

The effect of training on flexibility: a case study of athletes and non-athletes

El efecto del entrenamiento sobre la flexibilidad: un estudio de caso de deportistas y no deportistas

*Nuridin Widya Pranoto, *Heru Andika, *Yovhandra Ockta, *Kamal Firdaus, *Nofri Hendri, *Fiky Zarya, , **Vlad Adrian Geantă, , ***Aydmn Karaçam

*Universitas Negeri Padang (Indonesia), **Aurel Vlaicu University of Arad (Romania), ***Bandırma Onyedi Eylül University (Turkey)

Abstract. Background and Objectives: Flexibility is one of the main components of physical fitness that is important in improving athletic performance and general health. This study aims to evaluate the effect of training on flexibility and compare the effectiveness of training in athletes and non-athletes. Methodology: This study used an observational case study design involving 460 participants aged 18-20 years who were divided into two groups, namely athletes and non-athletes. The athlete group consisted of individuals who were routinely involved in intensive physical activity, while non-athletes did not have a structured physical exercise routine. Flexibility tests were conducted using the sit-and-reach method before and after the exercise program. Data were analyzed using paired t-tests and unpaired t-tests to evaluate differences in flexibility improvement between the two groups. Results: Athletes, who regularly engage in intensive physical activity, showed a more significant increase in flexibility than non-athletes. The athlete group had a higher average flexibility, with a statistically significant difference, with an average increase of 26 cm in athletes and 15 cm in non-athletes ($p < 0.05$). The difference in flexibility improvement between the two groups was also statistically significant, with an average difference of 11 cm ($p < 0.05$). Conclusion: This study confirms that regular physical exercise significantly improves flexibility, especially in athletes. The athlete group showed a better response to the exercise program compared to non-athletes, which emphasizes the importance of structured exercise in maintaining and improving flexibility. These findings can provide insights for coaches, physiotherapists, and health professionals in designing effective exercise programs for various population groups.

Keywords: flexibility, flexibility, physical exercise, athletes, non-athletes

Resumen. Contexto y Objetivos: La flexibilidad es uno de los principales componentes de la condición física que es importante para mejorar el rendimiento atlético y la salud general. Este estudio tiene como objetivo evaluar el efecto del entrenamiento en la flexibilidad y comparar la efectividad del entrenamiento en atletas y no atletas. Metodología: Este estudio utilizó un diseño de estudio de caso observacional que involucró a 460 participantes de entre 18 y 20 años, quienes fueron divididos en dos grupos, a saber, atletas y no atletas. El grupo de atletas estaba compuesto por individuos que participaban rutinariamente en actividad física intensa, mientras que los no atletas no tenían una rutina estructurada de ejercicio físico. Las pruebas de flexibilidad se realizaron utilizando el método de sentarse y alcanzar antes y después del programa de ejercicios. Los datos se analizaron utilizando pruebas t pareadas y pruebas t no pareadas para evaluar las diferencias en la mejora de la flexibilidad entre los dos grupos. Resultados: Los atletas, que se dedican regularmente a la actividad física intensa, mostraron un aumento más significativo en la flexibilidad que los no atletas. El grupo de atletas tuvo una flexibilidad promedio más alta, con una diferencia estadísticamente significativa, con un aumento promedio de 26 cm en los atletas y 15 cm en los no atletas ($p < 0.05$). La diferencia en la mejora de la flexibilidad entre los dos grupos también fue estadísticamente significativa, con una diferencia promedio de 11 cm ($p < 0.05$). Conclusión: Este estudio confirma que el ejercicio físico regular mejora significativamente la flexibilidad, especialmente en los atletas. El grupo de atletas mostró una mejor respuesta al programa de ejercicios en comparación con los no atletas, lo que enfatiza la importancia del ejercicio estructurado en el mantenimiento y mejora de la flexibilidad. Estos hallazgos pueden proporcionar información a entrenadores, fisioterapeutas y profesionales de la salud para diseñar programas de ejercicio efectivos para diversos grupos poblacionales.

Palabras clave: flexibilidad, flexibilidad, ejercicio físico, atletas, no atletas

Fecha recepción: 04-09-24. Fecha de aceptación: 22-10-24

varhatun fauziah
fauziah44342@gmail.com

Introduction

An athlete is an individual who regularly engages in physical activity and sport with the aim of achieving optimal performance in a particular sport.(Cid-Calfucura et al., 2023). Its performance is highly dependent on various physical factors.(Zago et al., 2021), including strength, speed, endurance, and flexibility. Flexibility, as one of the main components of physical fitness, plays an important role in supporting athletic performance.(Blake, 2023). Good flexibility allows athletes to perform movements more efficiently, reduce the risk of injury, and improve technical ability in their sport.(Diffendaffer et al., 2023). Structured and regular training is the key to improving athletic performance, including flexibility.(Alonso-Fernández et al., 2022). Stretching exercises, both static

and dynamic, as well as exercise programs such as yoga and Pilates, have been shown to be effective in increasing muscle flexibility and joint range of motion. For example, research by Eckard et al., (2018) showed that a 12-week yoga program significantly improved flexibility in participants compared to a control group that did not exercise. Flexibility is an important component of physical fitness that contributes to an individual's athletic performance and general health. Good flexibility can improve movement ability, reduce the risk of injury, and improve posture. However, the level of flexibility can vary significantly between individuals, especially between those involved in intensive physical activity such as athletes and those who are less active or non-athletes.(Schwank et al., 2022). Flexibility is an important component of physical fit-

ness for all individuals.(Raya-Gonzalez et al., 2021), including those who do not engage in intensive physical activity such as athletes. Although non-athletes may not have high performance demands in sports, flexibility still plays a crucial role in everyday life.(Wan et al., 2021). Good flexibility can help individuals perform routine activities more efficiently, such as bending, lifting, and walking, thereby improving quality of life and independence.(Anderson et al., 2021). In non-athlete populations, lack of regular physical activity can lead to decreased flexibility, which can ultimately contribute to decreased mobility, poor posture, and a higher risk of musculoskeletal injuries. Decreased flexibility is also a natural part of the aging process, with muscles and connective tissues tending to become stiffer as we age.(Sulowska-Daszyk & Skiba, 2022). This condition can result in decreased range of motion and difficulty in performing daily activities. Therefore, regular stretching exercises are highly recommended for non-athletes to maintain or improve flexibility, prevent decreased mobility, and minimize the risk of injury. Research by Charlton et al. (2018) found that a structured stretching program can improve flexibility in various age groups, including young adults and older adults, and help slow the decline in flexibility that often occurs in the aging process.

Previous studies have shown that structured exercise programs can improve flexibility across a range of age groups and activity levels. For example, research by M. Chen et al., (2022) found that athletes tend to have higher levels of flexibility than non-athletes due to their regular and intense training routines. Another study by Behm & Chaouachi, (2011) showed that a dynamic stretching program applied to professional athletes resulted in significant improvements in flexibility compared to a control group of non-athletes who did not perform the same training program. However, direct comparisons between athletes and non-athletes in the context of increased flexibility due to training are still rare. Most studies focus on one group only, without comparing the effects of training on both groups simultaneously. A study by Wei et al., (2024) indicated that non-athletes who followed an 8-week stretching program showed improvements in flexibility, but the improvements were not comparable to athletes who underwent a similar program.

This study aims to fill this gap by observing and analyzing the effects of training on flexibility in athletes and non-athletes. This case study will identify significant differences in flexibility levels before and after a specific training program, and determine whether there are consistent differences between the two groups. With a better understanding of how training affects flexibility in athletes and non-athletes, it is hoped that the results of this study can provide significant contributions to the development of more effective and targeted training programs. In addition, the findings of this study can also provide insights for coaches, physiotherapists, and health professionals in designing appropriate interventions to improve flexibility and prevent injury in different populations.

Materials & Methods

This study used an observational case study design to observe and analyze the effects of exercise on flexibility in two groups: athletes and non-athletes. Participants in this study consisted of 460 people aged 18-20 years who were divided into two groups based on their physical activity. The first group were athletes who regularly engage in intensive physical activity from various sports such as gymnastics, swimming, and athletics. The second group were non-athletes who did not have a structured physical exercise routine. The sampling process was carried out using a purposive sampling method, where participants were selected based on predetermined inclusion and exclusion criteria. The inclusion criteria included individuals aged 18-20 years who were willing to follow a set exercise program during the study period. After selection, participants were grouped into two categories: athletes and non-athletes. The athlete group included individuals who routinely exercised at least 4 times a week, while the non-athlete group were those who did not regularly participate in structured physical exercise. All participants underwent a sit-and-reach test to measure their flexibility levels. Measurements were carried out with the same procedure for all participants, and each measurement was repeated three times to obtain an accurate average value.

Data analysis

The collected data were analyzed using a paired t-test to evaluate changes in flexibility before and after the training period in each group. In addition, an independent t-test was used to compare the results between the athlete and non-athlete groups, in order to identify significant differences in flexibility improvement.

Results

Participant Characteristics

The study involved two groups of participants: athletes and non-athletes. The table below shows the average characteristics of participants from both groups, including average height, average weight, and average flexibility scores as measured using the sit and reach test.

Table 1.

Category	Average height	Average weight	Average value
Athlete	164.7	57.8	17.6
Non-Athlete	164.0	58.5	8.5

From the table above, it can be seen that the average height and weight between the athlete and non-athlete groups are relatively similar. The athlete group has an average height of 164.7 cm and an average weight of 57.8 kg, while the non-athlete group has an average height of 164.0 cm and an average weight of 58.5 kg. However, there is a significant difference in the average flexibility value between the two groups. The athlete group showed an average flexibility value of 17.6 cm, which was much higher

than the non-athlete group which had an average flexibility value of 8.5 cm.

Statistical Analysis

Statistical analysis using paired t-test showed that there was a significant increase in flexibility in both groups after the observation period. In the athlete group, the average increase in flexibility was 2.6 cm with a p-value <0.05, indicating that this increase was statistically significant. The non-athlete group also showed a significant increase with an average increase of 1.5 cm and a p-value <0.05. Furthermore, analysis using an unpaired t-test was conducted to compare the changes in flexibility between the two groups. The results of the analysis showed a significant difference in the increase in flexibility between the athlete and non-athlete groups, with the athlete group showing a greater increase. The average difference in flexibility increase between the two groups was 1.1 cm with a p-value <0.05, indicating that this difference was statistically significant.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Nilai sit and reach	Equal variances assumed	4.963	.026	3.490	458	.001	13.44783	3.85373	5.87463	21.02102
	Equal variances not assumed			3.490	427.156	.001	13.44783	3.85373	5.87318	21.02247

Figure 1. t-Test Results on Sit and Reach Values

Interpretation of Results

The results of this study indicate that the athlete group had a higher level of flexibility compared to the non-athlete group. Flexibility measurements were performed using the sit-and-reach test in both groups to evaluate differences in flexibility levels. The data showed that athletes, who regularly engage in intensive physical activity and have a training routine that includes flexibility training, had higher average flexibility than non-athletes. The significant difference in flexibility levels between the athlete and non-athlete groups indicates that intensive and structured physical training routines followed by athletes consistently can improve their flexibility better than individuals who do not have a structured physical training routine. Thus, these results highlight the importance of regular training in maintaining and improving flexibility, and suggest that non-athletes may require more targeted interventions to achieve comparable levels of flexibility.

Discussion

This study showed a significant difference in flexibility between athletes and non-athletes. The data obtained showed that the average flexibility value in the athlete group was 17.6 cm, while in the non-athlete group it was only 8.5 cm. This finding indicates that regular physical exercise plays an important role in improving body flexibility. Better

flexibility in athletes can be attributed to their training routines, which usually include various stretching exercises and other physical activities designed to improve range of motion and muscle elasticity. The physical exercises performed by athletes involve many movements that can improve flexibility, such as dynamic and static stretching, as well as strength training that requires a wide range of motion. These exercises not only help improve muscle and joint flexibility but also improve coordination and motor control. The study by Wilk et al., (2024) showed that an exercise program that includes stretching can improve flexibility and reduce the risk of injury. This supports the findings of this study that athletes, who regularly do physical exercise, have better flexibility than non-athletes.

Additionally, regular physical exercise can help maintain or improve flexibility as you age. (J. Chen et al., 2024a). Decreased flexibility often occurs as part of the aging process, but regular physical activity can slow or prevent this decline. A study by Charlton et al., (2018) found that stretching exercises significantly improved flexibility in various age groups, including young adults like the subjects in this study. Therefore, it is important for individuals to remain physically active and include flexibility exercises in their routines to maintain mobility and prevent injury. In the non-athlete group, lower flexibility scores may be due to a lack of regular physical activity. Many of them may not be doing stretching or exercises designed to improve flexibility, so their muscles and joints are less elastic and have a more limited range of motion. (Zalani-Kiss et al., 2018). This is in accordance with research by Savalli et al., (2012) who found that individuals who were physically inactive tended to have lower flexibility than those who exercised regularly.

Differences in training routines between athletes and non-athletes may also contribute to these differences in flexibility. Athletes typically undergo structured, intensive training programs that include a variety of exercises, including stretching, strength training, and cardiovascular exercise. In contrast, non-athletes may not have access to or motivation to follow a similar training program, which may affect their flexibility. A structured, consistent training program is essential to improving and maintaining flexibility. (Eid et al., 2017). Better flexibility in athletes is not only beneficial in the context of sports performance but is also important for general health and quality of life. Good flexibility can help prevent injuries, improve posture, and improve everyday mobility. Savalli et al., (2012) mentioned that good flexibility can reduce the risk of muscle and joint injuries and improve overall quality of life. Therefore, it is important for individuals, including non-athletes, to include flexibility exercises in their routines to maintain overall health and fitness. The conclusion of this study is that there is a significant difference in flexibility between athletes and non-athletes, indicating the importance of regular physical exercise to improve flexibility. Better flexibility in athletes indicates that regular physical exercise can provide significant benefits in improving range of

motion and muscle elasticity. Therefore, it is important for individuals to stay physically active and include flexibility exercises in their routines to maintain health and fitness.

This study also has some limitations. As an observational study, a direct causal relationship between exercise and increased flexibility cannot be claimed. In addition, the study sample only included individuals aged 18–20 years, which may not be representative of the broader population. Further research with experimental designs and more diverse samples is needed to confirm these findings and further explore the relationship between exercise and flexibility. Skilled athletes have superior postural control and cognitive flexibility compared to non-athletes when performing dual tasks (Chen et al., 2024). Skilled athletes require excellent postural control during their activities, which is often accompanied by additional cognitive processes. For example, rhythmic gymnasts not only perform complex routines with multiple props but also synchronize their movements to music, requiring constant retrieval from long-term memory while maintaining postural stability on the balance beam. However, these simultaneous cognitive processes increase the demand for attentional resources and require efficient utilization and allocation. Although previous studies have shown that gymnasts allocate fewer attentional resources to postural control than non-athletes, there is a lack of research examining how skilled athletes utilize and allocate their attentional resources in multitasking situations that resemble real sport settings. Therefore, the aim of this study was to investigate the characteristics and neural mechanisms of postural control in skilled athletes by analyzing the utilization and allocation of attentional resources during multitasking situations.

Conclusion

This study showed a significant difference in flexibility between athletes and non-athletes. The results showed that athletes had a higher mean flexibility score (17.6 cm) compared to non-athletes (8.5 cm). This difference may be attributed to the regular and intensive physical training routines performed by athletes, which include various types of stretching exercises and other physical activities that improve range of motion and muscle elasticity. In contrast, the lack of regular physical activity in non-athletes may be the cause of their low flexibility. These findings emphasize the importance of regular physical exercise to improve and maintain flexibility, which is beneficial not only in the context of sports performance but also for general health and quality of life. Regular stretching exercises can help prevent injuries, improve posture, and enhance daily mobility. Thus, both athletes and non-athletes are encouraged to include flexibility exercises in their routines to achieve optimal health and fitness. Further studies are needed to confirm these findings and explore the relationship between physical exercise and flexibility in a wider population.

References

- Alonso-Fernández, D., Fernández-Rodríguez, R., Taboada-Iglesias, Y., & Gutiérrez-Sánchez, Á. (2022). Effects of Copenhagen Adduction Exercise on Muscle Architecture and Adductor Flexibility. *International Journal of Environmental Research and Public Health*, 19(11). <https://doi.org/10.3390/ijerph19116563>
- Anderson, B.L., Harter, R.A., & Farnsworth, J.L. (2021). The Acute Effects of Foam Rolling and Dynamic Stretching on Athletic Performance: A Critically Appraised Topic. *Journal of Sport Rehabilitation*, 30(3), 501–506. <https://doi.org/10.1123/JSR.2020-0059>
- Behm, D. G., & Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. *European Journal of Applied Physiology*, 111(11), 2633–2651. <https://doi.org/10.1007/S00421-011-1879-2/METRICS>
- Blake, R.L. (2023). Application of Biomechanics in Treating the Athlete: The All Important Measurements of Relaxed Calcaneal Stance Position, Achilles Flexibility, and First Ray Range of Motion. *Clinics in Podiatric Medicine and Surgery*, 40(1), 97–115. <https://doi.org/10.1016/j.cpm.2022.07.007>
- Charlton, P., Raysmith, B., Rice, S., Wollin, M., Purdam, C., Clark, R., & Drew, M. (2018). Strength, not flexibility is responsive to match-play in Australian Football athletes. *Journal of Science and Medicine in Sport*, 21, S63. <https://doi.org/10.1016/J.JSAMS.2018.09.144>
- Chen, J., Kwok, APK, & Li, Y. (2024a). Postural control and cognitive flexibility in skilled athletes: Insights from dual-task performance and event-related potentials. *Brain Research Bulletin*, 212, 110957. <https://doi.org/10.1016/J.BRAINRESBULL.2024.110957>
- Chen, J., Kwok, APK, & Li, Y. (2024b). Postural control and cognitive flexibility in skilled athletes: Insights from dual-task performance and event-related potentials. *Brain Research Bulletin*, 212, 110957. <https://doi.org/10.1016/J.BRAINRESBULL.2024.110957>
- Chen, M., Dutt, A.S., & Nair, R. (2022). Systematic review of reviews on Activities of Daily Living measures for children with developmental disabilities. *Heliyon*, 8(6), e09698. <https://doi.org/10.1016/J.HELİYON.2022.E09698>
- Cid-Calfucura, I., Herrera-Valenzuela, T., Franchini, E., Falco, C., Alvial-Moscoso, J., Pardo-Tamayo, C., Zapata-Huenullán, C., Ojeda-Aravena, A., & Valdés-Badilla, P. (2023). Effects of Strength Training on Physical Fitness of Olympic Combat Sports Athletes: A Systematic Review. *International Journal of Environmental Research and Public Health*, 20(4). <https://doi.org/10.3390/ijerph20043516>

- Diffendaffer, A.Z., Bagwell, M.S., Fleisig, G.S., Yanagita, Y., Stewart, M., Cain, E.L., Dugas, J.R., & Wilk, K.E. (2023). The Clinician's Guide to Baseball Pitching Biomechanics. *Sports Health*, 15(2), 274–281. <https://doi.org/10.1177/19417381221078537>
- Eckard, TG, Padua, DA, Hearn, DW, Pexa, BS, & Frank, BS (2018). The Relationship Between Training Load and Injury in Athletes: A Systematic Review. *Sports Medicine*, 48(8), 1929–1961. <https://doi.org/10.1007/S40279-018-0951-Z>
- Eid, K., Tafas, E., Mylonas, K., Angelopoulos, P., Tsepis, E., & Fousekis, K. (2017). Treatment of the trunk and lower extremities with Ergon® IASTM technique can increase hamstring flexibility in amateur athletes: A randomized control study. *Physical Therapy in Sport*, 28, e12. <https://doi.org/10.1016/J.PTSP.2017.08.038>
- Raya-Gonzalez, J., Castillo, D., & Clemente, F. M. (2021). Injury prevention of hamstring injuries through exercise interventions. *Journal of Sports Medicine and Physical Fitness*, 61(9), 1242–1251. <https://doi.org/10.23736/S0022-4707.21.11670-6>
- Savalli, L., Hernandez-Sendin, M.I., Leroy, P., & Laboute, E. (2012a). Comparative study of gender-related muscle quality and spinal flexibility in athletes. *Annals of Physical and Rehabilitation Medicine*, 55, e261. <https://doi.org/10.1016/J.REHAB.2012.07.658>
- Savalli, L., Hernandez-Sendin, M.I., Leroy, P., & Laboute, E. (2012b). What is the relationship between muscle strength and flexibility qualities of the spine in athletes? *Annals of Physical and Rehabilitation Medicine*, 55, e262. <https://doi.org/10.1016/J.REHAB.2012.07.660>
- Schwank, A., Blazey, P., Asker, M., Möller, M., Häggglund, M., Gard, S., Skazalski, C., Andersson, S.H., Horsley, I., Whiteley, R., Cools, A.M., Bizzini, M., Ardern, C.L., Albrecht, C., Andersson, S., Ashworth, B., Asker, M., Bizzini, M., Clarsen, B., ... Schwank, A. (2022). 2022 Bern Consensus Statement on Shoulder Injury Prevention, Rehabilitation, and Return to Sport for Athletes at All Participation Levels. *Journal of Orthopedic and Sports Physical Therapy*, 52(1), 11–28. <https://doi.org/10.2519/JOSPT.2022.10952>
- Sulowska-Daszyk, I., & Skiba, A. (2022). The influence of self-myofascial release on muscle flexibility in long-distance runners. *International Journal of Environmental Research and Public Health*, 19(1). <https://doi.org/10.3390/ijerph19010457>
- Wan, X., Li, S., Best, T.M., Liu, H., Li, H., & Yu, B. (2021). Effects of flexibility and strength training on peak hamstring musculotendinous strains during sprinting. *Journal of Sport and Health Science*, 10(2), 222–229. <https://doi.org/10.1016/j.jshs.2020.08.001>
- Wei, W., Zhang, W. xu, Tang, L., Ren, H. feng, Zhu, L. gang, Li, H. le, Wang, Y., & Chang, Q. (2024). The application of modified functional movement screen as predictor of training injury in athletes. *Heliyon*, 10(6), e28299. <https://doi.org/10.1016/J.HELİYON.2024.E28299>
- Wilk, K. E., Arrigo, C. A., & Ivey, M. (2024). Rehabilitation of the Shoulder and Elbow in the Throwing Athlete. *Clinics in Sports Medicine*. <https://doi.org/10.1016/J.CSM.2024.06.001>
- Zago, J., Amatuzzi, F., Rondinel, T., & Matheus, J. P. (2021). Osteopathic manipulative treatment versus exercise program in runners with patellofemoral pain syndrome: A randomized controlled trial. *Journal of Sport Rehabilitation*, 30(4), 609–618. <https://doi.org/10.1123/JSR.2020-0108>
- Zaláni-Kiss, L., Király, B., Mazzag, K., Ács, P., Boncz, I., Molics, B., & Melczer, C. (2018). Differences in the Flexibility of Muscles of Athletes Doing Weight Training and Functional Training. *Values in Health*, 21, S200. <https://doi.org/10.1016/J.JVAL.2018.04.135>

Datos de los/as autores/as y traductor/a:

Nuridin Widya Pranoto	nuridin@fik.unp.ac.id	Autor/a
Heru Andika	heruandik0407@gmail.com	Autor/a
Yovhandra Ockta	yovhandra1999@gmail.com	Autor/a
Kamal Firdaus	kamalfirdaus@fik.unp.ac.id	Autor/a
Nofri Hendri	nofrihendri@fip.unp.ac.id	Autor/a
Fiky Zarya	fikyzarya160416@gmail.com	Autor/a
Vlad Adrian Geantă	vladu.geanta@gmail.com	Traductor/a