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# ORIGINAL

## PRESSURE INJURIES AND SKIN STRUCTURE CHANGES IN BASKETBALL ATHLETES: CASE OF WHEELCHAIR BASKETBALL PLAYERS IN TURKEY

**Özgür Toprak[1]*, Murat Özşahin [1]**

[1] Middle East Special Hospital, Department of Orthopedics and Traumatology, Adana, Turkey.
**E-mail:** drotoprak78@hotmail.com

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## ABSTRACT

In the past few years, different measures are being taken by the sports agency to offer new sports for disable athletes to motivate them. In this regard, the wheelchair (WC) basketball has also become very famous especially among the elite basketball players. Therefore, the main aim of this study is to determine the association between pressure injuries (PI) and skin structural changes in basketball players from Turkey. For this purpose, the skin blotting technique was utilized. 13 basketball players were selected for this study and the ultrasonographic images (UI) of their ischial regions were also obtained for qualitative analysis. The results obtained from this study showed that 2 of the 13 participants suffered from category II and III of PIs. The structural features were categorized as normal skin (NS), cloudy fat (CF) layer, deep and unclear superficial (US) fascia and anechoic lesion (AL) and fat infiltration (FI). The levels of CK-M (2.989 [2.81 – 3.48]) in the FI and AL group was higher than the non-FI and AL (1.42 [1.42 – 1.48]) after training (p= 0.04). However, the levels of IL-6 were higher in FI and AL group (23.6 [16.16 – 58.96]) than the non-FI and AL group (1.95 [1.75 – 4.45]) after rest (p= 0.04). Therefore, the combination of UI images, changes in skin structure is crucial to determine the deep tissue damage in WC basketball athletes.

**KEYWORDS:** Basketball; Wheelchair; Athletes; Skin Blotting; Turkey; Pressure Injuries

## 1. INTRODUCTION

Wheelchair basketball, a popular sport for people with disabilities, was

originally offered as a competitive event at the 1960 Paralympic Games in Rome. Wheelchair basketball is a sport that is accessible to those with physical disabilities that cause reduced lower limb function or lower body paralysis due to a number of conditions, including spinal cord injury (SCI) (Gioia et al., 2019). However, wheelchair basketball players incur the risk of secondary impairments such pressure injuries (PIs), which have been demonstrated to improve psychological status, quality of life, and community inclusion (Curtis & Dillon, 2019). A localized injury to the skin and/or underlying tissue known as a PI is often caused by pressure or pressure associated with shear stress over a bony prominence (Haesler, 2019). Activity limitation, mobility limitations, increased friction and shear stressors, poor nutrition, skin moisture difficulties, rising body temperature, advanced age, a lack of sensory awareness, or SCI have all been identified as risk factors for developing a PI (Haesler, 2019). Due to the frequently challenging and sophisticated physical performance, wheelchair basketball athletes have additional dangers, which raises the possibility of acquiring PIs. Pain, discomfort, and infection are only a few of the side effects of PIs for wheelchair basketball players, but they can also result in subpar performance, the inability to take part in games, and retention issues (Spilsbury et al., 2019). Although it has been predicted that 13% of persons with SCI have PIs after five years (Chen, DeVivo, & Jackson, 2020), wheelchair basketball players have been shown to have PI incidence rates ranging from 27 to 68% (Shimizu et al., 2020). Compared to non-athletes, wheelchair basketball players had a higher chance of developing PI. The high rate of PIs, particularly deep tissue injury (DTI), among wheelchair basketball players may be due to the severe collisions that occur during competition or to the increased pressure or friction/shear pressures caused by the "stop and dash" rule used in the sport. In previous investigations using ultrasonography, elite male and female wheelchair basketball players were reported to have prevalence rates for DTI of 45% and 68%, respectively (Mutsuzaki et al., 2019). The term "intact or nonintact skin with a localized area of persistent nonblanchable deep red, maroon, or purple color change, or epidermal separation exposing a dark wound bed or blood-filled blistering" is used to describe a suspected DTI. Changing skin color is frequently preceded by pain and temperature changes (Ayello, Delmore, Smart, & Sibbald, 2018). The examination of skin appearance alone is insufficient to identify suspected DTI, though. In a clinical setting, ultrasonography can be used to discover possible DTI. This has proven particularly useful in detecting hazy layered structures, heterogeneous hypoechoic lesions, and discontinuous fascia within the subcutaneous fat tissue layer (Yabunaka et al., 2019). According to (Gefen, 2021) study, people with SCI suffer tissue changes such muscle atrophy or fat infiltration into the muscles. The skin blotting technique (Minematsu et al., 2019) is a quick and painless technique that can be utilized in place of a histological biopsy evaluation. This treatment involves adhering a negatively charged nitrocellulose membrane to the skin's surface for ten minutes while hydrating it

with regular saline. The connected skin tissue's internal soluble protein is drawn by the membrane. Immunostaining of the blotting membrane reveals the pathologic condition of the skin (Minematsu et al., 2019; Ogai et al., 2021) provided evidence for the discovery of fluorescein-labeled dextran produced from implanted agarose gel in the dorsal skin of mice. They discovered that 1 hour after the membrane was applied to the skin surface, fluorescein-labeled dextran from subcutaneous adipose tissue could be identified (Minematsu et al., 2019). The purpose of this study is to look at pressure injuries and related alterations in skin structure in Turkish wheelchair basketball players. In order to improve the general health and performance of this particular athlete demographic, it aims to discover the prevalence, risk factors, and appropriate therapies for pressure injuries.

## 2. Literature Review

The sport of wheelchair basketball (WB) was developed in the United States in 1946 as a form of rehabilitation for a wounded World War II serviceman. The first recognized WB game was played on September 25, 1946, in the United States among a group of war veterans (Glattke, Tummala, & Chhabra, 2022). The International Stoke Mandeville Games hosted the inaugural league-level match in 1956. From this foundation, WB quickly expanded. The International Stoke Mandeville Games Federation, the first WB federation, was created in 1973 in response to the sport's tremendous recognition on a global scale. The International Wheelchair Basketball Federation (IWBF) was given the name change in 1989. Following the summer Paralympic Games every two years since 1975, the Federation has hosted recognized world championships (Najafabadi et al., 2023). A Paralympic sport known as wheelchair basketball (WB) is played by two teams of five players each and involves athletes with physical disabilities who can be divided into eight distinct classes (1.0-4.5). The game moves quickly as each side attempts to put points in the opponent's basket. This style of competition is well-liked all over the world and has appeared in every Paralympic Games (Sá, Costa e Silva, Gorla, Silva, & Magno e Silva, 2022). It is predicted that this practice contributes to sports injuries because it is a contact sport and because the mechanics of the sport need regular shoulder motions (throwing, passing, chair touching). Sports performance is adversely affected by the physical and psychological repercussions of sports injuries. Depending on the injury, an athlete may need to stop participating in the sport (Schneider, Seither, Tönges, & Schmitt, 2006). Tamai, Minematsu, Maeda, Yabunaka, and Sanada (2020) suggests that in wheelchair athletes, skin blotting with CK-M and IL-6 and ultrasonographic pictures could be used to identify early deep tissue damage. The prevention and treatment of pressure injuries may benefit from these strategies. Wheelchair basketball players experience a wide range of injuries with various traits, most of which are connected to biomechanics and athletics. These findings can help coaches design workouts to reduce reoccurring injuries and

can also be used to organize medical teams during sporting events (Sá et al., 2022). However, the focus of this study, was not on the favorable effects of WB to health. The epidemiology of injuries varied amongst sports, according to a study conducted at the London 2012 Paralympic Games, and it was noted that there was a need for specialized longitudinal studies for each of the several modalities (Engebretsen et al., 2019). 34 injuries were reported by WB for London 2012, of which 23% were overuse injuries and 65% were acute injuries (Willick et al., 2019). There were 4504 interventions during the Rio 2016 Paralympic Games, of which 399 players received physiotherapy. Eight WB athletes requested physical therapy during this match, totaling 11 sessions (Macedo et al., 2019), with severe injuries being the main incidents. Despite the fact that injuries have been linked to various studies on Olympic sports (Junge et al., 2020; Soligard et al., 2019), no similar research has been done on Paralympic sports. Although data on sports injuries in WB are available Derman et al. (2019), several details still need to be clarified. Due to differences and/or a lack of injury definition, bit data and specifics such as location, mechanisms, and injury risk factors are not adequately defined as of yet. In order to ascertain the epidemiological data, primary injury features, and body regions affected in WB players, further research is needed. This study Miah (2022) provides an overview of secondary problems in paraplegic wheelchair users who are not sports. Researchers attempted to determine whether there was any correlation between athletes and non-athletes with secondary issues in this case, and the findings revealed that there was some correlation. Physically, it can increase stamina, cardiovascular fitness, and muscle strength while lowering the incidence of chronic illnesses. From a psychological perspective, WB has been demonstrated to lessen anxiety and depressive symptoms while also fostering and enhancing social connections (Najafabadi et al., 2023). Despite the various advantages, WB can still result in injury, especially to the upper extremities, so precautions should be used. WB demands competitors to put out exceptionally high levels of cardiovascular fitness, muscular endurance, and strength (Rocco & Saito, 2006). The performance of WB players can also be enhanced by healthy sleeping habits. Wheelchair size and weight appear to be crucial success factors in WB, along with wheelchair mobility and biomechanical factors (Edmonds & Dengerink, 2019). WB can be an effective technique for therapists and coaches to improve the mental and physical well-being of their clients. It was recommended to do a literature study that is both health-related and emphasizes areas of competitive advantage and risk factors for athletes.

## 3. Method

### 3.1 Research Design

A cross-sectional observation research was the subject of analysis. In 2020-2021, the study was carried out during a training camp for top-tier Turkish male wheelchair basketball players.

### 3.2 Participants

For this medical study, 16 male wheelchair (WC) athletes were initially sought after. Only 13 willing individuals were chosen since three were dropped from the trial because of isocheimal edema.

### 3.3 Study Protocol

The study involved conducting participant interviews and performing physical assessments. Specifically, a certified wound, ostomy, and continence nurse (WOCN) conducted a comprehensive visual and tactile evaluation of the skin in the ischial regions. Simultaneously, an experienced ultrasonographer utilized diagnostic ultrasonographic equipment to capture images of the bilateral ischial tuberosities. Additionally, both the WOCN and the research team collected skin blotting samples at specific time points: in the morning (considered as baseline), in the evening (after training sessions), and again in the morning (following a period of rest). These samples were obtained from the unilateral ischial region, which was identified as having more pronounced tissue damage compared to the contralateral ischial region.

### 3.4 Measurements

#### 3.4.1 Participant Characteristics

Participant characteristics were obtained through interviews, including information regarding age, height, weight, the cause of disability, illness duration, reliance on assistive devices for daily activities, the type of cushion used for daily tasks and wheelchair basketball, prior participation in wheelchair basketball, history of pressure injuries, and any surgical history involving flap reconstruction for pressure injuries. Additionally, triceps skinfold thickness (TSF) and arm muscular circumference (AMC) on the non-dominant upper arm of the athletes were assessed three times each using a skinfold caliper and measuring tape. Subsequently, the average value for each measurement was calculated.

#### 3.4.2 Skin Structure Changes

A linear-array transducer with a frequency range of 5-18 MHz was employed to acquire B-mode ultrasound images of the bilateral ischial tuberosities, utilizing specialized ultrasonographic diagnostic equipment. To facilitate subsequent quantitative image analysis, the settings for gain and tissue depth were maintained at constant levels throughout the imaging process. Sonographers took measurements of the athletes' skin/fat and muscle layers while they were lying on their sides. Last but not least, the researchers, WOCN, and sonographer carried out qualitative classification in accordance with the morphological texture of the skin structure alterations. Using similar

morphological textures as a guide, the categories were created and given descriptive names. Additionally, using the same ultrasonographic diagnostic equipment, the sonographer captured images of samples of beef muscle (beef rump and marbled cow muscle) for comparison with the images of the players. The features of histological deep tissue injury (CK-M, IL-6) were identified by skin blotting. Before conducting the quantitative skin blotting test to evaluate the extent of muscle injury and the associated inflammatory response at the ischial region, the sampling site was moistened with standard saline solution. Subsequently, a segment of nitrocellulose membrane, sourced from Bio-Rad in Hercules, CA, was affixed to the moistened area on the participants' skin. (Ogai et al., 2021). We chose Interleukin 6 (IL-6) and muscle-type creatinine kinase (CK-M) as indicators of muscle injury. After physical exercise, CK-M increases between 24 and 72 hours later and is associated with muscle disruption (Brancaccio, Maffulli, & Limongelli, 2021) . In response to an inflammatory reaction, muscle tissue releases IL-6 (Sacheck et al., 2019).

### 3.4.3 Analysis

The median (interquartile range, or IQR), which represents descriptive statistics for attributes, was determined. According to whether low-echoic/anechoic lesions were present or not, structural characteristics of ultrasonographic pictures were categorized. To compare results between the two groups, a Mann-Whitney U test was applied. Statistics were deemed significant at a P value of 0.05. SPSS®24.0 for Windows® (SPSS Inc., Chicago, IL, USA) was used to perform all statistical analyses.

## 4. Findings

Table 1 shows the demographics and other medical conditions of the participants for this study. initially 16 male wheelchair (WC) athletes were recruited for this medical research. Three were removed from the study due to edema within their isocheimal region and only 13 voluntary participants were selected. It has been observed that the median age of the participants was 28 years, while their median height was 172.7 cm and weight was 63.3 kg. The median skinfold thickness in their triceps was found to be 8.4 mm while the muscle circumference in their arm was recorded to be 35.6 cm. 8 of the participants suffered from SC injury, while one of them suffered from ST and 2 had SB. Additionally, other two participants suffered from lower LA. The median duration of the associated disease was recorded to be 14.6 years. SD was found in ten of the participants. All of the participants were provided with assistive device to carry out their routine activities. Eight of the participants used WC in their daily lives while eight of them had PF. In case of utilization of cushion WC, 2 participants had gel while four had UF. PI history was observed in eleven of the participants while four of them went through flap reconstruction for these injuries.

**Table 1:** Demographics and medical conditions of the participants

| | | N = 13 |
|---|---|---|
| **AGE (YRS.)** | 28 | (23.6–31.1) |
| **HT (CM)** | 172.7 | (164.4–176.4) |
| **WT (KG)** | 63.3 | (56.7–68.7) |
| **TRICEPS SK (MM)** | 8.4 | (6.1–13.6) |
| **ARM MC (CM)** | 35.6 | (33.3–36.6) |
| **DISABILITY CAUSE SC INJURY** | 8.0 | (66.6) |
| **ST** | 1.0 | (8.4) |
| **SB** | 2.0 | (8.4) |
| **LOWER LA** | 2.0 | (16.6) |
| **DISEASE DURATION (YRS)** | 14.6 | (10.1-18.4) |
| **SD** | 10.0 | (76.9) |
| **ASSISTIVE DEVICE FOR ROUTINE** | 13 | 100 |
| **WHEELCHAIR** | 3 | 23 |
| **PF** | 8 | 61.5 |
| **CUSHION (WHEELCHAIR USE)** | | |
| **GEL** | 2 | 15.3 |
| **UF** | 4 | 30.7 |
| **UF FOR WHEELCHAIR USE FOR BASKETBALL** | 13 | 100 |
| **WC FOR BASKETBALL** | 8 | (6.1-11.4) |
| **PI HISTORY** | 11 | 84.6 |
| **FLAP RECONSTRUCTION FOR PI** | 4 | 30.7 |

*SK= skinfold thickness, MC= muscle circumference, ST= spinal tumor, LA= limb amputation, SB= spinal bifida, SC= spinal cord, SD= sensory disturbance, PF= prosthetic foot, UF= urethane foam, WC= wheelchair, PI= pressure injuries.*

Figure 1 shows that during the time of this study, two of the participants suffered from category II and III PIs within their ischemia regions.

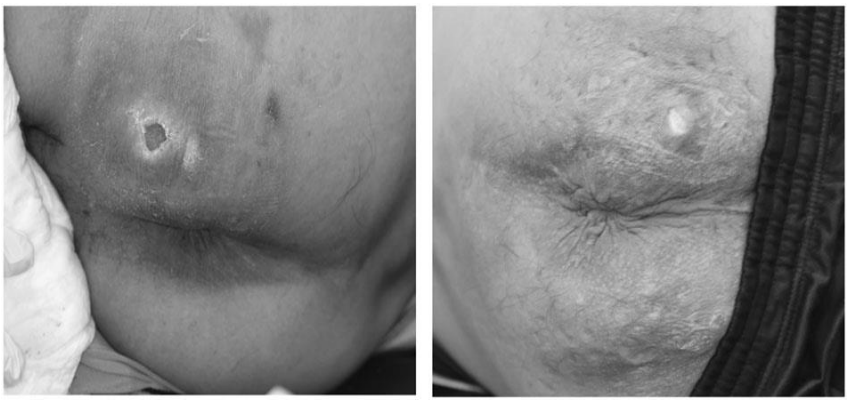


**Figure 1:** PIs cases. Figure (a) shows that one of the WC athlete had a PI of category II on the left region of ischial bone while figure (b) shows that the other WC athlete had a PI of category III on his right region of ischial bone

Figure 2 shows that about 24 “Ultrasonographic images” (UI) were attained from the “bilateral ischial region” for all 13 participants for this study. These images were later used for qualitative analysis. The structural features of the athletes’ skin were categorized as category 1: normal skin (NS), category 2: cloudy fat (CF) layer, category 3: deep and unclear superficial (US) fascia and category 4: anechoic lesion (AL) and fat infiltration (FI). Category 1 shows clear skin which differentiates between the subcutaneous tissue, muscle layer and the epidermis. Category 2 shows unclear fascia along with lower content of fat. Category 3 shows unclear or discontinuous superficial fascia within the subcutaneous tissue. It also represents the unclear deep fascia within the layer of the muscle. Category 4 shows that AL with FI within the muscle, confirming damage of the tissue. Thus, from figure 2 it has been observed that 3 images showed NS while 9 images showed deep and US fascia. However, 6 images showed CF layer and 6 collected images showed FI and AL.

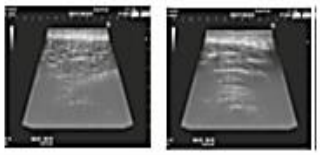
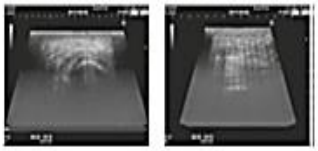
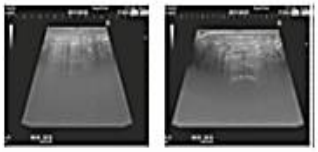
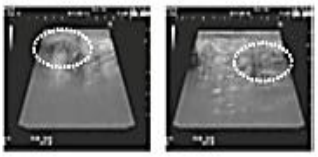
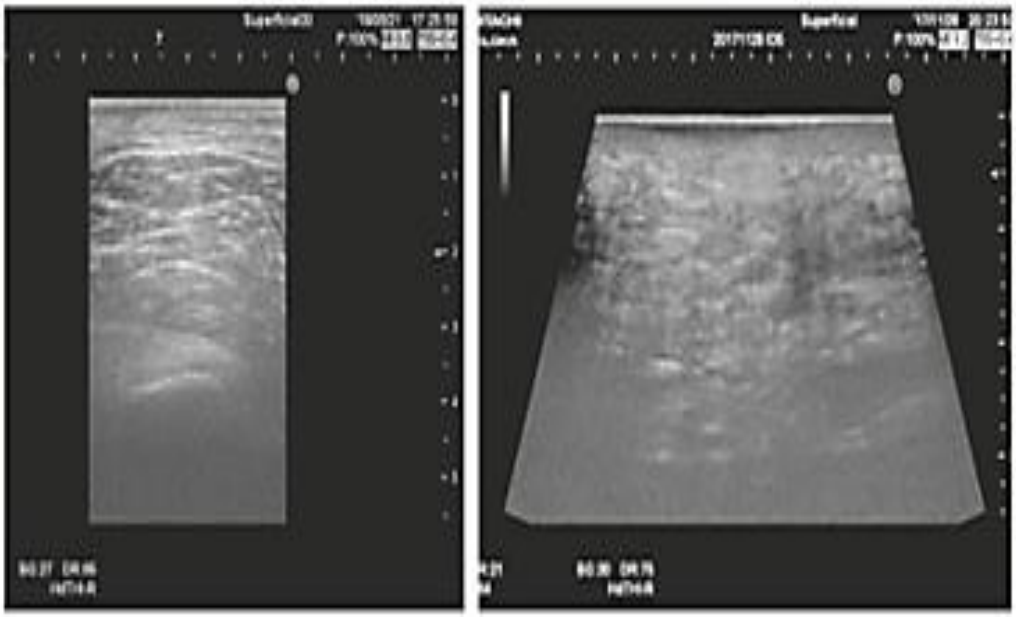
| | Typical Ultrasonographic images | Number of images |
|---|---|---|
| Normal skin structure |  | 3 |
| Unclear superficial and deep facia |  | 9 |
| Cloudy fat layer |  | 6 |
| Fat infiltration and low-echoic lesion/anechoic lesion |  | 6 |

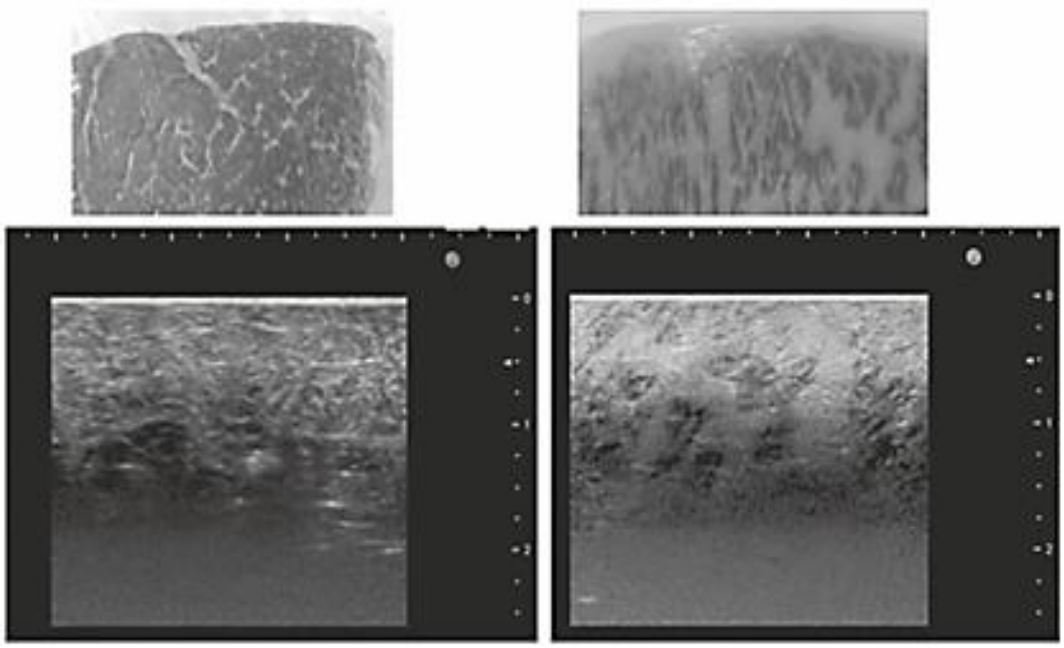
**Figure 2:** Changes in skin structure in ischial region of athletes

Therefore, to understand the changes in skin structure of the athletes, the UI images of the “beef rump muscle” (BRM) as well as the “marbled beef muscle” (MBM) were taken. Figure 3 shows the UI images for assessing the changes in skin structure of athletes. Figure 3 (a) shows clear skin of the athlete with able-body, however, figure 3 (b) shows that it is difficult to differentiate the muscle layer from the fat layer in case of athlete with SC injury. However, figure 4 (a) shows the clear SF fascia in case of BRM while figure 4 (b) shows FI in BMB.



**(a)** Able-bodied athlete **(b)** Athlete with SC injury

**Figure 3:** UI images of the athletes



**(a)** BRM **(b)** BMB

**Figure 4:** UI images of beef

The skin blotting results obtained for the participants of this study showed that the levels of CK-M were reduced in all 13 participants after they were put to rest after the training. However, in one participant, these levels were maintained at 3.6% during training while after rest these levels were found to be at 3.3%. Additionally, the levels of IL-6 also varied after the training as well as at rest in case of each participant as shown in figure 5.

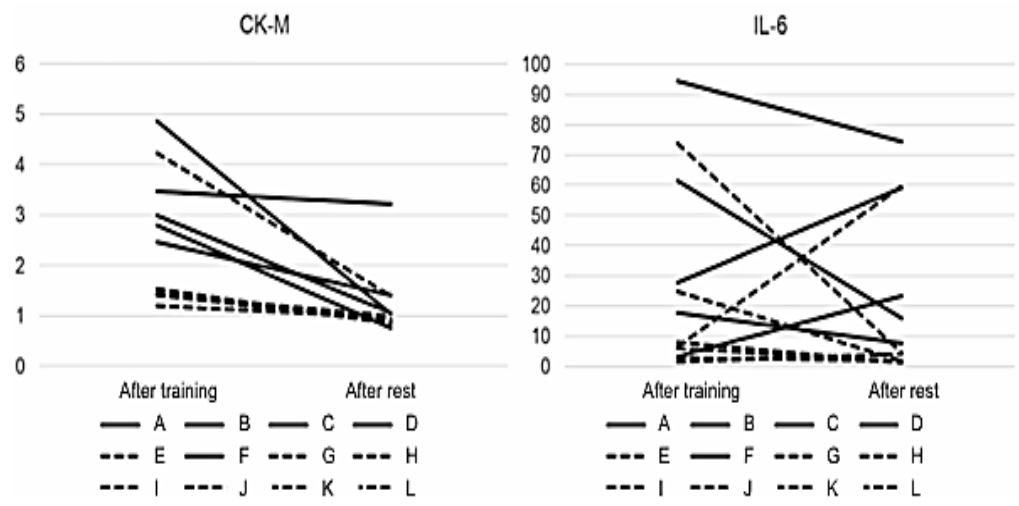



**Figure 5:** Tissue damage changes (skin blotting results)- the dotted lines show changes in FI and AL without UI while solid lines show changes in FI and AL with UI

The skin blotting was utilized to analyze the association between UI and the tissue damage. The features were classified into two different groups for quantitative analysis, based on the absence of presence of damage to the deep tissue. These groups include a FI and AL group and a non-FI and AL group. The levels of CK-M (2.989 [2.81 – 3.48]) in the FI and AL group was found to be significantly that the non-FI and AL (1.42 [1.42 – 1.48]) after training as the value of p was found to be 0.04. However, the levels of IL-6 were found to be higher in FI and AL group (23.6 [16.16 – 58.96]) as compared to the non-FI and AL group (1.95 [1.75 – 4.45]) after rest. In this case the value of p was 0.04 which was less than 0.05, showing positive outcomes as shown in table 2.

**Table 2:** Relationship between tissue damage, FI and AL

| | **UI of FI and AL** | | **Z** | ***p*** |
|---|---|---|---|---|
| | **Y (n= 6)** | **N (n= 7)** | | |
| **CK-M (AT)** | 2.989 (2.81 – 3.48) | 1.42 (1.42 – 1.48) | −2.18 | 0.04 |
| **CK-M (AR)** | 1.07 (1.06 – 1.42) | 0.93 (0.88 – 0.98) | −1.37 | 0.18 |
| **IL-6 (AT)** | 27.8 (17.67 – 61.34) | 6.62 (4.46 – 16.35) | −1.37 | 0.18 |
| **IL-6 (AR)** | 23.6 (16.16 – 58.96) | 1.95 (1.75 – 4.45) | −2.18 | 0.04 |

*AT= after training, AR= after rest, UI= Ultrasonographic image, N= no, FI= fat infiltration, Y= yes, AL= anechoic lesion*

## 5. Discussion

In this study, the ischial area muscle tissue of elite Turkish male wheelchair basketball players was examined for the first time in relation to skin structure changes and the traits of deep tissue damage. The levels of CKM and IL-6 in the group with fat infiltration and low-echoic lesion/anechoic lesion were significantly higher than those in the group with nonfat infiltration and low-echoic

lesion/anechoic lesion following training. Six out of 24 ischial pictures (about 25%) revealed signs of deep tissue injury in the subjects. The results of this study's analysis of the fat infiltration and low-echoic/anechoic lesion groups were consistent with DTI findings from an earlier ultrasonography-based study (Aoi et al., 2019). The hypoechoic lesion, discontinuous fascia, and heterogeneous hypoechoic area were observed in the fat infiltration and low-echoic lesion/anechoic lesion group. With the exception of two ischial regions with PIs, four ischial regions in our investigation showed no signs of suspected DTI. The National Pressure Ulcer Advisory Panel defines DTI as "intact or nonintact skin with a localized area of persistent non-blanchable deep red, maroon, or purple discoloration or epidermal separation revealing a dark wound bed or blood-filled blister" (Edsberg et al., 2019). A normal area revealed a low-echoic lesion upon inspection and palpation, according to (Kanno, Nakamura, Yamanaka, Kouda, & Tajima, 2019). Therefore, early ultrasonography scans for wheelchair basketball athletes are necessary to identify deep tissue injury. The results of this study's investigation into fat infiltration were consistent with those from a muscle sample taken from a marbled beef, in which the superficial fascia was indistinct and tissue deformation and high intensity were observed in the subcutaneous and muscle tissues. According to a prior investigation on anatomical aspects, patients with SCI had less muscle tissue than healthy individuals (Vallely, 2019). Every participant in this study who had SCI and fat infiltration together with low-echoic or anechoic lesions. However, different layer structures were visible on the ultrasonographic images of participants who had lost a lower limb due to amputation. Since lower body paralysis leads to dysfunction, the distortion and invasion of adipose tissue into muscle tissue, together with accompanying muscular atrophy, are the likely causes of the ultrasonographic findings in this study. The tissue tolerance to external forces may be decreased in wheelchair basketball athletes with SCI as a result of these anatomical abnormalities. After training, skin blotting revealed that the levels of CK-M and IL-6 were significantly higher in the groups with fat infiltration and low-echoic lesions/anechoic lesions than they were in the groups without these conditions. In the fat infiltration and low-echoic lesion/anechoic lesion group, as previously mentioned, the skin deformation showed discontinuous fascia and a mixture of subcutaneous tissue and muscle. An earlier investigation found a strong relationship between blood CK levels and subcutaneous edema, inflammation, and gluteal muscle damage (Hattori et al., 2019). Therefore, using skin blotting, it may be possible to identify muscle damage utilizing markers for CK-M level after exercise and IL-6 level after rest. A clinical evaluation in conjunction with the CK-M and IL-6 level tests may be able to identify muscle damage that necessitates rest, the use of wheelchair cushions that are appropriate for daily activities like basketball or other sports to manage pressure, or vibration therapy to increase blood flow (Arashi et al., 2010). Additionally, it's conceivable that the sample didn't accurately represent all

wheelchair athletes. Despite these drawbacks, the measurement error was decreased by using individual specialists to perform skin blotting, ultrasonography, and skin blotting membrane staining.

## 6. Conclusion

When compared to individuals without fat infiltration or low-echoic/anechoic lesions, individuals with these features showed an increase in CK-M levels after training and IL-6 levels after rest, which highlights the potential significance of these biomarkers in detecting early deep tissue damage, particularly muscle damage, in wheelchair athletes. Ultrasonographic imaging in combination with skin blotting techniques using CK-M and IL-6 markers could be used to quickly identify injuries. This comprehensive strategy has a great deal of potential for stopping the advancement of pressure injuries (PI) in this group of athletes. It can contribute to the overall health and performance optimization of wheelchair athletes by facilitating early intervention and targeted preventive efforts, minimizing the long-term effects of such injuries. The combination of skin blotting and ultrasonographic imaging, with an emphasis on the CK-M and IL-6 markers, offers a holistic approach to wheelchair athletes' healthcare. This strategy can reduce the risk of pressure injury (PI) development and progression by recognizing and treating early deep tissue damage, including muscular injuries. A timely response not only supports the health of athletes but also protects their competitive talents. This all-encompassing approach is an essential tool for improving wheelchair athletes' long-term health and performance results, which ultimately promotes a safer and more sustainable sporting environment.

## 7. Implications

The results of this study have a number of theoretical applications in sports medicine, biomechanics, and injury prevention. First off, the finding that wheelchair athletes with fat infiltration and low-echoic/anechoic lesions had higher CK-M and IL-6 levels adds to our knowledge of the physiological reactions to rigorous training and rest in this special population. This insight broadens understanding of the dynamics of muscle injury and inflammation in wheelchair athletes, which may apply to other sports as well. The study also emphasizes the significance of combining biomarker analyses with non-invasive imaging methods like ultrasonography in injury evaluation. This comprehensive strategy might be more useful in identifying early tissue injury in a range of athletic populations and people taking part in physically demanding activities. The finding of particular biomarkers, such as CK-M and IL-6, as potential indicators of tissue damage also offers up new directions for future sports medicine research on injury prediction, prevention, and targeted rehabilitation treatments. This study has a wide range of immediate applications for athletes, coaches, sports medicine professionals, and healthcare

professionals. First off, using CK-M and IL-6 markers in conjunction with ultrasonographic imaging is a useful way to improve the early detection of deep tissue injuries, especially in athletes who use wheelchairs. This can result in more prompt and precise interventions, which might lessen the severity and duration of injuries. The results also highlight the need for customized injury prevention programs that take into account the unique risk factors of athletes, such as fat infiltration and structural alterations. To reduce the incidence of pressure injuries (PI) and related problems, these tailored interventions might include modifications to training regimens, nutrition plans, and recuperation techniques. Incorporating routine ultrasonographic examinations and skin blotting procedures within their medical protocols will also be beneficial to wheelchair basketball teams and participants. This proactive approach to tissue health monitoring can lead to longer athletic careers and enhanced general wellbeing, emphasizing the usefulness of this study for the sports community.

## 8. Limitations and Future Research

The present study incorporates different limitations which are needed to be highlighted. For instance, this study incorporates a small sample size due to limited resources. This impacted the overall effectiveness of the study. Additionally, this study only focused on the association between PI and changes in skin structure, whereas no focus has been given on the psychological wellbeing of WC basketball players in this regard. Another limitation observed in this study is that it is cross-sectional, which impacts the overall value of the study. In order to deal with these limitations, the future research can incorporate a larger sample of WC basketball players to achieve effective outcomes. Moreover, the future research can also focus on the psychological wellbeing of the players. This can also be effective in improving the wellbeing of the associated players. Additionally, longitudinal study should be conducted in the future to achieve positive outcomes.

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