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B – Data Collection
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The Effects of Various Heel Slopes on Lumbosacral Biomechanical Angles in Students with hyper lordosis

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SUMMARY

Background: Posture disorders in school-age children are highly frequent. Poor movement and lack of physical mobility are the main causes of physical weaknesses. Thus, corrective exercises with the aim of solving these problems are significant. The aim of this study was an evaluation of the effects of various heel slopes on lumbosacral biomechanical angles in students with hyperlordosis.

Material/ Methods: In this quasi-experimental study, 15 female students who were diagnosed with hyperlordosis, participated in this study. They were divided into 3 groups (n=5) and performed corrective exercises on +3.7°, 0°, and -3.7° slopes for 8 weeks, 3 times a week. The changes in the lumbar lordosis angle (LLA), sacral based angle (SBA), and lumbosacral angle (LSA) were determined. Data were analyzed by SPSS 18 software using non-parametric test followed by the Kruscal-wallis test. $P<0.05$ was considered significant

Results: The results indicated no significant difference regarding the changes in LLA, SBA, and LSA in students with hyperlordosis ($p>0.05$) despite the decrease in the means of the angles in all groups.

Conclusions: The results showed that by increasing the heel slope, the lumbosacral slope decreases also the lumbosacral angle decreases by decreasing the heel slope, this may indicate an association between these angles.The findings 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.

Key-words: lumbosacral, heel slope, corrective exercise, hyperlordosis

INTRODUCTION

Having a proper physical condition is an important factor in doing activities as well as sports [1]. Physical condition is the outcome of coordination and co-operation between different organs of the body, especially the muscles and bones [2]. Previous studies on physical condition and skeletal disorders indicate the high incidence of spinal disorders in students [3]. The results of studies show that there is a high incidence of chronic backache in different social classes, which is probably due to the changes in spinal inclination, especially in the lumbar area and the lack of proper balance in lumbar and pelvic muscles [4,5]. On the other hand, posture disorders in school age children are most frequent [6]. Poor and inadequate physical activities during childhood and in one's teens are major causes of physical weaknesses and a threatening factor in delaying the growth process [7]. Therefore, corrective exercises, aiming to eliminate different physical weaknesses and improve the disorders, are quite essential to make the body healthy and to ensure a desired physical condition that is the coordination of different parts of the bodpmbalance in body posture happens over time and shortens or lengthens different parts of the body and consequently brings about weaknesses in both cases [8,9]. In addition to the bones and ligaments which affect the formation and preservation of lumbar inclination, muscles play an essential role, too. Muscular weakness, overstretching, spasms are often accompanied by incidences of posture disorders [10,11]. Clinical studies suggest that lumbar lordosis, pelvic rotation and performance of abdominal muscles and thigh extensors dramatically affect the anterior pelvic tilt and consequently increase lumbar inclination. Also creating normal lumbar lordosis is essential in the treatment of spinal disorders [12,13]. Abnormal posture stretches ligaments and muscles that indirectly influence lumbar spinal inclination [14]. Shoes, especially their heel height are influential factors affecting posture so that an inappropriate height can result in the creation of abnormal posture [15]. Also the heel is a major factor in changing the power in walking [16]. In most of the studies conducted so far, it is indicated that positive heel inclination decreases lumbar lordosis or has no effect on it. On the other hand, advocates of shoes with negative inclination believe that negative heel inclination decreases lumbar lordosis [17,18]. Most of the studies have investigated the incidence of disorders and dysfunctions and have paid less attention to corrective and treatment methods, especially in students that are at a growth age and possess a high potential to improve the disorder. Further, improving this dysfunction is very important to prevent its effects on other tissues and posture. Thus, the present study was aimed at investigating the effect of different heel inclinations on lumbosacral biomechanical angles in school age students with increased lumbar lordosis, while performing corrective exercises, to determine whether the use ofsuch inclinations accelerate the improvement of this dysfunction.

MATERIALS AND METHODS

This study was quasi-experimental and was carried out on 15 female students who were diagnosed with hyperlordosis based on their medical files, angles measurement, x-rays, and the test in which the subjects put their hands on their waist while standing directly in front of the wall with their head, shoulders, hips and heels attached to the wall. Having determined the samples, their parents were invited to a meeting and provided with a complete explanation about the study. They were then given the consent forms to complete, in the case of agreement being given for their children's participation in the study. Also before the start of the study, the participants were provided with a full explanation as to the research, its method and corrective movement. Then personal information forms including height, weight, age and medical records based on their medical files were completed (Table 1).

X-rays were taken of their feet (without shoes) from lateral lumbar and lumbosacral position. Prior to the taking of the x- rays samples, the participants stood for ten minutes to establish the position, then the samples were randomly classified into three groups of five each and performed corrective exercises for 8 weeks three time a week with the consultation of a physiotherapist and orthopedist and the employment of different prescribed recourses. Each of the groups carried out exercises on positive, zero and negative inclinationsunder the supervision and guidance of the researcher (Figure 1).

After 8 weeks of exercise a second x-ray wastaken to determine the changes in the lumbar lordosis angle (LLA), the sacral based angle (SBA) and the lumbosacral angle (LSA) as a result of thecorrective exercises performed and the differences resulting from standing on different slopes.

The angles were measured before the start and the end of the exercises under the comprehensive monitoring of a radiographer and orthopedist, which included the following:

- Lumbar lordosis angle (LLA): the angle between the tangent lines on the inferior edge 12T and the superior edge S1(Cobb method) (Fig. 2)
- Sacral based angle (SBA): the angle between the tangent line drawn on the superior edge S1 and the horizontal line (Fig. 3)

Table 1. Descriptive information about the samples including height, weight and age

Groups	Mean		
	Height (cm)	Weight (kg)	Age (years)
Group1 (positive slope)	135.6± 4.50	28.4± 2.30	10.8± 0.44
Group2 (zero slope)	142.4± 10.50	36.4± 11.7	10.8± 0.83
Group3 (negative slope)	141.6± 8.29	31.8± 4.32	11.2± 0.83

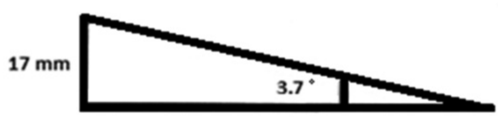

Fig. 1. Characteristics of the sloped block used in this study

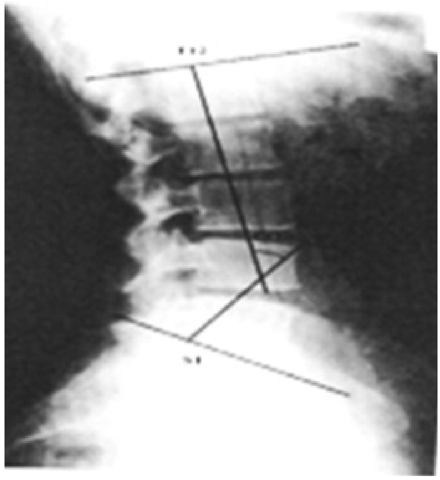

Fig. 2. Measurement of Lumbar lordosis angle by the Cobb method

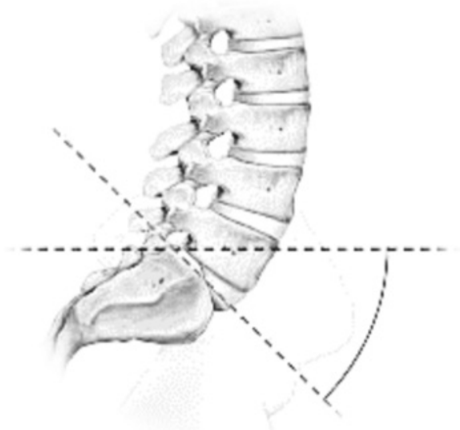

Fig. 3. Measurement of Sacral based angle (SBA)

Fig. 4. Measurement of Lumbosacral angle (LSA)

- 3.Lumbosacral Angle (LSA): the angle between the tangent line drawn on the superior edge S1 and the inferior edge L5 (Fig. 4)
- SPSS 18 software was used to analyze the obtained data. Non-parametric techniques followed by the Kruskal Wallis test were used to compare the changes of the angles in the groups. $P<0.05$was considered significant. The reason for using non-parametric tests was the low number of samples.

RESULTS

There was no significant difference between the various slopes used under the heel while doing corrective exercises on the lumbar lordosis angle (LLA) in students with hyperlordosis. The mean of LLA in the previous steps and then following corrective exercises are compared in Fig. 5 in which the blue line is indicative of the mean of this angle in the three groups before doing corrective exercises and the red line indicates the mean for the three groups after finishing corrective exercises.

The results of the Kruskal Wallis test for comparing the LLA between the groups after doing corrective exercises indicated that the mean changes for Group 1 (positive slope), Group 2 (zero slope), and Group 3 (negative slope) were -10.8, -9.6, and -13, respectively, which indicated no significant difference, despite the decline in the means of the groups (p=0.91) (Table 2)

There was no significant difference between the various slopes used under the heel while doing corrective exercises on the sacral based angle (SBA) in the students with hyperlordosis. The mean of SBA in each of the previous steps and after the completion of corrective exercises are compared in Fig. 6 in which the blue line represents the mean of this angle in the three groups before doing cor-

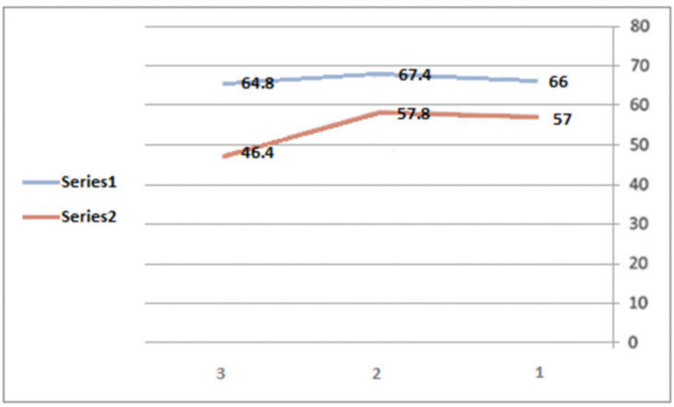

Fig. 5. Comparison of the mean changes for pre-test and post-test (LLA)

Table 2. The results of the Kruskal Wallis test for the comparison of LLA in the various groups

LLA changes	Mean changes Group1(positive slope)	Mean changes Group2(zero slope)	Mean changes Group3(negative slope)	Sig
	-10.8	-9.6	-13	0.91

rective exercises and red line shows the mean for the three groups after doing corrective exercises.

The results of the Kruskal Wallis test for comparing SBA between groups after doing corrective exercises indicated that the mean changes for Group 1 (positive slope), Group 2 (zero slope), and Group 3 (negative slope) were -5, -6.4, and -0.2, respectively, which revealed no significant differences, in spite of the decrease in the means of the groups (p=0.16) (Table 3).

There was no significant difference between the various slopes used under the heel while doing corrective exercises on the Lumbosacral angle (LSA) in the students with hyperlordosis. The mean of LSA in the previous steps and after the completion of corrective exercises are compared in Fig. 7, in which the blue line represents the mean of this angle for the three groups before doing correc-

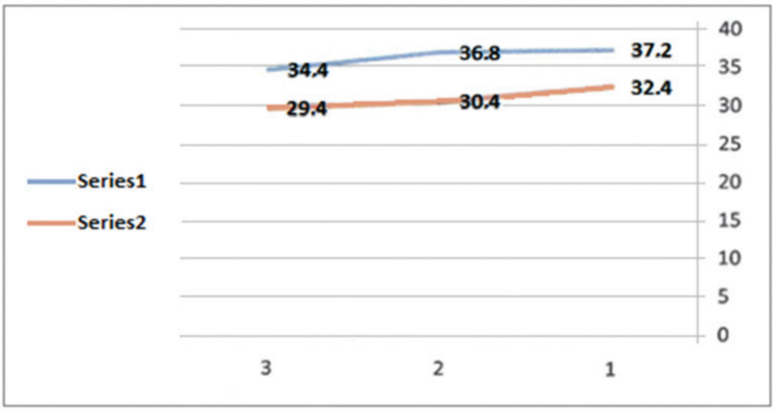

Fig. 6. Comparison of the mean changes for pre-test and post-test (SBA)

Table 3. The results of the Kruskal Wallis test for the comparison of SBA in the various groups

SBA changes	Mean changes Group1(positive slope)	Mean changes Group2(zero slope)	Mean changes Group3(negative slope)	Sig
	-5	-6.4	-0.2	0.16

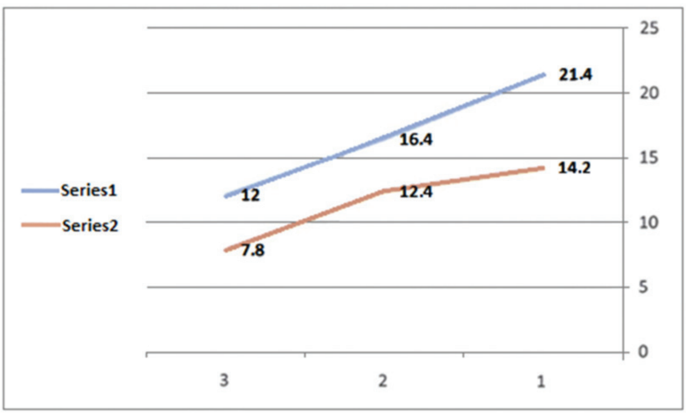

Fig. 7. Comparison of the mean changes for pre-test and post-test

Table 4. The results of the Kruskal Wallis test for the comparison of LSA in the various groups

LLA changes	Mean changes	Mean changes	Mean changes	Sig
	Group1(positive slope)	Group2(zero slope)	Group3(negative slope)	
	-13	-14	-15.2	0.50

tive exercises and the red line indicates the mean for the three groups after finishing corrective exercises.

The results of the Kruskal Wallis test for comparing LSA between groups after the completion of corrective exercises indicated that the mean changes of Group 1 (positive slope), Group 2 (zero slope), and Group 3 (negative slope) were -13, -14, and -15.2, respectively, which revealed no statistical significant difference, despite the decrease in the means of the groups (p=0.50) (Table 4).

DISCUSSION

The corrective exercises applied on the groups was the same and the only difference between groups was about the slope used under the subjects' feet. Thus, the differences in the results of the groups can be attributed to the different slopes used in various groups. Regarding the lumbar lordosis angle (LLA), there was a decrease in the angle of all groups as a result of doing corrective exercises. There was more decrease, however, in the negative slope than in other slopes and the decrease in the positive slope in the trained group was more than was the case for the zero slope, but this was trivial in extent. In fact, it can be argued that the zero slope has very little effect on lumbar lordosis and the effect of heel slope on lumbar lordosis is much more than the zero slope. However, the decreasing differences between the groups were not statistically significant. Also, there was a decrease in the sacral based angle (SBA) according to the results obtained from the means of three groups. But, the decrease in the trained group on the zero slope was higher than the other groups and the decrease in the trained group on the positive slope was higher than the negative slope. In fact, it can be argued that by increasing the heel slope, the lumbosacral slope decreases. However, these differences were not statistically significant in the three groups. With regard to the lumbosacral angle (LSA) which is the most important angle associated with lumbar lordosis, there was a decrease in all groups and the decrease in the groups standing on the negative slope was higher than the other groups and the group standing on the zero slope indicated more of a decrease than was observed in the group standing on the positive slope. The findings obtained in this group also revealed that the lumbosacral angle decreases by decreasing the heel slope, which is similar to the results obtained for the lumbar lordosis angle. This may, however, indicate an association between these two angles. Moreover, the differences between the groups were not statistically significant. Several studies have examined the effects of different slopes on the body, some of which are reported as follows:

In their study, Kim et al. asked the subjects to put on shoes with a negative heel inclination and walk. They investigated several physiological characteristics such as heart beat and oxygen consumption. They argued that walking with shoes with a negative heel inclination decreased the heart beat and energy consumption during walking, in comparison with normal shoes [19] . In a study by Meyers et al. it was reported that using negative heel inclination caused a significant change in the walking speed and step length, although motor coordination decreased [20]. Although the findings of the present study revealed non-significant differences between the angular changes in the groups standing on different slopes, using these slopes while doing corrective movements may accelerate the intended changes in people with hyperlordosis.

CONCLUSIONS

In this study, by increasing the heel slope, the lumbosacral slope decreases also the lumbosacral angle decreases by decreasing the heel slope, this may indicate an association between these two angles. The findings of this study can be applied in corrective exercises with more useful facilities to achieve better results in shorter periods of time to prevent the effects of hyperlordosis on other organs as well as an individual's posture. Furthermore, 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. Based on the results of the present study, further studies are suggested to examine larger number of samples, a larger age range, another sex as well as the effects of other slopes with different angles other than the slopes and angles employed in this study

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