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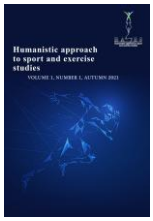

Compare the Flexibility of Iranian Adolescents and Young People in Two Selected Groups with Healthy and Spinal Deformity

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Abstract: Muscle weakness and shortness have a profound effect on the length and function of the body, causing abnormal pressure on the joints and other tissues. Deficiency or increase in flexibility is a factor in the stiffness and instability of moving parts and affects the maintenance of the desired condition. Therefore, the aim of this study was to compare the flexibility of Iranian adolescents and young people in two selected groups with healthy and spinal de-formity.

The statistical population of this study consisted of adolescents and young people across the country. The statistical sample consisted of 1263 girls and boys (with age range of 18-12 years old) from 5 geographical regions of the country, which could represent the whole country in terms of environment, culture, economy, and genetics and ac-counted for about 50% of the country's population. The flexible ruler was used to measure the arches of the spine in the sagittal plane, and the flexibility of the back and lumbar muscles, the trunk flexor muscles, and the trunk lateral flexor muscles were measured.

The results showed that there was a significant difference between the flexibility of the two groups of kyphotic and kypholordotic with healthy subjects among the adolescents and young girls, and adolescent boys ($P<0.05$), but in the two groups, lordotic and healthy, this difference was not significant ($P>0.05$). The flexibility was significantly different between the gender in both the kyphotic and kypholordotic groups among adolescents ($P<0.05$), but in the healthy and lordotic groups was not significant ($P>0.05$). Finally, the results showed that there was only a significant difference between the flexibility of young girls with kyphotics and kypholordotics compared with healthy individ-uals ($P<0.05$).

Based on the results of this study, it can be concluded that spinal deformity can lead to a decrease in the flexibility of adolescent's girls and boys, which indicates the need to correct situational abnormalities at an early age. There-fore, it is necessary to present special training programs with the approach of eliminating spinal weaknesses in order to prevent the spread of this type of deformities and provide the society with a healthy and efficient generation.

Keywords: Flexibility, Kypholordosis, Kyphotic, Lordosis.

1. Introduction

Despite the advancement of health and medical science, the growth of industry, and the inte-gration of machines and technology into people's lives, significant changes have occurred in their way of life. Without attention to their physical and psychological health, it is impossible to move towards a healthy society. Physical health and having an optimal physical condition are of particu-lar importance in human life, and both positive and negative changes can impact other aspects of human life. The consequences of poor physical condition are so extensive that their psychological, physical, economic, and social dimensions can be examined (1). Physical condition is defined as the relative arrangement of different parts of the body with each other. In fact, an optimal physical condition is a state of muscular-skeletal balance that protects supportive structures from injury or deformity. It is believed that due to this balance, muscle efficiency is at its highest level, and the least amount of pressure is exerted on the individual's body (3-2). In this context, attention to the role of the spine seems very important, as the spine, being the body's axis of movement, may suf-fer damage and deformity in various activities for various reasons (2). The positioning of the spine and maintaining its natural alignment depend on the effective functioning of muscles and liga-ments, and any weakness or shortening in the muscles supporting the spine disrupts posture and has adverse effects on the individual's body structure. If not addressed, these mechanical deformities will become permanent and irreparable (4).

In these circumstances, the imbalance of the musculoskeletal system creates undesirable changes in an individual's posture. One of the complications of this imbalance is postural changes in the spine, which have the highest prevalence among orthopedic disorders (5). In this context, flexibility is an important functional and operational aspect of the human body, without which the movement of various body parts may face limitations. In fact, flexibility means the ability of joints to move through their full range of motion, which is beneficial for optimal performance. Flexibility is primarily increased by stretching the soft tissues around the joint and is of great value to athletes in many sports activities, as it leads to an overall improvement in performance (6,1). With aging, both separately and simultaneously, muscle shortening also increases, which may be due to tissue changes resulting from aging and changes in individuals' activity levels. Researchers believe that this issue may be related to the mismatch between the muscular system and the rapid growth of the skeletal system during puberty (5).

Studies have emphasized that children and adolescents spend more than 35% of their school time sitting on chairs that are not ergonomically suitable for them or using heavy backpacks. As a result, these conditions lead to adaptability in posture and cause changes in body components (muscles, ligaments, cartilage) and the spine. When muscles remain inactive for long periods in a shortened position, they lose their natural mobility and become shortened, ultimately leading to re-duced flexibility (7).

The review of studies conducted in the country shows that the prevalence of postural disorders in Iran is high (5-2). Daneshmandi et al. (2005) found that more than 80 percent of the students studied had spinal deformities, with a higher proportion among girls (3). In another study, Karimiān et al. (2016) examined the prevalence of postural disorders in children. The results of this study indicated that lumbar lordosis had the highest prevalence among the boys and girls studied (4). In another study, Shojaei (2000) found that 86.44 percent of students in Sari County had lumbar lor-dosis, 16.12 percent had forward head posture, 13.53 percent had torticollis, and 32.34 percent had shoulder droop (2).

Singla and Zubia (2017) in a review study on research conducted in the field of kyphosis found that almost all studies conducted up to 2016 reported a high prevalence of kyphosis (5). In another study, Yang et al. (2018) examined the prevalence of spinal deformities in the sagittal plane. In this study, 113 participants with an average age of 14.4 years were involved, and the re-sults indicated a high prevalence of spinal curvature among the subjects (6). In a study conducted by Riemers et al. (1997) on 600 children and adolescents under 17 years old, it was concluded that 20% of the individuals had mobility issues and 30% had muscle shortening. The lack of coordina-tion due to muscle weakness on one hand and muscle shortening on the other, which leads to a lack of natural flexibility in the individual, may result in musculoskeletal problems and postural deform-ities.

A deficiency or excess in flexibility itself is a factor for stiffness or instability of the moving components and affects the maintenance of an optimal posture. Musculoskeletal disorders are ad-verse conditions that arise from environmental factors, lack of movement, and improper function-ing of muscles and joints. Postural disorders often result from the non-standard use of the body, repetitive incorrect functional behaviors, work pressure, and congenital disorders, leading to de-formities and musculoskeletal pain while altering the body's natural anatomical position. The oc-currence of disorders and incorrect postures is possible at any age; however, in young individuals, due to the immaturity of the skeletal system and high flexibility, the risk of developing incorrect postures increases, and the possibility of progression and eventual stabilization of these disorders is also greater (8).

Deviation from the optimal posture is not only visually unpleasant but also negatively affects muscle efficiency and predisposes individuals to musculoskeletal disorders and neurological condi-tions (9). Additionally, it has been shown that if the body remains in an unfavorable postural posi-tion for an extended period, some muscles become stretched while others shorten, adapting to this condition in a way that results in muscle tightness and stiffness in the shortened muscles and weakness and elongation in the opposing muscles (11,10). All these conditions contribute to vari-ous spinal deformities. Some researchers provide evidence of a relationship between spinal flexi-bility and the degree of kyphosis and lordosis, while others have shown that there is no significant relationship between these variables. However, the question has always been whether the physical fitness of individuals with physical deformities, especially spinal deformities, is affected by their posture. In other words, can deviation from the normal spinal position impact the physical fitness of adolescent and young male and female individuals, including spinal flexibility, and limit their ability to utilize their capacities? Available findings regarding the relationship between spinal cur-vatures and flexibility are contradictory and require further studies. Therefore, this study aimed to compare spinal flexibility with postural deformities in Iranian adolescents and young people in the sagittal plane through a national survey with a large sample size.

2. Materials and Methods

This study is a cross-sectional comparative study aimed at comparing flexibility in Iranian boys and girls aged 12 to 18 with kyphosis, lordosis, kypholordosis, and healthy individuals. The statis-tical population of this research consisted of adolescents and young people from across the country who were studying in middle and high school during the 2008-2009 academic year. For this pur-pose, 1,263 boys and girls aged 12 to 18 from the mentioned population were selected. Initially, five geographical regions of the country were chosen that could represent the entire country in terms of environmental, cultural, economic, and genetic factors, collectively accounting for about 50 percent of the country's population. Then, the selected cities in each province were considered based on the major city of that province. All participants were in good physical health.

After recording the initial characteristics of the subjects such as age, anthropometric indices like height (cm), weight (kg), body mass index (BMI = weight/height^2, kg/m^2), and examining and evaluating skeletal abnormalities in the sagittal plane by the examiner under experimental condi-tions.

Evaluation of the sagittal curves of the spine

To evaluate thoracic kyphosis and lumbar lordosis, both curves were measured separately with defined and specified landmarks using a flexible ruler. After identifying the landmarks on the ver-tebral column for measuring the thoracic and lumbar curves, the ruler was initially placed between the specified kyphosis points (spinous process T1 and T12) and lordosis points (spinous process T12 and S2), and uniform pressure was applied along the ruler so that there was no space between the skin and the ruler.

After the curvature of the ruler formed on the vertebrae in each of the regions, it was gently placed on the drawing board without changing the formed curvature on the ruler, and the curvature was drawn. The data obtained from the curvature, which pertained to the length and width of the curvatures, were placed into the mentioned formulas. During the test, care was taken to ensure that the subject did not bend forward or backward, and the pressure on the ruler should not be such that it causes a change in the position of the subject's spine (12-14). Finally, the curvature of the spine was calculated as an angle using the formula: $\theta = 4$ Arc tag (2H/L) (12). The number obtained from the formula is in radians, which was converted to degrees using a calculator or the formula set in the Excel file. This number in the target age group was compared with the normative value provid-ed by Rajabi et al. (2010), and if the measured curvature was greater than the normative value, the individual was classified as having

hyperlordosis (increased lumbar curvature) and hyperkyphosis (increased thoracic curvature) (14).

Flexibility assessment

To measure the flexibility of the extensor muscles of the back and lumbar region, the subject was first asked to stand with their feet shoulder-width apart. Then, the spinous processes of the 7C and 2S vertebrae were marked, and the distance between these two spinous processes was meas-ured using a tape measure. The distance between the spinous process of vertebra 2S and 10 centi-meters above it was considered as the lumbar region, and from there to the spinous process of ver-tebra 7C was considered as the thoracic region. To measure the flexibility of the trunk extensor muscles, the subject was asked to bend their trunk forward as much as possible without bending their knees. Then, the distance between the spinous process of the S2 vertebra and the marked point (this distance was 10 centimeters above the S2 vertebra in the standing position) was recorded as the flexibility of the extensor muscles of the lower back, and the distance above that was rec-orded as the flexibility of the extensor muscles of the upper back (15,1).

Figure 1: Measurement of the flexibility of the lumbar and dorsal extensor muscles

To measure the flexibility of the trunk flexor muscles, the subject was asked to lie face down on a bench. To secure the subject's body on the bench, the pelvis, ankles, and knees were fixed to the bench using stabilizing straps. The subject was then asked to bend their trunk backward as far as possible with both hands and then to extend their trunk. The distance from the upper notch of the sternum to the bench was recorded as the measure of trunk flexor muscle flexibility (15).

Figure 2: Flexibility test of trunk flexor muscles

To measure the flexibility of the lateral trunk flexor muscles, the subject was first asked to stand with their feet shoulder-width apart and their back against the wall. In the next phase, the subject had to bend their trunk in the frontal plane (without any anterior flexion) and without twisting the trunk, ensuring their hands did not separate from their body. Using a tape measure, the distance from the tip of the third finger to the ground was measured. The measurement obtained from the right side was considered as the flexibility of the left flexor muscles, and the measurement obtained from the left side was considered as the flexibility of the right flexor muscles for the individual (15).

Figure 3: Lateral flexibility measurement test

After collecting the research data, descriptive statistics methods such as frequency, mean, and standard deviation were used in the first section. To examine the normality of the data distribution, the Kolmogorov-Smirnov test was employed. Then, in cases with a normal distribution, the independent t-test was used. The significance level in the present study was set at 95 percent, with an alpha level of less than or equal to 0.05.

3. Results

The individual characteristics of the participants, including height, weight, and body mass in-dex, categorized by gender, are presented in Table 1.

Table 1: Descriptive statistics of the anthropometric characteristics of the subjects by gender

Level Significance	***T***	***The highest level***	***Mean ± Standard Deviation***	***Number***	***Group***	***Gender***
*001/0	-728/3	39.11	24/7±87/34	30	***Kyphotic***	***Teenage girls***
		35.39	55/6±84/28	44	***Healthy***	
233/0	-202/1	40.02	84/7±36/32	38	***Lordotic***	
		37.2	91/6±29/30	35	***Healthy***	
*001/0	-292/7	43.02	12/4±08/39	17	***Kifolordotic***	
		35.39	55/6±84/28	44	***Healthy***	
*003/0	-988/2	41.98	97/6±01/35	46	***Kyphotic***	***young girls***
		38.16	37/7±18/31	43	***Healthy***	
078/0	-785/1	40.38	96/6±42/33	85	***Lordotic***	
		37.37	37/7±31	43	***Healthy***	
*001/0	-175/4	42.61	1/5±55/37	15	***Kifolordotic***	
		38.16	96/6±18/31	83	***Healthy***	
*007/0	-748/2	35.02	22/5±8/29	73	***Kyphotic***	

		32.71	17/5±54/27	87	***Healthy***	***teenage boys***
571/0	-568/0	33.55	27/5±28/28	65	***Lordotic***	
		43.11	34/5±77/28	95	***Healthy***	
*001/0	-243/6	34.45	27/2±18/32	21	***Kifolordotic***	
		32.71	17/5±54/27	87	***Healthy***	
628/0	485/0	30.75	57/2±18/28	46	***Kyphotic***	***young boys***
		30.54	14/2±4/28	71	***Healthy***	
892/0	-136/0	31.26	9/2±36/28	42	***Lordotic***	
		31.21	92/1±29/28	75	***Healthy***	
302/0	-124/1	34.87	53/4±34/30	7	***Kifolordotic***	
		30.54	14/2±4/28	71	***Healthy***	

Significance at the (P <0.05) level

According to the results of the independent t-test (Table 2) in adolescent girls, young adults, and adolescent boys, there is a significant difference in flexibility between the two groups of ky-photic and healthy, and kypholordotic and healthy, while this difference is not significant in the two groups of lordotic and healthy (P>0.05). In examining the flexibility of adolescent girls and boys, there is a significant difference in the kyphotic and kypholordotic groups compared to the healthy group in both genders (P<0.05), but the difference in flexibility between the lordotic and healthy groups in both genders is not significant (P>0.05). The same comparison among young girls and boys shows that only the flexibility of kyphotic and kypholordotic young girls differs signifi-cantly from that of healthy individuals (P<0.05), and the flexibility of lordotic girls does not differ significantly from that of healthy individuals (P>0.05). Also, in young boys, there is no significant difference in flexibility among all groups (P>0.05).

4. Discussion and Conclusion

The present study aimed to compare the flexibility of adolescent and young girls and boys in the country in two selected groups: healthy and those with postural abnormalities in the sagittal plane of the spine. The results of the study showed a significant difference in the flexibility of ad-olescent girls, young girls, and adolescent boys with increased kyphosis compared to healthy indi-viduals. The results indicated a significant difference in the average flexibility of adolescent girls, young girls, and adolescent boys with kypholordosis and healthy individuals. In this regard, some researchers provide evidence of a relationship between spinal flexibility and the degree of kyphosis and lordosis, while other researchers have shown that there is no significant relationship between these variables. Moles et al. (1999) demonstrated that the degree of kyphosis and lordosis does not affect the range of motion of the spine (16), but Eon Hee et al. (2005) showed that due to exercise, kyphosis decreases and spinal flexibility increases. These researchers stated that the reduction in the degree of kyphosis is due to the increased strength of the back extensor muscles, and there is no significant relationship between spinal flexibility and the degree of kyphosis (17).

In a review study, He and Wang (2018) examined a total of 15 articles and stated that in stretching and lateral bending methods for adults with idiopathic scoliosis, spinal flexibility was greater with severe curves, but in patients with moderate curves, spinal flexibility was less (18). Many studies indicate that lumbar lordosis, pelvic rotation, and abdominal muscle function are in-terdependent. Many of these factors are good predictors of normal posture. During normal stand-ing, the degree of pelvic rotation is related to lumbar lordosis, and both are dependent on ab-dominal muscle function. Therefore, any improvement in muscle function can provide a more ap-propriate posture (19). According to the results of the study by Fatemi et al. (2015), eight weeks of Williams exercises improve the lumbar opening angle, flexibility of the hamstring muscles, flexibil-ity of the hip flexor muscles, flexibility of the lumbar extensor muscles, and abdominal muscle strength (20), and can reduce the prevalence of spinal deformities.

Based on this, the results of studies have shown that systematic and continuous exercise can affect the curves of the spine. Numerous studies indicate specific spinal adaptations in athletes. In this regard, repetitive spinal movements can influence the positioning of vertebrae within the range of

repetitive mechanical load (18). Additionally, hyperkyphosis is associated with low hamstring flexibility, weakness in abdominal and spinal muscles, which can lead to shortening of the iliopsoas muscle, weakness in abdominal and spinal muscles, and shortening of the hamstring muscles (19).

In relation to explaining the obtained results, it can be stated that some studies have reported differences in the angles of kyphosis and lordosis between the two sexes, with a greater hy-perkyphosis angle in men and a greater hyperlordosis angle in women. In this regard, Gonza-lez-Galoz and colleagues [1] (2019) in a review study, by examining published articles on the dif-ferential effects of exercise on the kyphosis angle in both sexes, found that most studies reported similar results. These researchers stated that exercise programs and consequently the increase in flexibility in the study groups in various studies have a significant impact on the kyphosis angle (19). On the other hand, some researchers provide evidence of a relationship between spinal flexi-bility and the degree of lordosis (21, 17), while other researchers have shown that there is no sig-nificant relationship between these two variables.

In examining the relationship between body type and lordosis curvature, some researchers could not demonstrate a significant relationship between lumbar lordosis and the components of endomorph, mesomorph, and ectomorph. However, the study by Ali and Ravash (2017) showed an increase in lordosis curvature with the endomorphic body type in men. Hershkovich et al. (2014) also demonstrated that in tall individuals with below-normal weight, there is a likelihood of in-creased spinal deformities (scoliosis and kyphosis). The results of the review study by Sadler et al. (2017) indicated a significant relationship between the spread of pain in the lumbar region and the reduction of the range of motion in the calf muscles. Considering the relationship between lumbar pain and lordosis status, examining the relationship between flexibility and lordosis status may be a way to prevent early occurrence of lumbar pain. Studies conducted on lordosis in different ages and genders have led to inconsistencies in the results.

According to the studies by Golb and colleagues (1995), individuals with kyphosis exhibit a muscular imbalance between the trunk flexor and extensor muscles due to the kyphosis condition. In these individuals, back muscles such as the trapezius, rhomboids, and spinal erectors (lumbar, thoracic, and cervical) are stretched, while the anterior trunk muscles, namely the intercostals, and the small and large pectorals, are shortened. According to Mahdavi Nejad's research (1992), im-plementing an exercise program and strengthening the back extensor muscles can lead to improved performance of these muscles and a significant reduction in thoracic kyphosis (3). Havanloo and colleagues (2009) studied the relationship between the strength and flexibility of trunk muscles and the degree of thoracic kyphosis in male elementary school students. The results of these studies in-dicated a significant relationship between thoracic kyphosis and all predictor variables in this re-search (strength of back extensor muscles, strength of scapular adductors, flexibility of shoulder girdle flexor muscles, and flexibility of chest-abdominal muscles). This means that with a decrease in the strength of trunk extensor and scapular adductor muscles, a decrease in the flexibility of chest-abdominal muscles, and also the shoulder girdle flexor muscles, the degree of thoracic ky-phosis increases (24).

In the present study, no significant difference in flexibility was observed between the two groups of lordotic and healthy individuals. In this regard, Elham Pour (2009) studied the impact of kyphosis and lordosis on some physiological variables, flexibility, and aerobic capacity in girls aged 15 to 18 in Tehran. The results of this study showed that among normal schoolgirls, there is a significant difference in aerobic capacity and flexibility concerning kyphosis and lordosis (7). The results of the research by Alizadeh et al. (2005) also indicated the absence of a significant relation-ship between lumbar curvature and the flexibility of the iliopsoas muscle of the left and right legs, as well as between lumbar curvature and abdominal muscle strength in male students at the Univer-sity of Tehran (25). The results of the research by Arshadi et al. (2009) regarding the investigation of the relationship between the strength of the back extensor muscles and the flexibility of the spine with the degree of kyphosis and lordosis showed that there is a significant relationship be-tween the strength of the back extensor muscles and the degree of kyphosis and lordosis, but no significant relationship was observed between the flexibility of the dorsal area with the degree of kyphosis and the flexibility of the lumbar area with the degree of lordosis. These researchers ex-plained the results of the study by stating that in the lumbar region, flexibility is greatly influenced by the ligaments and the annulus of the intervertebral discs, such that the quality of the annulus disc changes the flexibility of the lumbar area. The presence of such determining factors in the flexibility of that area likely diminishes the effect of changing the degree of lordosis on the range of motion (1).

Ultimately, the results of the present study showed that no significant differences were ob-served among the groups of young boys. Factors such as anthropometric characteristics, body structure, genetics, pathological factors, adaptability to the environment, gender, and growth stage can influence flexibility traits. Young children and elementary

school children are very flexible and possess balance and stability regarding this capability during the pre-pubertal period. At the same time, as their growth and development process progresses, the level of flexibility gradually de-creases due to the loss of elasticity and reduced exercise. In the pre-pubertal period, no significant change is observed in the time interval between the early and late stages of this period, and if any differences do exist, they are mainly seen among boys in the early part of this period compared to those closer to puberty.

Flexibility is one of the important factors of health-related fitness, and it is not expected that a child's physical condition will be the same as that of an adult. This is because during the growth period, a high level of flexibility and mobility is observed in children. The extensive range of mo-tion during childhood can lead to temporary deviations in physical condition, which may manifest as abnormal physical conditions in adulthood. However, this very factor, flexibility, can be used as a method to protect against inflexible body alignment. In this regard, experts believe that poor physical condition resulting from home and school activities leads to muscle imbalance in the body and ultimately results in postural changes. Therefore, they emphasize the need for parents and teachers to monitor adolescents and young people in performing their duties and physical activities to prevent permanent postural abnormalities in the future. Understanding the postural habits adopt-ed by children may lead to changes in the spine. Therefore, prevention and encouragement can be appropriate strategies for achieving a healthier physical condition and preventing painful syn-dromes.

Given the prevalence of spinal deformities among Iranian adolescents and young adults, both male and female, and the impact of these deformities on health-related fitness and skills, it is essen-tial to implement specific training programs aimed at addressing spinal weaknesses. This will help prevent the spread of such deformities and provide a healthy and efficient generation for society. Therefore, specialists should focus on lifestyle changes and improving the quality of life of com-munity members to prevent postural deformities and identify them at younger ages, as there is a greater potential for change at these ages, and we can hope for actions that yield desirable results.

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مقایسهٔ انعطاف پذیری نوجوانان و جوانان دارای ناهنجاری وضعیتی ستون فقرات و سالم در جامعهٔ ایرانی

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چکیده: ضعف و کوتاهی عضالت بر امتداد و عملکرد بدن تاثیر بسزایی دارد و زمینه وارد شدن فشارهای غیرمتعارف به مفاصل و سایر بافتها را فراهم می آورد. نقصان یا فزونی در انعطاف پذیری، عاملی برای سفتی و ناپایداری اجزای متحرک است و بر حفظ وضعیت بدنی مطلوب تاثیرگذار است. لذا هدف از اجرای این پژوهش، مقایسهٔ انعطاف پذیری نوجوانان و جوانان ایران در دو گروه منتخب دارای ناهنجاری وضعیتی ستون فقرات و سالم بود. جامعهٔ آماری این پژوهش متشکل از نوجوانان و جوانان سراسر کشور بود. نمونهٔ آماری شامل ۱۲۶۳ تن از دختران و پسران نوجوان (۱۲-۱۸سال) از ۵ منطقهٔ جغرافیایی کشور بود که میتوانست از نظر محیطی، فرهنگی، اقتصادی و ژنتیکی معرف کل کشور باشد و مجموعاً حدود ۵۰ درصد از جمعیت کشور را به خود اختصاص دهد. به منظور اندازهگیری قوس های ستون فقرات در نمای ساجیتال از خط کش منعطف استفاده شد و انعطاف پذیری عضالت بازکنندهٔ ناحیه پشتی و کمری، عضلات خم کنندهٔ تنه و عضلات خم کننده جانبی تنه اندازه گیری شدند. نتایج پژوهش نشان داد در دختران نوجوان، جوان و پسران نوجوان بین انعطاف پذیری دو گروه کایفوتیک و سالم و کایفولوردوتیک و سالم تفاوت معنادار ($P<0.05$) و در دو گروه لوردوتیک و سالم این تفاوت معنادار نبود ($P>0.05$) . در بررسی انعطاف پذیری نوجوانان دختر و پسر، در گروه های کایفوتیک و کایفولوردوتیک در مقایسه باگروه سالم در هر دو جنس تفاوت معناداری وجود داشت ($P<0.05$) اما تفاوت انعطاف پذیری در گروه های لوردوتیک و سالم در هر دو جنس معنادار نبود($P>0.05$). در نهایت نتایج نشان داد تنها در انعطاف پذیری دختران جوان کایفوتیک و کایفولوردوتیک در مقایسه با افراد سالم تفاوت معناداری داشت ($P<0.05$) با توجه به نتایج بدست آمده از این پژوهش، میتوان نتیجه گرفت ناهنجاریهای ستون فقرات میتواند منجر به کاهش انعطاف پذیری دختران و پسران نوجوان و جوان شود که این امر لزوم اصلاح ناهنجاریهای وضعیتی را در سنین پایین نشان می دهد. از این رو ضروری است تا برنامه های تمرینی خاص با رویکرد رفع ضعفهای ستون فقرات ارائه شود تا از اشاعهٔ این نوع ناهنجاریها پیشگیریهای لازم به عمل آمده و نسل سالم و کارآمد را در اختیار جامعه قرار دهد.

واژه‌های کلیدی: انعطاف پذیری، کایفولوردوتیک، کایفوتیک، لوردوتیک.