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Shoulder Pain, Disability, and Isometric Muscle Strength in Normal-Weight, Overweight, and Obese Saudi Schoolboys: A Cross-Sectional Study with Implications for Physical Therapy and Rehabilitation

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ABSTRACT: **Background**: Childhood obesity has become a major public health concern in Saudi Arabia and is increasingly recognized as a condition with important musculoskeletal consequences, including pain, reduced muscle performance, and functional limitation. However, most available evidence has focused on the spine and lower limbs, and shoulder-specific outcomes in Saudi children remain poorly characterized. Objective: This study aimed to compare shoulder pain intensity, shoulder disability, and bilateral isometric shoulder muscle strength among normal-weight, overweight, and obese Saudi schoolboys, and to determine whether these differences were consistent across school levels.

Methods: A cross-sectional comparative study was conducted among 432 Saudi boys aged 6–18 years recruited from 12 primary, middle, and secondary schools in the Western Region of Saudi Arabia, with 144 participants in each body mass index (BMI) category according to the Saudi BMI-for-age reference. Shoulder pain was assessed using the Numerical Pain Rating Scale (NPRS), shoulder disability using the Arabic Shoulder Disability Questionnaire (SDQ), and isometric strength of six shoulder movements bilaterally using a handheld dynamometer. Data were analysed using a two-way factorial multivariate analysis of variance (MANOVA), follow-up one-way analyses of variance, and Bonferroni-adjusted pairwise comparisons.

Results: BMI category had a significant multivariate effect on the assessed outcomes (Pillai's trace = 0.900, $F(78, 772) = 8.09$, $p < 0.001$, partial $\eta^2 = 0.450$), whereas school level and the BMI × school level interaction were not significant. Mean shoulder pain scores were 1.30 ± 1.26, 1.65 ± 1.30, and 2.72 ± 1.76, and mean SDQ scores were 2.32 ± 3.15, 2.49 ± 1.70, and 5.22 ± 3.32 in the normal-weight, overweight, and obese groups, respectively (both $p < 0.001$). Obese boys differed significantly from both other groups, whereas normal-weight and overweight boys did not differ. Shoulder strength decreased progressively across the three BMI categories for all 12 movements (partial $\eta^2 = 0.195$–0.286), with normal-weight boys producing 3.43–4.34 kgf more force than obese boys (Cohen's $d = 1.13$–1.41).

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Conclusion: Obesity among Saudi schoolboys was associated with greater shoulder pain and disability and with lower absolute isometric shoulder muscle strength. These findings support the inclusion of shoulder assessment within musculoskeletal screening and physiotherapy programs for school-aged children with obesity. Keywords: Paediatric Obesity; Shoulder Pain; Muscle Strength; Hand-Held Dynamometry; Disability Evaluation; Body Mass Index; Saudi Arabia.

Ethical Approval: Scientific Research Ethics Committee, King Faisal Medical Complex, Taif Health Cluster, Saudi Arabia (No. 2025-E-90; Registration No. H-02-T-123); ClinicalTrials.gov NCT07308028. **Informed Consent:** Written informed consent was obtained from parents or legal guardians, and assent was obtained from all participants; **Conflict of Interest:** The authors declare no conflict of interest; **Funding:** No external funding; **Data Availability:** Available from the corresponding author on reasonable request; **Acknowledgments:** The authors thank the participating schools, students, and their families.

INTRODUCTION

Childhood obesity is one of the most serious public health challenges of the twenty-first century and is now recognized as a chronic condition with consequences that extend well beyond metabolic and cardiovascular health. According to the World Health Organization, more than 390 million children and adolescents aged 5–19 years were living with overweight in 2022, including approximately 160 million who were living with obesity (25). Saudi Arabia is among the countries most affected by this trend. Analysis of national school screening data involving more than one million students indicated that approximately 10.4% were overweight, 10.7% were obese, and 4.5% were severely obese, with higher prevalence among boys than girls (4). A recent systematic review of Saudi studies similarly documented a progressive increase in obesity prevalence among children and adolescents over the past two decades (1).

Excess body mass during childhood and adolescence is increasingly understood to affect the developing musculoskeletal system. Increased mechanical loading, altered movement patterns, reduced physical fitness, and changes in muscle composition may collectively influence joint loading, posture, and functional capacity (14). Systematic reviews have demonstrated that overweight and obese children are more likely to report musculoskeletal pain than their normal-weight peers (15,18), and case-control evidence indicates that obese children report higher pain intensity and pain at more anatomical sites (23). Children with obesity have also been reported to demonstrate reduced muscle strength, impaired balance and motor skills, gait deviations, and postural malalignment, which may limit their capacity and willingness to participate in physical activity (14).

Despite this growing evidence base, most research examining the musculoskeletal consequences of paediatric obesity has focused on the lumbar spine and lower extremities, particularly the hip, knee, and foot (15,20). The shoulder complex has received comparatively little attention, although it plays an essential role in daily activities, school-related tasks, play, and sport participation. The shoulder relies on coordinated muscular activity for both mobility and dynamic stability, and alterations in muscle performance or symptom burden may therefore have meaningful functional consequences during childhood and adolescence.

The relationship between obesity and muscle strength in children is also complex. Systematic reviews have reported that children and adolescents with obesity frequently generate similar or greater absolute force in upper-limb tests such as handgrip dynamometry, whereas strength expressed relative to body mass and performance in tasks requiring displacement of the body are generally lower (3,22). However, most of this evidence is derived from handgrip and field-based tests, and isometric strength of the individual shoulder muscle groups, which can be quantified reliably using handheld dynamometry (19), has rarely been compared across BMI categories in paediatric populations.

To the best of our knowledge, no previous study has simultaneously examined shoulder pain, shoulder disability, and shoulder muscle strength across BMI categories among Saudi children. Therefore, this study aimed to compare shoulder pain intensity, shoulder disability, and bilateral isometric shoulder muscle strength among normal-weight, overweight, and obese Saudi schoolboys, and to determine whether these differences were consistent across primary, middle, and secondary school levels. It was hypothesized that obese boys would demonstrate greater shoulder pain and disability and lower shoulder muscle strength than their normal-weight peers.

MATERIALS AND METHODS

This cross-sectional comparative study was conducted between July 2025 and July 2026 in boys' schools located in the Western Region of Saudi Arabia and was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (24). The data presented in this article represent the shoulder-related outcomes of a larger research project that also examined upper-body posture, cervical range of motion, and neck pain, which are reported separately. The study was approved by the Scientific Research Ethics Committee of King Faisal Medical Complex, Taif Health Cluster, Saudi Arabia (Approval No. 2025-E-90; Committee Registration No. H-02-T-123), received institutional approval from Lincoln University College, Malaysia (Ref. No. LUC/RADMIN/SP/05/904), and was registered at ClinicalTrials.gov (NCT07308028). All procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from a parent or legal guardian of each participant, and written or verbal assent was obtained from each child according to age and level of understanding.

The study population comprised Saudi boys aged 6–18 years enrolled in primary (6–11 years), middle (12–15 years), and secondary (16–18 years) schools. Only boys were included in order to minimize the confounding influence of sex-related differences in growth, body composition, and muscle strength during childhood and adolescence. Participants were eligible if they were apparently healthy and able to stand independently. Exclusion criteria included congenital or acquired spinal deformity such as scoliosis, previous spinal or lower-extremity surgery, neurological or vestibular disorders, musculoskeletal injury within the preceding six months, limb-length discrepancy, regular participation in competitive sports, psychological or mental illness, and any other medical condition likely to influence posture or upper-limb function.

A stratified multistage sampling technique was employed. Schools were first stratified by educational level, and schools lacking a suitable private assessment room were excluded from the sampling frame. Twelve eligible boys' schools, comprising four primary, four middle, and four secondary schools, were then randomly selected from the 467 boys' schools in the region. Within each selected school, students were screened against the eligibility criteria, and a balanced allocation strategy was applied to recruit 12 boys from each BMI category per school. This approach yielded 48 participants per BMI category within each school level and a total of 144 participants in each BMI category (N = 432). The minimum sample size was estimated using the single-population proportion formula (17), assuming a 95% confidence level, a 5% margin of error, and an expected proportion of 0.50, which yielded a minimum of 384 participants; the sample was increased to 432 to permit equal allocation across the nine BMI-by-school-level cells and to accommodate potential missing data.

Anthropometric measurements were obtained by a trained research assistant. Body weight was measured to the nearest 0.1 kg using a calibrated digital scale (OHAUS Corporation, Parsippany, NJ, USA), and standing height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, with participants barefoot and wearing light clothing. BMI was calculated as body weight in kilograms divided by the square of height in meters, and participants were classified as normal weight, overweight, or obese according to the Saudi BMI-for-age reference percentiles for children and adolescents (2,8).

Shoulder pain intensity was assessed using the 11-point Numerical Pain Rating Scale (NPRS), ranging from 0 (no pain) to 10 (worst pain imaginable). The examiner explained the scale to each participant before administration, and participants rated the shoulder pain experienced at the time of assessment. The NPRS has demonstrated validity for the assessment of pain intensity in children and adolescents (16). Shoulder-related disability was assessed using the Arabic version of the Shoulder Disability Questionnaire (SDQ), which has demonstrated satisfactory validity and high test–retest reliability (intraclass correlation coefficient [ICC] = 0.97) among Arabic-speaking individuals with shoulder pain (9). The SDQ comprises 22 items addressing shoulder-related limitations during the preceding 24 hours, with total scores ranging from 0 to 22 and higher scores indicating greater disability. The questionnaire was completed in a quiet room during the school break, and for younger participants who had difficulty reading, the examiner read the items aloud and clarified their meaning in simple language without influencing the response.

Isometric shoulder muscle strength was assessed bilaterally for flexion, extension, abduction, adduction, internal rotation, and external rotation using a microFET®2 handheld dynamometer (Hoggan Scientific, LLC, Salt Lake City, UT, USA). Handheld dynamometry has demonstrated sufficient reliability for group-level assessment of shoulder muscle strength (19). All tests were performed in the supine position, and joint positions were standardized using a universal goniometer. Flexion and extension were tested with the shoulder flexed to 90° and the elbow extended, with the dynamometer placed on the anterior or posterior aspect of the arm just proximal to the elbow. Abduction and adduction were tested with the shoulder abducted to 45° and the

elbow extended, with the dynamometer placed on the lateral or medial aspect of the arm just proximal to the elbow. Internal and external rotation were tested with the shoulder abducted to 90° and the elbow flexed to 90°, with the dynamometer placed on the anterior or posterior aspect of the distal forearm. A standardized make-test procedure was used, in which the examiner held the dynamometer stationary while the participant gradually increased force to a maximal voluntary isometric contraction sustained for 3 seconds with standardized verbal encouragement. Following familiarization, three valid trials were performed for each movement with a 60-second rest interval, and the highest peak force was retained for analysis in kilogram-force (kgf). All strength measurements were performed by the same trained examiner.

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation, and there were no missing data. Normality was evaluated using the Shapiro–Wilk test together with histograms and Q–Q plots, and homogeneity of variances and covariance matrices was examined using Levene's and Box's M tests. Although formal tests indicated departures from normality for pain and disability scores, parametric analyses were retained given the large and balanced sample. A two-way factorial MANOVA was used to examine the main effects of BMI category and school level and their interaction on the full set of project outcomes; because Box's M test was significant, Pillai's trace was selected as the multivariate statistic owing to its robustness to this violation (21). Significant multivariate effects were followed by one-way analyses of variance for each shoulder outcome across BMI categories, with partial eta squared (η^2p) reported as the effect size. Pairwise comparisons were adjusted using the Bonferroni method and presented as mean differences with 95% confidence intervals, and Cohen's d was calculated using the pooled standard deviation and interpreted as small (0.2), medium (0.5), or large (0.8) (6). Statistical significance was set at $p < 0.05$.

RESULTS

All 432 participants completed the assessments and were included in the analysis. The mean age of the sample was 13.10 ± 3.54 years, and 375 participants (86.8%) were right-hand dominant. Age and height were comparable across the three BMI categories, whereas body mass and BMI increased progressively from the normal-weight to the obese group, as presented in Table 1.

Table 1. Characteristics of participants according to body mass index category

Variable	Normal weight (n = 144)	Overweight (n = 144)	Obese (n = 144)	Total (N = 432)
Age (years)	13.03 ± 3.56	13.15 ± 3.57	13.10 ± 3.52	13.10 ± 3.54
Body mass (kg)	52.04 ± 11.48	66.75 ± 14.57	78.58 ± 18.03	65.79 ± 18.44
Height (cm)	155.03 ± 16.68	155.40 ± 17.32	153.97 ± 17.57	154.80 ± 17.17
BMI (kg/m²)	21.45 ± 1.94	27.32 ± 1.47	32.69 ± 1.30	27.15 ± 4.86
BMI range (kg/m²)	18.52–24.84	25.07–29.84	30.01–34.94	18.52–34.94
School level, n (primary/middle/secondary)	48/48/48	48/48/48	48/48/48	144/144/144

Values are mean ± standard deviation unless otherwise stated. BMI, body mass index.

The two-way factorial MANOVA demonstrated a significant multivariate effect of BMI category on the combined outcomes (Pillai's trace = 0.900, $F(78, 772) = 8.09$, $p < 0.001$, $\eta^2p = 0.450$). In contrast, the main effect of school level was not significant (Pillai's trace = 0.150, $F(78, 772) = 0.80$, $p = 0.893$, $\eta^2p = 0.075$), and the BMI category × school level interaction was also not significant (Pillai's trace = 0.410, $F(156, 1552) = 1.14$, $p = 0.132$, $\eta^2p = 0.102$). Subsequent analyses were therefore conducted across BMI categories.

Shoulder pain intensity differed significantly across BMI categories ($F(2, 429) = 37.22$, $p < 0.001$, $\eta^2p = 0.148$), with the highest mean score observed in the obese group and the lowest in the normal-weight group (Table 2). Bonferroni-adjusted comparisons showed that obese boys reported significantly greater shoulder pain than both normal-weight boys (mean difference 1.42 points;

d = 0.93) and overweight boys (mean difference 1.07 points; d = 0.69), whereas the difference between normal-weight and overweight boys was not significant (p = 0.123) (Table 3). A similar pattern was observed for shoulder disability ($F(2, 429) = 48.21$, $p < 0.001$, $\eta^2p = 0.184$). Obese boys demonstrated significantly higher SDQ scores than normal-weight boys (mean difference 2.90 points; d = 0.90) and overweight boys (mean difference 2.73 points; d = 1.04), while normal-weight and overweight boys reported nearly identical disability scores (p = 0.999).

Table 2. Shoulder pain, disability, and isometric strength according to body mass index category

Outcome	Normal weight (n = 144)	Overweight (n = 144)	Obese (n = 144)	F(2, 429)	η^2p
Shoulder pain and disability					
Shoulder pain, NPRS (0–10)	1.30 ± 1.26	1.65 ± 1.30	2.72 ± 1.76	37.22	0.148
Shoulder disability, SDQ (0–22)	2.32 ± 3.15	2.49 ± 1.70	5.22 ± 3.32	48.21	0.184
Isometric strength (kgf)					
Flexion, right	13.98 ± 3.09	12.84 ± 2.76	10.11 ± 3.07	64.30	0.231
Flexion, left	14.01 ± 2.97	12.54 ± 2.63	10.12 ± 2.81	70.58	0.248
Extension, right	13.71 ± 2.95	11.92 ± 2.37	9.67 ± 3.29	70.31	0.247
Extension, left	13.89 ± 3.29	12.29 ± 2.30	9.56 ± 2.84	86.01	0.286
Abduction, right	13.70 ± 2.85	12.11 ± 2.46	9.90 ± 2.98	68.02	0.241
Abduction, left	13.78 ± 3.23	12.25 ± 2.20	9.78 ± 2.93	73.62	0.256
Adduction, right	13.82 ± 3.02	12.19 ± 2.41	9.67 ± 2.94	80.07	0.272
Adduction, left	13.76 ± 3.33	12.63 ± 2.37	10.28 ± 2.65	57.38	0.211
Internal rotation, right	14.17 ± 3.13	12.01 ± 2.44	9.86 ± 3.08	79.38	0.270
Internal rotation, left	13.28 ± 3.17	12.17 ± 2.67	9.85 ± 2.87	52.08	0.195
External rotation, right	13.74 ± 2.75	12.51 ± 2.45	10.07 ± 2.97	67.19	0.239
External rotation, left	13.44 ± 3.09	11.98 ± 2.24	9.55 ± 2.84	73.85	0.256

Values are mean ± standard deviation. All $p < 0.001$ (one-way analysis of variance). NPRS, Numerical Pain Rating Scale; SDQ, Arabic Shoulder Disability Questionnaire; kgf, kilogram-force; η^2p, partial eta squared.

Isometric shoulder muscle strength differed significantly across BMI categories for all 12 assessed movements (all $p < 0.001$), with effect sizes ranging from $\eta^2p = 0.195$ for left internal rotation to $\eta^2p = 0.286$ for left extension (Table 2). Across every movement and on both sides, normal-weight boys demonstrated the highest strength values, overweight boys demonstrated intermediate values, and obese boys demonstrated the lowest values, and all pairwise comparisons between BMI categories were statistically significant (Table 3). The differences between normal-weight and obese boys were large, ranging from 3.43 kgf for left internal rotation to 4.34 kgf for left extension, corresponding to approximately 25–31% lower strength in the obese group (d = 1.13–1.41). Differences between overweight and obese boys were also predominantly large (d = 0.78–1.06), whereas differences between normal-weight and overweight boys were small to medium (d = 0.38–0.77).

Table 3. Bonferroni-adjusted pairwise comparisons between body mass index categories

Outcome	Normal vs overweight	Normal vs obese	Overweight vs obese
Shoulder pain and disability			
Shoulder pain, NPRS	−0.35 (−0.77, 0.06) p = 0.123; d = −0.27	−1.42 (−1.84, −1.01) d = −0.93	−1.07 (−1.48, −0.65) d = −0.69
Shoulder disability, SDQ	−0.17 (−0.97, 0.64) p = 0.999; d = −0.07	−2.90 (−3.70, −2.10) d = −0.90	−2.73 (−3.53, −1.93) d = −1.04
Isometric strength (kgf)			
Flexion, right	1.14 (0.30, 1.99) p = 0.004; d = 0.39	3.87 (3.03, 4.72) d = 1.26	2.73 (1.88, 3.58) d = 0.93
Flexion, left	1.47 (0.67, 2.27) d = 0.52	3.89 (3.09, 4.70) d = 1.35	2.42 (1.62, 3.22) d = 0.89
Extension, right	1.79 (0.98, 2.61) d = 0.67	4.04 (3.23, 4.86) d = 1.29	2.25 (1.43, 3.06) d = 0.78
Extension, left	1.60 (0.80, 2.40) d = 0.56	4.34 (3.53, 5.14) d = 1.41	2.74 (1.94, 3.54) d = 1.06
Abduction, right	1.59 (0.81, 2.38) d = 0.60	3.80 (3.01, 4.59) d = 1.30	2.21 (1.42, 2.99) d = 0.81
Abduction, left	1.53 (0.72, 2.33) d = 0.55	4.00 (3.20, 4.80) d = 1.30	2.47 (1.67, 3.28) d = 0.95
Adduction, right	1.64 (0.85, 2.43) d = 0.60	4.15 (3.36, 4.95) d = 1.39	2.51 (1.72, 3.31) d = 0.93
Adduction, left	1.13 (0.33, 1.92) p = 0.002; d = 0.39	3.48 (2.69, 4.28) d = 1.16	2.36 (1.56, 3.15) d = 0.94
Internal rotation, right	2.15 (1.33, 2.97) d = 0.77	4.31 (3.48, 5.13) d = 1.39	2.15 (1.33, 2.98) d = 0.78
Internal rotation, left	1.11 (0.29, 1.94) p = 0.004; d = 0.38	3.43 (2.60, 4.25) d = 1.13	2.32 (1.49, 3.14) d = 0.84
External rotation, right	1.24 (0.46, 2.01) d = 0.47	3.67 (2.90, 4.45) d = 1.28	2.44 (1.66, 3.21) d = 0.89

Outcome	Normal vs overweight	Normal vs obese	Overweight vs obese
External rotation, left	1.45 (0.68, 2.23) d = 0.54	3.89 (3.11, 4.67) d = 1.31	2.44 (1.66, 3.21) d = 0.95

Values are mean difference (first group minus second group) with Bonferroni-adjusted 95% confidence interval; $p < 0.001$ unless otherwise stated. Cohen's d was calculated using the pooled standard deviation. For pain and disability, negative values indicate higher scores in the heavier group; for strength, positive values indicate lower strength in the heavier group.

DISCUSSION

This study compared shoulder pain, shoulder disability, and isometric shoulder muscle strength across BMI categories in a balanced sample of 432 Saudi schoolboys. The principal findings were that obese boys reported significantly greater shoulder pain and disability than both normal-weight and overweight boys, and that absolute shoulder muscle strength declined progressively from normal weight to overweight to obesity across all tested movements. These associations were not modified by school level, suggesting that the relationship between excess body mass and shoulder-related outcomes was evident from primary through secondary education.

The greater shoulder pain observed among obese boys is consistent with systematic reviews demonstrating that excess body weight is associated with musculoskeletal complaints as early as childhood (15,18), and with case-control evidence indicating that obese children report greater pain intensity and pain at more anatomical locations than healthy-weight peers (23). Previous studies have predominantly examined the back, hip, knee, and foot (20,23), and the present findings extend this evidence by suggesting that the shoulder should also be considered when evaluating musculoskeletal symptoms in children with obesity. Nevertheless, mean pain scores were relatively low in all groups, and the difference of approximately 1.4 points between obese and normal-weight boys should be interpreted within this context. Even modest differences in pain may be clinically relevant if they reduce children's willingness to participate in physical activity and sport.

Shoulder disability demonstrated a pattern closely paralleling that of shoulder pain. Obese boys reported more than twice the SDQ score of the other groups, whereas overweight and normal-weight boys did not differ, suggesting that shoulder-related symptoms and functional limitation become clearly apparent at the level of obesity rather than overweight. This interpretation is consistent with the view that paediatric obesity is associated with reduced physical functioning and greater activity limitation (14). The concurrent elevation of pain and disability may reflect a reciprocal relationship in which pain limits physical activity and reduced activity contributes to further deconditioning and weight gain (18). However, the cross-sectional design does not allow the direction of this relationship to be established.

The strength findings require careful interpretation. Systematic reviews have reported that children with obesity often produce similar or greater absolute force in upper-limb tests such as handgrip, with deficits appearing mainly when strength is normalized to body mass or assessed during weight-bearing tasks (3,22). In contrast, the present study found that obese boys produced lower absolute isometric force across all shoulder movements, with large effect sizes. Several explanations may account for this finding. First, the shoulder muscle groups assessed in this study differ from the forearm musculature that predominates in handgrip testing. Second, obesity may be associated with reduced muscle quality; among children and adolescents with overweight or obesity, higher body fat has been associated with greater muscle echo intensity and intramuscular adipose tissue (7), and in adults, obesity has been associated with fatty infiltration of the rotator cuff musculature even in the absence of tendon tears (11). Intramuscular adipose tissue has also been shown experimentally to impair skeletal muscle contraction (5). Third, lower habitual physical activity among obese children may reduce exposure to strength-developing activities (13). Finally, methodological factors should be acknowledged, as handheld dynamometry depends on examiner technique and stabilization (19), and the examiner could not be blinded to participants' body size during strength testing. Because muscle composition, physical activity, and pubertal status were not measured, these explanations should be regarded as hypotheses rather than established mechanisms.

School level did not significantly modify the associations between BMI category and shoulder outcomes, indicating that the BMI-related pattern was already present in primary school and persisted into adolescence. Notably, mean shoulder strength was similar across school levels (approximately 11.5–12.5 kgf) despite a substantial increase in mean height from 134 cm to 172 cm. This finding was unexpected, because upper-limb isometric strength normally increases with age during childhood and

adolescence (12). One possible explanation is a ceiling effect inherent to examiner-held make testing, in which the maximal force of older and stronger participants may be limited by the examiner's ability to stabilize the dynamometer. The absence of an age-related strength gradient should therefore be interpreted with caution and examined in future studies using fixed or belt-stabilized dynamometry.

From a clinical perspective, current guidelines recommend that children and adolescents with obesity be evaluated for musculoskeletal and functional consequences, including pain, strength, and motor function (10). The present findings support incorporating brief shoulder screening, including pain rating, a short disability questionnaire, and dynamometric strength assessment, into the evaluation of schoolchildren with obesity. Physiotherapy programs for this population may benefit from including shoulder and upper-limb strengthening alongside weight management and general physical activity promotion, although the effectiveness of such programs in reducing shoulder pain and disability requires confirmation in interventional studies.

Several limitations of this study should be acknowledged. The cross-sectional design precludes causal inference. The equal group sizes resulted from balanced allocation within schools; therefore, the sample does not reflect the population distribution of BMI categories, and the findings may not be generalizable to girls or to other regions of Saudi Arabia. BMI does not distinguish fat mass from lean mass, and strength was expressed only in absolute terms without normalization to body mass or lean mass. Physical activity, sedentary behaviour, backpack use, and pubertal status were not assessed and may have acted as confounders. The examiner was not blinded to body size during strength testing, which may have introduced measurement bias. In addition, pain and disability were self-reported, and the Arabic SDQ has been validated in individuals with shoulder pain rather than in healthy children. Future longitudinal and interventional studies incorporating body composition, maturation, physical activity, and normalized strength measures are needed to clarify the mechanisms underlying these associations.

CONCLUSION

This study demonstrated that obesity among Saudi schoolboys aged 6–18 years was associated with greater shoulder pain and shoulder disability, and that higher BMI category was associated with progressively lower absolute isometric strength across all shoulder movements, with these associations remaining consistent across school levels. These findings suggest that shoulder-related impairments should be considered part of the musculoskeletal profile of pediatric obesity and support the integration of shoulder pain, disability, and strength assessment into school-based screening and physiotherapy management of children with obesity. Future longitudinal and interventional research is needed to determine whether reducing excess body weight and improving shoulder muscle strength can reduce shoulder pain and disability in this population.

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