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THE INFLUENCE OF BODY TYPE, STRENGTH, AND FLEXIBILITY ON INJURY OCCURRENCE AMONG STOK BINA GUNA STUDENTS IN ARTISTIC GYMNASTICS SUBJECT

Hafiz Yazid Lubis[1], Muhammad Isnandar[2], Rahmad Sentosa Waruwu[3], Putra Anugrah Silaban[4]

[1-4] *Physical Education and Health Department, Sekolah Tinggi Olahraga dan Kesehatan Bina Guna, Jl. Alumunium Raya No.77, Tj. Mulia Hilir, Kec. Medan Deli, Kota Medan, Sumatera Utara, Indonesia*

Corresponding author. Email**:** yazid.fiz@gmail.com

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Abstract. This pilot study examined the association between body type, strength, flexibility, and injury risk among Bina Guna College of Sports and Health students. The project yielded significant outcomes. Fifteen volunteers participated in this study. A retrospective investigation with distinct samples was used. A questionnaire gathered the injury history. A previously created and verified grading system classified each individual's injury status as "high" or "low" based on this data. After body-type assessments, strength, and flexibility tests were performed. The MANOVA found no statistically significant difference between groups with low and high injury rates for the dependent variables. However, univariate analysis showed that low-injury patients had higher back extension and ankle dorsiflexion flexibility than those with more injuries (P=0.013). Independent t-tests demonstrated significant differences in age, stature, body mass, and years of gymnastics instruction (P=0.002–0.016) between low and high injury rates. This study indicated that strength and body type do not predict injury risk. Data suggests that gymnasts with low flexibility may be more likely to get hurt. Injury risk may also be linked to the duration of competitive gymnastics. Older, taller, and heavier Gymnasts may be more susceptible to injury. These discoveries for developing individualized training methods and injury prevention.

Keywords: gymnastics; injuries; prevention

INTRODUCTION

Beginner gymnastics student use their upper extremities as weight-bearing joints, imparting high repetitive loads. There are five common upper extremity injuries in the beginner gymnastics student: (1) "gymnast wrist"; (2) grip lock; (3) osteochondritis dissecans of the capitellum; (4) medial tensile injuries of the; and (5) glenohumeral instability (Hart et al., 2024). Risk factors for injury were having an age of ≥13 years and training for ≥8 hours per week at age 11 years (Purnell et al., 2010). Therefore, strength and flexibility are needed in gymnasts to perform movements (H. Lubis et al., 2023; H. Y. Lubis & Heri, 2018) . The intensity of training in terms of the number of hours spent in the gym per training session is also increasing, increasing a gymnast's exposure to injury (Bonanno et al., 2023; Permadi & Hidayatulloh, 2023). Due to the complex nature of the movements performed in gymnastics, a high level of stress is placed on the muscles, tendons, and joint structures of the body, and this is to a greater extent than in most other sports (Grigore et al., 2014). The above reasons justify an increasing interest in preventing sports injuries in gymnasts. Research suggests that deficits in strength and flexibility are risk factors for athletic injuries (Caine et al., 2008). Body type has also been identified as contributing to injury (Richmond et al., 2013).

The present pilot study makes a unique contribution to the field of sports science by examining differences in strength, flexibility, and body type between groups of STOK Bina Guna Gymnastics Students with low and high rates of injuries. The outcome of this study may pave the way for more extensive scale studies with a prospective design, which could, in a more definitive way, identify if the chosen variables are significant risk factors or predictors of injury. Even the information gained from this pilot study, however, may already aid injury prevention strategies and may have implications for coaches in selecting and training future gymnasts.

This research problem outlines the focus and scope of identifies several key elements:

1. Variables of Interest: Body type, strength, and flexibility are the variables that you are investigating.
2. Outcome of Interest: The main outcome of interest is injury

occurrence, suggesting that you are examining how body type, strength, and flexibility relate to the likelihood or frequency of injuries among this population.

The research urgency refers to the reasons or justifications for why this particular study on the influence of body type, strength, and flexibility on injury occurrence among Stok Bina Guna students in artistic gymnastics is important and timely. Here are some points that could contribute to the urgency of this research:

1. Health and Safety Concerns: Understanding how body type, strength, and flexibility contribute to injury occurrence can directly impact the health and safety of Stok Bina Guna students practicing artistic gymnastics. By identifying risk factors, coaches and trainers can implement better injury prevention strategies.
2. Performance Enhancement: Improving body type, strength, and flexibility could potentially enhance athletic performance among gymnasts. This research could provide insights into optimal training methods tailored to individual body types, leading to improved performance outcomes.
3. Evidence-Based Practices: There may be a lack of specific research focusing on the Stok Bina Guna population in artistic gymnastics. By conducting this study, you contribute valuable evidence that can inform training programs and policies specific to this group.
4. Educational and Institutional Impact: The findings could have implications for educational institutions like Stok Bina Guna in terms of curriculum development, coaching practices, and student welfare policies.
5. Contribution to Scientific Knowledge: This study could fill a gap in the existing literature on sports injuries and biomechanics in gymnastics, particularly in relation to body type, strength, and flexibility.
6. Long-term Health and Well-being: Insights gained from this study could potentially reduce the long-term physical consequences of injuries among gymnasts, promoting their overall health and well-being throughout their athletic careers and beyond.

By highlighting these points, you establish the relevance and urgency of investigating how body type, strength, and flexibility influence injury occurrence specifically among Stok Bina Guna students in artistic gymnastics

METHOD

Subjects

The subjects (N=15) were all Students of STOK Bina Guna. All subjects gave their informed written consent, and the study was carried out according to the guidelines of the Declaration of Helsinki. Subjects were tested during the training season over four weeks at the same place and time each week. For this study, an injury was defined as "a gymnastics-related incident that limited participation in any gymnastic class." Injuries were classified by the scoring system described previously (Caine et al., 2008). In brief, this system allows a score to be assigned to each injury incurred depending on the severity of the injury and the number of days training had to be interrupted. According to their scores, individuals were then classified as having a “low” (N=8) or “high” (N=7) injury status.

Testing Protocol

The subjects' body types were determined using the Heath-Carter body type method, which categorizes each individual into three possible body types: endomorph, mesomorph, or ectomorph. The percentage of body fat was estimated from 4 subcutaneous skinfolds (triceps, subscapular, supra iliac, medial calf) using Siri's equation for percentage body fat. A Holstein skinfold caliper measured skinfolds.

Anthropometric data included height, mass, two muscle girths (biceps, medial calf), and two bone widths (humerus, femur). Strength was assessed using two general strength tests (grip strength and standing vertical jump) and two muscular endurance tests (pull-ups and push-ups). According to Johnson and Nelson (1986), Grip strength was determined using a hand-held grip dynamometer adjusted for individual hand size. The vertical jump (using the chalk jump method) and the pull-up/push-up test were performed as Clarke previously described (Clarke, 1976). Flexibility was determined for the shoulder, wrist, ankle, back, and hamstring areas using previously explained procedures. All flexibility tests were carried out after a 30-minute general warm-up.

Data Analysis

Differences in strength and flexibility between the low and high-injury groups were assessed by multivariate analysis of variance (MANOVA). The relationship between body type and injury occurrence was explored using the chi-square test. Differences in anthropometric variables and injury scores were analyzed using an independent samples t-test. A less rigorous a-level may be appropriate when the risk of committing a Type II error may exceed that of Type I errors – often so with small sample sizes. Therefore, this study's results were considered significant at the 90% confidence level.

RESULT AND DISCUSSION

Injury Distribution

Significant differences were seen in the high-injury group's age (P=0.002), height (P=0.006), and weight (P=0.001). The two groups' percentages of body fat did not differ significantly, but their BMI did (P=0.001). The high injury group was classified as slightly "underweight," while the low injury group was in the lowest category, which is classified as "severe protein-energy malnutrition" for adults. Mesomorphy was shown to predominate in both groups, followed by ectomorphy (Table 1). Gymnastics participation was substantially longer in the high-injury group than in the low-injury group (P=0.016).

The low injury group incurred 7 injuries, giving an injury rate of 0.9 per student (0.3/1000 hrs). However, 2 out of the eight students did not experience any injuries. In comparison, the high injury rate group reported 27 injuries at a rate of 3.9 injuries per student (1.8/1000 hrs).

Injury and Strength

There were no significant differences between the strength capabilities of the low and high-injury groups. On closer inspection of the data, trends were observed (P=0.021), suggesting that the high-injury group scored better on the vertical jump than the low-injury group.

Injury and Flexibility

MANOVA did not reveal any significant differences between the flexibility capabilities of the low and high-injury rate groups.

However, univariate analyses indicated that the low injury rate group scored better on the back extension in the bridge (P=0.013) and ankle dorsiflexion (P=0.013; Table 2).

Table 1 Comparison of gymnasts with low (N=8) and high (N=7) injury status on selected anthropometric measures.

Item	Low Injury	High Injury
Age (yrs)	9.5 ± 1.3*	14.3 ± 3.3*
Stature (cm)	132.5 ± 6.8*	153.9 ± 17.3*
Mass (kg)	28.0 ± 4.3*	48.0 ± 12.8*
BMI	15.8 ± 1.3*	1.5 ± 0.5
Endomorphy	19.8 ± 2.5*	2.0 ± 0.6
Mesomorphy	4.0 ± 0.3	3.3 ± 0.9
Ectomorphy	3.4 ± 0.7	2.9 ± 0.9
Body Fat (%)†	19.4 ± 2.6	22.4 ± 3.3
Average Injury Score	2.9 ± 2.6*‡	19.1 ± 8.8*‡

*Significance P<0.05.

†Estimated from the sum of four skinfolds (2).

‡Groups were defined based on the rate of injuries.

Injury and Body Type

Out of the 15 subjects tested, 66.7% were *ectomesomorphs*. Three subjects were *meso-ectomorphs*, and the remaining 2 subjects were balanced meso-morph-ectomorphs (see Table 3). By categorizing the frequency of body types across injury status, it was observed that the dominant body type was distributed equally for both low and high-injury status groups.

Types and Location of Injuries

Table 4 provides an overview of the types of injuries incurred. Sprains and strains dominated the range of injuries by far, and the two together accounted for approximately 50% of the injuries in either the low or high-injury group. The percentage of acute injuries in the low-injury group was 88, as opposed to 70.4 in the high-injury group. The number of overuse injuries was significantly higher in the high-injury group than in the low-injury group (29.0 vs. 11.1%). As to the specific sites of injuries, the lower extremity, particularly the ankle, was affected in 50% of all cases. The lower back was the second most commonly injured site (13.8%), with the toes as a close runner-up (11.1%). No association between types of injuries and the factors of age, height, strength, or flexibility was identified. However, there was a clear association between the instrument and the number of injuries, with the beam alone accounting for almost three-quarters of all injuries in the low-injury group. In the high-injury group, the beam was still responsible for the highest proportion of the injuries (28%) immediately following.

The differences this research on "The influence of body type, strength, and flexibility on injury occurrence among Stok Bina Guna students in artistic gymnastics" from other studies, you can emphasize several aspects:

1. Specific Population: Your study focuses specifically on Stok Bina Guna students in artistic gymnastics. This population might have unique characteristics, training

environments, and coaching approaches compared to other gymnastic programs or general athletic populations.

2. Contextual Factors: Considerations such as cultural influences, training methodologies used by Stok Bina Guna, and the specific challenges or advantages faced by this group could differentiate your research. These factors might influence how body type, strength, and flexibility interact with injury occurrence.
3. Comprehensive Approach: Your study may take a comprehensive approach by examining multiple factors (body type, strength, flexibility) simultaneously and their combined influence on injuries. This holistic view can provide a deeper understanding compared to studies that focus on only one or two variables.
4. Practical Implications: Highlight how your findings could lead to practical implications tailored specifically for Stok Bina Guna students and their coaches. For instance, insights into injury prevention strategies or personalized training recommendations based on body type and flexibility profiles.
5. Methodological Innovations: If applicable, discuss any innovative methodologies or measurement techniques you employ that contribute to the advancement of research in this area. This could include detailed biomechanical assessments, longitudinal studies, or advanced statistical analyses.
6. Educational Impact: Consider how your research could impact educational practices within Stok Bina Guna or similar institutions, such as curriculum development, athlete monitoring, or injury management protocols.

By focusing on these differences, you can clearly articulate the unique contributions and relevance of your research compared to existing studies on similar topics in gymnastics or sports science

Table 2. Comparison of gymnasts with low (N=8) and high (N=7) injury status on selected strength and flexibility measures.

Item	Low Injury	High Injury
Strength		
Sargent Jump (cm)	37.6 ± 7.4*	45.7 ± 3.8*

Grip Strength (N/kg)	5.9 ± 0.9	5.9 ± 0.9
Pull Up: Push Up (Absolute score: PI†)	0.4 ± 0.2	0.3 ± 0.2
Flexibility		
Sit and Reach (cm)	31.8 ± 2.7	31.6 ± 3.5
Shoulder and Wrist Elevation‡ (cm)	25.7 ± 10.5	31.9 ± 14.0
Back Extension in Bridge‡ (cm)	22.6 ± 1.9*	25.3 ± 4.9*
Ankle Dorsi-flexion‡ (cm)	62.3 ± 8.0*	75.9 ± 10.3*
Ankle Plantar-flexion‡ (cm)	2.0 ± 1.7	1.8 ± 0.9

*Levels of significance P<0.05. †Ponderal Index. ‡Lower score=better performance (according to ref. 6).

Table 3. Distribution of body types across low (N= 8) and high injury (N=7) status groups

Body-type	Low Injury	High Injury
Ecto-Mesomorph	5	5
Meso-Ectomorph	2	1
Mesomorph-Ectomorph	1	1
Total	8	7

Table 4. Injury type distribution among high (N=7) and low injury groups (N=8)

Injury type	Low injury (%)	High injury (%)
Sprain	28.6	25.9
Strain	28.6	22.2
Fracture	–	18.6*
Abrasion	42.8*	3.7*
Elongation	–	11.1*
Contusion	–	7.4
Growth plate	–	3.7
Other	–	7.4
Total	100	100

*Significantly different at P<0.05.

CONCLUSION

Some of our data are derived from a retrospective research design. It is recognized that results may have been confounded to some extent by previous injuries. The student may have recovered from a past injury, which may not presently affect performance but may have altered physical characteristics such as strength and flexibility. In addition, our trial design is not free of the often-typical problems associated with retrospective studies. These problems have been explained in detail elsewhere and mainly have to do with the unreliability of the data depending on the individual's account. The above-mentioned problems, as well as the limited size and, thus, possibly above-normal homogeneity of the present sample, represent confounding variables. However, the retrospective approach is highly cost-effective and can indicate potential risk factors.

In the present study, most of the injuries reported were acute (Bolling & Leite, 2012; Glynn et al., 2022; Junaidi, 2013). Consistent with the findings of this study, many researchers have found that in gymnasts, the ankle is highly vulnerable to injury (Glynn et al., 2022; Mills et al., 2009; Pain et al., 2007). It was found in the present study that approximately 20% of the injuries were caused by dismounting or repetitive heavy landings; these may contribute to the high incidence of ankle injuries found. From this information, the quality of the landing mat should be considered carefully so that injuries such as these are reduced or prevented entirely. In addition, attention should be paid to new strategies to prevent injuries, especially exercises involving the beam, which is the most dangerous apparatus.

It has been stated that the pre-pubertal physique is favorable and has advantages in terms of strength-to-weight ratio. From this assumption, it was expected that the low-injury group would perform better on the pull-up/push-up test as the gymnasts in this group were significantly younger, lighter, and shorter. However, in this study, strength was not a significant factor in predicting injury risk. This may be because the two groups train for a similar number of hours per week and follow similar training programs in strength training. Inter-individual differences in strength across low and high-injury groups depended on which strength test was performed. Although group comparisons in strength thus did not reach significance, trends were suggesting that the high-injury group scored better on tests of absolute strength and power, as in the vertical jump and grip strength; conversely, the low-injury group performed better on the pull-up/push-up test. However, one should remember that this test relies heavily on a high strength-to-weight ratio. No definite conclusions are aimed since this study merely represented a pilot project. Similar small-scale studies offer helpful information that may assist in better designing later, more extensive studies, ideally needing a prospective design.

Trends also indicated that people with less flexibility are more likely to have injuries. These results suggest that a lower level of flexibility may contribute to injury risk. Many researchers suggest that deficits in flexibility can contribute to the greater occurrence of injury. By categorizing the frequency of body types across injury status, it was observed that the dominant body types were distributed equally for both low and high-injury groups.

There were no significant differences between the groups regarding hours of training per week.

However, the high-injury group had been participating in the sport significantly longer than the low-injury group. Thus, in effect, the high-injury group has had a more prolonged exposure to the sport and consequently may suffer more injuries as a result. The number of years participating in the sport is a significant factor in predicting injury risk.

It is apparent that many factors may contribute to injury risk within the same risk group, even when scoring similar results in the tests performed. In conclusion, the results of the present study teach us that flexibility, in particular, may affect injury risk among competitive female gymnasts. Age, stature, body mass, and number of years in the sport may provide more information about an individual's predisposition to injury than strength or body-type rating. It might be helpful to develop a form of physical assessment that, prior to participation, detects factors that predispose an individual to injury. An awareness of injury predisposition prior to the onset of intensive training may prevent the injury from occurring.

Furthermore, it is essential that the coach that athletes who have sustained previous injuries may be at a greater risk of injury. Children, especially those participating at the highest levels, deserve special consideration to avoid permanent damage. As intensive training of young athletes increases, so will the number of injuries incurred.

The introduction of an age limit would prevent the exploitation of children by excessive training routines and possibly reduce risk-taking. The data of the present pilot study may produce a valuable basis for more extensive prospective studies to generate conclusions with broader applicability and further identify the factors that may predispose young individuals to injury.

REFERENCES

Bolling, C., & Leite, M. (2012). Difference in injury profile in Trampoline and Artistic Gymnastics. *Journal of Science and Medicine in Sport*, *15*, S127–S128. https://doi.org/10.1016/J.JSAMS.2012.11.307

Bonanno, J., Casey, E., & Faustin, M. (2023). The youth athlete: Gymnastics. *The Youth Athlete: A Practitioner's Guide to Providing Comprehensive Sports Medicine Care*, 811–824. https://doi.org/10.1016/B978-0-323-99992-2.00078-5

Caine, D., Maffulli, N., & Caine, C. (2008). Epidemiology of Injury in Child and Adolescent Sports: Injury Rates, Risk Factors, and Prevention. *Clinics in Sports Medicine*, *27*(1), 19–50.

https://doi.org/10.1016/J.CSM.2007.10.008

Clarke, H. H. (1976). *Application of measurement to health and physical education* . Prentice-Hall.

Glynn, B., Laird, J., Herrington, L., Rushton, A., & Heneghan, N. R. (2022). 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*, *55*, 61–69. https://doi.org/10.1016/J.PTSP.2022.01.006

Grigore, V., Cosma, G., & Păunescu, M. (2014). Retrospective Study Regarding Artistic Gymnastics Injuries. *Procedia - Social and Behavioral Sciences*, *117*, 45–49. https://doi.org/10.1016/J.SBSPRO.2014.02.176

Hart, E., Bauer, A. S., & Bae, D. S. (2024). Common upper extremity gymnastics injuries and gymnastic specific return to play protocols. *Journal of the Pediatric Orthopaedic Society of North America*, *6*, 100016. https://doi.org/10.1016/J.JPOSNA.2024.100016

Junaidi, J. (2013). Cedera Olahraga Pada Atlet Provinsi Dki Jakarta (Pengaruh Pemahaman Pelatih, Sarana & Prasarana Olahraga dan Metode Latihan Terhadap Terjadinya Cedera Olahraga). *Gladi : Jurnal Ilmu Keolahragaan*, *7*(2), 746–764. https://doi.org/10.21009/GJIK.072.02

Lubis, H., Setiakarnawijaya, Y., Jauhari, M., Jasmani Kesehatan dan Rekreasi, P., Tinggi Olahraga dan Kesehatan Bina Guna, S., Jasmani, P., & Jurnal, G. (2023). The Effect of Arm Muscle Power, Waist Flexibility, And Self-Confidence on Front Handspring Skills in Artistics Gymnastics. *Gladi : Jurnal Ilmu Keolahragaan*, *14*(03), 357–368. https://doi.org/10.21009/GJIK.143.10

Lubis, H. Y., & Heri, Z. (2018). Analisis Gerak Round Off Sebagai Rangkaian Gerak Senam Lantai Pada Atlet Putra Persani Medan. *JURNAL PRESTASI*, *2*(4), 1–8. https://doi.org/10.24114/JP.V2I4.11908

Mills, C., Pain, M. T. G., & Yeadon, M. R. (2009). Reducing ground reaction forces in gymnastics' landings may increase internal loading. *Journal of Biomechanics*, *42*(6), 671–678. https://doi.org/10.1016/J.JBIOMECH.2009.01.019

Nelson, J. K., & Johnson, B. L. (1986). *Practical Measurements for Evaluation in Physical Education* (Subsequent). Macmillan Pub Co.

Pain, M. T. G., Mills, C., & Yeadon, M. R. (2007). Optimising Landing Strategies To Minimise Injury Risk During Gymnastics Landings. *Journal of Biomechanics*, *40*, S200. https://doi.org/10.1016/S0021-9290(07)70196-3

Permadi, A. P. P., & Hidayatulloh, D. T. (2023). Model of Based Physical Fitness Exercise Gurilapss Gymnastics (Mountain, Rimba, Ocean, Beach, River, Cultural Arts) Age 20-40 Years. *Gladi : Jurnal Ilmu Keolahragaan*, *14*(02), 229–237. https://doi.org/10.21009/GJIK.142.09

Purnell, M., Shirley, D., Nicholson, L., & Adams, R. (2010). Acrobatic gymnastics injury: Occurrence, site and training risk factors. *Physical Therapy in Sport*, *11*(2), 40–46. https://doi.org/10.1016/J.PTSP.2010.01.002

Richmond, S. A., Kang, J., & Emery, C. A. (2013). Is body mass index a risk factor for sport injury in adolescents? *Journal of Science and Medicine in Sport*, *16*(5), 401–405. https://doi.org/10.1016/J.JSAMS.2012.11.898