IJSPT
INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

Salamh PA, Hanney WJ, Boles T, et al. Is it Time to Normalize Scapular Dyskinesis? The Incidence of Scapular Dyskinesis in Those With and Without Symptoms: a Systematic Review of the Literature. *IJSPT*. 2023;V18(3):558-576. doi:10.26603/001c.74388

Original Research

Is it Time to Normalize Scapular Dyskinesis? The Incidence of Scapular Dyskinesis in Those With and Without Symptoms: a Systematic Review of the Literature

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Keywords: shoulder pain, scapular dyskinesis, overhead sports, scapular translation, symptomatic, asymptomatic

https://doi.org/10.26603/001c.74388

International Journal of Sports Physical Therapy

Vol. V18, Issue 3, 2023

Background

Up to 67% of adults experience shoulder pain in their lifetime. Numerous factors are related to the etiology of shoulder pain, one of which is thought to be scapular dyskinesis (SD). Given the prevalence of SD among the asymptomatic population a concern is that the condition is being medicalized (clinical findings suggested to require treatment but is ultimately a normal finding). Therefore, the purpose of this systematic review was to investigate the prevalence of SD among both symptomatic and asymptomatic populations.

Methods

A systematic review of the literature up to July of 2021. Relevant studies identified from PubMed, EMBASE, Cochrane and CINAHL were screened utilizing the following inclusion and exclusion criteria; inclusion: (a) individuals being assessed as having SD, including reliability and validity studies (b) subjects aged 18 or older; (c) sport and non-sport participants; (d) no date restriction; (e) symptomatic, asymptomatic, or both populations; (f) all study designs except case reports. Studies were excluded if: (a) they were not published in the English language; (b) they were a case report design; (c) the presence of SD was part of the studies inclusion criteria; (d) data were not present distinguishing the number of subjects with or without SD; (e) they did not define participants as having or not having SD. Methodological quality of the studies was assessed utilizing the Joanna Briggs Institute checklist.

Results

The search resulted in 11,619 after duplicates were removed with 34 studies ultimately retained for analysis after three were removed due to low quality. A total of 2,365 individuals were studied. Within the studies for the symptomatic athletic and general orthopedic population there were 81% and 57% individuals with SD, respectively, and a total of 60% among both symptomatic groups (sport and general orthopedic population). Within the studies for the asymptomatic athletic and general population there were 42% and 59% individuals with SD, respectively, and a total of 48% among both asymptomatic groups (sport and general orthopedic population).

Limitation

A strict inclusion and exclusion criteria was used to identify studies that provided the appropriate data for the purpose of this study. There was a lack of consistency for measuring SD across studies.

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Conclusion

A considerable number of individuals with shoulder symptoms do not present with SD. More revealing is the number of asymptomatic individuals who do present with SD, suggesting that SD may be a normal finding among nearly half of the asymptomatic population.

Level of Evidence

2a

INTRODUCTION

Within the adult population, 67% of individuals will experience shoulder pain at some point throughout their lifetime.[1] There are numerous factors related to the etiology of shoulder pain and it has been hypothesized that the presence of scapular dyskinesis (SD) is a contributing factor to shoulder pathology.[2,3] Scapular dyskinesis has been defined as alterations in scapular positioning at rest as well as during dynamic movement. Common variations in scapular movement[4,5] include increased scapular superior translation along with reduced scapular posterior tilt, upward rotation, and internal rotation.[6] Give the theorized relationship between SD and certain shoulder pathologies there have been several methods proposed to evaluate these alterations in scapular positions and movements.

McClure et al.[7] developed a commonly used method of identifying SD, the scapular dyskinesis test (SDT), to identify the presence of SD and classify individuals into three levels: normal motion, subtle dyskinesis, and obvious dyskinesis. This is one of several methods commonly used during an evaluation related to shoulder pathology presented in Supplement A Though the SDT has been proven to be a reliable and valid method of identifying SD[6,7] not all clinicians are trained to use this tool and current literature describes a wide variation of assessment methodology.[6] Along with this lack of homogeneity in assessment of SD, there is a lack of evidence to support the idea that identification and correction of SD may help to prevent or treat shoulder pathology. Even with this lack of evidence, identifying SD is a common screening tool for both symptomatic and asymptomatic individuals. The evaluation is especially common in predicting or preventing injury in overhead athletes, however there is conflicting evidence regarding the link between SD and injury in this population exists.[8,9] Clinicians often direct their treatment toward correcting the SD which could be normal movement variability.[10,11]

Because the identification of SD is a common part of a patient evaluation, it is often used to guide clinical decision making; however, there is considerable debate around linking the presence of SD to certain shoulder pathologies. Some studies have shown no difference in the prevalence of SD between symptomatic and asymptomatic populations.[12] This raises the question of utility when screening for SD in patients seeking treatment for shoulder pain as well as for the asymptomatic population.

The purpose of this systematic review of the current literature to investigate the prevalence of SD among both symptomatic and asymptomatic populations. Understanding the relationship between SD and the presence or absence of symptoms may help to direct conversations regarding the clinical utility of SD. The authors hypothesized that SD is a common finding that has been medicalized (clinical findings suggested to require treatment but is ultimately a normal finding).

MATERIALS AND METHODS

GUIDELINES

This systematic review utilized the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) guidelines during the search and reporting phase of the research process. The PRISMA statement includes a 27-item checklist designed to improve reporting of systematic reviews and meta-analyses.[13]

LITERATURE SEARCH

An online literature search was conducted utilizing PubMed, EMBASE, Cochrane and CINAHL from the dates of their origin until July 2021. The search strategy was created and performed by a biomedical librarian. An example of the search strategy used for the PubMed database is provided (Supplement B) and similar strategies were utilized for the remaining databases. The study was registered using the International Prospective Register of Systematic Reviews (PROSPERO) in May of 2020 with a corresponding reference number: CDR42020187045.

STUDY SELECTION

All titles were independently appraised by two authors (TB) and (AW) after the initial online literature search for studies to be retained. The abstracts of these titles were read to determine if the studies met the inclusion criteria. Studies with abstracts that met the inclusion criteria were accessed in their full-text format and then read to determine their eligibility for the review. The same two authors performed the study selection process for this review with a third author (PS) available to handle disagreements. The inclusion criteria for studies to be retained in the present review consisted of: (a) individuals being assessed as having SD, including reliability and validity studies (b) subjects aged 18 or older; (c) sport and non-sport participants; (d) no date restriction; I symptomatic, asymptomatic, or both populations; (f) all study designs except case reports. Studies were excluded if: (a) they were not published in the English language; (b) they were a case report design; (c) the presence of SD was part of the studies inclusion criteria; (d) data were not present distinguishing the number of sub-

jects with or without SD; I they did not define participants as having or not having SD.

DATA EXTRACTION

The data and results from the studies that were retained as part of the review were extracted using a format to identify study type, population, methods for evaluating SD, and the prevalence of SD. Data were extracted, reviewed, and analyzed by the primary author (PS) and verified by a research assistant (ZS). Discrepancies in data collection were resolved through discussion.

METHODOLOGICAL QUALITY ASSESSMENT TOOL

The Joanna Briggs Institute (JBI) checklist for prevalence studies was used to evaluate methodological quality within the individual studies.[14] There are nine items related to methodological quality included in the checklist which can be answered as yes, no, unclear, or not applicable. Following the scoring of each item, those individuals scoring the study are asked to provide an overall appraisal to include, exclude, or seek further information regarding if the article should be retained. The decision to include or exclude each article is then made by the reviewer(s) based on the completed checklist and consensus. Two authors, (DH) and (AM), performed the methodological quality assessment independently with discrepancies handled by the primary author if necessary. Prior to methodological quality assessment those involved in worked through scoring several unrelated prevalence studies in order to align definitions and interpretations of the various elements present in the JBI tool.

DATA SYNTHESIS AND ANALYSIS

Data were extracted and pooled to include the incidence of scapular dyskinesis, as defined by the authors, among those individuals that were symptomatic and those that were asymptomatic. The results were reported on percentage of incidence differentiating between classification of individuals with SD and shoulders with SD among each identified population. Data on relevant subcategories were identified and individually accounted for with separate analyses. Data from the identified studies did not allow for a quantitative analysis given the heterogeneity of several variables.

RESULTS

SEARCH RESULTS

The initial search resulted in 11,619 after duplicates were removed. Following title and abstract screening 11,505 were removed. Full text articles were retrieved for the remaining 114 studies of which 77 were removed due to not meeting the inclusion criteria. The remaining 37 studies were retained for quality assessment Figure 1.

Following quality assessment 34 articles were ultimately retained for analysis. Study characteristics for each of the 34 studies consisting that examined 2,365 individuals can be seen in Table 1. Retained studies were categorized into either symptomatic or asymptomatic within either an athletic population or a general orthopedic population.

The general orthopedic population among the retained studies included study participants where the upper extremity was of interest, primarily the shoulder. However, there were a small number of individuals that had neck pain where SD was also evaluated, which is more clearly identified in the results section.

METHODOLOGICAL QUALITY

Of the 37 articles assessed three[15–17] were excluded and 34[12,18–50] were included for synthesis (Table 2).

The excluded articles all had a score ⩽ 3 on the JBI tool. The reasoning for exclusion of articles was to remove poor quality studies due to low quality or high risk of bias. Otherwise, there would be little value in scoring quality if high- and low-quality studies are all given the same "voice". Additionally, the JBI tool is specifically designed to give the raters the choice of including or excluding the scored study based on their interpretation of the scoring. Of the included studies, 18[12,21–27,32,37–41,44,45,49,50] addressed the target population appropriately with the sample frame and had adequate sample sizes. However, only 13 studies[12,19,23,24,26,28,31,32,41,42,47,49,50] reported both the study subjects and setting in detail. Additionally, 11 studies[19,20,22–24,26,27,38,45,47,50] measured the condition in a standard reliable way, 15 studies[12,19,22,23,26,30,32,34–36,40–42,48,50] used valid methods to identify the condition, and 8 studies[21,22,32,37,39,41,48,50] included information on response rate as most studies were one-time measures. The JBI tool, like other quality and risk of bias assessment tools, does not advocate for a summative score as the constructs being scored are not similar. Therefore, in order to be as transparent as possible, we listed each item in the table along with their score, as well as provided a summary of those studies and which were the most common items not reported as you mention above.

PREVALENCE RESULTS

The number of studies with available data for the asymptomatic and symptomatic populations and relevant subgroups are reported. Table 3 reflects studies with available subgroup data for asymptomatic and symptomatic populations. Data for asymptomatic individuals are reported in Table 4. Finally, symptomatic athletic population results are reported in Table 5 while the asymptomatic general population results ae reported in Table 6.

Although the inclusion criteria were intentionally broad in respect to diagnoses for the symptomatic population, all but three studies[20,35,40] consisted of individuals with some form of shoulder pain including diagnoses such impingement, instability, rotator cuff tear, labral tear, and upper extremity pain, all of which are listed in Table 1. Two of the three studies[35,40] consisted of mixed upper extremity diagnoses but the SD data was not parsed out by diagnosis. The authors were able to examine them based on the inclusion criteria. This was an attempt to be transparent

Table 1. Characteristics for each of the retained studies

Authors	Setting Type	Population Type	Total Population/ Shoulders (n/ n)	With Scapular Dyskinesis (n)	Symptomatic (Y or N)	Methods
Akodu et al 2018	General population (from Department of Physiotherapy, U of Lagos)	77 undergraduates without history of shoulder or neck pathology	77/77 (reported as individuals with SD)	54 (a 1.5 cm asymmetry between R/L scapulae was considered the threshold for SD)	No	SICK scapula, Static Measurements 0 to 20 Point Rating Scale
Alves de Oliveira et al 2013	Amateur Athletes	30M amateur athletes (15 with SIS and 15 without); SIS mean age 22; control mean age 20.27	30/30 (dominant shoulders only)	SIS (14 (93.3%) present, 1 (6.7%) absent) Control (6 (40%) present, 9 (60%) absent)	15 symptomatic 15 asymptomatic	LSST
Balci et al 2016	Outpatient clinic at a university	53 subjects (40F/13M); diagnosed as unilateral AC (stage II) and SPN for at least 3 months	53/53 (shoulder in pain)	22	Yes	LSST
Bullock et al 2021	Wake Forest pitching lab	33 asymptomatic M high school baseball pitchers; mean age 16.3	33/33	15	No	McClure method (5 reps, etc.)
Camci et al 2013	General population	64 asymptomatic individuals	64/64 (reported as individuals with SD)	40 yes (24 no)	No	Yes/no method
Castelein et al 2016	General F population	19F with idiopathic neck pain; mean age 28.3 19F without (serving as control); mean age 29.3	38/38 (dominant shoulders only)	Neck pain group (9 yes, 10 no) Control group (8 yes, 11 no)	19 symptomatic 19 asymptomatic	Yes/no method described by Uhl et al. (visual observation)
Chen et al 2018	General orthopedic with SPN	186 (115F and 71M) individuals with shoulder conditions; mean age 45.74 SIS: 59, partial cuff tear: 6, FS: 23, bicep tendonitis: 15, GH OA: 13, cuff tendonitis: 10, SLAP tear: 10	186/186 (reported as individual, not shoulder)	Yes: 140 (type I, II, III) No: 46 (type IV)	Yes (all)	Kibler method
Christiansen et al 2017	Rehabilitation units, physical therapy clinics, and hospital setting	40 patients (27M and 13F) with SIS	40/40 (reported as individual with SD)	18	Yes (SIS)	McClure method (5 reps, etc.)
Da Silva et	Elite tennis	73 individuals (53 elite tennis players (31M	73/73	Tennis:	No	Kibler method (static, dynamic and

al 2008	players and controls (compare SD and subacromial space in tennis players)	and 22F) and 20 controls (9M and 11F)); tennis players mean age 14.8; control mean age 14.6	(reported individuals but then also broke it down into bilateral and dominant %)	23/53 had SD (19 bilateral, 3 dominant, and 1 non dominant) Control: 4/20 had SD (2 dominant and 2 non dominant)		ascending, descending)
Deng et al, 2017	Rehabilitation outpatient departments	102 patients (49M and 53F) with shoulder conditions (SIS: 28, cuff tear: 27, SLAP: 16, OA:15, FS: 8, bicipital tendonitis: 8)	102/102 (reported as individuals with SD)	Rest (type I-III): 83 Anterflexion (type I-III): 37 Scaption (type I-III): 39 Abduction (type I-III): 36	Yes	Kibler method
Frizziero et al 2018	Bowed string instrument students at conservatory	32 individuals (27F and 5M)	32/32 (reported as individuals with SD)	15	No	Flexion and abduction with 1 or 2 kg weight and videotaped. Scapular movement was classified as: normal (both tests were evaluated as normal, or one movement is evaluated as normal and the other as slightly abnormal); slightly abnormal (both movements are evaluated as slight or uncertain abnormality); abnormal (one of the two movements is evaluated as severe abnormality)
Hannah et al 2017	Strength profiles in healthy individuals with and without SD	40 healthy college aged participants (12M and 28F) *initial before age matched brought in to even SD numbers; mean age 22.2	40/40 (individuals with SD)	27 of 40	No	Yes/no method
Huang et al 2015	Outpatient clinic at a university hospital	60 patients (4 M and 15F) with unilateral shoulder condition	50/60 for raising phase 41/60 for lower phase (reported as individuals with SD and agreement levels)	Raising phase 6 of 50 had SD Lowering phase 29 of 41 had SD	Yes	Kibler and McClure combined method
Johansson	Pain in flatwater	31 kayakers (20M and 11F) (17 with SPN and	31/31	Pain: 15/17 had	Yes and No	Kibler and Sciasca method

et al 2016	kayakers and relationship to ROM and SD	14 without SPN); F mean age 16.6; M mean age 18.2	(reported as individuals with SD)	SD No Pain: 4/14 had SD Total: 19/31 had SD		
Kawasaki et al 2012	Does SD effect Rugby players during a season	103M rugby players; mean age 24.6	103/103 used for primary analysis	Type I: 6 Type II: 4 Type III: 23 Total Yes: 33 Type IV (No): 70	No	Kibler method Type I-IV
Lee et al 2017	Findings in asymptomatic elite volleyball players	26 elite indoor volleyball players	26/26 (dominant asymptomatic shoulders utilized)	7	No	Visual examination
Madsen et al 2011	Training and SD in competitive swimmers	78 competitive swimmers (44F and 34M); mean age 17	78/78 (athletes with SD)	After first time trial: 29 After half of training session: 53 Last three quarters of the training session: 57 Last quarter of the training session: 64	No	Yes/No system by McClure
Maor et al 2017	SD among competitive swimmers	20 competitive swimmers (6F and 14M); mean age 15.35	20/20 (athletes with SD)	Baseline: 6 1 hour of practice: 14 1.5 hours of practice: 17	No	Yes/No system by McClure
Moghadam et al 2018	General orthopedic	100F (47 hypermobile and 53 non-hypermobile)	100/200	Total (shoulders) *Dominant* Flexion: 60 Scaption: 62 Abduction: 61 *Nondominant* Flexion: 68 Scaption: 71 Abduction: 65	No (47 with GHJ generalized joint hypermobility but no symptoms)	Visual SD test
Nodehi et al 2020	Acromiohumeral distance and SD	44F (21 with RSP and 23 controls); mean age of control 22.43; mean age of RSP 22.95	44/88 (looked at dominant	Total (shoulders) Flexion: 17	No	Uhl yes/no method

	comparison		vs non-dominant)	Abduction: 29 RSP: (flexion dominant: 4, non-dominant: 5; abduction dominant: 22, non-dominant: 4) Control: (flexion dominant: 3, non-dominant: 5; abduction dominant: 1, non-dominant: 2)		
Park et al, 2013	Athletic population assessment of SD	89 athletes (178 shoulders) (75 baseball players, 7 other overhead sports, 2 golf, and 5 occasional sport) SLAP: 15, SIS:12, SLAP + SIS: 6, MCL: 22, SLAP + MCL: 2, VEO: 9, cuff tear: 5, glenoid OCD: 4, capitellum OCD: 4, multidirectional instability: 5, posterior labral tear: 5	89/178	Type I: 73 Type II: 39 Type III: 10 122: Total shoulders with SD out of 178 shoulders	Yes	Type I-IV via visual observation
Park et al, 2014	Athletic population evaluation of SD	165 patients, 127 were baseball players, 5 were athletes of other over-head sports, 5 played golf, 2 played table tennis, 1 was a diver, 1 participated in bowling, 1 was an archer, and 26 enjoyed occasional sports activities. Elbow: MCL tear: 54, VEO: 40, OCD: 3, medial epicondylitis: 2, common flexor muscle strain: 3 Shoulder: SLAP: 49, multidirectional instability: 6, SLAP: 31, Bennett lesion: 3, internal impingement: 8, long head of biceps tendon tendonitis: 20, cuff tear: 3, impingement: 44, functional impingement: 8, sub coracoid impingement: 8, GIRD: 53, subscapularis tear: 1	165/330	Type I: 130 Type II: 98 Type III: 52 280: Total shoulders with SD out of 330	Yes	Kibler's 4 type method
Plummer et al 2017	Observational SD	135 individuals (67 with shoulder pain (33 F and 34 M) and 68 healthy controls (41 F and 27 M); pain mean age 32.5; control mean age 27.4	135/135 (individuals with SD)	Flexion (87/135) Symptomatic:45 Asymptomatic:42 Abduction (81/135) Symptomatic: 45 Asymptomatic:36	67 symptomatic 68 asymptomatic	McClure Method
Rabin et al	Shoulder	74 consecutive patients referred to an	74/74	33	Yes	Visual observation, Kibler method

2018	outpatient clinic	outpatient shoulder surgery unit (6F/68M)	(reported as individual)			
Sahinoglu et al 2020	Posterior shoulder tightness on SD	121 college aged M (non-overhead athletes); mean age 21	121/242 (dominant and non-dominant shoulder)	Total-115 (dominant-56) (non-dominant-59)	No	McClure yes/no method
Sant et al 2018	SD in asymptomatic water polo players	25M semi-professional water polo players; study group mean age 23.3; control mean age 23.1	25/25 (individuals with SD)	23	No	Kibler method Type I-IV
Seitz et al 2015	Overhead athletes, comparing change in scapular kinematics between unweighted & maximal weighted contractions	25 asymptomatic overhead athletes (swimming-5, volleyball-15, water polo-5); SD mean age 20.3; w/o SD mean age 20.5	25/25, dominant shoulder	14	No	SD test, visual observation
Shah et al 2016	Musicians (guitar): presence of SD	40 participants (20 guitar professional guitar players and 20 age matched non guitar players)	40/40 (dominant shoulders only)	Asymmetrical (5 guitar players) (0 non guitar players) Dyskinetic (4 guitar players) (0 non guitar players)	No	LSST at 0, 45, and 90 with and without weights
Silva et al 2018	Musicians: presence of SD	72 musicians (24M & 48F). Selected 36 symptomatic (cervical, shoulder or upper extremity pain in the last year with constant symptoms lasting more than 1 week) & 36 control; symptomatic mean age 23.28; control mean age 25.03	72/72	Total - 35 (26 from symptomatic group, 9 from control group)	36	McClure and Tate method (Visually assessed participants by having them do five repetitions of bilateral, active, weighted shoulder flexion in the sagittal plane and bilateral, active, weighted shoulder abduction in the frontal plane)
Struyf et al 2014	Amateur sports, evaluating risk factors for developing SPN	113 recreational overhead athletes (59F & 54M), all aged>18 (tennis: 26, volleyball: 27, baseball: 5, badminton: 35, handball: 10); pain mean age 36.6; pain free mean age 33.2	113/113	62/113 demonstrated SD in dominant shoulder (33 winging & 29 forward tilting)	Baseline no pain 25/113 developed pain within 2 years	Diagnosed by visual observation in 3 positions: static with both arms relaxed (thumbs facing forward), hands placed on ipsilateral hips (thumbs facing backward) and arms in 90° of humeral abduction in the frontal plane (thumbs facing up)

Tsuruike et al 2018	Sport study (collegiate baseball)	30M collegiate baseball players (13 pitchers)	30/30	14 (Mild SD in 7 pitchers + 7 position players)	No	Kibler method
Welbeck et al 2019	Link between thoracic rotation, SD, and pain among swimmers	34 division I swimmers (13M and 21F); mean age 19.6;	34/34 (as individuals, not shoulders)	Total: 15 (6 male and 9 female)	No	McClure yes/no method
Yesilyaprak et al	University research laboratory	148 participants (58F/90M); no sporting activity or work with overhead movements	148/296	87 (reported as individual shoulder: 87/ 296)	No	SDT
Yüksel et al 2014	Reliability of SDT & LSST	83 healthy participants (32F & 51M), mean age 21.74, have active full shoulder motion	83/83	SDT detected 44 (53%), LSST detected 30 (36%). Both detected 20 (24%)	No	SDT & LSST

Abbreviations: AC; acromioclavicular, FS; frozen shoulder, GHJ; glenohumeral joint, GH OA; glenohumeral joint osteoarthritis, GIRD; glenohumeral internal rotation deficit, LSST; lateral scapular slide test, MCL; medial collateral ligament, OCD; osteochondritis dissecans, ROM; range of motion, ROTC; reserve officer training corps, RSP; rounded shoulder posture, SD; scapular dyskinesis, SDT; scapular dyskinesis test, SICK scapula; scapular malposition + inferior medial border prominence + coracoid pain and malposition + dyskinesis of scapular movement, SIS; shoulder impingement syndrome, SLAP; superior labrum anterior to posterior, VEO; valgus extension overload, M; Male, F; female, SPN; shoulder pain.

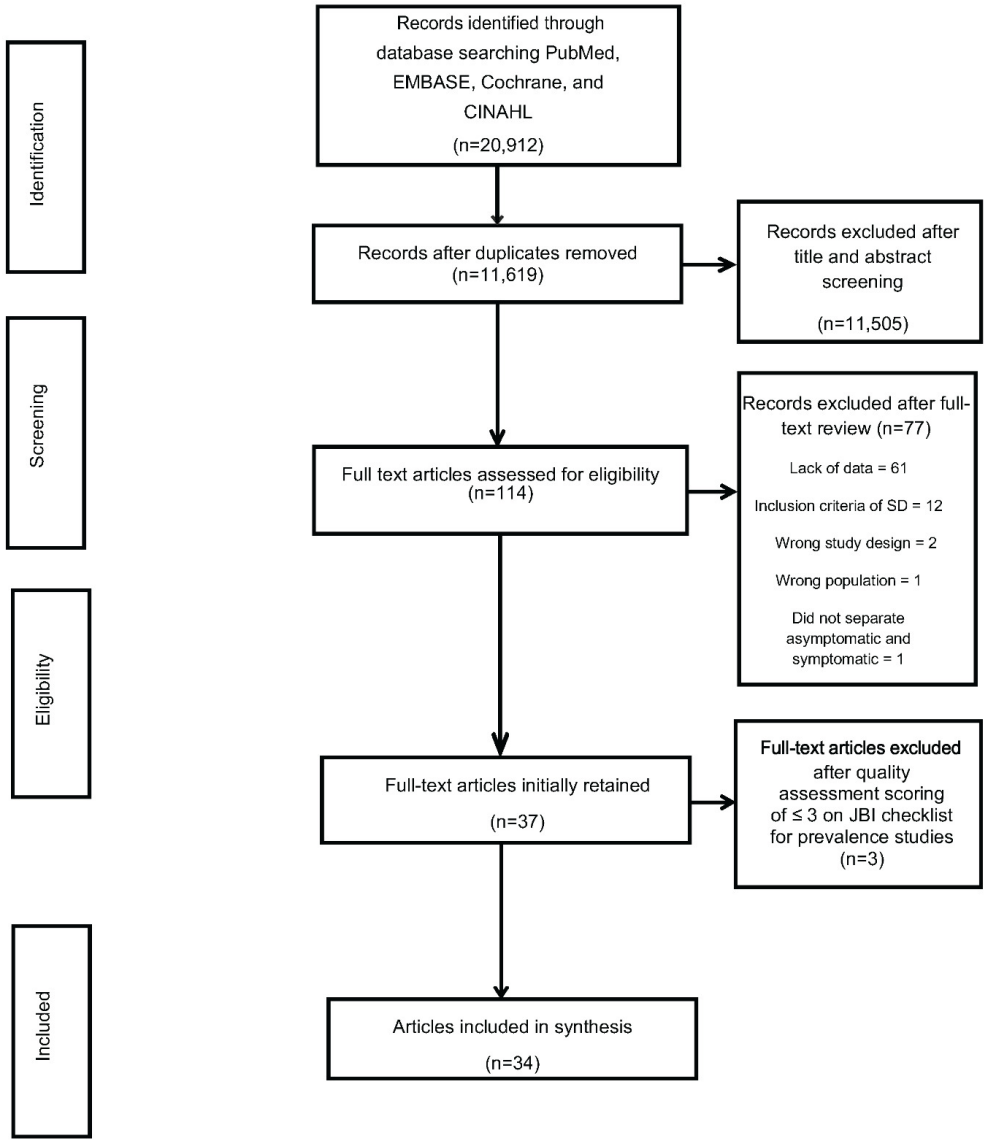

Figure 1. PRISMA flow diagram outlining study selection process

in instances were other diagnosis outside of shoulder conditions may have been considered as we were examining those studies that identify SD but could have been in a population of individuals with cervical or upper extremity conditions. The remaining study[20] included individuals with neck pain only with a total number of 19 subjects. Within the studies for the symptomatic athletic and general orthopedic population there were 81% and 57% individuals with SD, respectively, and a total of 60% among both groups. The two studies within symptomatic athletic population that looked at both shoulders individually demonstrated a total of 79% of individuals with SD considering at least one shoulder. Within the studies for the asymptomatic athletic and general population there were 42% and 59% individuals with SD, respectively, and a total of 48% among both. The four studies within asymptomatic general population that looked at both shoulders individually there was a total of 42% of individuals with SD.

DISCUSSION

The purpose of this systematic review was to examine the available literature in order to report the prevalence of SD among both the symptomatic and asymptomatic population. The results of this systematic review indicate that there is an overall presence of SD of 60% among symptomatic individuals. Among the asymptomatic population there is an overall presence of SD of 48% among those studies that identify individuals with SD. The low number of studies that identified individuals with SD per shoulder makes it difficult to determine true differences between those with and without symptoms. Despite the overall prevalence of SD being higher among those with symptoms compared to those without, there is still a considerable number of those that present with SD (nearly half of those studied) that are asymptomatic which questions the relevance of this finding. Furthermore, the total number of symptomatic individuals, 650, within studies investigating SD was just over half the number of those studies inves-

Table 2. Joanna Briggs Institute critical appraisal checklist for studies reporting prevalence data

Authors	1	2	3	4	5	6	7	8	9	Overall
Akodu et al 2018	1	1	1	0	1	0	0	1	0	I
Alibazi et al 2017	1	0	1	0	0	0	0	1	0	E
Alves de Oliveira et al 2013	1	0	1	0	1	0	0	1	0	I
Camci et al 2013	1	0	1	1	1	1	1	1	0	I
Castelein et al 2016	0	1	1	0	1	0	1	0	0	I
Chen et al 2015	0	0	1	0	1	0	0	1	0	E
Chen et al 2018	1	1	1	0	1	0	0	1	1	I
Christiansen et al 2017	1	1	1	0	1	1	1	1	1	I
Balci et al 2016	1	1	1	0	1	0	1	1	0	I
Bullock et al 2021	1	1	1	1	1	1	1	1	1	I
Da Silva et al 2008	1	1	1	1	1	1	1	1	0	I
Deng et al 2017	1	1	1	1	1	0	1	1	0	I
Frizziero et al 2018	1	1	1	0	1	0	0	1	0	I
Hannah et al 2017	1	1	1	1	1	1	1	1	0	I
Huang et al 2015	1	1	1	0	1	0	1	1	0	I
Johansson et al 2016	1	0	1	1	1	0	0	1	0	I
Kawasaki et al 2012	1	0	1	0	1	0	0	1	0	I
Lee et al 2017	1	0	1	0	1	1	0	0	0	I
Madsen et al 2011	1	0	1	1	1	0	0	1	0	I
Maor et al 2017	1	1	1	1	1	1	0	1	1	I
Moghadam et al 2018	1	0	1	0	1	0	0	1	0	I
Murty et al 2015	0	0	1	0	1	0	0	0	0	E
Nodehi Moghadam et al 2019	1	0	1	0	1	0	0	1	0	I
Park et al 2013	1	0	1	0	1	1	0	1	0	I
Park et al 2014	1	0	1	0	1	1	0	1	0	I
Plummer et al 2017	1	1	1	1	1	1	0	1	0	I
Rabin et al 2018	0	1	1	1	1	0	1	1	0	I
Sahinoglu et al 2020	0	1	1	0	1	1	0	1	0	I
Sant et al 2018	1	1	1	0	0	0	0	1	1	I
Seitz et al 2015	1	1	1	0	1	0	1	1	0	I
Shah et al 2016	1	1	1	0	1	0	0	1	1	I
Silva et al 2018	1	1	1	0	1	1	0	1	0	I
Struyf et al 2014	1	1	1	1	1	1	0	1	1	I
Tsuruike et al 2018	1	0	1	0	1	1	0	1	1	I
Welbeck et al 2019	1	0	1	1	1	1	0	1	0	I
Yesilyaprak et al 2016	1	1	1	1	1	0	0	1	0	I
Yüksel et al 2014	1	0	1	0	1	0	0	1	0	I

1=Yes, 0=No, Unclear, or Not Applicable, I=Included, E=Excluded; 1. Was the sample frame appropriate to address the target population?; 2. Were study participants sampled in an appropriate way?; 3. Was the sample size adequate?; 4. Were the study subjects and the setting described in detail?; 5. Was the data analysis conducted with sufficient coverage of the identified sample?; 6. Were valid methods used for the identification of the condition?; 7. Was the condition measured in a standard, reliable way for all participants?; 8. Was there appropriate statistical analysis?; 9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

tigating SD among asymptomatic individuals, 1,048. This was reported for transparency in how the data were presented.

When considering the population of those with general shoulder pain there were a total of 582 individuals within the studies examined in this review. Among this population there was a higher percentage of individuals with SD (57%) compared to those without (43%). However, whether SD is contributing to the symptoms experienced by this populations remains unclear. If SD is a contributing factor to the symptoms among the general orthopedic population with shoulder pain, then how is the high prevalence (57%) of SD

Table 3. Studies with available subgroup data for both asymptomatic and symptomatic populations

SYMPTOMATIC - Individuals (counted SD for an individual)						
Athletic/ Musicians	Study	Individuals (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage
	Alves de Oliveira et al 2013	15	14	93%	1	7%
	Johansson et al 2016	17	15	88%	2	12%
	Sliva et al 2018	36	26	72%	10	28%
	Total	**68**	**55**	**81%**	**13**	**19%**
General Orthopedic Population	Study	Individuals (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage
	Balci et al 2016	53	22	42%	31	58%
	Castelein et al 2016	19	9	47%	10	53%
	Chen et al 2018	186	140	75%	46	25%
	Christiansen et al 2017	40	18	45%	22	55%
	Deng et al 2017	102	37	36%	65	64%
	Huang et al 2015	41	29	71%	12	29%
	Plummer et al 2017	67	45	67%	22	33%
	Rabin et al 2018	74	33	45%	41	55%
	Total	**582**	**333**	**57%**	**249**	**43%**
Symptomatic Total	Individuals (n)	With Scapular Dyskinesis (n)		Percentage	Without Scapular Dyskinesis (n)	Percentage
	650	**388**		**60%**	**262**	**40%**

among the general population studied without symptoms explained?

There is considerable discussion in the literature regarding the presence of SD among overhead athletes with or without symptoms, as well as the presence of SD being a potential risk factor for sustaining injury in the future.[8,9,31,32,37] The current findings from the current study support the high incidence of SD among athletes with shoulder symptoms. However, it is important to note that only three studies with a total of 68 individuals investigated the presence of SD within the symptomatic athlete population while 16 studies with a total of 657 individuals investigating the presence of SD in the asymptomatic athletic population were included. Given the larger number of asymptomatic athletes who were described as having SD (from 20%-92%) it is clear that a large number of athletes present with SD and have no symptoms. This may indicate that it is a possibility that SD may be a normal adaptation for those participating in overhead sports.

Additionally, the timing of measuring SD is not consistently reported among the studies that contain overhead athletes and may add further evidence that SD is a normal adaptation within this population. Two studies[31,32] measured SD of asymptomatic competitive swimmers at various points of an individual training session. Both studies found that as training progressed, the number of individuals presenting with SD increased with a large number of participants presenting with SD at the end of the training session (82%[31] and 85%[32]). At first glance the initial perception may be that these results are suggestive of weakness or some compensatory mechanism that requires attention, however, it is possible that there is a normal adaptation related to the overall shoulder complex that causes this change to occur, particularly since these athletes were all competing at a high level without symptoms.

Table 4. Asymptomatic Individuals (counted SD for an individual)

ASYMPTOMATIC - Individuals (counted SD for an individual)						
Athletic / Musicians	Study	Individuals (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage
	Alves de Oliveira et al 2013	15	6	40%	9	60%
	Bullock et al 2021	33	15	45%	18	55%
	Da Silva et al 2008	53	23	43%	30	57%
	Frizziero et al 2018	32	15	47%	17	53%
	Johansson et al 2016	14	4	29%	10	71%
	Kawasaki et al 2012	103	33	32%	70	68%
	Lee et al 2017	26	7	27%	19	73%
	Madsen et al 2011	78	29	37%	49	63%
	Maor et al 2017	20	6	30%	14	70%
	Sant et al 2018	25	23	92%	2	8%
	Seitz et al 2015	25	14	56%	11	44%
	Shah et al 2016	20	4	20%	16	80%
	Silva et al 2018	36	9	25%	27	75%
	Struyf et al 2014	113	62	55%	51	45%
	Tsuruike et al 2018	30	14	47%	16	53%
	Wellbeck et al 2019	34	15	44%	19	56%
	Total	**657**	**279**	**42%**	**378**	**58%**
General Population	Study	Individuals (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage
	Akodu et al 2018	77	54	70%	23	30%
	Camci et al 2013	64	40	63%	24	37%
	Castelein et al 2016	19	8	42%	11	58%
	Da Silva et al 2008	20	4	20%	16	80%
	Hannah et al 2017	40	27	68%	13	32%
	Plummer et al 2017	68	42	62%	26	38%
	Shah et al	20	0	0%	20	100%

ASYMPTOMATIC - Individuals (counted SD for an individual)						
	2016					
	Yüksel et al 2014	83	54	65%	29	35%
	Total	**391**	**229**	**59%**	**162**	**41%**
Asymptomatic Total	Individuals (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage	
	1048	**508**	**48%**	**540**	**52%**	

Table 5. Athletic Population - Symptomatic

Study	Shoulders (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage	Shoulders (n)
Park et al 2013	178	122	69%	56	31%	178
Park et al 2014	330	280	85%	50	15%	330
Total	**508**	**402**	**79%**	**106**	**21%**	**508**

*Shoulders (counted SD for each shoulder)

Table 6. General Population – Asymptomatic

Study	Shoulders (n)	With Scapular Dyskinesis (n)	Percentage	Without Scapular Dyskinesis (n)	Percentage
Moghadam et al 2018	200	128	64%	72	36%
Nodehi et al 2020	88	17	19%	71	81%
Sahinoglu et al 2020	242	115	48%	127	52%
Yesilyaprak et al	296	87	29%	209	71%
Total	**826**	**347**	**42%**	**479**	**58%**

*Shoulders (counted SD for each shoulder)

This would not be unlike what is known regarding the increase in external rotation range of motion at the glenohumeral joint within a single game and over the course of the season in a baseball pitcher.[51] Within baseball pitchers this adaptation is not only normal, but necessary to perform at a high level.

LIMITATIONS

There are several limitations to this systematic review. The first limitation is that only included studies published in the English language were included which may have excluded published studies on this topic. Additionally, a very strict inclusion and exclusion criteria was applied in order to identify those studies that would provide the appropriate data for the purpose of this study. Lastly, there is a lack of consistency among how SD is measured across studies as well as populations, so it was not possible to perform a meta-analysis.

CONCLUSION

Within the symptomatic population, athletes have a higher percentage SD than the general orthopedic population. However, there are a considerable number of individuals with symptoms that do not present with SD. Perhaps more revealing is the number of asymptomatic individuals that present with SD, suggesting that SD may be a relatively normal finding among nearly half of the asymptomatic population studied within the literature. Until longitudinal studies are completed that monitor the predictive value of SD over time amongst asymptomatic populations, the relevance of this finding will remain uncertain.

ACKNOWLEDGEMENTS

Melinda Johnson, Reference/Academic Support Services Librarian, Nova Southeastern University and Zachary Smith

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

Submitted: September 19, 2022 CDT, Accepted: March 08, 2023 CDT

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Supplemental File B

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