

POSTURAL DEVIATIONS AND SPORTS INJURIES AMONG PHYSICALLY ACTIVE AND SEDENTARY COLLEGE STUDENTS

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SUMMARY

Sports injuries display multi-factorial etiology that primarily involves the interplay of compensatory biomechanics in the spine and lower extremity, environmental factors and footwear. We analyzed high school students in an attempt to formulate a predictive equation to screen development of sports injuries and to check the effect of rehabilitation programs and immobilization on healing of sports injuries. Information on age, gender, height, body weight, former posture deficiency, rate of sports injuries, immobilization period and application of functional rehabilitation following sports injury were obtained from 40 physically active college students (18 females, 22 males, 19-24 ages) and 35 sedentary college students (15 females, 20 males, 18-20 ages) through a questionnaire. Posture evaluation included the New-York Posture Test; and two researchers carried out the examination of genu varum and valgum, tibial torsion, and foot deformities. Inter-observer reliability was 0.79. Pes planus was the most frequent postural failure (80 % in athletes and 83 % in sedentary). Postural failures upon lateral postural evaluation were significant, especially in males ($p<0.01$). Shoulder injury was more evident with shoulder asymmetry and forward shoulder ($p<0.001$). Increased lumbar lordosis brought in significant risk for low back injuries ($p<0.001$). Postural changes at the knees was significant with knee injury frequency ($p<0.01$). High healing frequency and low injury recurrence was evident in the rehabilitated group ($p<0.000$). These results suggest that postural failure increases risk of injury and delays healing process after injury. Therefore, before resuming exercise training, postural failures should be both evaluated and corrected with appropriate methods.

Keywords: Posture test, healing, sports injury, rehabilitation, exercise

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ÖZET

FİZİKSEL OLARAK AKTİF VE SEDANTER ÜNİVERSİTE ÖĞRENCİLERİNDE POSTÜRAL DEVIASYONLAR VE SPOR SAKATLIKLARI

Spor sakatlıkları; omurga ve alt ekstremitedeki kompensatuar biomekanikğin, çevresel faktörlerin ve ayakkabı yapısının etkileşimini içeren mültifaktöryel bir etiyoloji sergiler. Spor sakatlıklarının oluşumunu ayırt edecek bir öngörü denklemi formüle etmeye ve rehabilitasyon programları ile immobilizasyonun iyileşmeye etkilerini belirlemeye yönelik olarak üniversite öğrencilerini inceledik. Fiziksel olarak aktif 40 (18 kadın, 22 erkek, 19-24 yaşlarda), ve sedanter 35 (15 kadın, 20 erkek, 18-20 yaşlarda) üniversite öğrencisi yaş, vücut ağırlığı, boy, postür yetmezliği hikayesi, spor sakatlığı sıklığı, immobilizasyon süresi ve sakatlık sonrası fonksiyonel rehabilitasyon açısından sorgulandı. Postür değerlendirmesi New-York postür testiyle yapıldı ve iki araştırmacı genu varum ve genu valgum, tibial torsion ile ayak deformitelerini inceledi. Gözlemci arası güvenilirlik 0.79 olarak saptandı. Pes planus en sık rastlanan postüral yetmezlikti (sporcularda % 80, sedanterlerde % 83). Lateral postür değerlendirmesinde postür yetmezliği özellikle erkeklerde anlamlıydı ($p<0.01$). Omuz asimetrisinde ve öne omuz varlığında omuz sakatlığı daha belirgindi ($p<0.001$). Artmış lomber lordoz bel sakatlıkları için anlamlı risk oluşturuyordu ($p<0.001$). Dizlerde postür değişikliği diz sakatlığı sıklığıyla ilişkili bulundu ($p<0.01$). Rehabilitasyon edilen grupta yüksek iyileşme oranı ve düşük sakatlık tekrarı belirgindi ($p<0.000$). Bu sonuçlar postüral yetmezliğin sakatlık riskini arttırdığını ve iyileşme sürecini uzattığını düşündürmektedir. Bu nedenle, antrenmana dönüş öncesinde postüral yetmezliklerin uygun yöntemlerle değerlendirilmesi ve düzeltilmesi gerekli görünmektedir.

Anahtar sözcükler: Postür testi, sağaltım, spor sakatlıkları, rehabilitasyon, egzersiz

INTRODUCTION

Etiology of sports injuries primarily involves the interplay of compensatory biomechanics in the spine and lower extremity, environmental factors and footwear (1). Cardiovascular control, physical adaptation testing, common motor skill testing and flexibility testing methods (5,9,23) evaluate performance and sport-specific conditional state of individuals; who are going to start exercise. However, while using

these methods, postural changes usually are not taken into consideration. Sportive activity by its nature, is injury prone. Especially overuse injuries may develop depending on the architecture and function of the body in athletes (30). Gieck (9) and Peterson (19) postulated that postural changes could develop depending on the type of sportive activity. For example, shoulder asymmetry and scoliosis can occur in racquet sports, especially when participation begins in the adolescent period and if the body is unilaterally used (19).

Many causative factors were identified leading to sports injuries such as fatigue, poor posture, muscle strength imbalance, leg strength discrepancy, joint hypo-mobility and failure to properly warm up (1,15,19). Salokun (24) suggested that players should be pre-selected according to somatotype characteristics in order to minimize the incidence of injuries in soccer.

Posture can be defined as the relative arrangement of the various parts of the body. In several investigations, it is emphasized that regular postural assessments should be done as part of an athlete's musculoskeletal evaluation and postural failures are treated before training (9,12,17,29). It is a common belief that sports facilitates correct and right posture. Nevertheless, it is known that postural deviations may be associated with certain kinds of sports injury and/or that postural changes occur particularly in sports started at an early age. Asymmetric body movements in hurling for instance, facilitates asymmetrical muscle development, so that scoliosis develops (27). Excess of lumbar lordosis is physiologic until the age of eight and is expected to decrease with increasing age, but with gymnastics this can increase. Abnormal stresses on the back may predispose or precipitate low back pain (1,17).

Immobilization periods and rehabilitation programs following sports injury will prevent the injury to get chronic (1,5). The vast majority of injuries, when identified early on, can be treated effectively with minor modifications in the training program, correction of underlying muscle and flexibility imbalances and postural disorders, and also by paying attention to appropriate footwear. Therefore, understanding of the anatomy, physio-pathology and predisposing biomechanical factors is essential for adequate injury treatment and prevention.

We analyzed high school students in an attempt to formulate a predictive equation to screen development of sports injuries. The aim of this study was:

- 1) To compare students who are involved in sports or not according to presence of postural disorders;
- 2) To evaluate the effect of postural disorders in the occurrence of sports injuries;
- 3) To determine the type and location of postural disorders which affect sports injuries;
- 4) To assess distribution of sports injuries according to sports branches;
- 5) To check if the athletes comply to immobilization following injury and if this factor has a role on the healing period; and
- 6) To determine the effect of rehabilitation programs in the healing of sports injuries.

MATERIAL AND METHODS

Subjects (Group I) were randomly chosen from students of the School of Physical Education and Sports. The control group (Group II) consisted of 18 students of the School of Tourism and 17 students of the Faculty of Agriculture, who were not occupied with sports. The University Ethical Committee approved the investigation. The age, sex, height, body weight, failure of posture, sports injury, recovery rate, immobilization period and application of functional rehabilitation program after injury was evaluated.

New-York Posture Test was used for posture evaluation. In this test; symmetry was scored for head, spine, pelvis, heels and soles from the posterior view; for neck, breast, shoulders, back, trunk, abdominal protrusion and waist from the lateral view, in relation to the vertical line and posture. Normal posture, mild postural defect and significant postural defect were scored with 5, 3 and 1 points. Highest scores were 30 for the posterior view and 35 for the lateral view. In the statistical analysis, total posterior and lateral view scores were used. To assess reliability of the posture test, two investigators independently conducted two trials on all individuals. Inter-observer reliability was found to be 0.79. Students who had low postural scores, were further examined clinically (17).

The measure of genu varum and genu valgum utilized in this report is the pelvic width to the distance between midpoints of the patellae, or the pelvic-patellar ratio. This measure is based on the concept that the ratio of pelvic width to the inter-knee distance is relatively small in those with genu varum and large in those with genu valgum. Tibial torsion was evaluated by the relationship of the line starting in the middle of the patella in the sitting position to the foot, the position of the feet during ambulation and walking and the appearance of the patella (11).

Feiss line was used to determine pes planus during posture test. Feiss line is a hypothetical line, which extends from just below the medial malleolus to the point where the metatarsophalangeal joint of the large toe rests on the floor. The space between the line and the floor may be divided into three for grading purposes. Normally the scaphoid tubercle is on the line. It may be at one third of the distance to the floor (first degree flat foot), at two thirds of the distance (moderate or second degree flat foot) or resting on the floor (complete or third degree flat foot) (29).

Investigators filled out questionnaires on retrospective injury experience. Fractures and dislocations were excluded, and only sprain, strain and overstress or overuse injuries were recorded. The questionnaires sought the following information:

- a) Site, type and mechanism of injury sustained during training and competition sessions of sports occupation.
- b) Time and type of treatment received.

Statistical analyses were made by SPSS statistical analysis programs (Student t-test, χ^2 test with Yates correction, Fisher χ^2 test) ($\alpha= 0.05$).

RESULTS

There were no height and weight differences between the groups. In the research group, mean age was higher (Table 1). About 77.5 % of the athletes and 85.7 % of the sedentary had posture failure upon evaluation from posterior view. However, there was no significant difference between the groups (Table 2). Most frequent postural failures were pes planus and heel valgus. Shoulder asymmetry was evident in the control group but statistically there was no significance (Table 3). No musculo-skeletal disorders such as muscle strength failure (by manual

Table 1. Physical properties of subjects.

	Group I (n=40)			Group II (n=35)			P
	Women	Men	Total	Women	Men	Total	
N	18	22	40	15	20	35	
Age, yr	20.8	22.8	21.8	19.7	19.7	19.4	2.869
Height, cm	167.0	178.0	173.0	168.3	174.7	171.9	0.349
Weight, kg	59.0	72.0	66.0	60.6	64.8	62.9	0.113

Table 2. Mean postural scores of subjects (Mean ± SD).

	Women			Men			Total		
	Group I	Group II	p	Group I	Group II	p	Group I	Group II	p
	Posterior Posture	27.2 ± 2.2	26.2 ± 2.1	0.06	27.2 ± 2.5	26.8 ± 1.7	0.34	27.2 ± 2.4	26.5 ± 1.9
Lateral Posture	34.2 ± 1.0	33.4 ± 2.5	0.22	34.7 ± 0.7	32.8 ± 3.0	0.01	34.5 ± 0.9	33.1 ± 2.8	0.003

Table 3. Type and frequencies (N) of postural disorders of subjects.

Type of postural disorder	Women			Men			Total		
	I	II	p	I	II	p	I	II	p
Shoulder asymmetry	1	1	0.70	4	7	0.21	5	8	0.24
Forward shoulder	-	1	0.44	1	1	0.74	1	2	0.45
Kifosis	1	5	0.046	1	2	0.48	2	7	0.048
Increased lumbar lordosis	8	3	0.16	1	-	0.51	9	3	0.09
Genu varum	3	4	0.36	5	6	0.65	8	10	0.39
Genu valgum	-	1	0.44	1	-	0.51	1	1	0.72
Tibial torsion internal	3	2	0.62	-	1	0.49	3	3	0.60
Tibial torsion external	1	1	0.70	-	-	-	1	1	0.72
Flattening metatarsal arcus	12	13	0.12	14	9	0.16	26	22	0.85
Hallux valgus	3	1	0.40	1	-	0.51	4	1	0.22
Heel varus	5	3	0.49	-	1	0.49	5	4	0.59
Heel valgus	4	7	0.11	6	7	0.65	10	14	0.16
Pes planus	16	15	0.16	16	14	0.65	32	29	0.75

muscle test) and/or scoliosis, which would explain shoulder asymmetry was found in either group. About 40.0 % of the athletes and 45.7 % of the sedentary had postural failure upon lateral posture evaluation. The differences were statistically significant (Table 2). Postural failure of sedentary boys was significant. Kyphosis was more evident in the control group (Table 3).

Knee status revealed no significant difference in both groups. Genu varum was more frequent in the males, whereas tibial torsion was more frequent in females. No difference about postural changes for the feet existed between groups. About 80 % of the athletes and 82.9 % of the controls had pes planus. For group I, the degree of pes planus was as follows: 16 % severe, 59 % moderate and 25 % slight (Table 3).

The sedentary group mentioned no pain and injury. Injuries were assessed by injury frequency since 29 athletes participated to more than one kind of sportive activity and injuries happened at more than one site and at one side more than once. From the total number of 88 injuries 34 were located at the upper extremities, 10 at the back, and 44 at the lower extremities. Upper extremity injuries occurred much more in volleyball, basketball and wrestling sports; back injuries in gymnastics and steps; and lower extremity injuries in football, basketball and track and field (Figure 1). The relationship between the kind of sports and the anatomical site according to type of injury could not be estimated. Anatomical localization of the upper extremity injuries was 27.5 % at the shoulder, 17.7 % at the elbow, 27.5 % at the wrist, 29.4 % at the hand and fingers (Figure 2). Lower extremity injuries were localized 7.1 % at the hip, 31.0 % at the knee, 50.0 % at the ankle and 11.9 % at the fingers (Figure 3). Ankle injuries were frequent in basketball, handball, football and athletics. Knee injuries were frequent in football.

Three out of 12 shoulder injuries, four out of 13 knee injuries and 10 out of 26 ankle injuries were relapses of former injuries. Shoulder injury was more evident in athletes who had shoulder asymmetry and forward shoulder ($p=0.001$). Increased lumbar lordosis imposed larger risk for low back injuries ($p=0.0002$).

Athletes who had genu varum or valgum, internal or external tibial torsion were analyzed for relationship between knee status and knee injury. Thus, 53.9 % of athletes who had postural deviations in their knees, and 7.4 % of athletes whose knees were normal had experienced sports injury in the past ($p=0.002$). It was found that athletes having postural in their knees had more frequent knee injury.

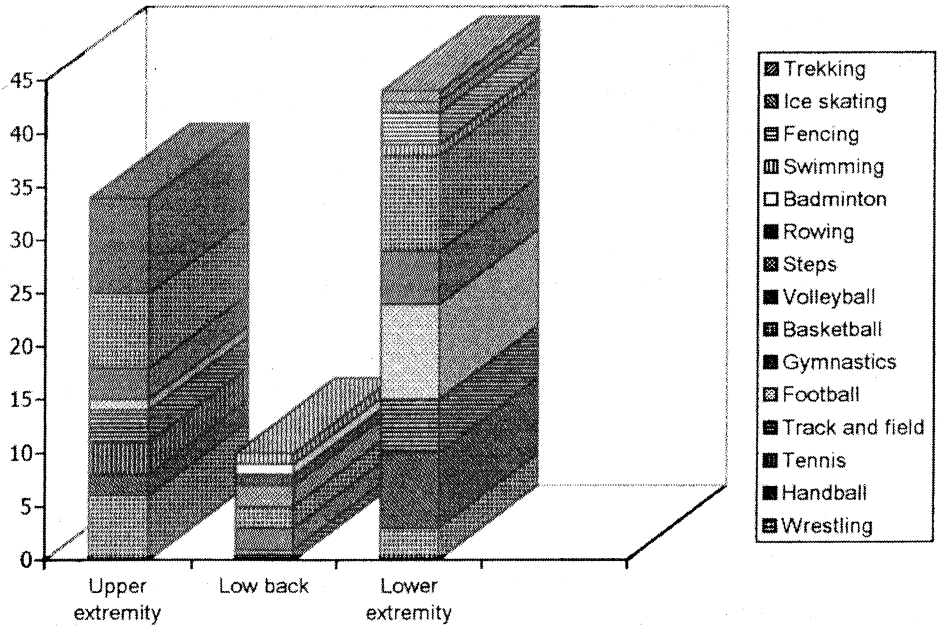


Figure 1. Anatomical distribution of injuries according to sports branches.

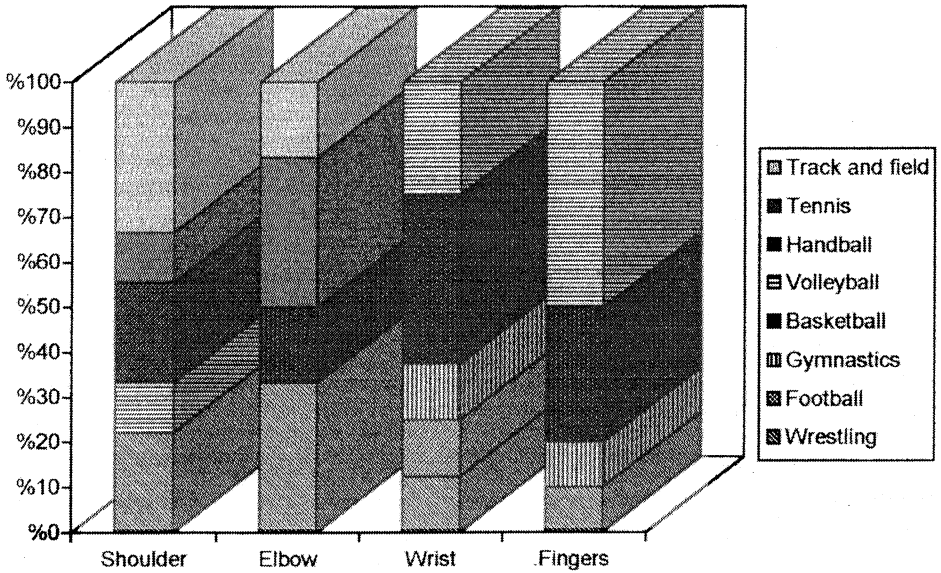


Figure 2. Anatomical distribution of upper extremity injuries.

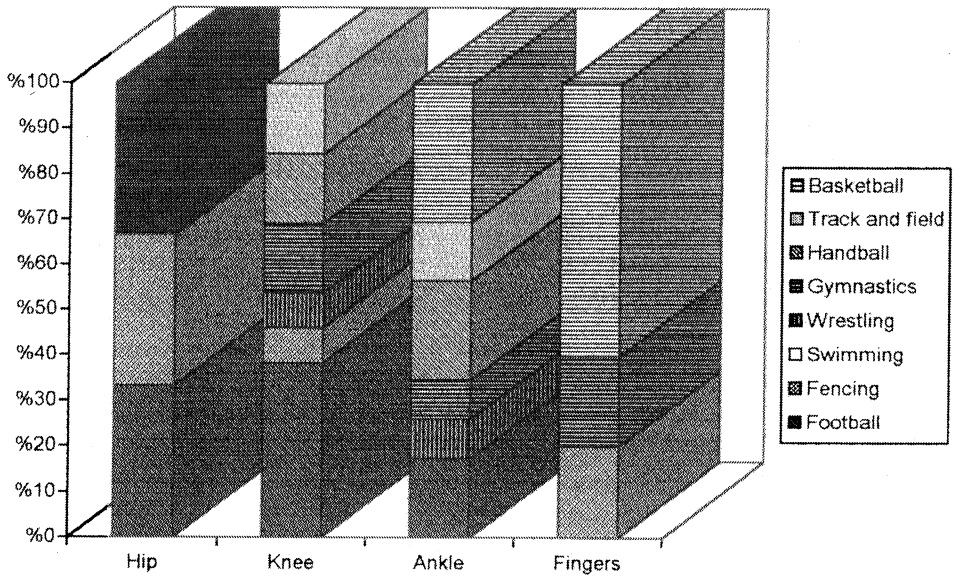


Figure 3. Anatomical distribution of lower extremity injuries.

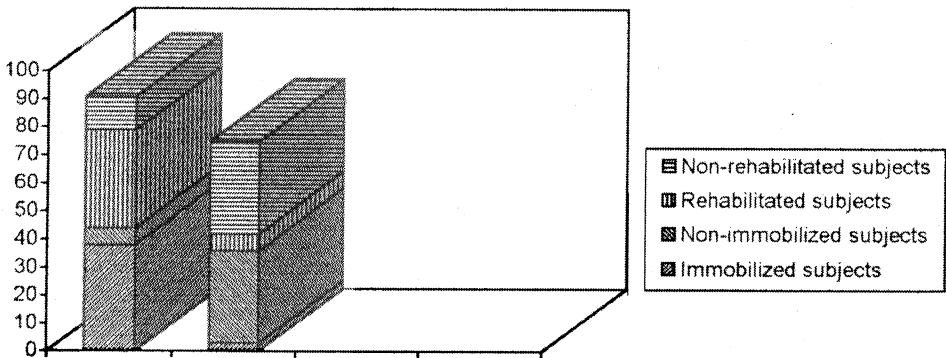


Figure 4. Proportion of recovery.

About 46.9 % of the athletes with foot deformities and 12.5 % without pes planus had sustained foot and/or ankle injuries in the past. Statistical analysis was made according to the occurrence of feet and knee postural deformity, predisposing to sports injury. There was no significance ($p=0.08$).

In eight of the 88 sports injuries, immobilization duration could not be remembered. A total of 92.7 % of the students who were immobilized

and 15.4 % who did not obey immobilization recommendations had injury recurrence. Immobilization was found to be an important factor in healing. Of the students, 52.3 % who had had sports injury did not apply a rehabilitation program ($p=0.000$). The rate of recovery was 85.4 % for the students who were treated with a rehabilitation program and 26.7 % for those who did not follow any rehabilitation program ($p=0.000$) (Figure 4). The rehabilitation program was made by the athlete himself in 82.9 %, by a masseur or specialist in 26.8 % of the cases. Healing frequency was higher, and recurrence was lower in the rehabilitated group. Little information was available on musculoskeletal injury treatment in athletes.

About 15 % of the sports students were thoroughly screened for postural disorders before starting sports activity; 5 % were not medically examined; and 27.5 % were only examined to attend the School of Physical Education and Sports. Health forms of 52.5 % students were filled upon verbal communication with the athletes.

DISCUSSION

On the basis of case series and clinical experience, a number of anatomic factors have been hypothesized to be associated with increased risk of injury (4,18). Authors have found that when the lower extremity is subjected to the greater forces of running, very small deviations from normal may lead to lower extremity injury (14).

There are a number of different ways of assessing posture (1,17, 21). Reasons for choosing the New-York posture test are the simplicity of equipment, objectivity, rapidity and low cost. We determined that the lateral postural score was better the posterior one in both groups. No difference exists between the posterior postural scores of the groups. The most frequent postural failure was pes planus and/or heel valgus/varus. Raine et al. (21) investigated head and shoulder posture variations in 160 asymptomatic women and men, and found no difference between genders.

Greenfield (10) stated that injured people had significant forward head position and that particularly the aching of the shoulder at humeral elevation was lower. In our investigation, no postural failure could be detected at the head and neck level. Shoulder asymmetry was found in one wrestler, two handball players and three track and field

athletes with shoulder injuries. The lower position of the injured shoulder could not be explained only with the injury, because screening for postural deviation was not made at the beginning of sports. In the sedentary group, postural habit and weight bearing could just explain shoulder asymmetry.

Increased lumbar lordosis was evident in Group I, especially in females. While the sedentary group with lumbar lordosis did not suffer from pain, the athletic group mentioned back pain during physical activity. It was postulated that in soccer and gymnastics the incidence of lumbar lordosis was high (5). Among football linemen, lumbar lordosis is further aggravated by the postural demands of the offensive stance. Lumbosacral and sacroiliac strains, and coccyalgia often might be traced to a lordotic position as the predisposing cause. Spondylosis and spondylolisthesis can result from the spine's response to the excessive and strenuous physical demands imposed (1). Because no postural evaluation records were available, and since students performed more than one kind of sports, the increase of lumbar lordosis could not be explained in relation to sports participation or sports branch.

It is sometimes suggested that postural deviations like lordosis and kyphosis tend to occur together in the same individual (1,27). There was no evidence for this in the present subjects. This finding suggests that increase of lumbar lordosis had developed following sports activity. In the sedentary group, three female students had increased lumbar lordosis with kyphosis. Because they did not have any history of trauma and spine disease, the cause of kyphosis among the female sedentary students was probably deficiency of physical activity and incorrect postural habit.

Kyphotic athletes who have well-developed but shortened pectoral muscles are frequently found among basketball players, gymnasts, weightlifters and football players. They are susceptible to anterior dislocations of the arm, particularly when the arm is forced into an abducted and extended position accompanied by outward rotation (1).

Previous studies have revealed that low physical fitness, excessive running mileage, high arches, low hamstring and low back flexibility are risk factors for injuries among basic trainees (4,16). Sports medicine literature suggests that extremes of anatomic variation and malalignment of the lower extremities predispose runners and athletes to injury

(6,18,20). Pronation or toeing out exposes the medial aspect of the knee joint to such an extent that when considerable lateral force is applied as in tackles or in sudden direction changes while moving at a high rate of speed, severe injury can result. Athletes who habitually walk or run in this fashion should be placed on a corrective program to obviate the habit and to reduce susceptibility to knee joint damage (1).

Pronation leads to prolonged internal rotation of the leg and may force the patella laterally from the femoral groove (22). Pronation also increases internal tibial torsion, which in turn stresses the medial side of the knee (14). Because the type and the mechanism of sports injury were mentioned subjectively in our investigation, no definite diagnostic approach could be done. Appropriate to the literature, postural failure at the knees and feet leads to increased risk of injury in the knees, feet and ankles (30). It was emphasized that causes of posteromedial shin pain were overuse and postural disorders of the foot and leg (8). Ankle valgus, pronation of foot and lateral rotation of leg which increase overstress and friction facilitate occurrence of sports injuries. It was found that femoral and tibial stress fractures occurred more frequently in pes cavus, whereas metatarsal fracture frequency was higher and prominent in pes planus. These findings reveal that feet with lower arcus can absorb shock pressure more than feet with higher arcus and, that corrective apparatus can improve the shock-absorbing feature of the arcus (25). No information about the fitness and training levels, and changes in the training program and environmental factors at the moment of injury could be attained.

Hopper (13) found that elite netball players with pronating foot types and with rear foot abnormalities were the most commonly injured, and that compensated rear foot varus supplied most of the lower limb injuries. No explanation was possible for the high incidence of flat feet amongst athletes and sedentary subjects.

Genu valgum causes strain on the medial collateral ligament and renders the joint somewhat more unstable and prone to injury, and extra stress is placed on the fibular collateral ligament (1). The frequency of genu varum in both groups was in accordance to the literature (30). Putukian (20) suggested that excessive Q angle and genu valgum may predispose women to higher risks of exercise- and sports-related injury. Anatomic variants of the lower extremity such as genu

valgum, high Q angle, excessive knee angle are associated with elevated risk of some types of overuse injury (3). Female athletes are at increased risk for certain sports-related injuries, particularly those involving the knee. Factors that contribute to this increased risk are the differences in exercise practice and gender anatomy and structure (15). Five of our female subjects who had genu varum and internal tibial torsion had knee injury.

Though excessive isolated external tibial torsion may elicit recurrent patellar dislocation (2), some of the postural changes can increase athletic ability. For example, Fuchs et al. (7) found that thigh-foot angle was lower in sprinters compared with controls and that medial tibial torsion increased sprinting ability.

In our investigation, most injuries occurred in football, basketball, volleyball, wrestling; and postural disorders had an important effect. Occurrence of upper extremity sports injuries in volleyball, basketball and wrestling; of lower extremity injuries in football, basketball and track and fields; and of low back injuries in gymnastics and steps were in concordance with the literature (5). In our subjects, sports injury occurred 50.0 % in the lower extremities, 38.6 % in the upper extremities and 11.4 % in the lower back. Injuries were frequent at the ankle and the knee. In an investigation among 398 athletes, injury frequency was 38.4 % at the ankle joint, 26.1 % at the knee, and 15.3 % at the foot, waist, and thigh (30). Highest injury rates were found in soccer, followed by gymnastics, volleyball, and martial arts. Injuries sustained during participation in soccer, volleyball, and gymnastics took the major part. The upper extremities followed lower extremities; and the ankle and foot were the most frequent site of injury for the lower extremities (26). Weir and his colleagues (28) found that the injury rate was highest in badminton, gymnastics, rugby and basketball. The rate of overuse injury was high in swimming, badminton and athletics. Several authors have reported stress fractures of the lower extremity secondary to faulty biomechanics (25). These results suggest that postural failure must be determined and treated before sports activity.

Wushao (30) found that risk of sports injury increased in relation with postural disorders. Only 15 % of our subjects were examined thoroughly including postural screening at the beginning to sports. Therefore, definite conclusion could not be made about development of postural disorder.

CONCLUSION

Most researchers agree that determining the ability of an athlete does not consist of just evaluating cardiovascular and respiratory function, common motor skill testing, and strength. Flexibility of all large joints, adaptation of the postural muscles, posture, balance and walking features must also be examined (5,9,30). This paper has examined the incidence of postural deviations in a group of students specializing in different types of physical activity. However, the present study does not eliminate the possibility that postural deviations predated the start of specialized physical activity. The most important findings are as follows: postural failure increases risk of injury and delay of healing process after injury, because of insufficient immobilization and rehabilitation. Therefore, medical examination of the individual should include evaluation of postural failures at the beginning of sports training. Failures should be corrected with appropriate methods, and attention should be paid for the immobilization period and sound rehabilitation methods should be used following injury for a complete functional treatment.

Most sports related injuries are not accidental and are potentially preventable. Future epidemiological prospective and retrospective studies will require methods to quickly and accurately measure anatomic risk factors among large populations of both genders. The goal is to reduce the severity of certain acute and overuse injuries and to prevent others. Such studies would require a multidisciplinary team of experts. Considering the significant time loss and cost that even relatively minor injuries cause, more work is required to define most common injuries, and importantly, to develop measures to decrease their incidence. Data such as presented in this report provide a foundation for developing more complex studies of the dynamic biomechanical determinants of injury.

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