis or it decreases lumbar lordosis. Some studies have reported that negative heel inclination causes a decrease in lumbar lordosis (Barbara, et al., 1991). In this study, the impact of positive, negative and zero heel inclinations on biomechanical angles were compared to identify the best heel slope for school children with increased lumbar lordosis and to take the required measures to improve, treat and prevent this disorder.

2. Material and Methods

This research was quasi-experimental which was carried out on 23 female students aged 10-11 with hyperlordosis through the test of putting their hands on their waist while standing directly in front of the wall with their head, shoulders, hips and heels

attached to the wall. Scanning and measurement of the angles revealed that three of them had no real lordosis and were excluded from the study. With reference to medical files, three other participants were excluded from the study, too, due to other physical and clinical problems. Also, two of them were excluded from the study due to their parents' disagreement to participate in the study. Finally, 15 students were selected as the study sample. After the research process was thoroughly explained to the students and the students' tendency to participate in the study was ensured, their parents completed the consent forms. Then, the information about the students' height, weight, age and medical records were obtained from their medical files. Lateral spinal and lumbosacral x-rays were prepared from their feet (without shoes). Before scanning, the samples were kept in the standing position in order to fix their position (5). The samples were then randomly assigned to 3 groups (n=5). Taking advice from the physiotherapist and orthopedist and under the full supervision and guidance of the researcher, the students performed the corrective exercises on +3.7°, 0°, and -3.7° slopes, respectively for 8 weeks, three times a week (Figure 1).

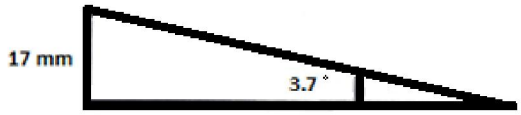

Figure 1. Characteristics of the sloped block used in the study

After 8 weeks of exercise, scanning was done again to determine the level of changes in the angles. The angles were measured with complete supervision of the radiographer on the x-rays both before and after exercises, which include as follows.

1. Sacral inclination angle (SIA): the angle between the drawn tangent line on the posterior margin of S1 and vertical line (Figure 2)

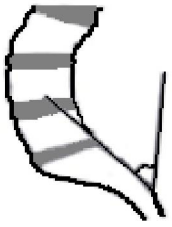

Figure 2. Measurement of SIA

2. Sacral lordosis angle L3-S1 (SLA L3-S1): the angle between the tangent lines on the superior edges of SLA L3-S1 (Figure 3)

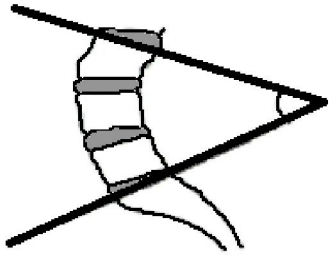

Figure 3. Measurement of SLA L3-S1

3. Sacral lordosis angle L1-L3 (SLA L1-L3) (Figure 4)

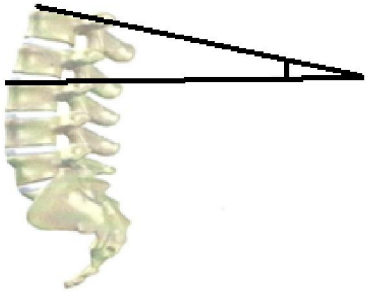

Figure 4. Measurement of SLA L1-L3

Finally, the data were analyzed by SPSS 16 software. Non-parametric statistical method and Kruskal-Wallis test were applied to compare the changes in the groups.

3. Results

The results of the data analysis indicated that the means of height, weight, and age of the groups with positive inclination were 4.50±135.6 cm, 2.30±28.4 kg, and 0.44±10.8 years, and in the group with zero inclination, were 8.29±141.6 cm, 4.32±31.8 kg, and 0.83±11.2 years, respectively (Table 1).

Comparison of the effects of various inclinations used under the heel while doing corrective movements on sacral inclination angle (SIA) indicated +11 for positive slope group, -1.2 for zero slope group and -1.6 for negative slope group, which revealed no statistical significant difference (P=0.47) (Table 2).

Table 1. Results of means for height, weight and age in various groups

Groups	Mean		
	Height (cm)	Weight (kg)	Age (year)
Group 1 (positive inclination)	4.50±135.6	2.30±28.4	0.44±10.8
Group 2 (zero inclination)	10.50±142.4	11.7±36.4	0.83±10.8
Group 3 (negative inclination)	8.29±141.6	4.32±31.8	0.83±11.2

Table 2. Comparison of the means of changes in SIA for various groups

	Mean of changes in group 1 (positive inclination)	Mean of changes in group 2 (zero inclination)	Mean of changes in group 3 (negative inclination)	Sig
Changes of SIA in groups after doing corrective movements	+11	-1.2	-1.6	0.47

Further, the effects of various inclinations used under the heels, while doing corrective movements, on sacral lordosis angle L1-L3 (SLA L1-L3) indicated -3.2 for positive inclination group, -6.6 for zero inclination group, and +1.4 for negative inclination group, which revealed no statistical significant difference (P=0.32) (Table 3).

Table 3. Comparison of the changes in sacral lordosis angle L1-L3 (SLA L1-L3) for various groups

	Mean of changes in group 1 (positive inclination)	Mean of changes in group 2 (zero inclination)	Mean of changes in group 3 (negative inclination)	Sig
Changes of SLA L1-L3 in groups after doing corrective movements	-3.2	-6.6	+1.4	0.32

In addition, the effects of various inclinations used under the heels, while doing corrective movements, on sacral lordosis angle L1-S1 (SLA L1-S1) indicated -34.6 for positive inclination group, -6 for zero inclination group, and +0.5 for negative inclination group, which revealed no statistical significant difference between groups (P=0.09) (Table 4).

Table 4. Comparison of the changes in sacral lordosis angle L1-S1 (SLA L3-S1) for various groups

	Mean of changes in group 1 (positive inclination)	Mean of changes in group 2 (zero inclination)	Mean of changes in group 3 (negative inclination)	Sig
Changes of SLA L3-S1 in groups after doing corrective movements	-4.6	-6	+0.5	0.09

4. Discussion

The findings indicated no statistical significant difference between various angles in different groups (P≥0.05). Regarding the sacrum lordosis angle L3-S1, the difference between groups was very little. However, despite the non-significant differences, there were more changes on the negative inclination in the standing group compared to the other two groups. The SIA increased in positive inclination in the standing group. For other groups, however, the decrease in the negative inclination group was higher than zero inclination in the standing group. Generally, it can be argued that SIA will increase when the heel inclination increases, and using positive heel inclination can, through increasing SIA, cause anterior pelvic tilt in the long term and

consequently result in changes in other angles. Sacral lordosis angle L1-L3 (SLA L1-L3) increased in negative inclination in the standing group, but it decreased in other groups. The decrease in zero inclination was higher than that of positive inclination in the standing group. In fact, it can be suggested that SLA L1-L3 increases by decreasing heel inclination. In spite of the differences in the changes observed between groups, the differences were not statistically significant. The changes in SLA L3-S1 were different than other angles. These decreasing changes in zero inclination in the trained group, however, were higher than other groups.

Further, there was a decrease in positive inclination changes in the trained group, less than zero inclination group, but there was no changes in the negative inclination in the trained group, which were trivial considering the possible errors in this study. The differences in this angle were not statistically significant between groups. Since the corrective movements applied on the three groups were the same and the only difference between groups was for the inclination used under the heels, therefore, the differences in the results of the groups can be attributed to the differences in the inclinations used for different groups.

Many studies have been conducted on the effects of different inclinations on the body, some of which are mentioned below:

Bendix et al. (1984) investigated the relationship between shoe heel slope and lumbar inclination. Their sample comprised of 18 people with a height of 2.5 - 4.5 cm under their heels. The findings showed that lumbar lordosis decreased as the heel height increased .

Moreover, Franklin et al. (1995) studied the effects of positive inclination on body posture. They required the participants to stand on a wooden block with positive inclination of 5.1 cm. They analyzed their skeletal system in the spine area after their position was fixed after 10 minutes. They reported a decrease in lumbar lordosis and pelvic inclination angle in the samples standing on the wooden block with positive heel inclination in comparison with zero inclination.

Furthermore, Russell, et al. (2004) conducted a study on 61 samples with no record of structural or neurological disorders. After evaluating the samples in the standing position with bare feet, each of the samples put on the shoes with positive heel inclination and stood for 10 minutes to fix his/her position. Then, the second evaluation of lordosis was carried out. All of the shoes had the heel height of 7.5-10 cm. The findings indicated that lumbar lordosis and sacral angles slightly decreased in the standing position on positive heel inclination compared to bare feet condition, but the difference was not statistically significant. Some of the subjects indicated an increase in lordosis, as well. The findings of this study showed that shoes with positive heel inclination had no significant effect on lumbar lordosis.

In their study, Kim et al. (2005) required the participants to put on shoes with negative heel inclination and walk, during which they investigated several physiological attributes such as heart beat and oxygen consumption. They concluded that walking with shoes with negative heel inclination decreased the heart beat and energy consumption while walking, in comparison with normal shoes.

Also, Myers et al. (2009) reported that using negative heel inclination caused a significant change in the walking speed and step length, although the motor coordination decreased.

Although the findings of the present study revealed non-significant differences between the angular changes in the groups standing on different inclinations, using these inclinations while doing corrective movements may accelerate the intended changes in people with hyperlordosis.

Further, the results of this study can be applied to corrective exercises with more useful facilities to achieve better results in shorter periods so as to prevent the effects of hyperlordosis on other tissues as well as individuals' posture. In addition, the findings obtained in this study can help parents choose more appropriate shoes for their children to both prevent the incidence of posture disorders during childhood and spinal disorders in adulthood.

Corresponding Author:
Tayebeh Mahvar
Department of education
Ayatollah Taleghani hospital
Kermanshah University of Medical Sciences,
Kermanshah, Iran
Email: mandanamahvar@yahoo.com

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