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Original Research

Low back pain in female adolescent gymnasts and functional pain scales

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ABSTRACT

Objectives: To determine the scores of gymnasts with low back pain (LBP) on two functional pain scales: the Micheli Functional Scale (MFS) and the Oswestry Low Back Pain Disability Questionnaire (ODQ).
Design: Cross-sectional study.
Setting: Gymnastics facilities.
Participants: Female gymnasts aged 7–18 years.
Main outcome measures: We grouped gymnasts into those having pain affecting gymnastics and those with pain not affecting gymnastics and then compared MFS and ODQ scores for various activities.
Results: Eleven of the 29 participants (38%) endorsed LBP during gymnastics and 18 had LBP not affecting gymnastics. There were no demographic differences between the two groups. A significantly greater proportion of gymnasts who had pain during gymnastics reported pain with jumping ($N = 11$, 100% vs $N = 8$, 44%, $p = 0.003$) and lifting weights ($N = 4$, 36% vs $N = 0$, $p = 0.016$) compared to those not having pain during gymnastics. There were no significant differences between the two groups for pain with spine flexion or extension or for hip flexibility.
Conclusions: Although gymnastics requires extreme flexion and extension of the spine, gymnasts whose pain affects them during gymnastics do not endorse more pain with these movements. Gymnasts with LBP during gymnastics are more likely to have pain with jumping and with lifting weights.

1. Introduction

Low back pain (LBP) is a common complaint among gymnasts (Cupisti et al., 2004; Goldstein, Berger, Windler, & Jackson, 1991; Hutchinson, 1999; Kruse & Lemmen, 2009). Studies published on LBP in gymnasts have observed mixed results, with some demonstrating a higher prevalence of LBP among gymnasts relative to non-gymnast adolescents (Hutchinson, 1999; Kirby, Simms, Symington, & Garner, 1981) and others showing no difference between these two populations (Cupisti et al., 2004; Piazza, Di Cagno, Cupisti, Panicucci, & Santoro, 2009). Gymnasts may be at higher risk of low back injuries due to the excessive forces placed on the spine during some of the movements in the sport (Purcell & Micheli, 2009). Extreme hyperextension of the spine occurs in skills such as back walkovers, back handsprings, reverse hecht elements (e.g. Tkatchev, Ray, Ricna), and Yurchenko vaults. In addition, the impact of landing dismounts from bars, vault, and beam can cause high levels of force to be placed through the spine (Gittoes & Irwin, 2012; Penitente & Sands, 2015). A strong core is necessary to perform the twisting and flipping skills in all events, thus an athlete who lacks core strength and stability may possess an increased risk of LBP and spinal injury (Ahmed, Shakil-Ur-Rehman, & Sibtain, 2014).

Previous studies indicate that there is no single cause of most cases of LBP in gymnasts; rather, this condition seems to be multifactorial (Goldstein et al., 1991; Heitkamp & Horstmann, 2005; Sweeney, Daoud, Potter, Ritchie, & Howell, 2019). Excessive flexibility, lack of mobility, lack of core strength, increased hours of training, rapid growth spurt, and increasing age and weight have all been associated with LBP in adolescent athletes and gymnasts

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(Jeffries, Milanese, & Grimmer-Somers, 2007; Jones & Macfarlane, 2005; Kakar et al., 2018; Kujala, Taimela, Erkintalo, Salminen, & Kaprio, 1996; Purcell & Micheli, 2009; Steele & White, 1986). Moreover, there are potentially many different etiologies of LBP in gymnasts, including spondylolysis, mechanical low back pain, apophysitis, and disc pathologies (Hutchinson, 1999; Kruse & Lemmen, 2009; Purcell & Micheli, 2009). Yet one more aspect of LBP in gymnasts warrants consideration: researchers have observed that many gymnasts with LBP continue to participate in their sport despite pain (Harringe, Lindblad, & Werner, 2004). Accordingly, gymnasts may be predisposed to continual pain that leads to risk of severe injury and long-term dysfunction (Piazza et al., 2009). Investigations into the types of activities that cause pain among gymnasts will help clinicians to better provide appropriate individualized care.

Further research is required to better understand the underlying causes and consequences of LBP in this population of unique athletes. Thus, the purpose of our study was to assess the factors associated with functional pain affecting gymnastics participation among adolescent female gymnasts. We used the Micheli Functional Scale (MFS) and Oswestry Low Back Pain Disability Questionnaire (ODQ), both of which are validated pain scales (d'Hemecourt et al., 2012; Fritz & Irrgang, 2001; MacDonald, d'Hemecourt, & Micheli, 2016; Vianin, 2008). We hypothesized that female artistic gymnasts with LBP affecting gymnastics performance were more likely to have higher scores on the functional pain scales and more likely to have pain with all forms of activities of daily living (ADLs) than those with lower self-reported pain during functional activities.

2. Materials and methods

2.1. Study design and participants

We conducted an observational study of adolescent female gymnasts from September 2016 to January 2018. Gymnasts participating in levels 3–10 of the USA Gymnastics Junior Olympic program who were between the ages of 7–18 years were included. Potential participants were contacted at their local training gyms and asked to participate. Male gymnasts and those participating in the USA Gymnastics Excel program or high school gymnastics programs were excluded from the study. Furthermore, in line with the purpose of our study, those who did not report the presence of LBP in the 12 months preceding the assessment were excluded, as we determined that a basement effect would be likely among gymnasts who did not report LBP (e.g. all participants who did not report pain would report a 0 on the functional outcome scales). Prior to study commencement, we received institutional review board approval. All participants who enrolled (and their legal parent/guardian if under 18 years of age) signed informed consent prior to enrollment. This study represents a secondary analysis from a previously published study (Sweeney et al., 2019).

2.2. Intake questionnaire

We obtained demographic data and medical history information for each participant, including age, ethnicity, height, weight, history of menarche, duration and frequency of gymnastics participation, and level of gymnastics (Table 1). This was obtained by standard questionnaires filled out by the participants, with the assistance of the parent if needed. Each participant reported history of LBP within the previous 12 months, whether this pain required alterations to her participation in gymnastics, and if she had received a clinical diagnosis for her pain. One-year recall of LBP was used for this study as this time frame has been shown to be nearly identical to lifetime recall prevalence of LBP (Milanese & Grimmer-Somers, 2010).

2.3. Grouping variable

Of the eligible participants (N = 30), 29 completed the MFS and the ODQ and were included in this study (d'Hemecourt et al., 2012; Fritz & Irrgang, 2001; MacDonald et al., 2016; Vianin, 2008). To compare gymnasts who had experienced LBP that affected them during gymnastics with those who experienced LBP that did not affect them during gymnastics, we grouped participants based on their response to the first MFS question regarding LBP and gymnastics. In this question, they were asked "to what degree does pain affect your gymnastics activity". Responses were documented on a 0–5 scale, where 0 = no pain, 1 = pain not affecting sports activity, 2 = pain had a minimal effect on sports activity, 3 = pain had a moderate effect on sports activity, 4 = pain had a severe effect on sports activity, and 5 = unable to participate in sports due to pain. We grouped participants who rated a 0 or 1 as those whose back pain did not affect them during gymnastics activity vs. those who rated a 2 or higher as those whose back pain affected gymnastics.

2.4. Outcome measures

In order to assess the multifaceted effect of pain during gymnastics on functional sport activities, activities of daily living, and hip flexibility, we obtained several measures from each participant. First, participants completed the remainder of the MFS. In this scale, they rated the degree of pain associated with back extension and/or upright activities, sitting and/or flexion activities, and jumping (see supplemental digital content) (d'Hemecourt et al., 2012; MacDonald et al., 2016). Responses were rated from 0 (able to complete the activity without limitations) to 4 (unable to perform the activity). We then categorized responses as no limitations (response of 0) or any limitations (response greater than 0).

Participants also completed the ODQ. In this questionnaire, participants rated their level of pain on 9 different activities of daily living, including personal care, lifting, walking, sitting, standing, sleeping, social life, and travelling (Fritz & Irrgang, 2001; Vianin, 2008). Participants provided ratings for each question that ranged from 0 (the activity caused no pain) to 5 (the pain prohibited the activity). We then categorized responses as no pain (response of 0 or 1) vs. some pain with activity (2 or higher).

In addition, flexibility measurements of each gymnast were obtained by a board-certified sports medicine physician. This included active and passive shoulder flexion in the supine position, active and passive hamstring flexibility, active and passive hip extension, active and passive prone knee flexion, and hip flexor flexibility with the Thomas test. Results from a previously published study using this data showed no significant difference in flexibility measurements and LBP in this population (Sweeney et al., 2019).

2.5. Statistical analysis

Continuous variables are presented as means (standard deviations) and categorical variables are presented as the number present in the group and percentages of the total. We first compared the demographic and injury history characteristics between the two groups (experienced pain during gymnastics vs. did not experience pain during gymnastics) using independent samples t-tests and Fisher's exact tests. We then compared the proportion of the two groups on whether or not they endorsed pain with flexion, extension, jumping, or activities of daily living using Fisher's exact tests. Finally, we compared the proportion of

Table 1
Demographic characteristics of participants who experienced back pain that did (n = 11) and did not (n = 18) affect gymnastics activities.

Characteristic	Back pain affecting gymnastics	Back pain not affecting gymnastics	P value
Age (years)	13.3 (2.5)	13.8 (3.0)	0.67
Height (cm)	150.9 (14.3)	147.5 (15.0)	0.56
Weight (kg)	43.7 (3.3)	42.5 (13.3)	0.80
Years of gymnastics participation	9.3 (1.9)	8.2 (2.9)	0.27
Average gym time per week (hours)	24.2 (4.8)	21.7 (5.7)	0.22
Gymnastics level	8.4 (2.0)	7.8 (2.5)	0.56
Experienced menses	5 (45%)	8 (44%)	>0.99

participants in each group who demonstrated positive Thomas tests using Fisher's exact tests and the active/passive hip extension range of motion using independent samples t-tests. All tests were two-sided, and significance was defined as $p < 0.05$. Statistical analyses were performed with Stata version 15 (StataCorp, College Station, TX).

3. Results

Sixty-seven individuals enrolled in the study. Of these, 37 did not report the presence of any LBP. Thus, 30 participants were eligible for the current study based on our inclusion/exclusion criteria. Twenty-nine of the participants completed the MFS and ODQ and were included in full study analysis. Of these 29 individuals, 11 (38%) reported that their LBP affected gymnastics activities. There were no significant differences in participant characteristics or gymnastics activity levels between the two groups (Table 1). The majority of participants in both groups reported they did not receive a formal diagnosis from a clinician for their LBP (Table 2). There was no difference between groups in the proportion of patients who reported seeing a doctor for their back pain (36% vs. 39%; $p = 1.0$).

A significantly greater proportion of gymnasts with LBP that affected their gymnastics activity reported pain during jumping relative to gymnasts whose LBP did not affect their participation in gymnastics activities (Table 3). There were no significant differences between the groups for extension or flexion pain during gymnastics (Table 3). A significantly greater portion of gymnasts with LBP that affected gymnastics reported pain with lifting heavy weights (Table 4). There were no significant differences between groups on hip flexibility measures with the Thomas test or with active/passive hip extension tests (Table 5).

4. Conclusions

Our study of a select group of female adolescent gymnasts demonstrates that this athletic population will often continue participation in their sport despite experiencing LBP. In addition, they report no worse levels of pain or disability when performing certain back motions crucial to the sport (back extension and flexion). Despite the fact that there was no statistical significance between the groups regarding flexion and extension pain, the data suggests a higher rate of flexion/extension pain among the group who reported pain affecting gymnastics, which may be clinically significant. A larger sample size may have demonstrated that those gymnasts with LBP during gymnastics have more pain with flexion and extension, however, further study is needed.

Prior work suggests that gymnasts with LBP were older and trained more hours per week than those without LBP (Sweeney et al., 2019). In our investigation, however, we found no statistically significant difference in ages between our groups. We also found that the presence of LBP during gymnastics was associated with higher levels of pain and disability with jumping and lifting. Moreover, the majority of female gymnasts with LBP in our study had not received any formal diagnosis. It is unclear for the reasons why so many gymnasts had not received a diagnosis, however, this could also be a future area for investigation. Overall, our study extends the existing knowledge on this topic by demonstrating 1) LBP is common among adolescent gymnasts, 2) the underlying diagnosis or etiology of the LBP often remains elusive, and 3) gymnasts with LBP that affects them during gymnastics often have pain with lifting weights and jumping.

Gymnasts spend countless hours focused on gymnastics-specific skills that require spinal flexion and extension. In contrast, many gymnasts do not receive proper training on proper jumping or landing mechanics despite the fact that jump training can benefit these athletes (Colclough, Munro, Herrington, McMahon, & Comfort, 2018). Furthermore, gymnasts often jump and land from a very high surface when they perform dismounts. This type of jumping is unlike that in sports such as soccer, basketball, or volleyball, in which athletes jump and land from ground height. If a gymnast has poor mechanics during landing from a height, forces may not be absorbed properly, leading to LBP (Haddas, James, & Hooper, 2015). In addition, individuals with LBP often use maladaptive strategies in jumping and other activities which could cause further injury (Hammill, Beazell, & Hart, 2008).

Table 2
The characteristics of back pain experienced among both participant groups.

Back Pain Characteristic		Back pain affecting gymnastics	Back pain not affecting gymnastics
Diagnosis	Spondylolysis (stress fracture)	1 (9%)	2 (11%)
	Spondylolisthesis	0 (0%)	1 (6%)
	Disc problem	1 (9%)	1 (6%)
	Sacroiliac problem	1 (9%)	1 (6%)
	Apophyseal avulsion fracture	1 (9%)	0 (0%)
	General tightness	0 (0%)	1 (6%)
	None documented	7 (64%)	12 (67%)
Altered training due to pain time	None	3 (30%)	8 (44%)
	<1 week	1 (10%)	5 (28%)
	1–4 weeks	3 (30%)	5 (28%)
	1–3 months	2 (20%)	0 (0%)
	3–6 months	1 (10%)	0 (0%)

Table 3
Comparison between groups on measures of self-described functional extension, flexion, and jumping measures on the Micheli Functional Scale.

Variable	Back pain affecting gymnastics	Back pain not affecting gymnastics	P value
Extension pain during gymnastics or running	11 (100%)	13 (72%)	0.13
Flexion pain during gymnastics or running	10 (91%)	11 (61%)	0.11
Pain during any jumping activities	11 (100%)	8 (44%)	0.003*

*$p < 0.05$.

Table 4
Comparison between groups on measures of self-described functional abilities on the Oswestry Disability Questionnaire.

Variable	Back pain affecting gymnastics	Back pain not affecting gymnastics	P value
Moderate back pain or worse	11 (100%)	13 (76%)	0.13
Pain with washing/dressing	4 (36%)	3 (18%)	0.38
Pain with lifting heavy weights	4 (36%)	0 (0%)	0.016*
Pain with walking	3 (27%)	2 (12%)	0.35
Pain with sitting	7 (64%)	5 (29%)	0.12
Pain with standing	4 (36%)	4 (24%)	0.67
Pain that affects sleep	1 (9%)	2 (12%)	>0.99
Pain restricting social life	1 (9%)	1 (6%)	>0.99
Pain when travelling	4 (36%)	1 (6%)	0.06

Table 5
Comparison between groups on range of motion and special test measurements.

Variable	Back pain affecting gymnastics	Back pain not affecting gymnastics	P value
Thomas Test (n, % positive tests)			
Left Thomas test (iliopsoas)	2 (18%)	4 (22%)	>0.99
Right Thomas test (iliopsoas)	2 (18%)	3 (17%)	>0.99
Left Thomas test (rectus femoris)	2 (18%)	3 (17%)	>0.99
Right Thomas test (rectus femoris)	2 (20%)	2 (11%)	0.60
Left Thomas test (IT band)	1 (9%)	2 (11%)	>0.99
Right Thomas test (IT band)	2 (18%)	1 (6%)	0.54
Hip Extension (ROM degrees)			
Left active	19.2 (7.9)	21.3 (9.2)	0.52
Right active	18.0 (6.5)	21.3 (9.3)	0.30
Left passive	25.1 (8.5)	27.1 (8.6)	0.55
Right passive	24.9 (9.1)	25.4 (7.3)	0.85

Previous research in young adults (non-gymnasts) has shown that individuals with LBP land differently than those without LBP, though it is unknown if the altered mechanics led to the LBP or if the pain caused the individuals to change the way they landed (Haddas et al., 2015). Over the last decade, changes to the rules in gymnastics have rewarded more difficult power and strength based movements. Therefore, gymnasts need more strength and power to perform these high level skills and may need to change some of their training habits to include weight-training. Because of the lack of training in certain areas, we suspect that improper mechanics while jumping and lifting weights could be a cause of LBP in this population; however, more research is needed to support this idea.

In our sample of young female gymnasts, we found flexibility was not associated with higher functional pain scores on the MFS or ODQ. Our findings are consistent with previous literature which indicated no relationship between LBP, ODQ scores, and flexibility after implementation of an exercise program for spinal flexibility among individuals with LBP (Kuukkanen & Malkia, 2000; Moreno-Perez, Lopez-Valenciano, Ayala, Fernandez-Fernandez, & Vera-Garcia, 2018). In contrast, some studies have found a relationship between factors such as lumbar movement control and abdominal endurance with non-specific LBP (Abdelraouf & Abdel-Aziem, 2016; Luomajoki, Kool, de Bruin, & Airaksinen, 2008). Taken together, it is likely that LBP is multifactorial in its etiology (MacDonald, Stuart, & Rodenberg, 2017; Sweeney et al., 2019), and that no single ROM or flexibility test is able to discretely identify those with and without LBP experienced during gymnastics. Further research is needed to examine sport-specific movement patterns and the contribution to LBP.

Clinicians who care for female adolescent gymnasts may consider sport-specific recommendations for those with LBP, including modifying activity (e.g. avoiding or decreasing repetitions of specific jumps, dismounts, and vaults) and possibly avoiding cross-training routines such as weight-lifting or other resistance training in the early stages of rehabilitation if these movements cause pain. As the treatment progresses, these activities could be gradually worked back into the gymnast's training routine while continuing to monitor the individual's pain and disability using the MFS and ODQ. In addition, gymnasts should follow an individualized return to sport progression that would typically start with basic skills in a neutral spine on beam and bars before progressing to more advanced tumbling, vaulting, and dismounts (Sweeney, Howell, James, Potter, & Provance, 2018). Furthermore, the specific diagnosis would alter the progression: a gymnast with spondylolysis would limit extension-based movements while an athlete with disc pathology may initially need to avoid flexion-based movements and skills if these movements cause pain. Therefore, any gymnast with LBP should be thoroughly evaluated by a clinician familiar with the demands of gymnastics and an accurate diagnosis be made. With this clinical understanding, an appropriate return to sport progression may then be created while keeping in mind the specific movements that cause the athlete pain. Although any return to sport protocol should avoid painful activities, our findings suggest that jumping and lifting weights should be thoughtfully added in returning gymnasts to sport.

Our study has limitations, and our findings should be interpreted in light of them. We examined a convenience sample including a relatively small number of competitive female artistic gymnasts in one geographic area of the United States. We did not include male gymnasts or those in recreational gymnastics programs. Therefore, our findings may have limited generalizability. Future studies should seek to include male and females, as well as a diverse set of skill levels, in order to better delineate the sources of pain experienced during gymnastics. Furthermore, although we used two different validated surveys to distinguish between our two groups, we were limited in our sample size, thus necessitating the grouping of gymnasts into those who had no pain or pain that did not impact them during gymnastics vs those who had pain during gymnastics. In addition, the youth gymnasts in our study may have had difficulty properly scaling their pain or understanding what it means to have pain affect gymnastics. No previous study has divided athletes in such a way and as such, our findings should be considered preliminary. Finally, we were unable to account for the differing etiologies of pain as most gymnasts had not received a formal diagnosis for their LBP. This in itself is a significant finding but also a potential limitation: it may be that different diagnoses cause pain with different activities and this should be examined further.

In conclusion, we observed that gymnasts with LBP affecting them during their sport report higher levels of pain and disability in activities that involve jumping and lifting weights. There was no difference in flexion and extension based activities between the groups. The reasons for this are unclear, but it is likely that LBP in gymnasts is multi-factorial and should be further examined to better understand how to prevent and treat the condition in this population.

Ethical approval

The IRB of the corresponding author's institutions gave ethical approval for this research study. All subjects and their parents gave informed consent.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

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