

## **Hagen Hartmann & Klaus Wirth**

### **Literaturbasierte Belastungs- und Beanspruchungsanalyse unterschiedlicher Kniebeugevarianten unter Berücksichtigung möglicher Überlastungsschäden und Anpassungseffekte**

#### **Kniegelenk- und Wirbelsäulenbeanspruchung in Abhängigkeit von Kniebeugetiefe und Lasthöhe**

#### **Summary**

In the science and practice of strength training it is sometimes suggested that the deep squat entails an increased injury risk of the lumbar spine and the knee joint. Avoiding deep flexion is believed to minimize the magnitude of knee joint forces. Because within the first 50° of knee flexion calculated retropatellar compressive forces are lower, execution of half or quarter squats is recommended when overuse injuries and degenerative changes of the patella-tendon-complex exist. This recommendation is based on calculation of knee joint forces that occurred during the execution of half- and deep-back squats. These values cannot be extrapolated to quarter squats because the following were not taken into account a) the influence of reversal of motion with minor retropatellar contact-zone and lower or missing tendofemoral support-surface and b) the different weights that can be tolerated with the particular squat. This misconception is particularly important when making recommendations for elite training: Due to the advantageous positions of the lever arms at the knee- and hip joints, quarter (and half) squats necessitate higher weights to induce effective training stimuli of the hip and leg extensors compared with deep squats. Accordingly this results in increased knee joint forces and requires a greater degree of torso stabilization to counteract impairing discal shear forces. These relationships were ignored in recent publications so far that have discussed

load and stress of the knee joint and the spinal column at different squatting depths. Provided that the movement pattern is learned correctly under supervision of a qualified trainer and weights are gradually increased, the deep squat presents an effective training exercise for protection against injuries, particular in junior athlete development. Contrary to commonly voiced concerns, deep squats do not entail increased risks of injury of the passive tissues.

## Zusammenfassung

In Wissenschaft und Praxis des Krafttrainings wird mitunter angenommen, dass die tiefe Kniebeuge eine erhöhte Verletzungsgefahr der Lendenwirbelsäule und des Kniegelenks aufweist. Ein Verzicht auf tiefe Gelenkpositionen soll das Ausmaß der Kniegelenkkräfte minimieren. Entsprechend wird bei Überlastungsbeschwerden und degenerativen Veränderungen des Patella-Sehnen-Komplexes die Durchführung der halben oder Viertel-Kniebeuge empfohlen, da innerhalb der ersten 50° Kniebeugung die geringsten retropatellaren Kompressionskräfte berechnet wurden. Diese Empfehlung basiert auf Kalkulationen von Kniegelenkkräften, die bei Ausführung der tiefen und halben Nackenkniebeuge auftraten. Diese Werte können jedoch nicht auf die Viertel-Kniebeuge übertragen werden, da hierbei a) der Einfluss der Bewegungsumkehr bei geringerer retropatellarer Kontaktzone und geringerer oder fehlender tendofemorale Unterstützungsfäche und b) die unterschiedlichen Lasthöhen der jeweiligen Kniebeugevariante unberücksichtigt blieben. Dies ist insbesondere im Leistungssport von trainingspraktischer Relevanz: Aufgrund der günstigeren Hebelverhältnisse in Knie- und Hüftgelenken sind in der Viertel-Kniebeuge (und halben Kniebeuge) höhere Lasten als in der tiefen Kniebeuge erforderlich, um Trainingsreize der Hüft- und Beinextensoren zu applizieren. Dies resultiert in einer entsprechenden Zunahme der Kniegelenkkräfte und erfordert eine größere Stabilisierungsarbeit im Rumpf, um schädigenden distalen Scherkräften entgegenzuwirken. Diese Zusammenhänge blieben in renommierten Publikationen bisher unberücksichtigt, in denen die Belastung und Beanspruchung des Kniegelenks und der Wirbelsäule in unterschiedlichen Kniebeugetiefen diskutiert wurde. Vorausgesetzt, dass unter professioneller Trainerbetreuung die Bewegungstechnik korrekt erlernt und die Belastung allmählich gesteigert wird, stellt die tiefe Kniebeuge eine effektive verletzungsprotektive Trainingsmaßnahme auch im Nachwuchsbereich dar und birgt, entgegen der landläufigen Meinung, keine erhöhten Verletzungsrisiken des passiven Bewegungsapparates.

**Schlagworte:** Wirbelsäulenbelastung, retropatellarer Anpressdruck, tibiofemorale Kompression, Kniegelenkbelastung, tendofemorale Umwicklungseffekt

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