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Original Research Paper-Sports

Effect of Eight Weeks of Selected Corrective Exercises, with and Without Medical Insoles, on the Level of Sole Pressure in Adolescent Girls with Genu Valgum

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ABSTRACT:
Background: Abnormal alignment of the knee joint, the largest joint in the body, causes discomforts such as genu valgum and compensatory deformities. It is necessary to provide some appropriate working procedures with a more detailed study of the effect of these abnormalities on performance. **Method**: The current study is a semi-experimental research with a pre-test, and post-test design, 1 control group, and 2 experimental groups. The measurement tool is an RS-SCSN-foot leveler and a caliper, which was used to detect and distribute the amount of pressure on the sole and the angle of the genu valgum. 9 people with genu valgum were identified from among the people who were referred to the Arak Rehabilitation Center. They were randomly selected into 3 groups based on the purposeful conditions. The control group continued their daily activities without making any changes. Experimental group 1, besides medical insoles, also performed selected corrective exercises. Experimental group 2 performed corrective exercises without using insoles. The selected exercises were performed for 8 weeks and 3 days a week for 1.5 hours. The qualified individuals used insoles at least 6 hours a day. The descriptive indices and the relationship between the variables were analyzed using the Shapiro-Wilk test, besides all statistical calculations through the Spss software version 22 at a significance level of $P<0.05$. **Findings**: The results of Tukey's test in the post-test showed that the control group has a significant difference from the exercise group with insole (sig 0.42) and the exercise group (sig 0.39). **Results**: Thus, the selected corrective exercises without medical insoles have an effect on the pressure level of the soles of adolescent girls with genu valgum. There was no significant difference between the exercise group with insole and the exercise group (sig 0.999). However, the results of the follow-up test reveal that exercise alone has a greater effect than exercise with an insole on the amount of sole pressure in teenage girls with genu valgum.

Keywords: Selected corrective exercises, Medical insoles, Foot pressure level, Genu valgum

INTRODUCTION:

The development of countries has many indicators, one of which is the health and well-being of the individuals. The future of any society depends on its dynamics and physical and mental health. The greatest national capital of any society is the existence of healthy and capable individuals, especially young people. Musculoskeletal abnormalities that continue until adulthood begin with the use of non-standard equipment, inappropriate environmental factors, and lack of proper education in schools for students (1). The direct and indirect effects of the abnormalities of the lower limb can be examined in the physical and physiological dimensions. The lower limb, as a base of support for a person, is also supposedly a factor in his displacement. Failure to prevent and correct these abnormalities leads to secondary disorders in other parts of the lower limb. Since the abnormal alignment of the joints, including the knee joint, as the largest joint in the body, causes discomfort such as arthritis, joint wear, and compensatory deformities, we should provide some appropriate working procedures with a closer look at the effect of these abnormalities on performance (1). Genu valgum and genu varum occur during the normal growth and development of a child (2). Genu valgum in which the muscles of the inner leg area are weakened and the muscles of the outer area are shortened, causing changes in the natural alignment of the body in the lower limb, may limit changes in the center of gravity of the body regarding body's support, control, and balance. Children in most cases have one of the changes in the knee. Proper knee alignment is important for normal joint function and balance. The body's weight in a balanced knee is transferred evenly through the middle of the joint. When the knee is not balanced and perfectly straight, knee injuries can occur because of more weight and pressure on a side. When our legs are not aligned directly from the hips, knees, and ankles, it can create an unnatural force in the knee area, cause many compensatory reactions in the movement chain (flat feet, arthritis, lumbar disc, etc.), and finally, change the walking pattern and even the distribution and amount of pressure on each toe (2). One of the most common compensatory reactions that

occurs after a genu valgum is a change in the arch of the foot followed by a change in the pressure of the foot and disruption of the natural pattern of plantar pressure distribution (3). Since knee changes cause changes in all movement patterns, even the walking pattern and consequently the pattern of the amount of pressure in the leg (4), this emphasizes the necessity of correcting deformities, especially deformities of the lower limbs because of their chains and the negative effect on other organs (5). Many researchers believe that corrective activities are a very important and effective tool for correcting and preventing these anomalies. Some consider the use of tools and aids to be effective alongside corrective activities. One of the auxiliary devices and a non-invasive method for correcting the deformities of the lower limbs is the medical insole (6). Medical insoles aim at rearranging bone structures, changing the movement pattern of the lower limb and normal distribution of foot pressure while walking, and most importantly, reducing symptoms of compensatory complications of the lower limb (7). Finally, we hope that correcting the knee according to the chain of motion corrects other compensatory deformities and affects the walking pattern and the amount of pressure on the toes, which is at the lowest part of the chain of motion. If the adolescents undergo physical therapy as soon as possible, such as movement therapy and the use of orthoses, they will undergo a shorter treatment period because of their skeletal age, the condition of their bones and muscles, and their physical condition, and will not spend their future in offices and clinics. Consequently, they will not require surgery and invasive treatment methods (4, 5). Female adolescents are taught to sit on two legs (instead of cross-legged) and repeat this pattern of sitting throughout their lives, they are more prone to suffering from genu valgum, double pressure on the soles of the feet, and problems with the movement chain of the feet because of having relatively wider hips, increasing the angles of the quadriceps muscle, reducing the resistance of the hips (8). About 30% of adolescents in Tehran (2016) had knee axis deviation, including 27% bracket knee and 3% genu varum. 11% of them had foot deformity, which was excessive arch of foot in 2% and flatness of foot in 9% (9).

All these deformities show extra pressure on the chain of the lower limb, especially the base of the lower limb, i.e. the sole. Medical insoles are widely used for the successful treatment of many injuries of biomechanical inefficiency of the lower limbs (10). The history of using these devices goes back to the end of the 19th century; Whitman was the father of modern insoles in 1889 (10, 11). Nowadays, the use of insoles has a success rate of over 75% in non-surgical treatment of lower limb problems such as plantar fasciitis, anterior knee pain, flat feet, and Achilles tendonitis (12). Generally speaking, medical insoles are used for rearranging the bone structures, changing the movement pattern of the lower limb while walking, and most importantly, reducing the symptoms of the complications of the lower limb (12, 13). Moreover, correction programs include biomechanical correction and strengthening of an organ and physical fitness and beauty (14). Corrective movements examine and treat acquired weaknesses and abnormalities in the bones, joints, and muscles. Abnormalities in individuals' organs are mostly spread because of inappropriate movements, reduced physical activity, and inappropriate environmental conditions (15). Gurbannejad Asl (2019) conducted research entitled The Effect of Selected Corrective Exercises on Genu Varum and Genu Valgum and their Changes on the Right and Left leg angle of student-athletes. He concluded that the statistical results of eight weeks of selected corrective exercises on genu varum and genu valgum and their changes on the q-angle of the right and left leg showed that the experimental group in the post-test had a greater average difference than the control group in the amount of genu varum and genu valgum and the change of the q-angle. In conclusion, the role of the selected corrective exercises was to reduce the angle q of athletes suffering from genu varum and genu valgum, as a suggestion to athletes, trainers, and rehabilitation specialists (15). Ashuri et al. investigated the effect of 8 weeks of corrective exercises on the genu valgum deformity of female students in the first grade of secondary school in Malair. The results showed that the average size of the deformity of genu valgum of the students before corrective exercises was equal to 5.320 and it was equal to 5.672 after eight weeks of corrective exercises. The average difference between these two sizes is 0.351. the genu valgum deformity of students has improved significantly after eight weeks of corrective movement exercises. Age and height had no significant relation with genu varum deformity. Therefore, therapists, athletes, trainers, sports medicine specialists, and trainers should use this exercise protocol to correct genu valgum syndrome (15). Farahbod et al. studied the prevalence of lower limb abnormalities in adolescents. The findings revealed that genu varum was 23% and genu valgum was 21.2% in the whole sample in knee abnormalities. Flat feet showed 50% and hollow feet 10.1% of prevalence. The conclusions showed that the prevalence of lower limb abnormalities in students is very high and requires training and, if necessary, practical interventions to prevent pain and other complications in the future (13). Bahrami et al. (2015) investigated the extent and causes of deformities in the upper and lower limbs of boys and girls aged 11 to 15 years in the Lorestan province. Research has shown that 57.7% of boys and 68.9% of girls have deformities in the knee area. They reported 4.2 genu valgum in boys and 14.4 in girls (14). Goodman (2001) believes that the anomalies that have a functional root, unlike the neurological anomalies, can be compensated and corrected by performing corrective movements. Therefore, performing corrective actions eliminates the problems, reduces structural and functional disorders, increases the individuals' life and health, and improves their

quality of life. Since the researcher has not found research similar to this study so far, its findings can guide future research to achieve future goals and prevent the onset of complications. Thus, this study investigates the effect of eight weeks of selected corrective exercises, with and without medical insoles, on the level of plantar pressure in adolescent girls with genu valgum.

Procedure:

Because adolescents have more than 85% of lower limb abnormalities, and girls are more prone to this type of abnormalities, the researcher evaluated the effect of eight weeks of selected exercises along with the effect of corrective exercises with and without medical insoles on the amount of pressure on the soles in the adolescent girls with genu valgum.

Thus, 90 people with an age range of 10-15 years, after filling out the consent form to participate in the research and the right to withdraw for any reason, were purposefully selected as the sample of this research and randomly divided into 3 groups (1 control group and 2 groups experimental). All subjects were suffering from genu valgum. The information was collected through a personal information questionnaire. A precise medical scale made in Germany, seca, was used to determine the weight of the subjects.

The subjects were asked to stand without shoes and with their heels, hips, back, and back of the head attached to the wall to determine the height. So a ruler was placed on the subject's head and the subject's height was recorded in centimeters. Therefore, a standard tape measure was used for this. An Elton caliper, model CA64, made in China, measured the knee angle and the amount of genu valgum. All the samples were scanned by a 3D scan machine made in Japan (such that they stand without shoes and socks on the glass screen connected to the machine without weight transfer and look in front without moving). The pressure distribution pattern was recorded for comparison after applying changes to the subject (the validity and reliability of all devices were confirmable). The pressure distribution pattern was taken in the pre-test and recorded for all 3 groups. Each session explained the test to the subjects by the examiner. The subjects of both experimental groups started corrective exercises for 8 weeks, with the difference that one of the groups, besides the corrective exercises, spent at least 6 hours on the specially made medical soles (as medical sandals) day and night. The control group during this period was asked not to participate in any specific physical activity because the activity level of all the subjects in the control and experimental groups was supposedly similar. So the control group was used to control the possible effect of exercises and daily activities on changing the pattern of foot pressure and knee angle. The sole scan was taken again after performing the exercises for both training groups and using medical insoles for one of the groups along with the corrective exercises, and compared with the scan before the intervention. The results: raw data of the measurement of the research variables were analyzed using descriptive and inferential statistics. The statistical method was mixed ANOVA according to the groups. Descriptive indicators (centrality and dispersion) categorized and summarized the data, the Shapiro-Wilk test analyzed the relationship between the variables, and Spss software version 22 performed all statistical calculations at a significance level of $P<0.05$.

Table 1: Statistical analysis of paired t-test of foot pressure

Variable	Group	Stage	Mean	Standard deviation	T	Sig.
Foot pressure	Exercise with insole	Pre-test	113.50	13.31	15.65	0.001
		Post-test	97.50	14.85		
	Exercise	Pre-test	119.90	18.35	43.86	0.001
		Post-test	97.20	18.91		
	Control	Pre-test	114.90	16.22	-4.29	0.061
		Post-test	116.60	16.05		

As you can see in the above table, there is a significant difference between the subjects' pressure of the feet soles in the training group and the sole, in the pre-and post-test (sig=0.001). Since the mean value has also decreased in the post-test, the selected corrective exercises with medical insoles have an effect on the pressure of the soles of the feet in adolescent girls with genu valgum. As the results show, the null hypothesis of the research is rejected: The selected corrective exercises with medical insoles have no effect on the amount of plantar pressure in adolescent girls with genu valgum. Hypothesis 1 of the research is confirmable: the selected corrective exercises with medical insoles have a significant effect on the distribution pattern of plantar pressure in adolescent girls with genu valgum. As the results of the paired t-test show in Table (2-4), there is a significant difference between the pressure of the subjects' soles of the feet in the training group before and after the test (sig=0.001). Since the average value has also decreased in the post-test, selected corrective exercises without medical insoles have an effect on the amount of foot pressure in adolescent girls with genu valgum.

Therefore, the null hypothesis of the research that there is no effect of selected corrective exercises without medical insoles on the foot pressure in adolescent girls with genu valgum is rejected, and the hypothesis 1 is confirmable based on which selected corrective exercises without medical insoles has a significant effect on the foot pressure in adolescent girls with genu valgum. Likewise, there is no significant difference between the subjects' pressure of the soles of the feet in the control group before and after the test

(sig=0.061). The parametric test of one-way analysis of variance was used after checking the homogeneity of variances by Levene's test, and then Tukey's post hoc test to examine the differences between groups. The following tables report the results of the tests.

Table 2: One-way statistical analysis of variance of plantar pressure

Variable	Group	Mean	Standard deviation	F	Sig.
Foot pressure in the pre-test	Exercise with insole	113.50	13.31	0.437	0.651
	Exercise	119.90	1835		
	Control	114.90	16.22		
Foot pressure in post-test	Exercise with insole	97.50	14.85	4.432	0.022
	Exercise	97.20	18.91		
	Control	116.60	16.05		

As the results of the parametric one-way analysis of variance (ANOVA) showed, there was no significant difference in the pressure of the soles of the feet of the groups before the interventions (sig=0.651), but this difference was significant after the interventions (sig=0. 022)
Now, we will use Tukey's post hoc test to examine the difference between groups.

Table 3: Results of the follow-up test of plantar pressure in the pre-test

Variable	Group	Group	Mean difference	Sig.
Foot pressure in the pre-test	Exercise with insole	Exercise	-6.40	0.652
		Control	-1.40	0.979
	Exercise	Exercise with insole	6.40	0.652
		Control	5.00	0.769
	Control	Exercise with insole	1.40	0.979
		Exercise	-5.00	0.769

The results of Tukey's post hoc test in the pre-test showed that the control group has no significant difference from the exercise group and insole group (sig=0.979), nor the exercise group (sig=0.769). There was no significant difference also between the exercise group and insole group and exercise group (sig=0.652).

Table 4: Results of Tukey's follow-up test of plantar pressure in the post-test

Variable	Group	Group	Mean difference	Sig.
Foot pressure in the post-test	Exercise and exercise with an insole	Exercise	0.30	0.999
		Control	-19.10	0.42
	Exercise	Exercise and exercise with an insole	-0.30	0.999
		Control	-19.40	0.39
	Control	Exercise and exercise with an insole	19.10	0.42
		Control	19.40	0.39

The results of Tukey's follow-up test in the post-test showed that the control group had a significant difference between the exercise and exercise with the insole (sig=0.42) and the exercise group (sig=0.39), but there was no significant difference between the exercise and exercise with the insole and the exercise group (sig=0.999). In conclusion, selected corrective exercises with and without medical insoles have an effect on the amount of plantar pressure in adolescent girls with genu valgum.
Likewise, the results of the follow-up test showed that exercise alone (sig=0.39) had a greater effect than exercise with insoles (sig=0.42) on the pressure of the soles of the feet in adolescent girls with genu valgum.

DISCUSSION AND CONCLUSION:

These results are in line with the report of Morley et al. (2010), Chen et al. (2010), and Ritchie et al. (2011). Since the parts of the body act like a chain and each part affects the other part, changing the level of the foot by using medical insoles and doing sports exercises in individuals with flat feet can lead to improvement of the height of the internal longitudinal arch and correcting the flatness of the soles of the feet. This can affect the axis of the pelvis tilt, the arch of the back, and the angle of the knee by correcting the axis of the lower limb. One of the basic human needs in daily activities is to have healthy upper and lower limbs. The foot compared to other parts of the human body shows more structural changes (16). Part of the complications of foot deformities are about the functions of the arches of the feet. Since the functions of these arches are to create more mobility in the soles of the feet and absorb and generalize the blows that are inflicted on the body from the area of the soles of the feet, these arches do not allow all incoming forces to the body (17). Medical insoles reduce the pressure on the heel and sole by transferring a significant part of the body weight to the arch of the foot. The area of the arch of the foot in shoes that do not support the arch of the foot does not participate in the distribution of pressure of body weight. Corrective sports movements along with an external device (medical insole) are a method that can be very effective in the early stages of bone complications. Performing appropriate stretching and strengthening exercises can have a significant effect in improving the abnormalities. So medical insoles and corrective movements together and their mutual influence, considering the chain-like nature of the organs, can be very effective in improving the complication. Corrective exercises are a well-known effort that corrects abnormal body positions such as genu valgum, genu varum, increased back kyphosis,

scoliosis, and lumbar lordosis by coordinating the favorable and unfavorable muscle groups through strength and stretching exercises. Corrective exercises include stretching exercises, strength exercises, and neuromuscular facilitation exercises (18). As it seems, strength exercises affect the length of muscle tendons, move different skeletal parts, and stabilize ligaments. Stretching exercises act as a coordinator of the similar and opposite muscles. Some changes are created, following the implementation of corrective exercises in skeletal muscles, such as an increase in total contractile protein, especially in myosin fibers, an increase in the amount and strength of connective tissue, tendons, and ligaments, an increase in capillary density in each muscle fiber, an increase in the number of fibers during the longitudinal division of muscle fibers and so on, which increases muscle strength and endurance (19). Abnormalities of the organs, especially the lower limbs, are visible more among female students than boys because of the condition of their appearance and lack of movement. The longer the time between the occurrence of abnormalities and the start of treatment, the greater the vulnerability. The program of corrective movements includes stretching, strength, and mobility exercises. If these components are performed accurately and regularly, they can have significant effects on improving abnormalities. It seems necessary to provide an age-appropriate exercise program to improve and prevent the development of abnormalities because of the high prevalence of abnormalities in childhood and adolescence. Physical education and sports science are the fields of human education that have a special position in the present era.

We can study the importance and value of this powerful phenomenon from different aspects (20). One of these aspects is the science of corrective movements regarding those suffering from physical weaknesses and physical and movement complications. The number of this group of individuals is very large and increasing dramatically. It requires serious attention, especially when it is associated with children, adolescents, and young people who are in their growing age (21, 22). Students in any society are the most important group and ensuring their physical and mental health is one of the most important duties of the officials and workers. Thus, physical education, as a science that has a special position in the current age, should take effective steps in the direction of expanding the health and providing physical and mental health of this valuable group. Parents and teachers who know the correct body position and its factors can contribute to the health of children and adolescents. Therefore, a correct health education program should not forget to teach the correct body position. Since the duration of these exercises was 8 weeks, it seems that the changes in the knee angle are caused by the acute response of the muscles to the prescribed exercises and not a nervous response. Although these changes may cause a decrease in the angle of genu valgum by increasing muscle strength and coordination, if the person stops his exercises, these changes will return to the initial state again in a short time and the angle of genu valgum will increase. Therefore, individuals who intend to improve their posture with the help of corrective exercises should continue these exercises over time so that they do not suffer from complications of lack of exercise. We introduce the proper posture and optimal performance to the individual during the corrective movement program, and the proper body structure is restored to him. Therefore, we will relax the muscles that are shortened and stiffened with corrective exercises (through neuromuscular facilitation and removal of spontaneous inhibition) and we will activate and strengthen the weak muscles. All these steps were performed through skill, stretching, activation, and integration techniques designed by the National Academy of Sports Medicine (NASM). These movements and techniques will improve the biomechanics of your body and will remove negative pressures from the body. As it is clear, accumulated negative pressures can cause pain and affect your ability to move normally. Corrective exercises will be the first step in your new training program to prepare and get fit. Your program will begin with a comprehensive and complete body assessment. As the results of a comprehensive body assessment reveal, you and your exercise instructor will take action to address pain, joint defects, muscle imbalances, and altered postural patterns. You will be able to recognize and respond to your body language, after about 4 to 8 weeks of starting the corrective exercise program, and the details of the messages your body will send you.

Corrective movements will bring you strong legs to build a new body by removing weak links in your body structure and strengthening your body's structural coordination. You can use orthoses as an aid to achieve results sooner besides corrective exercises, and to improve the intended complication. The World Health Organization formed some time ago the operational plan for the expansion of assistive devices because of the considerable prevalence of disability. The member countries must ensure the promotion of rehabilitation services, including services of assistive devices to disabled individuals. Prescribing assistive devices or orthoses for individuals with disabilities is an important part of the rehabilitation program to improve their health, quality of life, and performance (23). An orthosis is an aid that is placed externally in line with a person's body or organ to apply mechanical pressure to change or correct the functional and structural characteristics of the neuromuscular or skeletal system on the body or organ (24). Since the most prescribed of the orthoses were the orthoses of the lower limbs or medical insoles, and corrective exercises are supposedly the basis of strengthening the body, the researcher embarked upon to see if these two factors together can have the same effect they have individually. The result was that selected corrective exercises with and without medical insoles affect the amount of pressure on the soles of the feet in

adolescent girls with genu valgum. As the results of the follow-up test show, exercise alone (sig=0.39) has a greater although not significant effect than exercise with insoles (sig=0.42) on the distribution of pressure on the soles of the feet in adolescent girls with genu valgum.

Message of the article

The implementation of corrective exercises regarding the physical and mental conditions of children and adolescents, their interest in participating in group movement activities, and the positive aspects of participation, cooperation, competition, and joy in games and exercises, are associated with achieving both corrective and educational goals.

This article is an extract of a thesis on the effect of eight weeks of selected corrective exercises, with and without medical insoles, on the level of plantar pressure in adolescent girls with genu valgum, with Irandak ID 2789723 and ethical code IR.ARAKU.REC.2022.095 was approved by the University of Arak with a perfect score.

Appreciation

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Appendices

Description of corrective exercises according to NASM (National Academy of Sports Medicine) including stretching and strengthening exercises:

Sit and stretch the legs forward, then hold the toes with both hands and rotate them inwards.		Hold for 30-15 seconds and release. Repeat it for 6-8 sets after 5 seconds of rest.
While standing, grab one of the legs by the wrist and turn it inward. Do also this movement with the other leg.		Hold for 30-15 seconds and release. Repeat it with the other leg after 5 seconds of rest. Repeat it for 6-8 sets.
Place on the outer edge of the foot and transfer your body weight to the outer edge of the foot.		Hold for 30-15 seconds and release. Repeat it for 6-8 sets after 5 seconds of rest.
While sitting cross-legged, raise one thigh with the help of hands and bring the knee close to the chest. The trunk should be upright.		Hold for 30-15 seconds and release. Repeat it with the other leg after 5 seconds of rest. Repeat it for 6-8 sets.
While sitting with your legs wide open, try to raise both legs and then cross them as much as possible.		Repeat for 15-30 seconds and release. Repeat it for 6-8 sets after 5 seconds of rest.
Lie down on your back. Hands are next to the body and legs are fully extended. Now try to lift one leg and pass it over the body, bringing it closer to the paw of the opposite hand.		Repeat for 15-30 seconds and release. Repeat it with the other leg after 5 seconds of rest. Repeat it for 6-8 sets.
Bend at the waist. Place the palms on the knees. Bend your knees slightly and push outwards with your hands. Return the knee to the original position and repeat the movement with resistance.		Repeat it 6-8 times for 10 seconds with a 5-second rest interval at a slow speed.

Sit down and put the soles of the feet together, put pressure on the knee with both hands so that it is close to the ground.		Repeat it 6-8 times for 10 seconds with a 5-second rest interval at a slow speed.
Sit and stretch your legs. Place one leg with the bent knee on the other leg. Move in this position the bent knee up and down alternately. Repeat the movement several times.		Repeat it 6-8 times with a rest interval of 5 seconds at a slow speed and do it again with the other leg.
Stand on one leg. Hold the opposite ankle with your hand and pull it upwards. In contrast, try to push the knee down. Repeat the movement several times.		Repeat it 6-8 times for 10 seconds with a 5-second rest interval at a slow speed. Do it again with the other leg.
Sit on the floor. Bend your knees and place the soles of your feet on the floor. Put a ball between your legs and press the ball inwards for a few seconds.		Repeat it 6-8 times for 10 seconds with a 5-second rest interval at a slow speed.

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