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ASSESSMENT OF TRUNK ASYMMETRY AND POSTURAL DISORDERS IN OPTIMIST AND LASER CLASS SAILORS

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ABSTRACT

Objective: The relationship between sports participation, trunk asymmetry, and postural disorders remains controversial. This study aimed to investigate trunk asymmetry and associated postural disorders among licensed Optimist and Laser sailors.

Materials and Methods: This single-center cross-sectional study included licensed Optimist and Laser sailors aged 9-18 years. Postural assessment included the Adams forward-bending test; evaluation of shoulder, scapular, and lumbar asymmetry; scoliometer measurements; thoracic, knee, and ankle deformities; thoracic kyphosis; lumbar lordosis; and skinfold thickness measurements.

Results: A total of 58 licensed sailors were included. Five participants (8.6%) had an axial trunk rotation (ATR) greater than 5°, while one participant (1.7%) had an ATR greater than 7°. Mild shoulder asymmetry was observed in 25 sailors (43%), and mild scapular asymmetry was observed in 30 sailors (51%). Mild low-back asymmetry was identified in 13 sailors (22%), whereas moderate asymmetry was observed in seven sailors (12%). Anterior chest deformity was detected in 3 sailors (5%), lumbar lordosis in 10 sailors (17%), and thoracic kyphosis in 5 sailors (8%). No significant correlation was found between scoliometric measurements and skinfold thickness values ($p>0.05$). Significant correlations were identified between sailing duration and low-back asymmetry; between lumbar lordosis and thigh fat percentage; and between shoulder asymmetry and weekly training duration, calf fat percentage, scapular asymmetry, and low-back asymmetry.

Conclusion: Young sailors may demonstrate trunk asymmetry and postural alterations associated with repetitive asymmetric loading patterns. However, due to the cross-sectional design, the absence of a control group, and the lack of radiographic confirmation, no causal relationship between sailing participation and IS can be established. Further controlled longitudinal studies are required to clarify these associations.

Keywords: Idiopathic scoliosis, trunk asymmetry, sailing athletes, postural disorders

INTRODUCTION

Idiopathic scoliosis (IS) is a three-dimensional spinal deformity characterized by lateral curvature and vertebral rotation, affecting approximately 2-3% of adolescents during growth spurts[1,2]. Although the etiology of IS remains unclear, both genetic predisposition and environmental factors are believed to contribute to its development[3,4]. Among environmental factors, sports participation has attracted increasing attention because repetitive asymmetric loading patterns and intensive training during skeletal growth may influence spinal alignment[5].

The relationship between sports and IS remains controversial. Previous studies have reported increased scoliosis prevalence in athletes participating in gymnastics, dance, and swimming, potentially due to repetitive asymmetrical movements, generalized joint laxity, delayed maturation, and mechanical stress on the immature spine[6-8]. In contrast, other studies have suggested that regular sports participation may have either no effect or even a protective role against scoliosis progression[9]. Therefore, current evidence regarding the influence of sports on IS remains inconclusive.

Sailing is a physically demanding sport requiring prolonged asymmetric postures, trunk stabilization, and repetitive unilateral loading. Within this sport, the Optimist class serves as a starting point for boys and girls under the age of 15. Beyond this age, sailors often transition to single-seater

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vessels like the Laser 4.7, followed by Laser Radial, or European class[10]. Optimist and Laser classes, commonly practiced by children and adolescents, involve sustained counterbalancing maneuvers and asymmetrical muscle activation patterns. Despite these biomechanical characteristics, limited evidence exists regarding the frequency of axial trunk rotation (ATR) positivity and postural asymmetries among young sailors.

The primary hypothesis of this study was that young sailors participating in Optimist and Laser classes would demonstrate increased trunk asymmetry findings and postural alterations associated with repetitive asymmetric loading patterns during sailing. A secondary hypothesis was that sailing exposure and body composition parameters may be associated with the severity of postural asymmetries and ATR measurements.

Ethical Approval

The Ethics Committee of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital approved the design and protocol of the study in agreement with the principles of the Declaration of Helsinki and ethical standards for human experimentation (approval no: 2019-11-02, date: 10.06.2019). All participants and their parents were informed about the study. Signed informed consent was obtained from parents.

MATERIALS AND METHODS

This cross-sectional study was conducted among licensed Optimist and Laser class athletes from the İstanbul Sailing Club. The inclusion criteria were: (1) age between 9 and 18 years, (2) both genders, (3) participation in sailing training for at least four hours per week, and (4) active registration in a sailing sports club. The age range of 9-18 years was selected because this period corresponds to rapid skeletal growth and adolescence, during which IS most commonly develops and progresses. Furthermore, Optimist and Laser sailing categories are predominantly practiced within this age group. Exclusion criteria included previous spinal surgery, unwillingness to participate, or lack of parental consent.

A priori power analysis was not performed because the present study was designed as an exploratory pilot investigation evaluating postural disorders in a specific athletic population. This limitation has been acknowledged in the discussion section.

Female and male participants were not age-matched because the study aimed to evaluate all eligible licensed sailors available during the recruitment period. Additionally, the sailing population within the club consisted predominantly of male athletes. All participants were provided detailed information about the study's purpose, procedures, and data usage.

Data Collection

Postural examinations were performed visually in the standing position by two physiatrists with more than 10 years of experience and one physiotherapist with more than 5 years of experience in spinal deformities and scoliosis rehabilitation.

Demographic data, age at puberty, age at menarche, Tanner scale, body type, Adams forward-bending test, shoulder, scapula, and lumbar asymmetry, scoliometer results, spinal flexibility, thoracic deformity, back kyphosis, lumbar lordosis, scoliosis, leg length discrepancy, knee and ankle deformities, and skinfold thicknesses (SFTs) were recorded.

Position of shoulders in frontal and sagittal plane, spine alignment, knee, scapula position, lordosis, kyphosis, scoliosis, spina iliaca anterior superior, thoracic deformities (pectus carinatum/excavatum), knee deformities (genu varum, genu valgum, recurvatum), and foot deformities (pes planus, pes cavus, calcaneovalgus) were evaluated by visual observation[11]. Shoulder asymmetry was defined as inequality in shoulder height in the frontal and sagittal plane. Scapular asymmetry was evaluated according to differences in scapular prominence or position. Low-back asymmetry was defined as visible asymmetry in lumbar contour or waistline alignment during standing posture. Thoracic kyphosis and lumbar lordosis were assessed clinically in the sagittal plane by visual inspection. Increased thoracic kyphosis was defined as excessive posterior thoracic curvature, while increased lumbar lordosis was defined as excessive inward lumbar curvature relative to normal sagittal alignment.

Inter-rater and intra-rater reliability analyses were not performed, which represents a limitation of the study.

Measurements and Outcomes

ATR measurements were performed during the Adams forward-bending test using a standard scoliometer. Participants were instructed to bend forward with knees extended and palms together. Measurements were obtained at the thoracic and lumbar regions, and the highest ATR value was recorded for analysis. ATR angles were measured from the sacrum, lumbar, thoracic, and cervical spine for all participants using the scoliometer device labelled MIZUHO OSI (U.S. Patent no. 5,181,525). ATR measurements obtained using the scoliometer were used as screening parameters for trunk asymmetry. An ATR value of 5° was selected as the referral threshold based on previous scoliosis screening studies demonstrating that this cut-off provides acceptable sensitivity for detecting clinically significant spinal deformities[12]. Radiographic confirmation was not performed within the scope of this study.

SFT measurements were included to evaluate body composition characteristics and possible associations between adipose tissue distribution, body type, and postural asymmetry findings in adolescent sailors. Since body composition may influence biomechanical loading patterns and athletic performance, these measurements were explored as potential contributing factors.

All SFT measurements were assessed by the same individual on the right side as prescribed by the anthropometric standardization reference manual[13]. SFT measurements were made using a Holtain brand SFT caliper (Holtain Ltd., UK) with an accuracy of ±0.2 mm according to the protocol of Keys and

Brozek[14].

The average fat percentage of athletes was calculated according to the Yuhasz formula as follows: "% fat=0.153 (T+SS+A+SI)+5.788"[15]. Somatotypes (endomorphy, mesomorphy, ectomorphy) were assessed according to the method described by Heath-Carter[16].

Statistical Analysis

Continuous variables are reported as mean ± standard deviation or median (minimum-maximum) according to data distribution. The Shapiro-Wilk test was used to assess normality. Categorical variables were reported as percentages. Spearman correlation analysis was used to define associations between SFT and ATR. No correction for multiple comparisons was applied because the analyses were considered exploratory. P-values ≤0.05 indicated statistical significance with a 95% confidence interval. Analyses were performed using SPSS 22.0 (SPSS Inc., IBM, Armonk, NY, USA).

RESULTS

The study population consisted of 58 participants, with a mean age of 12.6±2.0 years. Gender distribution revealed that 12 (21%) were female, while 46 (79%) were male . Anthropometric measurements indicated a mean height of 157±13.7 cm and a mean weight of 47.6±13.1 kg. Regarding sailing experience, 6 (10%) had less than two years of experience, 41 (71%) had been sailing for 2 to 5 years, and 11 (19%) had more than five years of sailing experience. Tanner staging revealed that 16 (28%) of participants were classified as Tanner stage 1, while 14 (24%) were categorized as Tanner stage 2 in terms of sexual development. Notably, 98% of the participants were free from additional diseases. The Beighton score, a measure of joint laxity, was 1.2±1.8 for the upper extremity and 0.6±0.9 for the lower extremity. Body composition analysis indicated that 32 (55%) of the participants exhibited a mesomorphic body type, 15 (26%) were classified as endomorphic, and 11 (19%) as ectomorphic (Table 1). Furthermore, 34% of the participants were involved in sports activities other than sailing (Figure 1).

Postural assessment findings are summarized in Table 2. Among the participants, 5 (8.6%) exhibited an ATR angle greater than 5°, with only 1 (1.7%) exceeding 7°, all of whom were male. Leg length discrepancies were observed in 1 (1.7%) sailors. Head posture was generally normal in 50 (86%) participants. Shoulder asymmetry findings indicated that 25 (43%) had mild shoulder asymmetry, 5 (8%) had moderate shoulder asymmetry, and 1 (1.7%) exhibited severe shoulder asymmetry. Scapular asymmetry was mild in 30 (51%) and severe in 1 (1.7%). In terms of low-back asymmetry, 13 (22%) exhibited mild asymmetry, 7 (12%) had moderate asymmetry, and 1 (1.7%) had severe low-back asymmetry.

SFT measurements indicated that the highest values were observed in the abdomen, averaging 12.9±5.2, followed by the calf, triceps, suprailiacus, thigh, and biceps. Correspondingly, body fat percentage, calculated using the Yuhasz formula, was highest in the abdomen, followed by the calf, triceps, suprailiacus, thigh, and biceps in Table 3 (3.54±2.8, 3.45±2.7, 3.43±2.74, 3.35±2.81, 3.17±2.74, and 2.93±2.88, respectively).

Correlation analyses were performed to explore associations between ATR and SFT parameters, and results were summarized in Table 4. Scoliometric measurements at the thoracic 12 level showed a significant negative correlation with abdominal SFT (p=0.023, r=-0.298, and p=0.01). However, no significant correlations were observed between other scoliometric and SFT measurements (p>0.05).

Positive and significant correlations were observed between sailing time and low-back asymmetry (p=0.008, r=0.344), lumbar lordosis and thigh fat percentage (p=0.049, r=0.259), swimming and increased lumbar lordosis (p=0.002, r=0.391), and the presence of hip asymmetry while playing basketball, which was negatively correlated (p=0.027, r=-0.290), while positively correlated with knee deformity (p=0.003, r=0.377).

Table 1. Demographic characteristic of study population

Age (year) (mean ± SD)	12.6±2
Gender (female/male), (%)	12 (21%)/46 (79%)
Height (cm), (mean ± SD)	157±13.7
Weight (kg) (mean ± SD)	47.6±13.1
Beighton score (mean ± SD)	
Upper extremity	1.2±1.8
Lower extremity	0.6±0.9
Tanner stage (%)	
Stage 1	16 (28%)
Stage 2	14 (24%)
Stage 3	11 (19%)
Stage 4	12 (21%)
Stage 5	5 (8%)
Dental braces treatment (%)	21 (36%)
Sailing time (%)	
<2 years	6 (10%)
2-5 years	41 (71%)
>5years	11 (19%)
ADAMS test positive (%)	2 (3%)
Body type (%)	
Mesomorphic	32 (55%)
Endomorphic	15 (26%)
Ectomorphic	11 (19%)

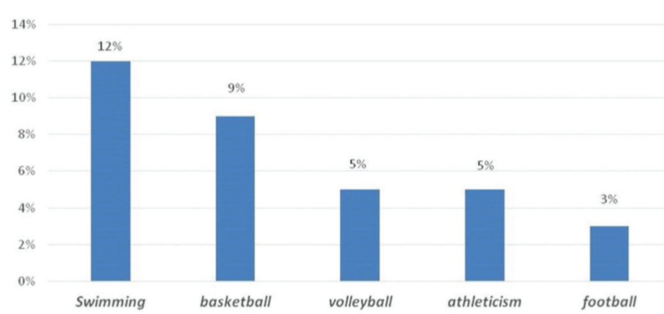

Figure 1. Sports activities other than sailing among the participants

Table 2. Postural assessment evaluation of participants

Axial trunk rotation, n (%)	
>5°	5 (8.6%)
>7°	1 (1.7%)
Head position, n (%)	
Normal	50 (86%)
Right	6 (10%)
Left	2 (3%)
Shoulder asymmetry, n (%)	
None	27 (47%)
Mild	25 (43%)
Moderate	5 (8%
Severe	1 (1.7%)
Scapula asymmetry, n (%)	
None	27 (47%)
Mild	30 (51%)
Moderate	1 (1.7%)
Severe	0
Low-back asymmetry, n (%)	
None	37 (64%)
Mild	13 (22%)
Moderate	7 (12%)
Severe	1 (1.7%)
Anterior chest deformity, n (%)	3 (5%)
Lomber lordosis, n (%)	10 (17%)
Thoracal kyphosis, n (%)	5 (8%)
Knee deformity, n (%)	9 (16%)
Foot deformity, n (%)	30 (52%)
The leg length discrepancy, n (%)	1 (1.7%)

Table 3. Body fat percentage of paticipants calculated using the Yuhasz formula

	Mean ± standard deviation	Median (minimum-maximum)
Triceps fat ratio (%)	3.43±2.74	4.51 (2.95-5.87)
Biceps fat ratio (%)	2.93±2.88	4.17 (3.39-5.39)
Sacroiliac fat ratio (%)	3.35±2.81	4.32 (3.6-6.45)
Abdomen fat ratio (%)	3.54±2.8	4.46 (3.39-7.04)
Thigh fat ratio (%)	3.17±2.74	4.37 (3.17-5.29)
Calf fat ratio (%)	3.45±2.7	4.61 (2.95-5.58)

Tanner stage exhibited positive correlations with lumbar asymmetry, increased lumbar lordosis, and thigh fat percentage (r=0.457, and p<0.001; r=0.443, and p=0.001; r=0.317 and p=0.016, respectively). Moreover, shoulder asymmetry demonstrated positive correlations with weekly training hours, calf fat percentage, scapular asymmetry, and low-back asymmetry (r=0.305, and p=0.020; r=0.288, and p=0.029; r=0.444, and p<0.001; r=0.639, and p<0.001, respectively). Scapular asymmetry was positively correlated with shoulder and low-back asymmetry (r=0.444 and p<0.001; r=0.445 and p<0.001, respectively).

Furthermore, the presence of low-back asymmetry, sailing time, Tanner stage, shoulder asymmetry, and scapular asymmetry was positively correlated with overall asymmetry (r=0.344, and p=0.008; r=0.457, and p<0.001; r=0.639, and p<0.001; r=0.445, and p<0.001, respectively). Body type exhibited negative correlations with sacroiliac and calf fat percentages (r=-0.268 and p=0.042; r=-0.303 and p=0.021, respectively). Additionally, the percentage of triceps fat and the percentages of biceps, sacroiliac, abdominal, thigh, and calf fat were positively correlated (r=0.854, p<0.001; r=0.935, and p<0.001; r=0.900, and p=0.000; r=0.888, and p<0.001; r=0.886, and p<0.001, respectively). Conversely, biceps fat percentage correlated negatively with increased dorsal kyphosis (r=-0.262, and p=0.047).

DISCUSSION

The present study evaluated trunk asymmetry findings and postural disorders in young Optimist and Laser sailors, a population that has received limited attention in the literature. The observed frequency of ATR positivity and postural asymmetry findings suggests that repetitive asymmetric loading during sailing may be associated with postural adaptations. However, because of the cross-sectional design and lack of a control group, the findings should be interpreted cautiously.

Previous studies evaluating sports participation and IS have primarily focused on gymnastics, dance, and swimming, whereas evidence regarding sailing athletes remains scarce. The current findings contribute to the limited literature by demonstrating associations between sailing duration, training intensity, shoulder asymmetry, lumbar asymmetry, and sagittal posture changes. One-handed sailing may be associated with repetitive asymmetric loading patterns that could contribute to postural asymmetries in predisposed individuals.

The relationship between exercise and sports and IS is controversial in the literature. For instance, Warren et al.[17] conducted a study with 75 professional dancers, and they found that 18 (24%) had AIS delayed onset of menstruation than healthy participants. Also, Hellström et al.[18] showed a 2- to 3-fold rise in the frequency of AIS among athletes compared to non-athletes by examining the thoracolumbar vertebrae radiographically. They concluded that male gymnasts had scoliosis more frequently than football players. On the other hand, according to McMaster et al.[19], dancing, skating, gymnastics/karate, and horseback riding protect from AIS progression. In addition, a large cross-sectional observational study comparing the prevalence of AIS among athletes and non-athletes showed that systematic sports practice was not associated with the development of AIS or affected the grade of the primary scoliotic curve[20].

Due to these contradictory results in the literature, this study we planned is essential in revealing the postural disorders of Optimist and Laser class licensed sailors and the relationship of this sport with scoliosis. Anthropometric measurements of professional athletes have gained importance because the

Table 4. Correlation between skin fold thickness and axial trunk rotation

		Sacrum	Lumbar 3	Thoracic 12	Thoracic 6-8	Cervical 7
Abdominal skin thickness	r	0.138	-0.155	-0.298*	-0.163	-0.016
	p	0.303	0.245	0.023	0.222	0.908
Thigh skin thickness	r	0.033	-0.175	-0.243	-0.173	-0.079
	p	0.805	0.188	0.066	0.193	0.553
Calf skin thickness	r	0.225	-0.025	-0.124	-0.033	0.034
	p	0.090	0.853	0.355	0.807	0.802
Triceps skin thickness	r	0.165	-0.133	-0.187	-0.134	0.052
	p	0.215	0.320	0.160	0.316	0.696
Biceps skin thickness	r	0.230	-0.071	-0.246	-0.120	0.109
	p	0.082	0.594	0.063	0.368	0.416
Suprailiac skin thickness	r	0.176	-0.092	-0.201	-0.148	-0.016
	p	0.186	0.493	0.130	0.268	0.906

*: Correlation is significant at the 0.05 level, **: Correlation is significant at the 0.01 level, Spearman's rho

structural body characteristics of the athletes indirectly affect the success of sports. We found a significant relationship between sailing time, low-back asymmetry and lumbar lordosis. Also, we demonstrated that shoulder asymmetry is correlated with weekly training hours, scapular asymmetry, and low-back asymmetry. It is important to note that shoulder asymmetry positively correlated with calf fat percentage.

SFT measurements are widely used as practical and non-invasive field methods for estimating body composition; however, they do not provide the same level of accuracy as advanced imaging techniques such as magnetic resonance imaging or dual-energy X-ray absorptiometry. It is known that subscapular, abdomen, triceps and thigh regions SFTs' are suitable parameters for assessing the body composition and measurements taken from these regions were found reliable[13,21].

Palomino-Martín et al.[21] conducted a study with 180 sailors from 42 international teams participating and found that the skin on the thigh was the thickest. This was followed by the lower leg and triceps. When skin folds are evaluated individually, only the skin folds on the triceps, thigh and anterior thigh seem to be of greater importance for performance[21]. Additionally, they found that the profile of the top optimistic competitors tended to be meso-ectomorphic, and better athletic performance was associated with a reduction in adipose tissue overall. On the contrary, our results showed that the thickest SFT measurement was in the abdomen, followed by the lower leg and triceps, respectively. This may be a consequence of sailors participating in international championships being the most professional in their countries, and therefore, they have been performing this sport for the longest time. On the other hand, in our study, sailors performing this sport for more than five years constituted only 19% of all participants.

In our study, over half of the sailors exhibited a mesomorphic body type, and the majority had mild shoulder and scapula asymmetry along with foot deformities. Interestingly, our findings contrast with previous studies that reported associations between scoliosis and pelvic asymmetry, leg length discrepancies, and musculoskeletal disorders[22]. Notably, successful Optimist sailors tended to exhibit a meso-ectomorphic body profile, emphasizing the potential performance benefits of reduced adipose tissue[21]. This may be attributed to their extensive experience, as 81% of participants in our study had been engaged in the sport for less than five years.

Another result that we obtained with this study is the prevalence of ATR measurement of ≥5° was 8.6% of sailors, which was assessed by scoliometer, surpassing the prevalence in the normal age-matched population[22]. Additionally, we found correlations between training hours and shoulder asymmetry, lumbar lordosis in those combining swimming with sailing, and lumbar asymmetry in basketball players. Similarly, Becker[8] found a significant prevalence of structural scoliosis (6.9%) in teenagers engaging in competitive swimming programs. The increased frequency of scoliosis was attributed to a coexisting muscular imbalance, which is typically considered a causal factor in scoliosis development. This imbalance was believed to result from repetitive swimming exertion and subsequent potential vertebral adaptation[8].

The observed postural asymmetries may reflect sport-specific adaptations related to repetitive asymmetric loading rather than structural scoliosis itself. Therefore, the findings should not be interpreted as evidence of a causal relationship between sailing participation and IS development.

Study Limitations

This study has several limitations. First, the absence of a control group consisting of non-athlete adolescents limits direct comparison regarding the prevalence of trunk asymmetry findings. Second, the cross-sectional design does not permit causal interpretation of the observed associations. Third, the sample size was relatively small, and no a priori power analysis was performed because the study was designed as an exploratory pilot investigation. Additionally, scoliosis assessment relied on scoliometer-based ATR measurements without radiographic confirmation. Since scoliometer evaluation is a screening method rather than a diagnostic tool, the findings should be interpreted as trunk asymmetry or ATR positivity rather than confirmed scoliosis. Inter- and intra-rater reliability analyses were also not conducted. Furthermore, radiographic spinopelvic parameters such as Cobb angle, sagittal vertical axis, pelvic incidence, and pelvic tilt were not evaluated because the study was designed as a non-radiographic screening investigation in asymptomatic athletes.

CONCLUSION

The present study demonstrated a considerable frequency of trunk asymmetry findings and postural alterations among young Optimist and Laser sailors. Repetitive asymmetric loading during sailing may be associated with postural adaptations in adolescent athletes. However, due to the cross-sectional design, absence of a control group, and lack of radiographic confirmation, no conclusions regarding causality or scoliosis risk can be drawn. Future prospective controlled studies including radiographic assessment are needed to better understand the relationship between sailing and IS.

Ethics

Ethics Committee Approval: The Ethics Committee of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital approved the design and protocol of the study in agreement with the principles of the Declaration of Helsinki and ethical standards for human experimentation (approval no: 2019-11-02, date: 10.06.2019).

Informed Consent: All participants and their parents were informed about the study. Signed informed consent was obtained from parents.

Footnotes

Authorship Contributions

Concept: A.M.T., F.Y.A., A.B., Ç.Ç., Design: A.M.T., F.Y.A., Y.S.Ö., Ç.Ç., Data Collection or Processing: A.M.T., F.Y.A., A.B., Y.S.Ö., Analysis or Interpretation: Y.S.Ö., Ç.Ç., Literature Search: A.M.T., A.B., Y.S.Ö., Writing: A.M.T., F.Y.A., Ç.Ç.

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