

# ACUTE BIOMECHANICAL EFFECTS OF A KNEE SUPPORT ON ATHLETES WITH FATIGUED MUSCLES AND A HISTORY OF INJURY

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## INTRODUCTION

Knee injuries are some of the most common joint injuries in sports. They affect structures, such as ligaments, the menisci, cartilage, and bones. After such an incident, there is a chance that the knee may remain unstable, in particular when the muscles fatigue, significantly increasing the risk of recurring injury. Knee supports, such as Bauerfeind AG's Sports Knee Support, have been designed to improve joint stability and exert proprioceptive stimuli using mechanical stabilization and compression. Previous studies have primarily focused on torn anterior cruciate ligaments (ACL), neglecting other knee injuries as well as the impact from fatigued muscles. This study therefore examines the acute biomechanical effects on people actively exercising who have a history of various one-sided knee injuries and wear a knee support while their muscles are fatigued. The assumption is that wearing the knee support has a positive effect on the biomechanics of the injured leg, with knee joint stability improving and pain reducing during movement.

## METHODOLOGY

### Study institute

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### Test subjects

50 people involved in sporting activities took part (aged  $33.5 \pm 9.6$  years; 31 male, 19 female) who have had one-sided knee injuries in the last 1 to 10 years. Injury types included torn ligaments, meniscus damage, cartilage defects, fractures, and non-specific pain.

### Test protocol

After a standardized fatigue protocol (for example jumps, lunges, wall sits, etc.), the following exercises were performed:

- **Running**
- **Counter-movement jumps<sup>1</sup> (CMJ)**

The tests were performed under three conditions:

1. Healthy leg
2. Injured leg without a support
3. Injured leg with a support (Sports Knee Support, Bauerfeind AG)

Biomechanical parameters were recorded using 3D motion capture and a load sensing platform as well as subjective information about pain and stability perception (Visual Analog Scale [VAS]).

## RESULTS

### Subjective assessment

The test subjects' subjective assessments showed that wearing the knee support during running resulted in a significant reduction in pain levels. On the VAS (0 = no pain, 10 = extreme pain), the average value of  $2.1 \pm 1.4$  without the support decreased to  $1.9 \pm 1.3$  with the support ( $p = 0.004$ ;  $d = 0.15$ ), which represents a relative reduction of 9.5%. During the jumping test, the level of pain remained consistent at an average of  $2.2 \pm 1.4$ , whether the support was used or not. Perceived stability during running improved from  $2.0 \pm 1.4$  to  $1.8 \pm 1.3$ , (0 = very stable, 10 = very unstable), though the difference was not statistically significant ( $p = 0.125$ ).

\* Running and Jumping After Muscle Fatigue in Subjects with a History of Knee Injury: What Are the Acute Effects of Wearing a Knee Brace on Biomechanics? Bioengineering 2025, 12, 661. <https://doi.org/10.3390/bioengineering12060661>

## Motor function

### Running

The average running speed was  $3.3 \pm 0.4$  m/s. Compared to the healthy leg, the injured leg without the support had significantly lower maximum knee abduction torque<sup>2</sup> (1.91 Nm/kg vs. 1.70 Nm/kg;  $p = 0.015$ ;  $d = 0.39$ ), which is about 10.9% (Fig. 1b).

Wearing the knee support resulted in several significant changes on the injured side. Maximum knee flexion torque<sup>3</sup> increased from 1.90 Nm/kg without the support to 2.24 Nm/kg with the support ( $p = 0.001$ ;  $d = 0.46$ ), i.e. an increase of around 17.9% (Fig. 1a). At the same time, knee abduction torque with the Sports Knee Support reduced by 10.5% compared to not wearing a support (from 1.70 to 1.52 Nm/kg;  $p = 0.006$ ;  $d = 0.31$ ) (Fig. 1b).

The reduction in maximum medio-lateral knee acceleration<sup>4</sup> was particularly significant: It decreased from  $15.94 \text{ m/s}^2$  to  $9.20 \text{ m/s}^2$  ( $p < 0.001$ ;  $d = 1.10$ ), which represents a reduction by 42.2% (Fig. 1c). Ground contact time also reduced slightly, from 257.1 ms to 253.8 ms ( $p = 0.015$ ;  $d = 0.10$ ), representing a decrease by about 1.3%.

### CMJ

Compared to the healthy leg, the injured leg had reduced maximum knee flexion during CMJ ( $77.1^\circ$  vs.  $74.4^\circ$ ;  $p = 0.015$ ;  $d = 0.12$ ), a difference of 3.5%. With the Sports Knee Support, this value increased to  $79.2^\circ$  compared to the injured leg without the support ( $p < 0.001$ ;  $d = 0.21$ ), which represents an increase of 6.5% (Fig. 2a). Wearing the support resulted in further significant improvements in several biomechanical parameters. Maximum knee flexion torque increased from 1.59 Nm/kg (without the support) to 1.73 Nm/kg (with the support;  $p = 0.026$ ;  $d = 0.23$ ), i.e. an increase of around 8.8% (Fig. 2b). Maximum medio-lateral knee acceleration reduced from  $11.10 \text{ m/s}^2$  to  $7.18 \text{ m/s}^2$  ( $p < 0.001$ ;  $d = 0.99$ ) with the support, representing a decrease by 26% (Fig. 2c).

The jumping height, on the other hand, only changed slightly: from  $33.7 \pm 6.8$  cm without the support to  $33.2 \pm 6.8$  cm with the support ( $p = 0.007$ ). This corresponds to a not clinically relevant decrease of 1.5% (clinically relevant:  $> 5\%$ ).

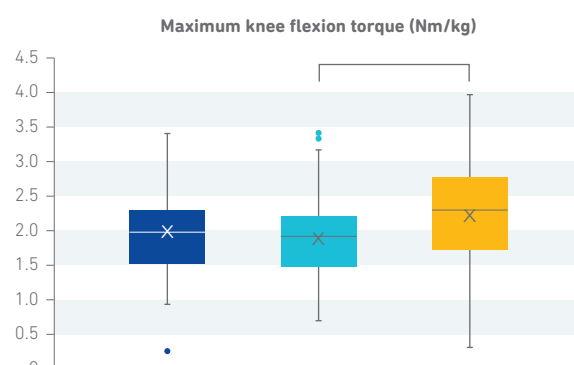


Fig. 1a: Maximum knee flexion torque

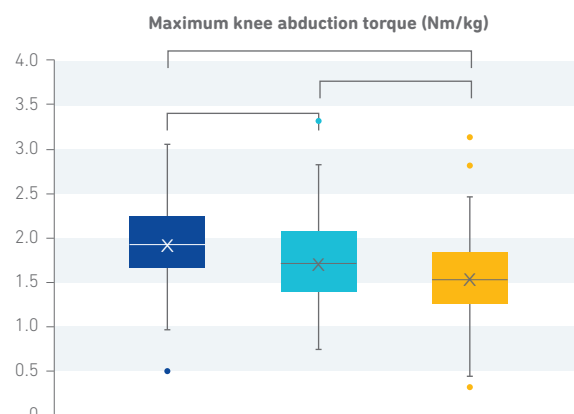


Fig. 1b: Maximum knee abduction torque

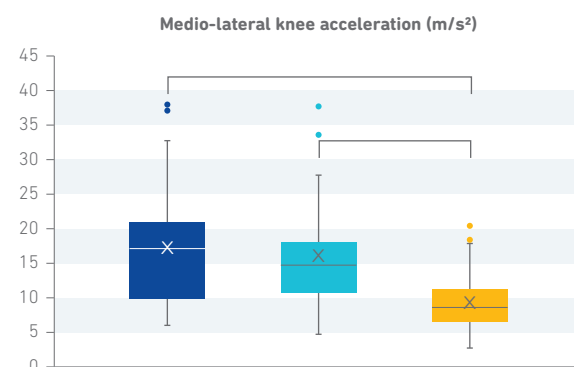


Fig. 1c: Medio-lateral knee acceleration

- Healthy knee joint
- Injured knee joint without a support
- Injured knee joint with the support

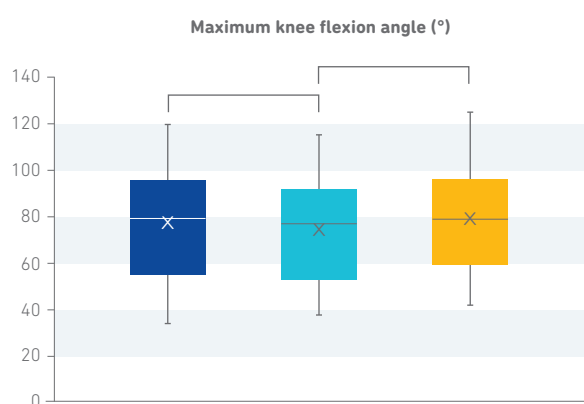


Fig. 2a: Maximum knee flexion angle

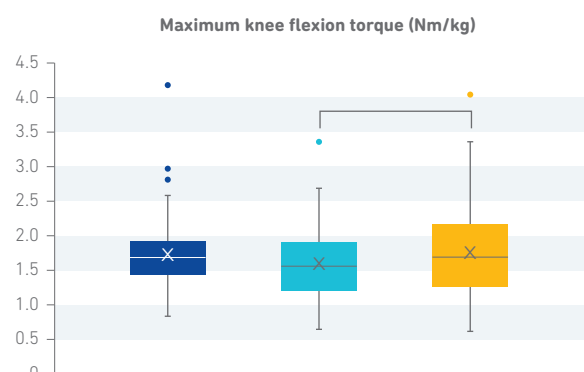


Fig. 2b: Maximum knee flexion torque

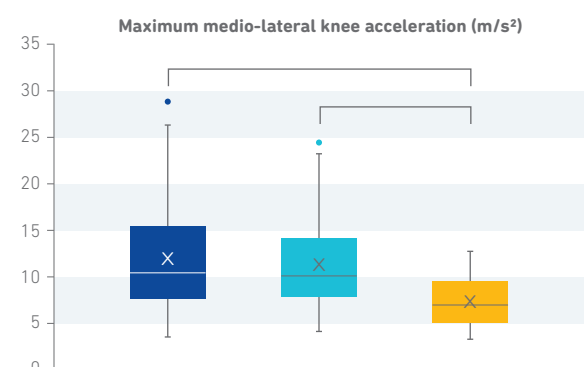


Fig. 2c: Maximum medio-lateral knee acceleration

- Healthy knee joint
- Injured knee joint without a support
- Injured knee joint with the support

## CONCLUDING OBSERVATION

This study substantiates the hypothesis that a knee support exerts biomechanically positive effects on an injured leg with fatigued muscles. Particularly noteworthy is the significant reduction in frontal plane acceleration, which indicates improved knee joint stabilization. The neuromuscular guidance exerted by the support's specific design (e.g. compression knit with integrated silicone pad) helps with joint axis control.

On a sagittal plane, increased flexion torque and greater knee flexion angles resulted in normalization of joint strain. These changes indicate improved function and therefore possibly more trust in how much strain the joint can be subjected to. The subjective effects (less pain, improved stability) support these results.

## CONCLUSIONS

When people actively involved in exercise have fatigued muscles and wear the knee support (Sports Knee Support), the results are the following:

- **Improved stability and load-bearing on a frontal plane** (lower abduction torque, lower medio-lateral acceleration)
  - **Normalized movement and load-bearing on a sagittal plane** (higher flexion torque, higher knee flexion)
- ➔ **STABILIZATION OF THE KNEE JOINT DURING MOVEMENT**
- Subjectively perceived **less pain** and **improved stability**

These results advocate the targeted use of knee supports for preventing (recurring) injuries during sports, especially with fatigued muscles.

### List of terms:

- <sup>1</sup> In biomechanics, a **Counter-Movement Jump (CMJ)** is a vertical jump where the athlete first performs a rapid downwards movement (dive), before jumping straight up as high as possible.
- <sup>2</sup> **Knee abduction torque** describes forces that are exerted resulting in the tibia being pushed in a lateral direction relative to the femur, i.e. outwards. Landing after a jump or lateral evasion can generate high knee abduction torque. In sports medicine, it is often associated with an increased risk of anterior cruciate ligament injuries (ACL).
- <sup>3</sup> **Knee flexion torque** describes forces that bend the knee joint (flexion). That means: forces exerted on the tibia: The resulting muscle strength of the hamstrings or external forces (e.g. weight force when landing) pull the lower leg backwards relative to the thigh. This generates torque which wants to bend the knee.
- <sup>4</sup> In biomechanics, the **maximum medio-lateral knee acceleration** describes the highest measured acceleration of the knee on the frontal plane – i.e. laterally to the center of the body – during a certain movement or exertion.