

EPIDEMIOLOGY OF WRIST PAIN IN AUSTRALIAN GYMNASTS

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Original article

Abstract

Wrist pain in adolescent gymnasts is generally considered a 'normal' consequence of the sport. If pain is ignored it may lead to an injury of the distal radial growth plate and subsequent long term wrist dysfunction. There is a lack of epidemiology research on the prevalence of wrist pain in adolescent gymnasts with previous research documenting wrist injuries as part of general injury statistics. We aimed to investigate the life time and point prevalence of wrist pain in Australian gymnasts. A survey was designed to collect data from 10-18 year gymnasts who participated in gymnastics. Data was collected on: (i) historical experience of wrist pain (ii) current wrist pain; (iii) the influence of apparatus on wrist pain; and (iv) treatment modalities utilised. Results found there was a high life time (92.6%) and point prevalence (70.6%) of wrist pain in adolescent gymnasts. When grouped by age there was no significant difference in life time or point prevalence between genders. When grouped by training 1-10 hours per week, females had significantly higher life time prevalence ($p = 0.013$) than males. When grouped by training 11-25 hours per week males showed a significantly higher life time prevalence ($p = 0.005$) and point prevalence ($p = 0.004$). Wrist braces were reported as the primary method of management for wrist pain. This study promotes research into injury prevention strategies aimed at decreasing the prevalence of wrist pain and the consequence of wrist injury in adolescent gymnasts.

Keywords: *adolescence gymnast, distal radial growth plate, ground reaction forces, wrist brace, apparatus.*

INTRODUCTION

Although the positive benefits of gymnastics are well recognised (Gustavsson, Thorsen, & Nordstrom, 2003; Zanker, Osborne, Cooke, Oldroyd, & Truscott, 2004) consequent wrist pain is endemic in gymnasts (Di Fiori, Puffer, Aish, & Dorey, 2002; Guerra et al., 2016; Kox, Kuijer, Kerkhoffs, Maas, & Frings-Dressen, 2015). Gymnasts spend most of their training and competition weight bearing

through their hands. This results in challenges to their wrists which are exposed to repetitive axial compression and torsional loading in varying degrees of wrist extension and ulnar and radial deviation (Webb & Rettig, 2008; Zetaruk, 2000). Typically, wrist injuries fall into two main categories: bone injury, such as fractures and the distal radial growth plate (physis) compromise; and soft tissue trauma, such as

ligament sprains and ruptures. The younger the age a gymnast starts his or her career, the growth phases in adolescence and the training pre-competition are factors influencing the development of wrist pain (Dobrescu & Zaharia, 2010; Kerr, Hayden, Barr, Klossner, & Dompier, 2015). In addition, the ground reaction forces acting on the wrist when gymnasts learn new skills or increase intensity of training cause repetitive submaximal loading which may result in microscopic tissue damage (Zanker et al., 2004). It is acknowledged that wrist pain is related to compressive loading with the apparatus, muscular strength, neuromuscular performance and technique (Malina et al., 2013). Wrist pain and subsequent injuries may occur when excessive wrist loading results in premature closing of the radial physis with consequent delayed closure of the ulna resulting in positive ulna variance. The radial physis is most vulnerable to injury during growth periods whereas, after puberty, the area of vulnerability shifts to the ligamentous tissues particularly the triangular fibrocartilage complex (Dwek, Cordoso, & Chung, 2009). Gymnasts and coaches generally regard wrist pain as a natural and acceptable consequence of the sport and often refrain from seeking medical attention (Bak, Kalms, Olesen, & Jorgensen, 1994).

Wrist injury studies of both National and International elite and non-elite competitive gymnasts (9-17 years of age) have indicated abnormalities consistent with distal radial stress syndrome (physis) in 10-85% of the cohort (Caine, Di Fiori, & Maffulli, 2006; Caine, Roy, Singer, & Broekhoff, 1992). Research on elite female gymnasts, who were diagnosed with radial physis injury, indicated that 58% of those who reported wrist pain had not missed or modified training sessions (Di Fiori et al., 2002) and, in a recent study of elite male gymnasts diagnosed with physis injury, they had continued to train with wrist pain for up to 6 months (Guerra et al., 2016).

Wrist pain and injuries in Australian gymnasts have been recorded as part of

general injury statistics in gymnasts since the early 1990s. Injury prevalence in elite gymnasts (mean age 15 years, training 36 to 40 hours per week) over a 10 year period indicated that wrist injuries represented 29% of all physical injuries (Dixon & Fricker, 1993). A study over 12 months of 47 elite female gymnasts (mean age 11.3 years, training 21 to 37 hours per week) and 115 non-elite female gymnasts (mean age 13.1 years, training 6 to 30 hours per week) determined the number, site and type of injury sustained (Kolt & Kirkby, 1995). These researchers combined wrist and hand injury and indicated that these injuries constituted 11.5 % of total injuries recorded. The same authors also compared the results from their initial study with findings over a further 18 months in a similar cohort and found that wrist and hand injuries were 9.7% of the total injuries recorded (Kolt & Kirkby, 1999). The increased participation in gymnastics over the last 20 years (Morgan, 2015) combined with evolving techniques and more difficult routines to gain better scores at competition, there have been no published data on wrist pain prevalence in Australian gymnasts. Therefore, the purpose of this study was to obtain current data on: (i) the lifetime prevalence (LTP) and point prevalence (PP) of wrist pain in Australian gymnasts between 10-18 years of age; (ii) how gymnasts treated their wrist pain; and (iii) the use of wrist braces.

METHODS

A cross sectional descriptive survey was designed to collect data from 10 to 18 year old male and female gymnasts who participated in Artistic Gymnastics, Rhythmic Gymnastics, Trampoline and Acrobatic Gymnastics. The survey was administered using a standard website with an open-source survey application (Survey Monkey; <http://www.surveymonkey.com>). The project was granted approval by the Human Research Ethics Committee of the University of the Sunshine Coast (S/12/446)

and endorsed by the Australian Institute of Sport.

The survey was designed with the objective of collecting data from Australian gymnasts on: (i) historical experience of wrist pain (life time prevalence: LTP); (ii) current wrist pain (point prevalence: PP); (iii) the influence of apparatus on wrist pain; and (iv) treatment modalities utilised. Questions were formulated in consultation with a panel of coaches, physiotherapists, and doctors involved with the management of gymnast injuries. The primary objectives of these preliminary consultations were to ensure that the questions were both relevant and easily understood by the target age group. The survey was circulated by Gymnastics Australia to affiliated clubs via its monthly newsletter and through social media (Facebook). The survey was voluntary and anonymous and active online between 30th May 2013 and 30th September 2013.

The survey was divided into three sections with all questions requiring either a yes/no response or the selection of the most appropriate option from a drop-down menu. Section 1 sought demographic data about participant age, gender, the state or territory of their gymnastic club, number of years of gymnastics participation, and number of days and number of hours trained per week. The participants nominated their performance level which, for the purposes of this study, were categorised into three groups: Club, National and International. Section 2 sought information on the participants' experiences of wrist pain. Because gymnasts are known for their high pain threshold and frequent denial of pain (Harringe, Lindblad, & Werner, 2004) it was considered appropriate to document wrist pain with a simple yes/no answer as opposed to requesting a description of the pain on a visual analogue scale. Questions on wrist pain included lifetime prevalence (i.e. whether at any stage during their gymnastic career they had experienced wrist pain while performing gymnastics), point prevalence (whether they were currently

experiencing wrist pain) and whether the wrist pain was thumb side, mid dorsum or fifth finger side. Participants were also asked: (i) if wrist pain had prevented them from participating in gymnastics training in the four weeks prior to completing the survey; (ii) on what apparatus wrist pain was experienced on when participating; and (iii) whether they currently had any treatment for their wrist pain and, if so, did they self-manage or consult a health professional. Section 3 asked whether they ever wore wrist braces, and, if so when.

Analysis of the gymnast's responses were categorised by their indicated performance level and age groups (10 to12, 13 to15 and 16 to18 years). The time that gymnasts trained each week were grouped into 1 to10 hours, 11 to 25 hours and 26 to 40 hours.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS -22 Inc. Chicago, USA). Descriptive statistics, means and standard deviations were used to summarise and compare variables. Independent t- tests were used to determine whether there were differences of life time and point prevalence of wrist pain between males and females, age groups, levels of gymnastics, and hours trained per week. Fisher's exact test was used to determine whether there were gender differences between lifetime prevalence and point prevalence of wrist pain. An alpha level of $p = < 0.05$ was used for all statistical tests.

RESULTS

A total of 399 gymnasts (15% male, 85% female) agreed to participate in the survey. However, 162 answered less than 30% of the questions and, because of the incomplete responses, were not included in the analysis. Thus, data from 237 gymnasts, 47 male gymnasts (46 artistic and 1competitive acrobatic gymnast), and 190 female gymnasts (186 artistic, 3 competitive trampoline, and 1 competitive acrobatic) were analysed. The mean age of the

gymnasts was 14.8 years (SD \pm 2.5years) and there was no significant difference (P=0.582) for gender (males 14.35 \pm 2.6), (females 14.89 \pm 2.5). Respondents were from all states and territories: Queensland (31.2%), Victoria (29.5%), New South Wales (18.1%), Tasmania (5.2%), Australian Capital Territory (4.6%) and Western Australia (4.6%) South Australia (4.2%) and Northern Territory (2.5%).

Twenty-two percent of the respondents had participated in gymnastics for 1-5 years, 54.7% between 6 to 10 years and 23.3% between 11 to 13 years. Club gymnasts trained between 3 and 16 hours per week, the National group between 8 to 20 hours per week and the International group between 20 to 35 hours per week. Twenty one percent of the gymnasts made up the Club group, 53% the National group and 26% the International group.

There was a high LTP (92.6%) and PP (70.6%) of wrist pain in adolescent male and female gymnasts (Table 1). The prevalence rates recorded for males were not significantly different to those for females (Table 1). There was no significant difference between gender for LTP, PP or ever having experienced wrist pain during gymnastics activities and current wrist pain.

When grouped by age, there was no significant differences in LTP or PP between gender (Table 1). When grouped by level, there was no significant differences in LTP or PP between males and females (Table 2). However, when grouped by hours of training, females had significantly higher LTP ($p = 0.013$) when training between 1 to 10 hours per week than males (Table 3). For those respondents who trained 11 to 25 hours per week, males displayed a significantly higher LTP ($p = 0.005$) and PP ($p = 0.004$) when compared to females.

Gymnasts reported their wrist area of pain as mid dorsum of wrist (53.2%), the radial side (30.3%) and little finger side (17%). Wrist pain had prevented (35.4%) gymnasts from upper limb weight bearing training over the previous month. Of this

group, 68 % were females training between levels 4-10 and 31% were males training between levels 6-10. Twelve percent of the females and 20% of the males in this group indicated they wore braces for training, 32% of females 30% of the males for training and competition and none indicated they wore braces for competition only.

Male gymnasts who reported current wrist pain identified the cause as: the pommel (75%), the parallel bars (23%), the high bar (8.6%), the floor (41%), handstands (16%), the vault (11%) and the rings (4.3%). The percentage of females who experienced current wrist pain identified the vault (30%), the floor (64%), handstands (19%), the balance beam (25%), and uneven bars (15%).

Gymnasts, in consultation with their team coach or physiotherapist, treated their wrist pain with a combination of braces (39.6%), taping, icepacks and stretches (29%), exercises (20.7%), massage (16.4%) and heat packs (10.4%). Three gymnasts used wrist splints, one used anti-inflammatories and one had had a cortisone injection into the affected wrist. Further advice was sought from medical practitioners, physiotherapists, coaches and trainers by 59% of gymnasts. Wrist braces had been worn by 28% of the gymnasts at some stage during their gymnastic career. At the time of the survey 15% of all the gymnasts wore wrist braces for training, 22.8% wore braces for both training and competition and 1.3% wore braces for competition only.

Table 1

Differences between male and female age groups and prevalence of wrist pain.

Participants	Lifetime prevalence						Point prevalence						
	Age	Males	Females	Males	Females	p	Mean	95% CI	Males	Females	p	Mean	95%CI
years				n (%)	n (%)		Diff		n (%)	n (%)		Diff	
10-12	17	43	17 (100)	41 (95)	0.708	-0.041	-0.26,0.17	11 (65)	32 (74)	0.347	0.165	0.18,0.51	
13-15	12	58	12 (100)	53 (92)	0.334	0.075	0.07,0.23	12 (75)	45 (71)	0.794	0.039	0.25,0.33	
16-18	18	89	17 (94)	79 (97)	0.484	0.033	0.12,0.01	17 (76)	74 (74)	0.856	0.021	0.21,0.25	
Total	47	190	46 (98)	173 (90)		0.067	0.46,0.46	40 (85)	151 (79)		0.225	-0.657,.1.10	

Table 2

Differences between male's and female's performance level of gymnastics and prevalence of wrist pain.

Participants	Lifetime Prevalence						Point Prevalence						
	Level	Males	Females	Males	Females	p	Mean	95% CI	Males	Females	p	Mean	95%CI
				n (%)	n (%)		Diff		n (%)	n (%)		Diff	
Club	10	42	10 (100)	38 (90)	0.985	0.0013	0.13,0.13	7 (70)	34 (81)	0.495	0.055	0.103,0.212	
National	22	102	21 (95)	93 (91)	0.664	0.019	0.006,0.06	19 (86)	82 (80)	0.446	0.068	0.12,0.108	
International	15	46	14 (93)	41 (89)	0.32	0.073	0.072,0.21	14 (93)	35 (76)	0.502	0.55	0.10,0.215	
Total	47	190	44 (94)	172 (90)		0.0553	0.314,0.42	40 (85)	151 (79)		0.673	0.23,0.53	

Table 3

Differences between male's and female's hours trained and prevalence of wrist pain.

Participants	Lifetime Prevalence						Point Prevalence						
	Hours	Males	Females	Males	Females	p	Mean	95% CI	Males	Females	p	Mean	95%CI
trained				n (%)	n (%)		Diff		n (%)	n (%)		Diff	
1-10	7	60	5 (71)	56 (93)	0.013*	-0.186	0.13,0.13	7 (70)	47 (78)	0.502	0.055	0.10,0.21	
11-25	34	101	34 (100)	90 (89)	0.005*	0.232	0.006,0.06	19 (86)	79 (78)	0.004*	0.068	0.12,0.10	
26-40	6	29	5 (83)	27 (93)	0.664	-0.019	0.07,0.21	14 (93)	25 (86)	0.307	0.55	0.10,0.21	
Total	47	190	44 (94)	173 (90)		0.027	-0.63,.0.5	40 (85)	151 (79)		0.241	-0.21,0.69	

* Denotes significance ($p < 0.05$) between genders

DISCUSSION

The results of this study indicate that Australian gymnasts (aged 10 to 18) have both a high LTP and PP of wrist pain. This is higher than studies overseas (47% to 84%)(Caine & Harringe, 2013; De Smet, Claessens, Lefevre, & Beunen, 1994; Di Fiori et al., 2002) however, direct comparison is difficult as study designs vary considerably in the definition of injury, how injury rates are determined, reporting system of pain/injuries and diversity of study populations. In this study, the 16-18 year old national level artistic male gymnasts who trained 11-25 hours per week had the highest reported LTP (100%) and PP (86%) This correlates with previous research consistent with the older artistic gymnasts having had a greater accumulated exposure to training with more complex and increased difficulty of skills. However, research has shown that regardless of age or competition level both injury rate and proportion of time loss were greatest among those gymnasts experiencing rapid growth (Caine & Harringe, 2013; Caine & Nassar, 2005; Di Fiori, 2006) This correlates with our study with 100% of the males and 95% of the females aged 10 to 12 years (club and national) reporting LTP of wrist pain. This was closely followed by the 13-15 (club and national) year age group with 100% of the males and 92% of the females reporting LTP. The 10 to 12 year old gymnasts are at the beginning of a rapid growth phase and have a greater risk of sustaining long term wrist pain and injury to the distal radial epiphysis (Dobyns & Gabel, 1990). Ossification of the radial epiphysis and non-union of the epiphysis and metaphysis is observed in females between 10.1 years and 13.2 years and in males between 10 years and 13.4 years (Baumann et al., 2009). Therefore, repetitive compression loading during gymnastic training may predispose this age group (10-15 years) to wrist injury of the distal radius and ultimately influence carpal development and function (Hsu & Light, 2006). Compressive loads at the wrist

have been found to be 1.5 body weight (BW) for handstands increasing to 10.6 BW for flairs on the pommel (Bradshaw & Hume, 2012; Markolf, Shapiro, Mandelbaum, & Teurlings, 1990). Mechanical loading of the soft tissue structures during athletic activity is one possible stimulus to maintain and or increase the strength of biological tissue (Brueggerman, 2010). However, overuse of the soft tissues occurs from the repetitive submaximal loading particularly when inadequate time is allowed to complete normal processes of repair and adaptation (Brueggerman, 2010). In our survey 70% of the males reported PP of pain when performing on the pommel. This confirms previous evidence that the loads on the wrists while performing on the pommel are the single most important factor contributing to wrist pain in male gymnasts (Markolf et al., 1990). An elite male gymnast may perform up to 300 circles on the pommel each training session and then repeat these four day a week. This activity places potentially damaging loads on the wrist. Gymnasts accept these risks as part of their normal training model but there is no evidence that the Australian training model is influencing the development of wrist pain in our gymnasts. When the overseas epidemiology studies are considered, it suggests that the problem of wrist pain in gymnasts is global and of long standing.

The definition, reporting and recording of gymnastic injuries has varied over the years from injuries only being reported if they produced disabilities that were considered serious enough to be seen by a doctor (Snook, 1979) to the current recommended procedure of Gymnastics Australia for medical injury reporting which states that 'any incident that requires active treatment or alters gymnastic training or competition is considered reportable'. This definition, however, is open to interpretation by gymnastic clubs. If common reporting criteria defines 'reportable wrist pain' as only that which requires the gymnast to miss training it may

underestimate the long-term risks to gymnasts who persist in training, self manage and only consider reporting the problem when the pain is intense and 'alters' their training schedule. Pain or functional limitation, are often of gradual onset and intermittent and many gymnasts will continue to train and compete despite the presence of the symptoms. Inadequate diagnosis and treatment of overuse injuries, many of which involve radial epiphyseal changes, may delay the healing process and furthermore result in permanent disability (Frush & Lindenfield, 2009). The apparent reluctance to seek advice needs to be addressed by the gymnasts and their medical team.

The results of our survey found that the gymnast's primary management for wrist pain was self- management including wearing commercially available wrist braces (either Panda Paws or Reisport wrist extension block) taping, ice packs, massage, stretching and strengthening in combination with advice from their coaches on training modification. Further management included advice from professionals such as a Doctor or physiotherapist.

Despite the wearing of braces, there is only one study, designed for male gymnasts with physis injury, to support how a brace may be of benefit in dissipating compression loading acting on the wrist while performing on the pommel (Grant-Ford, Sitler, Kozin, Barbe, & Barr, 2003) and none on the current commercially available braces gymnasts tend to use. Wrist braces studies in other sports have shown them to be effective in protecting athletes from sustaining wrist fractures, ligament sprains and ligament ruptures when they fall onto an outstretched hand (Russell, Hagel, & Francescutti, 2007) by blocking wrist hyperextension. When considering that gymnasts will often 'fall onto an outstretched hand' loading through the wrist as part of their normal gymnastic activity it would be advantageous to have a brace design effective as an adjunct to current

injury prevention in the adolescent gymnasts. Also, as suggested in a review of wrist injuries in athletes aged 10 to 14 years (Kox et al., 2015), a specific protocol for wrist screening and preventative strategies with a proactive rather than a reactive approach to gymnast's wrist pain is warranted. Furthermore, if these strategies were implemented when symptoms occur, and athletes encouraged to report injuries there would be a decrease in prolonged wrist pain, injury and re-injury. Finally, education of the gymnasts and coaches is paramount to teach awareness of the long-term effects of wrist pain. The coach's duty of care, knowledge and management of injured gymnasts has a major influence on the culture of athletes. The coach is involved with each gymnast from preparation and training regimes through to decisions about whether a gymnast is fit to train or compete. The coach is best placed to understand the potential consequences of growth plate injury during periods of growth and respond appropriately. Coaches also need to be aware of the culture they are creating and mindful of each of their gymnasts physical and psychological needs. No two gymnasts are the same, reacting differently to training methods and the 'no pain, no gain' attitude expressed by many coaches is not appropriate (Sands, Caine, & Borm, 2003).

CONCLUSION

Australian adolescent gymnasts had both a high reported lifetime and point prevalence of wrist pain which is largely unreported. Wrist pain does not need to be endemic in adolescent gymnasts. The paradigm needs to change from wrist pain acceptance to wrist injury prevention.

LIMITS TO SURVEY

Clearly these data are limited to the cohort of Australian gymnasts who completed the survey. Although the survey recruitment was for all gymnasts between

10-18 years we acknowledge that there is always possibility for bias with potentially only gymnasts with injury or pain completing the survey as it was topical for them. Issues such as these are typical to all pain/ injury research survey with some care required to avoid over interpreting results. Although the survey and research information was widely publicised on gymnastic web sites, in gymnastics Australia's monthly newsletter to clubs and Facebook, posters in clubs and personal contact with coaches, the number of respondents was less than anticipated. Numbers were also compromised as 162 of the 399 respondents answered less than 30% of the questions so were removed from the data. The higher number of female respondents was expected as within the 199,000 members of gym sports registered with Gymnastics Australia 76% are female. (Australia, 2016).

RECOMMENDATIONS

Defining reporting procedures for wrist pain is strongly recommended with ;

1. Early reporting of wrist pain, correct diagnosis, and appropriate management to avoid long term pain
2. Once wrist pain is reported any musculoskeletal issues should be addressed,
3. training modified such as decreasing repetitions, changing the order in which circuit training is done to avoid overload on the wrist and shorter training sessions.
4. Prior to returning to normal training implement a physical ability test to measure the gymnast's current functional fitness to the level of training expected.

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