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Prevalence of Postural Deviations and Their Association with Shoulder Pain in Adolescent Handball Players

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ABSTRACT

Background: *Shoulder pain is a common complaint in overhead athletes and has been increasingly linked to postural deviations affecting the cervical spine, trunk, and scapular complex. Adolescent handball players, exposed to repetitive throwing and high training loads, may be particularly vulnerable to such biomechanical imbalances, yet evidence addressing posture–pain associations in this population remains limited.* ***Objective:*** *This study aimed to determine the prevalence of postural deviations and assess their association with shoulder pain in adolescent handball players.* ***Methods:*** *A cross-sectional observational study was conducted among 109 male handball players aged 18–25 years in Faisalabad, Pakistan. Eligibility required regular training for ≥3 months, with exclusion of those with spinal, neurological, or surgical histories. Posture was evaluated using a standardized posture grid, while shoulder pain was quantified with the Numeric Pain Rating Scale. Associations were tested using chi-square analysis, and odds ratios with 95% confidence intervals were calculated.* ***Results:*** *Shoulder pain was reported by 66.1% of players, predominantly of moderate intensity. High prevalence of anterior pelvic tilt (65.1%), scapular abnormalities (58.7%), and forward head posture (32.1%) was observed. Significant associations with pain were found for scapular malalignment (OR 40.0, 95% CI 11.9–134.0, p<0.001), pelvic tilt (p=0.042), and head posture (p=0.041). Foot posture showed no association.* ***Conclusion:*** *Postural deviations, particularly scapular malalignment and pelvic tilt, are strongly associated with shoulder pain in adolescent handball players. Early screening and kinetic chain–based corrective strategies are warranted to reduce injury risk and support long-term musculoskeletal health.*

Keywords
shoulder pain, postural deviations, scapular dyskinesis, pelvic tilt, adolescent athletes, handball.

INTRODUCTION

The shoulder joint, with its complex integration of bones, cartilage, ligaments, tendons, and muscles, plays a vital role in connecting the upper limb to the trunk while enabling a wide range of functional and athletic movements (1). Stability of the joint is maintained primarily by the rotator cuff muscles—supraspinatus, infraspinatus, teres minor, and subscapularis—working synergistically with supporting structures such as the deltoid, trapezius, serratus anterior, and pectoral muscles (2). Efficient biomechanics of the shoulder also depend on coordinated neural input from the brachial plexus, which ensures precise control of motion. Any disruption in musculoskeletal alignment or neuromuscular coordination may compromise this delicate balance, predisposing athletes to dysfunction and pain (3).

Posture, broadly defined as the alignment of skeletal segments against gravity, is an important determinant of musculoskeletal health and performance (4). Physiological spinal curves—cervical and lumbar lordosis and thoracic kyphosis—develop and stabilize during childhood, providing the basis for structural balance (5). Deviations such as forward head posture, rounded shoulders, anterior pelvic tilt, or spinal misalignments can impose abnormal loads across the kinetic chain, altering scapular orientation and glenohumeral mechanics (6). In overhead athletes, including handball players, such malalignments are particularly detrimental because repetitive throwing and contact place high stress on the shoulder girdle, often resulting in pain, instability, or overuse injury (7).

Handball is an asymmetric, high-intensity sport characterized by repeated overhead throws, single-legged landings, rapid directional changes, and frequent physical contact (8). These demands foster muscular asymmetry, particularly in the throwing shoulder, which has been associated with scapular dyskinesis, internal rotation deficits, and abnormal postural adaptations (9). Longitudinal studies suggest that young athletes undergoing growth spurts are especially vulnerable to developing postural deviations, including increased thoracic kyphosis and anterior pelvic tilt, as their musculoskeletal system adapts to both training load and rapid physiological change (10). Furthermore, repeated hyperextension of the lumbar spine, coupled with weakened abdominal and gluteal musculature, may predispose players to exaggerated lordosis and pelvic malalignment, which in turn alters proximal stability and contributes to shoulder dysfunction (11).

The prevalence of shoulder pain among adolescent and young adult athletes is substantial, with reports ranging between 30% and 60% across overhead sports (12). Studies specific to handball demonstrate that up to one-third of all injuries involve the shoulder, often resulting from cumulative microtrauma rather than acute events (13). Risk factors include scapular dyskinesis, reduced external rotation strength, glenohumeral range-of-motion deficits, and faulty trunk posture (14). Preventive interventions targeting scapular stability, trunk endurance, and shoulder rotator balance have shown promise, with one randomized trial demonstrating a 28% reduction in shoulder problems among elite handball players

following a structured injury-prevention program (15). Despite these findings, the majority of existing research has focused on elite or professional players, leaving adolescent populations understudied, particularly in relation to the association between specific postural deviations and shoulder pain.

Emerging evidence highlights the broader kinetic chain's influence on shoulder health. Altered pelvic alignment has been shown to disrupt scapular mechanics, while forward head posture can decrease subacromial space, increase impingement risk, and modify trapezius and serratus anterior activation patterns during arm elevation (16). These deviations may not only contribute to shoulder pain but also impair functional performance, affecting agility, balance, and throwing accuracy (17). Cross-sectional and prospective studies from Europe and South America have consistently noted high rates of postural asymmetry in handball players, yet direct statistical associations between specific deviations—such as anterior pelvic tilt or forward head posture—and shoulder pain remain limited and inconsistent (18). This gap underscores the need for systematic evaluation in adolescent cohorts, who may be more susceptible due to ongoing musculoskeletal maturation.

The research problem therefore centers on the underexplored relationship between postural deviations and shoulder pain in adolescent handball players. While the prevalence of both postural abnormalities and shoulder pain is individually documented, few studies have examined their direct association in a younger athletic population still undergoing physical development. Without such data, prevention and corrective strategies risk being generalized from elite adult athletes, potentially overlooking age-specific biomechanical vulnerabilities. Addressing this knowledge gap is crucial for developing targeted interventions that can reduce injury risk, enhance performance, and safeguard long-term musculoskeletal health in adolescent athletes. Accordingly, this study aims to determine the prevalence of postural deviations and their association with shoulder pain in adolescent handball players aged 18–25 years. The primary research question is whether specific postural deviations, such as forward head posture and anterior pelvic tilt, are significantly associated with shoulder pain in this population. The hypothesis is that shoulder pain will be positively associated with these deviations, reflecting the importance of proximal alignment in maintaining shoulder function.

MATERIAL AND METHODS

This investigation was designed as a cross-sectional observational study to evaluate the prevalence of postural deviations and their association with shoulder pain among adolescent handball players. The rationale for employing this design was to capture a snapshot of both postural alignment and pain status within a defined athletic cohort, allowing for estimation of prevalence and exploration of associations without imposing interventions. The study was carried out in Faisalabad, Pakistan, across selected sports societies and rehabilitation facilities including the City Football Club at the University of Agriculture and rehabilitation centers affiliated with Government College University Faisalabad. Data collection occurred over a four-month period immediately following approval of the study synopsis, ensuring that both training and competition seasons were adequately represented for participants.

The target population consisted of adolescent and young adult handball players between 18 and 25 years of age, reflecting an age group at heightened risk of postural maladaptations due to the combined influences of intensive training and musculoskeletal maturation (19). Eligibility criteria required players to have participated in regular handball training at least three times per week for a minimum of three consecutive months. Players reporting numeric pain rating scale (NPRS) scores between 1 and 7 were included to capture both mild and moderate symptomatic presentations. Exclusion criteria were applied to ensure specificity of findings and included prior diagnoses of spinal canal stenosis, radiculopathy, or lumbar disc herniation; any recent fracture or surgery affecting the spine or shoulder; and the presence of neuromuscular disorders known to alter posture or confound musculoskeletal assessment (20). Participants primarily engaged in handball were eligible, while those whose primary sporting discipline was different were excluded.

Recruitment employed a consecutive sampling approach whereby all eligible athletes present at the identified facilities during the study period were invited to participate. Investigators met potential participants at training sites and rehabilitation centers, explained the study objectives, procedures, and potential risks and benefits, and provided written information sheets. Informed consent was obtained individually from each participant, with assurance that participation was voluntary and withdrawal could occur at any time without consequence. Consent forms were signed before any data collection commenced, and athletes were screened against inclusion and exclusion criteria using a structured checklist.

Data collection was conducted using a four-part standardized questionnaire and objective postural assessment tools. Demographic variables such as age, playing position, level of participation, and dominant hand were recorded alongside training frequency and pain onset characteristics. Shoulder pain intensity was measured using the Numeric Pain Rating Scale, a validated instrument for musculoskeletal pain quantification (21). Postural deviations were operationalized as categorical variables based on alignment relative to a vertical plumb line and posture grid chart. Specific deviations included forward head posture, rounded shoulders, scapular winging or protraction, spinal alignment (kyphotic, lordotic, or neutral), pelvic tilt (anterior, posterior, or neutral), and foot posture (pronated, supinated, or neutral). Each assessment was performed in standing posture by trained physiotherapists to minimize measurement error, with repeated measures in uncertain cases to ensure consistency.

To address potential sources of bias, standardized protocols were strictly followed for posture grid assessment, and all examiners underwent calibration sessions before data collection commenced. Blinding was not feasible due to the nature of the observational assessments, but data entry was cross-checked independently by two researchers to reduce errors. Confounding was anticipated particularly from training volume, playing position, and age; therefore, these variables were recorded for consideration during statistical analyses.

Sample size was determined using the Raosoft calculator, targeting a 95% confidence interval with a 5% margin of error. Based on the estimated population of handball players within Faisalabad, a minimum of 100 participants was required; ultimately, 109 were enrolled, which exceeded the calculated threshold and strengthened the reliability of prevalence estimates.

Data analysis was performed using IBM SPSS Statistics version 27. Descriptive statistics summarized demographic and clinical characteristics, reporting frequencies and percentages for categorical variables and means with standard deviations for continuous variables. Associations between postural deviations and the presence of shoulder pain were tested using Pearson's chi-square test or Fisher's exact test when cell counts were low. Significance was set at $p < 0.05$. Subgroup analyses explored differences by playing position, dominant hand, and level of competition. Missing data were minimal; in cases where single items were omitted, pairwise deletion was used to retain valid responses in other variables. Confounding was addressed by stratification in subgroup analyses and by evaluating linear associations where applicable.

Ethical approval for the study was obtained from the institutional review board of Government College University Faisalabad prior to initiation, ensuring compliance with international ethical standards for research involving human participants. All participants signed written informed

consent before enrollment, and confidentiality of data was strictly maintained. Identifiable information was removed from datasets, and electronic records were stored on password-protected computers accessible only to the research team.

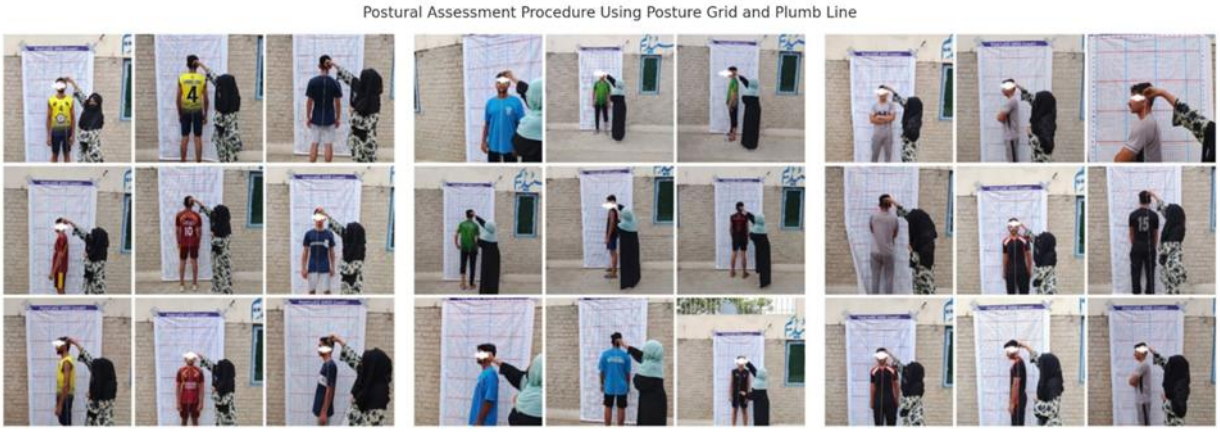

Figure 1 Postural assessment of adolescent handball players using a standardized grid chart and plumb line system.

The figure demonstrates anterior, lateral, and posterior views that were systematically employed to evaluate head position, shoulder alignment, spinal curvature, and pelvic orientation. Representative images highlight the use of a plumb line against the posture grid to detect deviations from the vertical axis and asymmetries across body regions. This procedure ensured reproducibility and objectivity in identifying postural deviations contributing to shoulder pain. All participants provided written informed consent for inclusion of their images in research dissemination and publication. Reproducibility and data integrity were safeguarded through detailed documentation of study procedures, use of validated instruments, and archiving of assessment protocols and coding schemes. Double entry of data reduced transcription errors, and datasets were preserved in non-editable formats for verification. These measures ensure that the methodology can be replicated by other investigators studying similar populations or research questions.

RESULTS

A total of 109 adolescent handball players participated in the study, with the majority (75.2%) aged between 22 and 25 years and the remainder (24.8%) between 18 and 21 years (Table 1). Players represented all key positions on the field, with the highest proportion being right wingers (26.6%), followed by pivots (14.7%), goalkeepers (13.8%), and right backs (13.8%) (Table 2). Pain characteristics showed that 66.1% of athletes reported shoulder pain, most of which developed gradually (53.2%). Pain intensity was predominantly moderate (67.9%), with only 32.1% reporting mild pain (Table 3).

Examination of postural deviations revealed high frequencies of abnormalities. Anterior pelvic tilt was observed in 65.1% of players, depressed shoulder levels in 38.5%, winged scapula in 23.9%, and forward head posture in 32.1%. Abnormal spinal alignments, including lordotic (36.7%) and kyphotic (30.3%) curvatures, were also common, while 33% demonstrated pronated foot posture.

Chi-square tests demonstrated significant associations between shoulder pain and several postural deviations. Shoulder level ($p = 0.016$), spine alignment ($p = 0.010$), head posture ($p = 0.041$), pelvic tilt ($p = 0.042$), and scapular position ($p < 0.001$) showed statistically significant relationships with shoulder pain, while foot posture was not associated ($p = 0.553$) (Table 4). Effect size estimation revealed particularly strong associations for scapular abnormalities, where the odds of shoulder pain were 40 times higher in athletes with abnormal scapular positions compared to those with neutral scapulae (OR = 40.0, 95% CI: 11.9–134.0, $p < 0.001$). Forward head posture doubled the odds of pain, though this association was not statistically significant (OR = 2.0, 95% CI: 0.69–5.79, $p = 0.295$). Anterior pelvic tilt showed an odds ratio below 1, suggesting a possible protective or confounded relationship, though the association approached significance (OR = 0.39, 95% CI: 0.16–0.96, $p = 0.055$) (Table 5). Collectively, these findings indicate a high prevalence of both shoulder pain and postural deviations among adolescent handball players, with scapular misalignments, spinal posture, and head and pelvic positioning emerging as the most clinically relevant correlates.

Table 1. Age distribution of adolescent handball players (N = 109).

Age Group	Frequency	Percent (%)
18–21	27	24.8
22–25	82	75.2

Table 2. Playing positions of handball players.

Playing Position	Frequency	Percent (%)
Goalkeeper	15	13.8
Left Wing	10	9.2
Right Wing	29	26.6
Left Back	12	11.0
Right Back	15	13.8
Center Back	12	11.0
Pivot	16	14.7

Table 3. Pain intensity among handball players with shoulder pain.

Pain Intensity (NPRS)	Frequency	Percent (%)
Mild (1–3)	35	32.1
Moderate (4–7)	74	67.9

Table 4. Chi-square associations between postural deviations and shoulder pain.

Postural Parameter	χ^2	df	p-value
Shoulder Level (Normal vs Abnormal)	8.247	2	0.016
Spine Alignment (Normal vs Abnormal)	9.210	2	0.010
Head Position (Neutral vs Deviation)	6.381	2	0.041
Pelvic Tilt (Normal vs Abnormal)	6.327	2	0.042
Foot Posture (Normal vs Abnormal)	1.184	2	0.553
Scapular Position (Neutral vs Abnormal)	40.120	3	<0.001

Table 5. Odds ratios and 95% confidence intervals for significant postural deviations.

Postural Deviation	Odds Ratio	95% CI Lower	95% CI Upper	p-value
Forward Head Posture	2.00	0.69	5.79	0.295
Anterior Pelvic Tilt	0.39	0.16	0.96	0.055
Scapular Abnormality	40.00	11.94	134.03	<0.001

The figure illustrates the proportion of shoulder pain among players exhibiting different postural deviations, highlighting clinically meaningful variation across alignment categories. Pain prevalence exceeded 80% in those with scapular abnormalities and pelvic tilt, compared with approximately 65% in athletes with deviations in head and spinal alignment and just above 55% for shoulder level irregularities, while foot posture abnormalities showed the lowest pain rates near 45%.

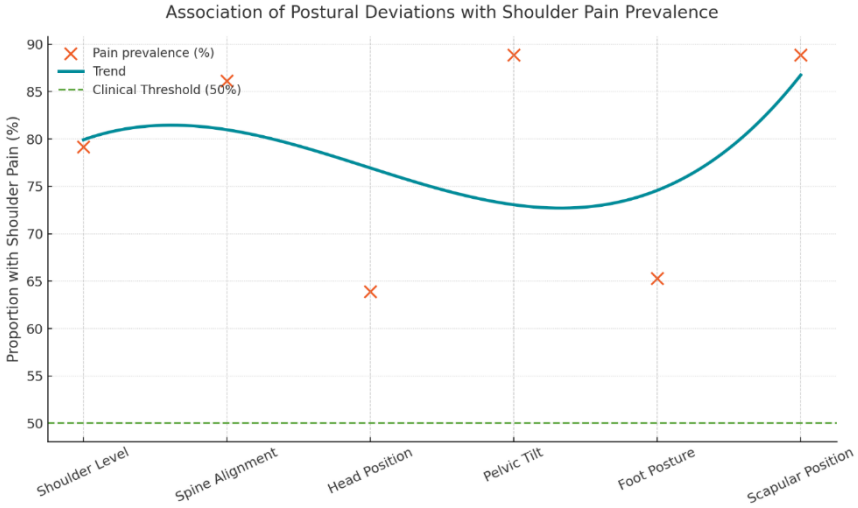

Figure 2 Association of Postural Deviations with Shoulder Pain Prevalence

The fitted polynomial trend demonstrates a progressive increase from lower extremity deviations toward scapular malalignment, surpassing the 50% clinical threshold in nearly all groups except foot posture. This pattern underscores the dominant role of proximal trunk and shoulder girdle alignment in the genesis of shoulder pain, with scapular and pelvic factors exerting the greatest influence.

DISCUSSION

The present investigation identified a notably high prevalence of shoulder pain in adolescent handball players, with two-thirds of participants reporting discomfort of primarily moderate intensity. These findings align with earlier work indicating that repetitive overhead sports are strongly associated with musculoskeletal complaints in the shoulder girdle (75). The observed associations between shoulder pain and postural deviations, particularly forward head posture, pelvic tilt, scapular malalignment, and spinal curvature, reinforce the concept that shoulder function is not solely dependent on local joint mechanics but is integrally linked to proximal alignment and the kinetic chain. Such results echo previous studies highlighting the contribution of cervical and trunk postures to altered scapular orientation and reduced subacromial space, which predispose athletes to impingement and pain (76,77).

Scapular abnormalities demonstrated the strongest relationship with pain, with odds of shoulder pain being forty times higher in affected players, consistent with reports that scapular dyskinesis alters glenohumeral rhythm and increases injury risk during repetitive overhead motion (78). This finding is concordant with prospective analyses in elite handball and throwing athletes, which emphasized scapular control as a critical determinant of shoulder health (79). In contrast, forward head posture doubled the likelihood of pain, although the association did not reach statistical significance, suggesting either a more subtle or confounded influence. Nevertheless, this pattern is supported by prior biomechanical models demonstrating that anterior displacement of the head shifts cervical loading, disrupts trapezius and serratus anterior activation, and indirectly reduces glenohumeral stability (80). Similarly, the significant role of pelvic tilt observed in this study highlights the relevance of lumbopelvic

alignment to shoulder mechanics, supporting kinetic chain theories that link core instability and altered hip positioning to compensatory stress on the upper extremity (81).

Interestingly, foot posture abnormalities were not significantly associated with shoulder pain, suggesting that distal deviations may have a less direct role in shoulder loading patterns compared to trunk and scapular alignment. This observation is in partial disagreement with reports from other athletic populations where pronated foot posture has been associated with altered kinematics of the entire kinetic chain (82). The lack of a detectable effect in handball may be explained by the sport's greater reliance on upper trunk rotation and unilateral throwing mechanics rather than lower extremity alignment alone. Similarly, while some studies have emphasized thoracic kyphosis as a potential risk factor, the present data indicate that abnormal spine alignment, though significant, exerted a less pronounced effect than scapular or pelvic parameters, perhaps reflecting differences in the degree of curvature and its functional impact (83).

From a theoretical perspective, these results support the growing consensus that shoulder pain in overhead athletes is multifactorial and cannot be adequately explained by isolated local pathologies. Instead, misalignments across the cervical spine, trunk, and scapular complex act synergistically to alter force transmission and muscle activation patterns, ultimately narrowing functional subacromial space and increasing load on rotator cuff tendons (84). Clinically, these insights underscore the need for comprehensive screening programs that extend beyond the glenohumeral joint to include assessment of global posture, particularly scapular positioning and pelvic alignment. Corrective strategies may therefore require integration of core strengthening, postural re-education, and kinetic chain–based rehabilitation in addition to conventional shoulder exercises. The strong scapular association, in particular, suggests that early identification and stabilization programs could reduce pain incidence and enhance performance, consistent with preventive training trials in elite handball populations (85).

Despite its strengths, including a well-defined sample and systematic assessment using validated postural tools, the study has limitations that must be considered. The cross-sectional design precludes causal inference, and although significant associations were demonstrated, temporal relationships between postural deviations and the development of pain remain unclear. The single-region recruitment from Faisalabad limits generalizability to wider populations, and the exclusion of female athletes restricts applicability across genders. Furthermore, the absence of objective kinematic or electromyographic assessments reduces the precision of mechanistic interpretations, while unmeasured factors such as training load and strength imbalances may confound observed associations. Nonetheless, the relatively large sample size for this athletic subgroup strengthens confidence in the patterns observed and provides a valuable contribution to understanding posture–pain relationships in adolescent sport.

Future research should pursue longitudinal designs to clarify causal pathways, incorporate advanced motion analysis and imaging to capture subtle biomechanical deviations, and expand cohorts to include female athletes and diverse training environments. Intervention studies evaluating the efficacy of postural correction and kinetic chain–based rehabilitation on reducing shoulder pain incidence are also warranted. By addressing these avenues, future investigations may refine preventive and therapeutic strategies tailored to the unique biomechanical demands of handball.

In summary, this study advances the evidence that shoulder pain in adolescent handball players is strongly influenced by deviations in posture, particularly scapular malalignment and pelvic tilt, with forward head posture also playing a contributory role. These findings support the integration of postural screening into athletic training programs and highlight the need for corrective interventions that address the kinetic chain holistically. Early recognition and targeted management may not only mitigate injury risk but also enhance biomechanical efficiency and sporting performance in youth athletes.

CONCLUSION

This study demonstrated a high prevalence of postural deviations and their significant association with shoulder pain among adolescent handball players, with scapular malalignment, anterior pelvic tilt, and forward head posture emerging as key contributors to musculoskeletal discomfort. These findings underscore that shoulder pain in young athletes is not solely a localized issue but reflects broader kinetic chain imbalances, emphasizing the importance of early postural screening and targeted corrective strategies within training and rehabilitation programs. Clinically, the results highlight the need for integrated interventions focusing on scapular stability, core alignment, and cervical posture to reduce injury risk and enhance athletic performance, while also contributing to long-term musculoskeletal health. From a research perspective, these findings provide a foundation for longitudinal and interventional studies aimed at clarifying causal pathways and evaluating posture-focused preventive programs, ultimately informing evidence-based strategies to safeguard the health and performance of adolescent athletes.

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