MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.59218/makrjms.2024.4.88.93

Muscle Adaptation and Injury: A Cross Sectional Study of Athletes and Non-Athletes

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ABSTRACT

This study addresses the comparative analysis of muscle adaptation and injury prevalence in athletes and non-athletes. Given the distinct physical demands placed on athletes, understanding these differences is crucial for developing targeted injury prevention and rehabilitation strategies. The primary aim is to evaluate the differences in muscle adaptation between athletes and non-athletes. Additionally the study seeks to compare the incidence and types of muscle injuries in both groups, hypothesizing that athletes, due to their rigorous training, might exhibit both advanced muscle adaptation and a higher rate of certain types of injuries. A cross-sectional design was employed, with a total sample size of 200 participants (100 athletes and 100 non-athletes). Participants were recruited through sports clubs and community centers. Standardized assessments were conducted to evaluate muscle adaptation, including muscle strength, endurance and flexibility. Injury data were collected through self-reported questionnaires and verified with medical records. Preliminary analysis indicates that athletes show significantly higher muscle strength and endurance compared to non-athletes. However, athletes also reported a higher incidence of specific muscle injuries, particularly in areas subjected to repetitive stress. Non-athletes showed a lower overall injury rate but a higher prevalence of injuries resulting from everyday activities. The findings suggest that while athletes exhibit enhanced muscle adaptation, they are also at a higher risk for certain muscle injuries. This underscores the need for tailored injury prevention programs for athletes. For non-athletes the lower injury rate but higher prevalence of everyday activity-related injuries indicate a potential area for public health intervention.

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Key Words
Muscle adaptation, sports injuries, athletes, non-athletes, cross-sectional study

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Received: 18 November 2023
Accepted: 4 January 2024
Published: 5 January 2024

Citation: A. Sivapriy and K.A. Malar Vannan, 2024. Muscle Adaptation and Injury: A Cross-Sectional Study of Athletes and Non-Athletes. Res. J. Med. Sci., 18: 88-93, doi: 10.59218/makrjms.2024.4.88.93

INTRODUCTION

Muscle adaptation in response to physical activity is a well-documented phenomenon, exhibiting significant differences between athletes, who undergo rigorous training regimes and non-athletes. Understanding these adaptations is crucial in the context of sports medicine and rehabilitation sciences. Athletes are known to develop enhanced muscle strength, endurance and flexibility due to consistent and targeted training[1]. However this enhanced adaptation often comes with an increased risk of sport-specific injuries[2].

Conversely, non-athletes, while generally less prone to such specialized injuries, may face musculoskeletal issues related to a lack of regular physical activity or everyday physical demands[3]. The incidence of muscle injuries in non-athletes is often attributed to inadequate physical conditioning, which contrasts with the overuse injuries typically seen in athletes[4]. The impact of physical activity on muscle adaptation and injury has been a focus of numerous studies. However, there is a gap in research comparing these aspects between athletes and non-athletes, especially in a cross-sectional framework[5]. This study aims to fill this gap by providing a comparative analysis of muscle adaptation and injury prevalence between these two distinct groups.

Understanding these differences is not only vital for optimizing athletic performance and injury prevention strategies but also for developing effective physical activity guidelines for the general population. This could significantly contribute to public health initiatives aimed at reducing the risk of musculoskeletal injuries and improving overall physical well-being[6].

Aim:

- To compare muscle adaptation and injury prevalence between athletes and non-athletes in a cross-sectional analysis

Objectives:

- To evaluate and compare the levels of muscle strength, endurance and flexibility between athletes and non-athletes
- To identify and analyze the incidence and types of muscle injuries in both athlete and non-athlete groups
- To explore any correlating factors, such as training intensity and lifestyle choices, that may influence muscle adaptation and injury risks

MATERIAL AND METHODS

Study design and participants: This cross-sectional study was conducted over a period of six months. The sample comprised 200 individuals, divided into two groups 100 athletes (professional or semi-professional) and 100 non-athletes (individuals with no professional or semi-professional sports background). Inclusion criteria for athletes included active engagement in sports training for at least the past two years. Non-athletes were included based on a lack of structured sports training history. All participants were aged between 18 and 35 years.

Inclusion criteria

Age range: Participants aged between 18 and 35 years, to focus on population that is typically active and at a stage where muscle adaptation due to training is pronounced. Individuals who are actively engaged in sports training, either as professional or semi-professional athletes, for at least two years prior to the study. This includes participants from various sports disciplines to cover a broad spectrum of athletic activities. Individuals who do not engage in any organized sports or structured athletic training. This group may include those who engage in casual or recreational physical activities but not on a competitive or regular training basis.

Participants must be free from any chronic musculoskeletal disorders or conditions that could influence muscle adaptation or injury risk independently of their athletic or non-athletic status. Willingness to participate in the study, with signed informed consent.

Exclusion criteria: Individuals younger than 18 or older than 35 years, as the focus is on an age group most likely to be actively engaged in sports or have significant differences in muscle adaptation due to lifestyle. Individuals with a history of chronic musculoskeletal diseases or disorders, such as rheumatoid arthritis or chronic back pain, which could confound the results related to muscle adaptation and injuries. Individuals who have had major surgery or a significant musculoskeletal injury within the past six months, as this could affect their current muscle condition and injury status.

Professional athletes who are currently in a recovery or rehabilitation program for sports-related injuries, as their training and muscle condition might not reflect their typical state. Pregnant women, due to the physiological changes that can affect muscle strength, endurance and flexibility assessments. Individuals who are unable to understand the study or give informed consent for any reason.

Data collection: Participants underwent a series of assessments to measure muscle strength, endurance and flexibility. Muscle strength was measured using standard dynamometry techniques, while endurance was assessed through endurance repetition tests

specific to different muscle groups. Flexibility was measured using the sit-and-reach test. Injury data were collected through a combination of self-reported questionnaires, which included questions about injury types, frequency and severity and a review of medical records where available.

Statistical analysis: Data were analyzed using SPSS software (Version 25.0). Descriptive statistics were used to summarize the demographic characteristics of the study participants Comparative analysis between athletes and non-athletes fr muscle strength, endurance, flexibility and injry prevalence was performed using independent ttests for continuous variables and chi-square tests forcategorical variables. A p-value of less than 0.05 was cnsidered statistically significant.

Ethical considerations: Ethical approval for the study was obtained from the Institutional Review Board. All participants provided informed consent before participation and confidentiality was maintained throughout the study by anonymizing the data.

OBSERVATION AND RESULTS

Table 1 reveals significant differences in muscle adaptation and injury prevalence between the two groups. A notably higher percentage of athletes (80%) exhibited high muscle strength compared to non-athletes (40%) with an Odds Ratio (OR) of 6.00, indicating a strong association. Similarly, high muscle endurance was more prevalent in athletes (70%) than in non-athletes (30%) with an OR of 5.67. Flexibility, although higher in athletes, did not show a statistically significant difference between the groups. In terms of injuries, athletes reported a higher incidence of muscle injuries and repetitive strain injuries in the past year, with 50% of athletes experiencing muscle injuries compared to 20% of non-athletes and 40% suffering from repetitive strain injuries versus 10% in non-athletes. Interestingly, non-athletes reported a higher prevalence of activity-related injuries, contrasting with the lower injury rates in other categories. These findings underscore significant disparities in muscle adaptation and injury patterns between athletes and non-athletes, with athletes showing enhanced muscle capabilities but also a higher risk of certain injuries.

Table 2 presents a comprehensive analysis of various muscle injuries in both groups. Athletes demonstrated a significantly higher overall incidence of muscle injuries (60%) compared to non-athletes (30%) with an Odds Ratio (OR) of 3.50, indicating a substantial difference. Specific injury types such as sprains and strains and tendonitis were notably more prevalent in athletes, with ORs of 5.33 and 4.67, respectively, suggesting a strong association with athletic activity. Interestingly, muscle cramps were reported almost equally in both groups, showing no significant statistical difference. Contrarily, non-athletes had higher instances of contusions and non-specific muscle pain, with lower odds of these injuries among athletes. Overuse injuries were predominantly seen in athletes, aligning with the high-intensity nature of athletic training. This data highlights the distinct injury profiles between athletes and non-athletes, with athletes more prone to injuries related to intensive physical activity, while non-athletes suffer more from injuries related to everyday activities and non-specific pain.

Table 3 elucidates the relationship between various lifestyle factors and their impact on muscle adaptation and injury risk in both demographic groups. A striking 80% of athletes reported high training intensity, significantly greater than the 20% among non-athletes, with a pronounced Odds Ratio (OR) of 16.00, indicating a strong correlation with athletic training. Regular cardio exercise and strength training were also more prevalent among athletes, suggesting a link to enhanced muscle adaptation. Lifestyle habits such as smoking and frequent alcohol consumption were notably less common in athletes, reflected in the markedly low ORs of 0.16 and 0.25, respectively. This suggests a potential protective effect of athletic lifestyle against these habits. Athletes also showed higher rates of adequate sleep and stress management practices, further supporting the role of holistic lifestyle choices in physical health and injury prevention. However the difference in maintaining a balanced diet was not statistically significant between the two groups. This comprehensive analysis highlights the profound impact of training and lifestyle choices on muscle health and injury risk, differentiating athletes from non-athletes.

DISCUSSION

Table 1 to compare the findings with existing literature in the field. The observed higher prevalence of high muscle strength and endurance in athletes compared to non-athletes, with Odds Ratios (OR) of 6.00 and 5.67 respectively, aligns with the findings of Revathy *et al.*[1] who noted enhanced musculoskeletal adaptation in athletes due to rigorous training. This is further supported by the work of Miranda *et al.*[2] who found that targeted athletic training significantly improves muscle strength and endurance.

However the lack of a significant difference in flexibility, as indicated by an OR of 1.50, is intriguing and some what contrasts with the findings of Fagundes *et al.*[3] who reported a more pronounced

Table 1: Comparison of muscle adaptation and injury prevalence between athletes and non-athletes: a cross-sectional analysis

Variable	Athletes (n = 100)	Non-athletes (n = 100)	Odds Ratio (OR)	95% CI	p- value
Muscle strength (high)	80 (80%)	40 (40%)	6.00	3.12-11.57	<0.001
Muscle endurance (high)	70 (70%)	30 (30%)	5.67	2.95-10.89	<0.001
Flexibility (above average)	65 (65%)	55 (55%)	1.50	0.82-2.74	0.185
Muscle injuries (past year)	50 (50%)	20 (20%)	4.00	2.15-7.44	<0.001
Repetitive strain injuries	40 (40%)	10 (10%)	6.00	2.74-13.15	<0.001
Activity-related injuries	10 (10%)	30 (30%)	0.25	0.11-0.58	0.001

Table 2: Incidence and types of muscle injuries in athletes and non-athletes: a comparative study

Injury Type	Athletes (n = 100)	Non-athletes (n = 100)	Odds ratio (OR)	95% CI	p- value
Total muscle injuries	60 (60%)	30 (30%)	3.50	1.96-6.25	<0.001
Sprains and strains	40 (40%)	10 (10%)	5.33	2.47-11.50	<0.001
Tendonitis	20 (20%)	5 (5%)	4.67	1.62-13.46	0.004
Muscle cramps	15 (15%)	20 (20%)	0.71	0.34-1.47	0.356
Contusions	5 (5%)	15 (15%)	0.29	0.10-0.86	0.025
Overuse injuries	30 (30%)	5 (5%)	7.50	2.78-20.21	<0.001
Non-specific muscle pain	10 (10%)	25 (25%)	0.33	0.14-0.77	0.011

Table 3: Correlation of training intensity and lifestyle factors with muscle adaptation and injury risk in athletes and non-athletes

Correlating factor	Athletes (n = 100)	Non-athletes (n = 100)	Odds ratio (OR)	95% CI	p-value
High training intensity	80 (80%)	20 (20%)	16.00	7.85 - 32.60	<0.001
Regular cardio exercise	90 (90%)	70 (70%)	4.50	1.83 - 11.04	0.001
Strength					
Training	85 (85%)	40 (40%)	8.08	3.95 - 16.54	<0.001
Smoking habit	5 (5%)	25 (25%)	0.16	0.06 - 0.43	<0.001
Alcohol consumption (>2x/week)	10 (10%)	30 (30%)	0.25	0.11 - 0.56	0.001
Adequate sleep (>7 hrs/night)	70 (70%)	50 (50%)	2.33	1.28 - 4.24	0.005
Balanced diet	75 (75%)	65 (65%)	1.62	0.84 - 3.13	0.152
Stress management practices	60 (60%)	35 (35%)	2.86	1.56 - 5.24	0.001

difference in flexibility between athletes and non-athletes. This discrepancy might be attributed to the specific nature of the athletic training or the sports involved in both studies. The higher incidence of muscle injuries and repetitive strain injuries in athletes, as shown in this study, echoes the research of Marques-Sule *et al.*[4]. They highlighted that the intense physical demands placed on athletes often lead to a higher risk of such injuries. This is consistent with the high ORs of 4.00 for muscle injuries and 6.00 for repetitive strain injuries observed in the current study. Conversely, the higher prevalence of activity-related injuries in non-athletes, with an OR of 0.25, is an interesting finding. This may reflect the lower physical conditioning in non-athletes, making them more susceptible to injuries during everyday activities. This is in line with the observations made by Teixeira *et al.*[5] who emphasized the impact of a sedentary lifestyle on injury risk.

Table 2 to contextualize these findings with existing research in the field. The significantly higher overall incidence of muscle injuries in athletes (60%) compared to non-athletes (30%) with an Odds Ratio (OR) of 3.50 aligns with the findings of Mochizuki *et al.*[6] who reported similar trends in their study focusing on sports-related injuries. This is indicative of the increased risk associated with intense physical activity and training in athletes.

Particularly the higher rates of sprains, strains (40% in athletes vs. 10% in non-athletes, OR = 5.33) and tendonitis (20% in athletes vs. 5% in non-athletes, OR=4.67) are consistent with the observations made by Morlin *et al.*[7]. They suggested that repetitive and high-impact activities common in athletic training contribute to these specific types of injuries. Interestingly the prevalence of muscle cramps was similar in both groups, which resonates with the findings of Ireland *et al.*[8] who noted that factors other than athletic activity, such as hydration and electrolyte balance, play a significant role in cramps.

Contrarily the higher incidence of contusions in non-athletes (15% vs. 5% in athletes, OR = 0.29) could be attributed to the lack of conditioning and protective measures during everyday activities a point highlighted in the study by de Abreu *et al.*[9]. The notably high incidence of overuse injuries in athletes (30% vs. 5% in non-athletes, OR = 7.50) echoes the research by de Souza *et al.*[10] emphasizing the stress of repetitive motions in sports. Lastly the lower prevalence of non-specific muscle pain in athletes (10% vs. 25% in non-athletes, OR = 0.33) suggests a potential protective effect of regular physical activity a hypothesis supported by Kopiczko *et al.*[11].

Table 3 offers valuable insights into how lifestyle factors affect physical health in different populations. The data shows a stark difference in high training intensity between athletes (80%) and non-athletes (20%) with an Odds Ratio (OR) of 16.00, suggesting that intense training is strongly associated with being an athlete. This finding aligns with research by Miranda *et al.*[2] who emphasized the critical role of training intensity in athletic performance. The prevalence of regular cardio exercise was higher in athletes, with 90% of athletes engaging in such activities compared to 70% of non-athletes (OR = 4.50). This supports findings by Fagundes *et al.*[3] highlighting cardio exercise as a key component of athletic training. Strength training showed a similar trend, with 85% of

athletes participating versus 40% of non-athletes (OR = 8.08) corroborating the research by Marques-Sule *et al.*[4] which identified strength training as integral to athletic conditioning. Notably, lifestyle habits like smoking and alcohol consumption were significantly lower in athletes, echoing the findings of Teixeira *et al.*[5] that athletes tend to avoid habits detrimental to physical performance and health. The study also found athletes were more likely to have adequate sleep and engage in stress management practices, which are essential for recovery and performance, as noted by Mochizuki *et al.*[6]. Interestingly, while a higher percentage of athletes reported following a balanced diet, this was not significantly different from non-athletes, which contrasts with the findings of Morlin *et al.*[7] who suggested a more pronounced difference in dietary habits between these groups.

CONCLUSION

The study provides comprehensive insights into the differences in muscle adaptation and injury prevalence between these two distinct populations. Our findings reveal that athletes exhibit significantly higher muscle strength and endurance compared to non-athletes, likely attributable to their rigorous training regimes. However, this enhanced physical capability comes with a heightened risk of certain types of injuries, particularly repetitive strain injuries, which are less common in non-athletes.

Interestingly the study also highlights the differences in lifestyle choices between athletes and non-athletes, with athletes more likely to engage in health-promoting behaviors such as regular exercise, adequate sleep and stress management practices. This suggests a holistic approach to health and well-being that extends beyond physical training. The higher incidence of activity-related injuries in non-athletes points to the potential risks associated with a lack of regular physical conditioning. This underscores the importance of incorporating moderate physical activity into the routine of non-athletic populations to enhance muscle strength and reduce injury risks.

In conclusion, this study not only emphasizes the physical benefits of athletic training but also draws attention to the injury risks associated with high-intensity sports activities. It calls for a balanced approach in training and underscores the importance of injury prevention strategies tailored to both athletes and non-athletes. For public health the findings advocate for promoting regular physical activity and healthy lifestyle choices to improve muscle adaptation and minimize injury risks in the general population.

Limitations of study

Cross-sectional design: Being a cross-sectional study, it captures data at a single point in time. This design limits the ability to establish causality or track changes over time, making it challenging to determine if the observed differences in muscle adaptation and injury are directly caused by the athletic training or other factors.

Sample size and diversity: The sample size of 200 participants, though adequate for initial analysis, may not be representative of the broader population. Additionally the study may lack diversity in terms of age, ethnicity, type of sports and level of athletic performance, which can influence muscle adaptation and injury risks.

Self-reported data: The reliance on self-reported questionnaires for injury history may introduce recall bias. Participant's recollection of past injuries could be inaccurate, leading to potential underreporting or overreporting.

Control of confounding variables: While the study attempts to control for major factors, there may be other confounding variables, such as genetic predispositions, nutritional status and previous injury history, that were not fully accounted for.

Specificity of sports and training regimens: The study groups participants broadly into athletes and non-athletes without considering the specific types of sports or training regimens. Different sports have varying impacts on muscle adaptation and injury risks, which this study does not differentiate.

Generalizability: The findings, while significant, may not be generalizable to all athletic or non-athletic populations, especially considering the specific demographics and geographical location of the sample.

Physical assessment techniques: The methods used to assess muscle strength, endurance and flexibility might have inherent limitations and may not capture the full complexity of muscle adaptation.

Psychological factors:

The study does not account for psychological factors such as stress, motivation and mental health, which can significantly impact both athletic performance and injury recovery.

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