

Gymnastics Training Consequences: Possibility of Upper and Lower Body Pain

Surdiniaty Ugelta*, Nina Sutresna, Asti Rahayu, Afianti Sulastrri, Jajat

Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, 40154, West Java, Indonesia

Received July 15, 2022; Revised August 27, 2022; Accepted September 22, 2022

Cite This Paper in the Following Citation Styles

(a): [1] Surdiniaty Ugelta, Nina Sutresna, Asti Rahayu, Afianti Sulastrri, Jajat, "Gymnastics Training Consequences: Possibility of Upper and Lower Body Pain," *International Journal of Human Movement and Sports Sciences*, Vol. 10, No. 5, pp. 939 - 944, 2022. DOI: 10.13189/saj.2022.100510.

(b): Surdiniaty Ugelta, Nina Sutresna, Asti Rahayu, Afianti Sulastrri, Jajat (2022). *Gymnastics Training Consequences: Possibility of Upper and Lower Body Pain*. *International Journal of Human Movement and Sports Sciences*, 10(5), 939 - 944. DOI: 10.13189/saj.2022.100510.

Copyright©2022 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract In gymnastics, injury is one of the causes of not achieving training goals. This is likely to happen to athletes, instructors, and participants in general. The severity type of the injury is determined by the type of gymnastic activity performed. This study aimed to examine the potential for injury or pain that can occur in the upper body and lower body, before and after exercise. This research was conducted using a descriptive research design, which involved a population sample of 108 Indonesian female gymnastics athletes. Data were obtained through observation and questionnaires regarding the condition of the athletes before and after participating in the exercise. The results showed that the most pain occurred in the upper body area (shoulder, back and waist), while the lower body parts where the injury commonly emerged were the hips, hamstrings, and the hollow of the legs. It is also possible that the injury came up long after the exercise. From the observation data, the highest incidence of pain in the upper body is in the waist (34 people) and the least is in the shoulders. While in the lower body, the most pain complaints occurred in the pelvis (30 people) and the least occurred in the thighs (5 people). Thus, it can be concluded that the potential for injury due to movement activities in gymnastics has different proportions for each location. Based on these findings, to avoid the negative impact of these injuries, it is necessary to carry out strengthening exercises in areas that are prone to experiencing pain or injury.

Keywords Injury, Pain, Gymnasts, Lower Body,

Upper Body

1. Introduction

Achievement sports or elite sports aim to produce champions. Likewise, the coaching carried out by the Indonesian National Sports Committee (KONI), one of which is in the gymnastics branch, both at the National and International levels is planned to create champions. However, all efforts will be in vain when athletes experience an injury or pain during training or competition. Moreover, the occurrence of injuries during competition not only endangers the individual athletes themselves, but can also potentially destroy the entire team [1]. Some important abilities possessed by an athlete include VO₂max capacity, strength, and muscle endurance. One alternative to improve body composition is through CrossFit exercises [2]. However, this exercise requires a high routine and carries a high risk of injury to the gymnast. The same thing happens in early childhood gymnastics, where the demand for this sport is increasing, indicating that this sport is liked by children. This sport is considered to be able to bring joy and is beneficial to health. On the other hand, this sport also carries an ongoing risk of injury, and has long-term effects and severity if an injury occurs at an early age [3].

In US children, the body area most frequently injured is the upper limb (42.3%), lower limb (49.1%), most of which are injured in trampolines, falls and acrobatic

gymnastics [4]. According to pediatrics, lower extremity injuries are more common in club-level gymnasts [5]. It was noted that the three most common body parts injured in female gymnasts were the feet (21.0%), ankles (19.3%), and knees (14.0%) [6]. A study over a period of 16 years found ankle injury as the most common injury among female artistic gymnasts in US colleges, and the second most common injury in men [7,8]. The study, which was carried out by observing gymnasts from the US, diagnosed children with strain/ sprain (44.5%) and fracture/dislocation (30.4%) [9]. Ankle injuries are the most common and the number one cause of lost time in training and competition in the British Gymnastics Artistic Squad [10].

For a gymnast, the movement of jumping, resisting, and leaning on either hand or foot when landing, has become a routine. This is an unavoidable part of gymnastics in all numbers, ranging from artistic gymnastics, rhythmic gymnastics, aerobic gymnastics, acrobatic gymnastics, and trampolines. One part of the body that often gets pressure, resistance and impact is the component in the lower body. This is because the lower body plays an important role, especially when the gymnast is leaning, resisting, and landing. Therefore, some parts require extra attention by observing the movement of the body from the hip joints, knees, ankles, to toes. Parts such as ligaments, heel pads and foot pads at the tips of the toes, as well as the dominant muscles and other muscles involved in the work also need to be considered. Likewise, the lower back muscles (hips and hips) are also at risk for injury.

Low back pain is a common consequence of gymnastics, one of which is influenced by the presence of postural muscle weakness and abnormal postures (Endurance, no date). Consequences of injury to gymnasts due to weak lower back muscles and poor posture can have a negative impact by making the muscles work unstably [11,12]. Lower back injuries can also be caused by overtraining. The etiology of lower spine injuries in gymnasts can be attributed to the nature of the training, inherent skeletal abnormalities, poor posture, as well as the inability of the lumbar spine muscles to control movement and protect against injury [11]. The lower spine is a common site of acute or chronic injury in gymnasts following the manifestation of excessive pain.

Gymnastics is associated with activities that have a high risk of injury. It has been reported that an average of 4.8 emergency room injuries per 1000 participants occur annually. It was noted that of all women's sports, gymnastics was one of the most injured. It has been reported that the total incidence of injuries tends to increase until the middle of the competitive season, while new injuries show a marked increase during certain training periods and during competition [13].

Therefore, injury prevention should be the main focus [14]. Currently, research that examines the level of risk of injury in gymnastics is still very limited. This study aims to map the risk of body location that has the potential to cause

pain/injury as a consequence of exercise activities. By knowing the risk of injury, it is hoped that gymnastics coaches and individual athletes can be more careful in anticipating the risk of injury that can occur.

2. Materials and Methods

Research Methods

This study was conducted using a descriptive method to obtain an overview of the pain felt by Indonesian female gymnasts due to injuries accumulated during the gymnastics training routine. The participants involved consisted of artistic gymnasts, rhythmic gymnasts, and aerobic gymnasts. Data collection was carried out through observation techniques, distributing questionnaires and interviews to all national athletes of gymnasts in Indonesia, which are located at the national sports development center, Jakarta, Indonesia. The research took place from March to August 2020.

Participants of this study consisted of 108 women's national gymnastics athletes aged 16-30 years who had followed the length of training between 11-20 years. Participants were divided into three categories of gymnastics: artistic gymnastics, rhythmic gymnastics, and aerobic gymnastics.

This study was a quasi-experiment employing a pre-post-test design. The treatment had been carried out for 3 months, with exercise intensified five times a week. The total population of this study was 108 female gymnastics athletes. The inclusion criteria in this study were female gymnastics athletes who had won the provincial-level championship and were entitled to take part in the 2021 national championship. The results of the calculation of the Slovin formula for research with a known population resulted in the number of research respondents, which involved a total of 85 national gymnastics athletes with a precision value of 5%, with the Consecutive sampling technique.

Supporting data and information were obtained using several techniques, namely observation, interviews and distributing questionnaire forms, either directly or through social media. The thematic analysis framework is included in the questions in order to obtain information according to the theme to be revealed. Questionnaire questions contain 1) information about complaints, injuries, or pain felt in body parts, bones, muscles, joints, and ligaments due to gymnastic training routines; and 2) accumulation of pain/injury in the upper and lower body areas that can have an impact on severity in the future [5,6].

The collected data were then analyzed using the McNemar test from the SPSS version 26 program. The McNemar test is a non-parametric statistical tool used to test the difference between two paired samples (members of the same sample), and the form of the data scale used is a nominal or dichotomous scale.

3. Results and Discussion

Results

The number of Indonesian National Gymnastics Athletes involved in this study were 85 gymnastics athletes, consisting of 45 rhythmic gymnastics (52.9%), 28 artistic gymnastics (32.9%) and 12 Aerobic Gymnastics (14.1%) athletes. The characteristics of Indonesian national gymnastics athletes can be seen in Table 1. The participants studied had a fairly wide age range, but most participants were at the age of 18 years and had attended training to become professional athletes for at least one year.

Table 1. Characteristics Women's National Gymnastics Athlete, Indonesia 2021 (n=85)

No	Variable	mean	mode	(min-max)
1	Age	16±2.4	18	(16-30)
2	BMI	18.7±4.6	20.3	(13.7-24.9)
3	Practice Length	8.16±3.9	8	(11-20)

Table 2 shows that there are differences in pain complaints in the upper body area before and after giving treatment to participants, especially in the shoulders, elbows, and waist (p -value <0.05). Of all the complaints of pain that arise, most occur in the loin location.

Discussion

The results showed that the risk of pain in the lower extremities was greater than that of pain in the upper extremities. This is in accordance with statistical data which show that the majority (50-70%) of acute injuries during exercise occur in the lower extremities. This can occur due to excessive movement of the ankle joint and excessive inward rotation of the tibia can cause overload and injury to the foot and knee [15].

The anterior, lateral, and inner posterior muscles of the foot play an important role in supporting the body, both in static and dynamic conditions. The job of this muscle is to stabilize the body while standing and provide strength and stabilize the lower body when moving. These muscles also function to slow down when they stop moving or running, turning, and cutting [16]. The presence of this muscle function is important for the ankle, for the toes, and for controlling the forward swing of the foot, such as the swinging motion of the foot when walking. Injury to the nerves, muscles and tendons can cause pain that causes the muscles to become weak, impairing the gymnast's movements and risking permanent injury.

A 16-year study found that in US college gymnasts, there were differences in having a greater risk of injury in women than in men [17]. The probability of injury to women has a greater proportion of the lower extremity apparatus (75%) than men (33.3%) [18]. Ankle injuries are the number one injury burden in women [10]. It was further explained that generally female gymnasts adopted the strategy of landing with 'stiff feet' in accordance with the code of points of the Federation Internationale de Gymnastique. Deductions from the judges for dropping/landing with a different squat position have different rules for female and male gymnasts. In women's numbers, this position can lead to a reduction of up to 0.5 points, but this does not apply to male gymnasts, even though the difference of 0.5 points can be the difference in the determining value between the gold and silver winners at the 2016 Rio Olympics.

On the other hand, research has shown that landing with stiff feet, which has become a routine for female gymnasts, is actually at risk of causing injury to the leg area in female gymnasts. Thus injuries to gymnasts due to repetitive routines on the landing surface and landing with stiff feet can cause injury to athletes, especially in the lower area [19].

The results of other studies show that the type of landing surface and the height of the jump have a considerable influence on the value of plantar pressure or foot pads. The presence of a mattress/mattress can significantly reduce plantar pressure, so that a mattress/mattress can be used during training to avoid injury. However, it is clear that the use of additional mats on the race floor can increase the mean asymmetry value by about 3.5%, which can be attributed to changes in athlete performance. The type of surface at the time of landing has an impact on the sole of the foot. The athlete's habits, the type of landing surface, and the height of the jump have a considerable influence on the pressure on the soles of the feet. Using an additional mattress can reduce the risk of injury by 3.5% [20]. In landing, leaning, and resisting not only the feet that play a role in the exercise routine, but the arms also play a role. Starting from the palms, hands, wrists, elbows, shoulders and back often experience pain, and 33% of female gymnasts experience wrist pain for more than three months [21].

The most injury or pain in the upper body is in the wrist area used to support the body's weight [21]. Excessive loading at an early age has long-term injury effects on the upper body, especially in the wrist area, as well as the elbow and shoulder area [22]. Injuries occur because most of the load rests on the upper extremity. Wrist pain due to the strength of the gymnast's body is more than twice his body weight, and can withstand up to 16 times his body weight [14].

Table 2. Differences in Upper Body Complaints Before and After Treatment

Limbs	Complaints Before	Complaints After		P-Value
Pelvic Total	There is	There is	There isn't any	0.001*
	There isn't any	6	0	
		24	55	
		30	55	
Hips Total	There is	There is	There isn't any	0.289
	There isn't any	1	2	
		6	76	
		7	78	
Upper thigh Total	There is	There is	There isn't any	0.001*
	There isn't any	3	0	
		17	65	
		20	65	
Lower Thighs Total	There is	There is	There isn't any	0.004*
	There isn't any	2	1	
		5	77	
		7	78	
hamstrings Total	There is	There is	There isn't any	0.219
	There isn't any	2	1	
		5	77	
		7	78	
Knee Total	There is	There is	There isn't any	0.001*
	There isn't any	4	1	
		14	66	
		18	67	
Shinbone Total	There is	There is	There isn't any	0.006
	There isn't any	2	1	
		11	71	
		13	72	
Calf Muscles Total	There is	There is	There isn't any	0.001*
	There isn't any	5	1	
		20	59	
		25	60	
Ankle Total	There is	There is	There isn't any	0.001*
	There isn't any	2	1	
		27	55	
		29	56	
Heel Total	There is	There is	There isn't any	0.004*
	There isn't any	0	0	
		9	76	
		9	76	
Heel Bottom Cushion Total	There is	There is	There isn't any	0.008
	There isn't any	1	0	
		8	76	
		9	76	
Foot Basin Total	There is	There is	There isn't any	0.250
	There isn't any	1	0	
		3	81	
		4	81	
Toes Total	There is	There is	There isn't any	0.031
	There isn't any	1	0	
		8	76	
		9	76	
Toe Pads Total	There is	There is	There isn't any	0.500
	There isn't any	0	0	
		2	83	
		2	83	

Shoulder injuries among female artistic gymnasts [14] occur as a result of repeated and sustained weight training of the upper extremities. In a way that almost no other sport does due to special requirements, gymnasts experience a large number of overuse injuries to the upper extremities [15]. Other studies suggest pain in the lower back area is a consequence of gymnasts. This can occur due to weak postural muscle endurance (Endurance, no date). In accordance with the research findings, the most pain in the lower body is the area under the back, namely in the waist area in female Indonesian gymnastics athletes. This pain can occur due to excessive loading. In addition, the position of the torso connecting the upper torso and the pelvis is a mobile structure, bounded both inferiorly and superiorly by the stiffer structures of the spine and pelvis. Other transition zones also occur in the hip, knee and ankle areas. ('Mid- and Low-back Injuries', no date). In the literature, it has been reported that excessive eversion of the ankle joint and excessive inward rotation of the tibia can cause overload and injury to the foot and knee [23].

The participation of gymnasts in pursuing a sport of gymnastics generally starts from the interest of parents, children, or information from people around or social media, and the sport of gymnastics is interesting like a circus game because of the acrobatic element. The reasons for doing acrobatic skills training can be for recreation; to improve fitness; as additional training for performing arts and other sports such as dance, cheerleading, circus arts, air sports and extreme sports; and as preparation for gymnastic competitions [24].

Participants pursue this sport with a specific purpose, because some sports require gymnastic skills to support achievements in the sport they are engaged in, such as the ability to do splits, balances, turns, etc. These movements are needed by several other sports. Maybe at first the child just does it for fun. However, after being able to perform simple movements, the trainer will certainly provide heavier and more difficult movements. A movement that is considered easy to do repeatedly will be boring. So that the child does not enter the bored and saturated area, the trainer is ready with new or difficult movements.

It has become part of the characteristics of children who always want to get something new and challenging, as well as quite high curiosity. The desire to excel and the thirst for praise make the child strive harder to achieve his goals. The more challenging the movement that is attempted, then this is where the coach must be more careful and aware of the possible risk of injury. When a child experiences an injury and pain for the first time, it will usually cause trauma so that the child will have difficulty being invited to practice again.

By knowing well all the risks of injury that can occur, it is hoped that the trainers can implement training strategies in the form of strengthening the body parts that are at risk of injury to avoid the emergence of pain events both in the short-term during training, and in the long term after the competition.

4. Conclusions

This study has successfully determined how often for upper- and lower-body injuries or pain to develop both during and after exercise. This study tested 108 Indonesian female gymnasts. Regarding the athletes' health prior to and following the exercise, information was gathered by observation and questionnaires. The findings indicated that the shoulder, back, and waist regions of the body experienced the most discomfort, while the hips, hamstrings, and hollows of the legs were the most common sites of injury in the lower body. It is also conceivable that the injury developed years after the workout. According to the observational data, the waist (34 persons) has the highest incidence of upper body pain and the shoulders have the lowest prevalence, while in the lower body, the pelvis (30 individuals) experiences the highest pain complaints and the thighs the least (5 people). Therefore, it can be inferred that the risk of harm from gymnastics movement activities varies depending on the region. Based on these findings, it is vital to perform strengthening exercises in the areas that are vulnerable to pain and injury in order to reduce the detrimental effects of these injuries.

Acknowledgments

We are very grateful to Universitas Pendidikan Indonesia.

REFERENCES

- [1] Purnell, M. et al. 'Physical Therapy in Sport Acrobatic gymnastics injury: Occurrence, site and training risk factors', *Physical Therapy in Sport*. Elsevier Ltd, (2010), 11(2), pp. 40–46. doi: 10.1016/j.ptsp.2010.01.002.
- [2] Wagener, S. et al. 'CrossFit ® – Development', (2020). pp. 1–9. doi:10.1016/j.orthtr.2020.07.001
- [3] Pourkazemi, L., Varkiani, M. E., & Alizadeh, M. H. Comparison of Children and Youth Gymnastic Injuries via Sport Medicine Federation Injury Surveillance System in Iran, 2009- 2010. *Procedia - Social and Behavioral Sciences*, (2013). 82, 274–277. <https://doi.org/10.1016/j.sbspro.2013.06.259>
- [4] Grapton X, Lion A, Gauchard GC, Barrault D, Perrin PP. Specific injuries induced by the practice of trampolines, tumbling and acrobatic gymnastics. *Knee Surg Sports Traumatol Arthrosc.* 2013 Feb;21(2):494-9. doi: 10.1007/s00167-012-1982-x. Epub 2012 Apr 5. PMID: 22476523.
- [5] Caine D, Maffulli N, Caine C. Epidemiology of injury in child and adolescent sports: injury rates, risk factors, and prevention. *Clin Sports Med.* 2008 Jan;27(1):19-50, vii. doi: 10.1016/j.csm.2007.10.008. PMID: 18206567.
- [6] O'Kane JW, Levy MR, Pietila KE, Caine DJ, Schiff MA.

- Survey of injuries in Seattle area levels 4 to 10 female club gymnasts. *Clin J Sport Med*. 2011 Nov;21(6):486-92. doi: 10.1097/JSM.0b013e31822e89a8. PMID: 21959798.
- [7] Zachary Y. Kerr, Ross Hayden, Megan Barr, David A. Klossner, Thomas P. Dompier; Epidemiology of National Collegiate Athletic Association Women's Gymnastics Injuries, 2009–2010 Through 2013–2014. *J Athl Train* 1 August 2015; 50 (8): 870–878. doi: <https://doi.org/10.4085/1062-6050-50.7.02>
- [8] Edouard P, Steffen K, Junge A, Leglise M, Soligard T, Engebretsen L. Gymnastics injury incidence during the 2008, 2012 and 2016 Olympic Games: analysis of prospectively collected surveillance data from 963 registered gymnasts during Olympic Games. *Br J Sports Med*. 2018 Apr;52(7):475-481. doi: 10.1136/bjsports-2017-097972. Epub 2017 Oct 14. PMID: 29032364.
- [9] Gupta, R, Singh, A, Singh, KK, et al. Fracture of proximal humerus with dislocation of glenohumeral joint in a 3 year old child: a case report. *J Orthop Case Rep* 2013; 3: 26–28
- [10] Glynn, B., Laird, J., Herrington, L., Rushton, A., & Heneghan, N. R. Analysis of landing performance and ankle injury in elite British artistic gymnastics using a modified drop land task: A longitudinal observational study. *Physical Therapy in Sport*, (2022). 55, 61–69. <https://doi.org/https://doi.org/10.1016/j.ptsp.2022.01.006>
- [11] Sands WA, Shultz BB, Newman AP. Women's gymnastics injuries. A 5-year study. *Am J Sports Med*. 1993 Mar-Apr;21(2):271-6. doi: 10.1177/036354659302100218. PMID: 8465924.
- [12] d'Hemecourt, Pierre A., and Anthony Luke. "Sport-specific biomechanics of spinal injuries in aesthetic athletes (dancers, gymnasts, and figure skaters)." *Clinics in sports medicine* 31.3 (2012): 397-408.
- [13] Carla DiScala, Ilana Lescohier, Martha Barthel, Guohua Li; Injuries to Children with Attention Deficit Hyperactivity Disorder. *Pediatrics* December 1998; 102 (6): 1415–1421. 10.1542/peds.102.6.1415
- [14] Kaldas, J. et al. 'SC', *Physical Therapy in Sport*. (2017). Elsevier Ltd. doi:10.1016/j.ptsp.2017.07.006.
- [15] Arampatzis, A., Morey-klapsing, G. and Bru, G. 'Orthotic effect of a stabilizing mechanism in the surface of gymnastic mats on foot motion during landings'. (2005).15, pp. 507–515. doi: 10.1016/j.uglyin.2004.12.002.
- [16] Sammarco, Vincent James, D. A. Sammarco GJPorter, and L. C. Schon. "Injuries to the tibialis anterior, peroneal tendons, and long flexors of the toes." *The foot and ankle in sport* (2007): 121-146.
- [17] Miller, Heather, Louise Fawcett, and Alison Rushton. "Does gender and ankle injury history affect weightbearing dorsiflexion in elite artistic gymnasts?." *Physical Therapy in Sport* 42 (2020): 46-52.
- [18] Prassas S, Kwon YH, Sands WA. Biomechanical research in artistic gymnastics: a review. *Sports Biomech*. 2006 Jul;5(2):261-91. doi: 10.1080/14763140608522878. PMID: 16939157.
- [19] Amaro, AM. Differences among plantar pressure of acrobatic gymnasts when they jump over two competition floors. Does the presence of mattresses affect the gymnasts' performance? Différences entre la pression plantaire des gymnastes', *Science & Sports*. Elsevier Masson SAS, 2020 pp. 1–9. doi: 10.1016/j.scispo.2020.05.006.
- [20] Wolf, MR, Avery, D. and Wolf, JM. Upper Extremity Injuries in Gymnasts', *Hand Clinics*. Elsevier Inc., 2017. 33(1), pp. 187–197. doi:10.1016/j.hcl.2016.08.010.
- [21] Paz, DA et al. Upper extremity overuse injuries in pediatric athletes: clinical presentation, imaging findings, and treatment, *Journal of Clinical Imaging*. Elsevier BV, 2015 pp. 1–11. doi: 10.1016/j.clinimag.2015.07.028.
- [22] Mauck, Benjamin, et al. "Gymnast's wrist (distal radial physeal stress syndrome)." *Orthopedic Clinics* 51.4 (2020): 493-497.
- [23] Davis, Kirkland W. "Imaging pediatric sports injuries: upper extremity." *Radiologic Clinics* 48.6 (2010): 1199-1211.
- [24] Purnell, Melinda, et al. "Acrobatic gymnastics injury: Occurrence, site and training risk factors." *Physical Therapy in Sport* 11.2 (2010): 40-46.