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Sports Injuries and their Association with Entry Level Body Mass Index in Young Athletes: a Case Control Study

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ABSTRACT

Objective: To find the association between sports injuries and entry level body mass index in young athletes.
Study Design: Case Control Study.
Place and Duration of Study: Different Sports Academies of Abbottabad, Pakistan from Sep 2021 to Aug 2022.
Methodology: Newly inducted young athletes, aged between 19 – 23 years, were included in the study. Record of the athletes was explored to note their entry level BMI, along with the personal and medical history. Those who got sports injuries during first three months of training were labeled as cases. Those athletes who remained injury free but otherwise were similar to cases in all aspects were labeled as controls. Controls were selected at Case: Control ratio of 1:2. BMI was divided into five categories.
Results: A total of 1302 male participants were included in this study. Out of these, 434 participants (0.33%) had received sports injuries (cases), whereas the remaining 868 participants (0.66%) were injury free (controls). A strong association of sports injuries was observed with lower entry level BMI, in the cases (p-value=0.02). Furthermore, 40(87%) of the cases belonged to Category 1 (BMI <18 Kg/m^2) while 164 (80.4%) were within Category 2(BMI =18.1-18.4 Kg/m^2). The lowest percentage of sports injuries i.e. 8.3% (22 participants) was observed in Cat 4 (BMI = 23.1-24.9 Kg/m^2).
Conclusion: The study provides scientific evidence of association of sports injuries with lower entry level BMI. It implies that sports injuries can be prevented by revising selection standards of physical fitness and introducing safer limits of entry level BMI.

Keywords: Body Mass Index, Musculo-skeletal injuries, Sports Injuries.

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INTRODUCTION

Physical training worldwide, is designed to develop fitness in trainees, through strenuous physical activities including, running, resistance training and load marches.[1] Fitness incorporates different components which include body composition, muscular endurance, aerobic endurance, muscular strength, flexibility, mobility, and balance.[2] For many individuals, the nature and volume of training is far greater than they have experienced ever before. Failure to acclimatize to sudden rise in high impact physical activity is a major factor that contributes in the subsequent development of Musculo-skeletal injuries (MSKIs) at the very start of training.[3]

Body Mass Index (BMI) is a Weight to Height ratio. It serves as an indirect method of body composition analysis. It may not differentiate between Fat-Free Mass (i.e. bone and muscle mass) and Percentage Body Fat.[4] Extremes values of BMI (high and low) are associated with increased risk of MSKIs in addition to other related health conditions. According to Accession Medical Standards Analysis & Research Activity (AMSARA) of Walter Reed Army Institute of Research USA, individuals having BMI less than 18 Kg/m^2 or greater than 33 Kg/m^2 are particularly at a greater risk of developing training related injuries.[5] An additional important factor is the interaction between the level of fitness and BMI with the risk of injuries. Individuals with low physical fitness and lower levels of BMI may be at greater risk. Lower levels of BMI may be an indicator of lesser muscle mass or bone content. These subjects may lack the requisite strength for strenuous physical tasks.[6]

Sports injuries are common among young athletes and can have a significant impact on their performance and health. Identifying factors that contribute to these injuries is crucial in timely preventing these injuries and promoting safer athletic

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practices. BMI is widely used to assess the fitness level of athletes at the start of their training or career.[7-8] However, it is unclear how BMI at the entry level may influence the risk of sports injuries. Young athletes with a higher or lower BMI may experience different types of injuries due to their body composition. For example, those with a higher BMI might be at greater risk for joint and muscle injuries, while athletes with a lower BMI could face issues related to bone density and strength. This study aims to examine the association between entry-level BMI and the occurrence of sports injuries in young athletes. Understanding this relationship can help coaches, trainers, and medical professionals, tailor training programs to reduce the risk of injury and improve overall athletic performance hence ensuring the long-term health and success of young athletes.

METHODOLOGY

The case-control study was carried out from September 2021 to August 2022 at Different Sports Academies of Abbottabad, Pakistan. Approval of Ethical Committee was sought before start of the study from Armed Forces Post Graduate Medical Institute, Rawalpindi. The sample size was calculated taking the average injury rate as 2.64 per 1000 athletes from the previous literature.[9]

Inclusion Criteria: Newly inducted young male athletes, aged 19-23 years were included in the study.

Exclusion Criteria: Athletes with the previous history of any injury or having health related issues were excluded from the study.

The case control study was conducted to find out the association between sports injuries and body mass index (BMI) in young athletes. Newly inducted young athletes, aged between 19 – 23 years, were included in the study while athletes with the previous history of any injury or having health related issues were excluded. Record of the athletes was explored to note their entry level BMI, along with the personal and medical history. Those who got sports injuries during first three months of training were labeled as cases. Those athletes who remained injury free but otherwise were similar to cases in all aspects were labeled as controls. Controls were selected at Case: Control ratio of 1:2. Thus 434 cases were identified and at the ratio of 1:2, 868 controls were selected. Odds Ratio was calculated to find out the association between sports injuries and entry level body mass index in these young athletes.

Record of medical/ personal history and that of physical examination of the athletes were explored. All those who suffered from injuries were taken as "Cases". Those who were undergoing the same training but did not develop sports injuries were taken as "controls". It was ensured that controls were identical to cases except for presence of injuries. Matching was done to select Controls at Case: Control ratio of 1:2. Thus for 434 cases, 868 individuals were selected as controls; making sample size of 1302. It was ensured that Controls are similar to Cases in all respects except for the presence of sports injures. BMI was divided into five categories (Category 1 through 5). Category 1 & 2 (BMI < 18 Kg/m^2 and 18.1-18.4 Kg/m^2, respectively) were classified as underweight. Cat 3 & 4 (BMI=18.5-23 Kg/m^2 and 23.1-24.9 Kg/m^2, respectively) were classified as normal-weight, whereas Cat 5 (BMI > 25 Kg/m^2) was classified as overweight. All possible confounders i.e. Age, gender, demographic variations were balanced in both the groups by matching. Same parameters of data were collected from both cases and controls alike i.e. entry level BMI, medical history, anthropometric measurements, personal history etc. Entry level BMI was taken as Body Mass Index of an individual at the start of selection just before entering into training cycle is referred to as Entry level BMI. Sports Injury was taken as any physical injury caused to trainee as a result of training in the first 12 weeks is referred as sports injury. Medical conditions e.g. fever, diarrhea, hypo/hypertension, hypoglycaemia, diabetes, myocardial infarction etc; and surgical conditions e.g. appendicitis, intestinal obstruction, RTAs were not included in sports injuries.

Statistical Package for Social Sciences (SPSS) version 25.0 was used for the data analysis. Quantitative variables with normal distribution were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Chi-square test was applied to explore the inferential statistics. Odds Ratios (OR) were calculated to determine the possible associations. OR=1 was interpreted as no association, OR >1 as positive association, whereas >4 interpreted as strong association.

RESULTS

A total of 1302 male participants were included in this study, with 434 cases (receiving exclusive sports injuries) and 868 controls (who remained free of sports injuries). The mean age of the study participants was 20.12±1.50 years. The mean weight, height and BMI of

the study participants were 174.39±1.80 cm, 65.70±0.26 Kg, 21.57±0.71 kg/m² respectively. Out of cases, 40% of athletes suffered sports injuries in initial 3 months of their physical training. However, majority of the complaints were of minor nature i.e. body aches, pain in legs, muscle cramps and joint sprains. 75% of the injuries occurred in the initial 3 months of training. Of all the types of the injuries, Stress Fractures (SFs) were the most significant, as these take considerably longer time to heal (average time being 12-16 weeks) thus resulting in loss of precious training time and resources. Majority (>90%) of injuries were found to have involved lower limbs. In the lower limb, Tibia was injured more (84%) than any other bone. Right side was commonly involved (67%) than the left side.

Out of 434 cases, 204(47.0%) athletes had low BMI. Whereas, out of 868 healthy athletes i.e controls, 822(94.7%) had normal BMI. There was statistically significant difference of BMI between cases and control group with p value of <0.001 and odds ratio (OR) of 15.80 as shown in Table-I.

A strong association of sports injuries was observed with lower entry level BMI (*p*-value=0.02). BMI was divided into five categories (Cat 1 through 5). Cat 1 & 2 (BMI <18 Kg/m² and 18.1-18.4 Kg/m², respectively) were classified as underweight. Cat 3 & 4 (BMI=18.5-23 Kg/m² and 23.1-24.9 Kg/m², respectively) were classified as normal-weight, whereas Cat 5 (BMI > 25 Kg/m²) was classified as overweight. Amongst the 46 participants belonging to Cat 1, 40 (87%) suffered exclusive sports injuries (cases) whereas out of the total 2014 participants belonging to Cat 2, 164(80.4%) received exclusive sports injuries (cases). The lowest incidence of sports injuries i.e. 8.3% (22 cases) was observed in Cat 4, whereas in the over-weight Cat (Cat 5), 41.2% of participants also as reported sports injuries, as shown in Table- II.

DISCUSSION

This study revealed a strong association between low entry-level body mass index (BMI) and the occurrence of sports injuries in young athletes. Athletes with lower BMI were found to be at a higher risk of injuries, especially those affecting the bones and muscles. A low BMI often indicates reduced body fat and muscle mass, which can lead to decreased strength and stability, making the body more vulnerable to stress and impact during physical activity. This may result in an increased likelihood of fractures, sprains, and other types of injuries.

The practice of sport by adolescents generates physiological, psychological, and social benefits. These include improved health conditions, self-esteem, social interactions, and decreased risk of depression. However, sports practice is inevitably linked with the appearance of injuries. Moreover, this circumstance is aggravated by the increasing sports participation among adolescents in recent years. Only in the United States, it was reported that 3.5 million youth received medical care each year for injuries that occurred during sports practice.[10] In addition, two-thirds of those injuries required care in emergency units. LeBrun *et al*., estimated that 23 million adolescents suffer sports injuries annually on the African continent.[11]

This higher incidence of sports injuries is often attributed to a greater level of sports specialization and more intense practice. This theory is supported by the fact that young athletes' injury patterns seen in recent years are similar to those observed in mature athletes.[12-14] Under these circumstances, it is exigent to design strategies to reduce the incidence of sports injuries in adolescents due to their high cost in economic terms and the overload of health systems. Likewise, reducing the risk of suffering injuries in such a significant population group will reduce youth

Table-I: Comparison of Body Mass Index Among Study Groups (n=1302)

Entry Level Body Mass Index	Study Groups		Total	*p*-value	Odds Ratio
	Cases (n=434)	Controls (n=868)			
Low	204(47.0%)	46(5.3%)	250	< 0.001	15.8
Normal	230(53.0%)	822(94.7%)	1052		

Table -II: Comparison of Body Mass Index Categories in Study Groups

Study Groups	Body Mass Index Categories (Kg/m²)					Total	*p*-value
	Under Weight		Normal Weight		Over Weight		
	Category 1 < 18	Category 2 18.1–18.4	Category 3 18.5–23	Category 4 23.1–24.9	Category 5 > 25		
Cases	40(87.0%)	164(80.4%)	202(25.7%)	21(8.3%)	7(41.2%)	434	0.02
Controls	6(13.0%)	40(19.6%)	579(74.3%)	233(91.7%)	10(58.8%)	868	
Total	46	204	781	254	17	1302	-

sports attrition, promote lifetime participation in sports, and produce improvements in public health associated with the regular practice of sports.[15] In this regard, it is essential to highlight that there is a clear tendency to abandon sports practice during adolescence due to intrapersonal, interpersonal, and structural constraints.[16-18]

In our study 1302 male participants were included, with 434 cases (who suffered sports–related injuries) and 868 controls who remained injury free. Our study showed strong association of injuries with low entry level BMI (*p*-value=0.02). This finding is in line with the findings of a study by Prieto-gonz *et al*., suggesting a higher incidence of certain types of injuries, particularly fractures, in underweight athletes owing to a lower bone density.[19] Amongst the 46 participants belonging to Cat 1, 40(87%) suffered exclusive sports injuries whereas out of the total 2014 participants belonging to Cat 2, 164(80.4%) received exclusive sports injuries. The lowest incidence of sports injuries i.e. 8.3% (22 cases) was observed in Cat 4, whereas in the over-weight Cat (Cat 5), 41.2% of participants also as reported sports injuries. These findings are consistent with similar study, Kimura *et al*.[20] suggesting that sports injuries are reported to be associated with the under-weight and over-weight categories. It was reported that over-weight athletes are at a 1.5-1.7 fold increased risk of sports injuries especially joint stress.

The findings highlight the importance of considering an athlete's body composition when designing training programs, particularly for those with a lower BMI or Higher BMI than a normal-weight range. Adequate nutrition, strength training, and injury prevention strategies may help address the risks associated with a lower BMI, ensuring that young athletes can train and compete safely. By focusing on building muscle strength and improving overall physical fitness, coaches and trainers can help reduce the injury risks in athletes with low BMI.[19,20] These results underscore the need for further research to explore preventive measures and to better understand how body composition affects injury patterns in sports, contributing to safer athletic development.

CONCLUSIONS

The study has provided scientific evidence of association of sports injuries with lower entry level BMI. It also highlights that a higher than normal BMI may also put the athlete at a risk of certain types of sports injuries. Therefore, the study implies that sports injuries can be prevented by revising selection standards of physical fitness and introducing safer limits of entry level BMI.

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Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

MFA & MKA: Conception, study design, drafting the manuscript, approval of the final version to be published.

SQ: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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