Journal of Kinesiology and Wellness
A Publication of the Western Society for Kinesiology and Wellness
Volume 15, Number 1, 2026 (Advance Online Publication)
ISSN# 2323-4505

Effects of Isokinetic Training After Knee Chondroplasty With BioCartilage on Hamstrings-to-Quadriceps Ratio: A Case Study

Samantha A. Searles and Zachary M. Gillen
Texas Christian University

Background: This case study examined the effects of a 12-week isokinetic training program after knee arthroscopy with chondroplasty of the medial femoral condyle using BioCartilage on the absolute and normalized hamstrings-to-quadriceps ratio (HTQ) in a female. **Methods:** One female (age = 30 years, height = 174.90 cm, body mass = 92.56 kg) underwent a 12-week isokinetic training program consisting of 3 days/week. Maximal voluntary isometric contractions (MVIC) and isokinetic knee extension and flexion at 60, 120, 180, 240, and $300° \cdot s^{-1}$ were tested before and after the 12-week isokinetic training program on an isokinetic dynamometer. Cross-sectional area (CSA) of the quadriceps and hamstrings was assessed with B-mode ultrasound. **Results:** HTQ CSA increased from pre- to post-test by approximately 2.29% in the operative and 1.07% in the nonoperative leg. Absolute and normalized HTQ on the operative leg decreased at MVIC, 60, and $180° \cdot s^{-1}$, and HTQ on the nonoperative leg decreased at 60, 120, and $240° \cdot s^{-1}$. **Conclusions:** Within the first 12 weeks following post-operative rehabilitation and medical clearance after knee chondroplasty with BioCartilage, isokinetic training was accompanied by increased HTQ CSA in both legs, while HTQ increased at moderate and fast velocities on the operative leg and at isometric and very fast velocities on the nonoperative leg, although all changes were below the minimal detectable change (MDC). This case suggests that isokinetic training may be a useful rehabilitation tool alongside traditional physical therapy.

Keywords: strength training, knee injury, muscle balance, lower limb muscle balance

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

BioCartilage is a cartilage allograft extracellular matrix used to augment cartilage repair following marrow stimulation. It serves as a scaffold at the repair site and differs from matrix-induced autologous chondrocyte implantation (MACI), which involves implantation of cultured autologous chondrocytes on a collagen membrane. Previous research has examined clinical outcomes after microfracture augmented with BioCartilage for focal knee cartilage defects (Cole et al., 2021). Rehabilitation typically involves minimal to no weight-bearing for the first three weeks, progressing to full weight-bearing and pain-free return of range of motion by 12 weeks post-surgery (Brusalis et al., 2020; Cole et al., 2021; Gillen, 2023). However, one exercise modality for knee rehabilitation that is non-weight-bearing but allows for muscular development through a selected range of motion is isokinetic training (Horwath et al., 2019; Ünlü et al., 2020), which allows the practitioner to control movement velocity and range of motion while the subject is still able to exert muscular force.

Historically, the hamstrings-to-quadriceps ratio (HTQ) has been suggested as an important factor in recovery from knee injury, in which the hamstrings should be two-thirds as strong as the quadriceps, yielding an HTQ of 0.67 (Ruas et al., 2019). A lower HTQ indicates an imbalance, leading to compensation in the quadriceps

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

The first author (Samantha Searles) of the present manuscript is a doctoral student and Zachary Gillen, Ph.D., endorses the publication of the manuscript.

The data presented in this study are available on request from the corresponding author.

Correspondence concerning this article should be addressed to Zachary M. Gillen, Ph.D., Roach Institute of Athlete Engineering, Department of Kinesiology, Texas Christian University, 3005 Stadium Drive, Fort Worth, TX 76109. Email: z.gillen@tcu.edu

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

and increased force placed on the knee in the frontal plane (Coombs & Garbutt, 2002). After knee surgery, patients likely have bilateral deficits in force production, decreased power production, and a persistent strength gap between the hamstrings and quadriceps of the injured and non-injured legs (Coombs & Garbutt, 2002; Lee et al., 2018). This imbalance can impair motor control and reduce range of motion in the injured leg, hindering activities of daily living. One way to reduce this imbalance is to measure HTQ to gauge a training program's success and eligibility for returning to activities of daily living.

Increasing the muscular strength and size of the lower extremity can improve range of motion, force production, and increase motor control due to improvement in the activation of the musculature about the knee, alongside the rate and magnitude at which action potentials are sent to the activated muscles (Hewett et al., 2004, 2005; Horwath et al., 2019). These improvements can increase HTQ, giving practitioners a way to monitor the progression of muscular imbalances during rehabilitation. An HTQ value of 0.67 has been historically utilized as a threshold for muscular balance and injury risk reduction in both clinical and athletic populations (Ruas et al., 2019), indicating that values below this could reflect quadriceps dominance and are associated with increased knee injury risk, especially in females (Ruas et al., 2019). However, research on the effects of isokinetic training after surgical intervention on HTQ improvements remains limited. Previous research found that isokinetic training, specifically concentric contraction, increased muscular strength after surgery compared with traditional physical therapy interventions (Rivera-Brown et al., 2022). Thus, our study aimed to monitor changes in HTQ using an isokinetic training program following knee chondroplasty with BioCartilage.

Methods

The participant was a 30-year-old female (height = 174.90 cm, body mass = 92.56 kg) who regularly participated in resistance and aerobic training 3–5 days per week, with a history of involvement in competitive sports and no history of musculoskeletal injuries, and underwent a right knee arthroscopy with chondroplasty of the medial femoral condyle with BioCartilage. Arthroscopy is a minimally invasive procedure used to visualize and treat intra-articular pathology, while chondroplasty involves debridement and smoothing of damaged articular cartilage. BioCartilage is a micronized allograft cartilage extracellular matrix scaffold used to augment cartilage repair following marrow stimulation (Cole et al., 2021). Although the physician also referred to the procedure as MACI, the surgical description provided was right knee arthroscopy with chondroplasty of the medial femoral condyle with BioCartilage. Therefore, the present manuscript uses this procedural description rather than classifying the surgery as autologous chondrocyte implantation. This study was approved by Mississippi State University's Institutional Review Board (IRB) for the protection of human subjects (IRB no. 22-043). Prior to participation, the participant completed an approved consent form and PAR-Q+2015 (Warburton et al., 2015).

The participant self-reported a sudden onset of severe pain in her right knee during box step-up exercises while resistance training and was diagnosed with a complex tear of the medial meniscus with chondromalacia and a microfracture of the medial femoral condyle. The following surgery was performed: right knee arthroscopy with chondroplasty of the medial femoral condyle with BioCartilage. The knee was completely immobilized until the first physical therapy appointment 4 days post-surgery. A physical therapy protocol began at 3 days/week for 10 weeks, then at 2 days/week for 14 weeks. The participant then began a 3-day/week physical therapy program that involved greater volumes, intensities, and real-world scenarios for 3 weeks, with a follow-up appointment with the orthopedic surgeon 2 weeks later, at which she was medically cleared to begin all forms of physical activity. The participant then volunteered to participate in an isokinetic resistance training program (Gillen, 2023), which was administered by a researcher who was a Certified Strength and Conditioning Specialist with Distinction. This protocol was inspired by previous research (Baumgart et al., 2018; Gillen, 2023; Ong et al., 2023; Vincent et al., 2019).

Data from this participant have been examined in a previous study (Gillen, 2023), but that study did not involve quantification of HTQ. Instead, the previous study reported increases in total thigh musculature strength, size, and power production, along with bilateral and unilateral vertical jump performance (Gillen, 2023). The study included 38 visits, with the first being familiarization and the last being final testing. During the first visit to the lab every week, before the exercise treatment, height (centimeters) and body mass (kilograms) were recorded using a digital scale (Defender 5000, Ohaus Corporation, Parsippany, NJ) and stadiometer (Heightronic 235D, QuickMedical, Warwick, RI), and the right and left thigh circumferences were recorded with a standard retractable tape measure at 50% of the thigh length, determined from the highest point of the anterior superior iliac spine to the lateral border of the patella. Panoramic cross-sectional images of the entire quadriceps and entire hamstrings muscle groups were taken at 50% of the

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

thigh length to quantify muscle size using a portable brightness mode (B-mode) ultrasound-imaging device (GE LOGIQ e, USA) interfaced with a multifrequency linear-array probe (12 L-RS; 5–13 MHz; 38.4-mm field of view). Images were taken at the same site, at 50% thigh length, and at the same time across the weeks of the present study. Ultrasound equipment settings were optimized for image quality with a gain of 58 dB and a frequency of 12 MHz. Images were analyzed using ImageJ software (version 1.53a; National Institutes of Health, Bethesda, MD). We quantified muscle cross-sectional area (CSA) of the quadriceps and hamstrings using ImageJ's polygon function to select the largest region of interest that included as much of the muscle group as possible while excluding surrounding fascia.

The participant was seated on a calibrated isokinetic dynamometer (HUMAC NORM, Computer Sports Medicine, Inc., Stoughton, MA, USA) with restraining straps over the trunk and ipsilateral thigh, and the lateral epicondyle of the femur was aligned with the axis of rotation of the dynamometer head. For maximal voluntary isometric contraction (MVIC) measurements, the leg was set at an angle of 60° below the horizontal plane (Thompson & Xu, 2023). The participant completed three 5-second MVICs of the knee extensors and knee flexors, with one minute of rest between attempts. Following the MVICs, the range of motion was set from 0° to 90°, with 0° representing full knee extension. The participant completed three maximal voluntary isokinetic knee extensions and flexions at 60, 120, 180, 240, and $300° \cdot s^{-1}$ in random order, with one minute of rest between each angular velocity. This protocol was performed on both legs. For the isometric and isokinetic muscle actions, the repetition with the highest peak torque value was used for all subsequent comparisons. Metrics taken during each isometric and isokinetic muscle action are presented in Table 1 and were expressed as absolute values and relative to the muscle CSA of the respective muscle group. Calculations of HTQ were taken as peak torque from leg flexion divided by peak torque from leg extension for absolute and normalized values. Previous research has demonstrated variable test-retest reliability of HTQ across the velocity spectrum. Searles et al. (2026) reported acceptable absolute HTQ reliability at MVIC and $60° \cdot s^{-1}$ for the left leg (intraclass correlation coefficient [ICC] ≥ 0.75) and at MVIC for the right leg (ICC = 0.76), whereas ICCs were between 0.63–0.66 from 120–$300° \cdot s^{-1}$. Searles et al. (2026) reported the following minimal detectable change (MDC) values for the left leg: 0.18 for MVIC, 0.16 for $60° \cdot s^{-1}$, 0.33 for $120° \cdot s^{-1}$, 0.37 for $180° \cdot s^{-1}$, 0.46 for $240° \cdot s^{-1}$, and 0.36 for $300° \cdot s^{-1}$. The MDC values for the right leg were: 0.19 for MVIC, 0.20 for $60° \cdot s^{-1}$, 0.26 for $120° \cdot s^{-1}$, 0.33 for $180° \cdot s^{-1}$, 0.25 for $240° \cdot s^{-1}$, and 0.35 for $300° \cdot s^{-1}$. Comparatively, the left leg absolute HTQ changes were 0.062 for MVIC, −0.073 for $60° \cdot s^{-1}$, −0.099 for $120° \cdot s^{-1}$, 0.024 for $180° \cdot s^{-1}$, −0.030 for $240° \cdot s^{-1}$, and 0.023 for $300° \cdot s^{-1}$. The right leg absolute HTQ changes were −0.011 for MVIC, −0.039 for $60° \cdot s^{-1}$, 0.048 for $120° \cdot s^{-1}$, −0.014 for $180° \cdot s^{-1}$, 0.055 for $240° \cdot s^{-1}$, and 0.191 for $300° \cdot s^{-1}$, all below the MDCs reported in Searles et al. (2026). These findings indicate that changes in HTQ, particularly at higher velocities, should be interpreted cautiously because of greater measurement variability.

Table 1: *Metrics taken from the isokinetic dynamometer software.*

Isokinetic Metric	Definition
Peak torque (Nm)	Peak value of the gravity corrected torque signal during the muscle action.
Mean power (W)	Average torque value of the gravity corrected torque signal multiplied by the angular velocity.

The training protocol consisted of 3 isokinetic resistance training sessions per week with 24–48 hours between sessions, and 48–72 hours between the final session of the week and the first session the following week. For the isokinetic resistance training protocol, weeks 1–4 consisted of two sets of 10 maximal isokinetic knee extensions and flexions at 60, 180, and $300° \cdot s^{-1}$ with one minute of rest between sets. During weeks 5–8, the participant performed three sets of 10 repetitions at each angular velocity, and during weeks 9–12, the participant performed four sets of 10 repetitions at each angular velocity. Odd-numbered weeks involved concentric-only muscle actions on days 1 and 3, and eccentric-only muscle actions on day 2. Even-numbered weeks involved eccentric-only muscle actions on days 1 and 3, and concentric-only muscle actions on day 2 (Kellis & Baltzopoulos, 1995; Roig et al., 2009). The order of angular velocities and the leg trained first were always randomized.

Results

Right Leg

From baseline to Week 12, absolute HTQ decreased at MVIC (−2.79%), $60° \cdot s^{-1}$ (−6.43%), and $180° \cdot s^{-1}$ (−2.25%), and increased at $120° \cdot s^{-1}$ (+9.6%), $240° \cdot s^{-1}$ (+10.76%), and $300° \cdot s^{-1}$ (+48.6%; Figure 1). Normalized HTQ followed the same pattern, decreasing at MVIC (−4.89%), $60° \cdot s^{-1}$ (−8.42%), and $180° \cdot s^{-1}$ (−4.40%), and increasing at $120° \cdot s^{-1}$ (+7.11%), $240° \cdot s^{-1}$ (+8.26%), and $300° \cdot s^{-1}$ (+45.2%; Figure 2). Baseline and Week 12 values are reported in Table 2.

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

Table 2: *Baseline and Week 12 testing outputs for HTQ on the operative and nonoperative legs across velocity conditions.*

	Absolute HTQ		Normalized HTQ	
Velocity	**Baseline**	**Week 12**	**Baseline**	**Week 12**
Operative leg				
MVIC	0.394	0.383	0.532	0.506
60	0.607	0.568	0.819	0.750
120	0.500	0.548	0.675	0.723
180	0.623	0.609	0.841	0.804
240	0.511	0.566	0.690	0.747
300	0.393	0.584	0.531	0.771
Nonoperative leg				
MVIC	0.228	0.290	0.305	0.383
60	0.516	0.443	0.690	0.586
120	0.540	0.441	0.722	0.584
180	0.495	0.519	0.661	0.686
240	0.534	0.504	0.714	0.667
300	0.458	0.481	0.612	0.637

Note. Velocities are in $^\circ \cdot s^{-1}$. HTQ = hamstrings-to-quadriceps ratio; MVIC = maximal voluntary isometric contraction.

HTQ CSA increased from 0.741 at baseline to 0.758 at Week 12 (+2.29%), peaking at 0.797 at Week 5 (Figure 3).

Left Leg

From baseline to Week 12, absolute HTQ increased at MVIC (+27.2%), $180^\circ \cdot s^{-1}$ (+4.85%), and $300^\circ \cdot s^{-1}$ (+5.02%), and decreased at $60^\circ \cdot s^{-1}$ (−14.15%), $120^\circ \cdot s^{-1}$ (−18.33%), and $240^\circ \cdot s^{-1}$ (−5.62%; Figure 1). Normalized HTQ followed the same pattern, increasing at MVIC (+25.57%), $180^\circ \cdot s^{-1}$ (+3.78%), and $300^\circ \cdot s^{-1}$ (+4.08%), and decreasing at $60^\circ \cdot s^{-1}$ (−15.07%), $120^\circ \cdot s^{-1}$ (−19.11%), and $240^\circ \cdot s^{-1}$ (−6.58%; Figure 2). Baseline and Week 12 values are reported in Table 2. HTQ CSA increased from 0.748 at baseline to 0.756 at Week 12 (+1.07%), peaking at 0.780 at Week 3 (Figure 3).

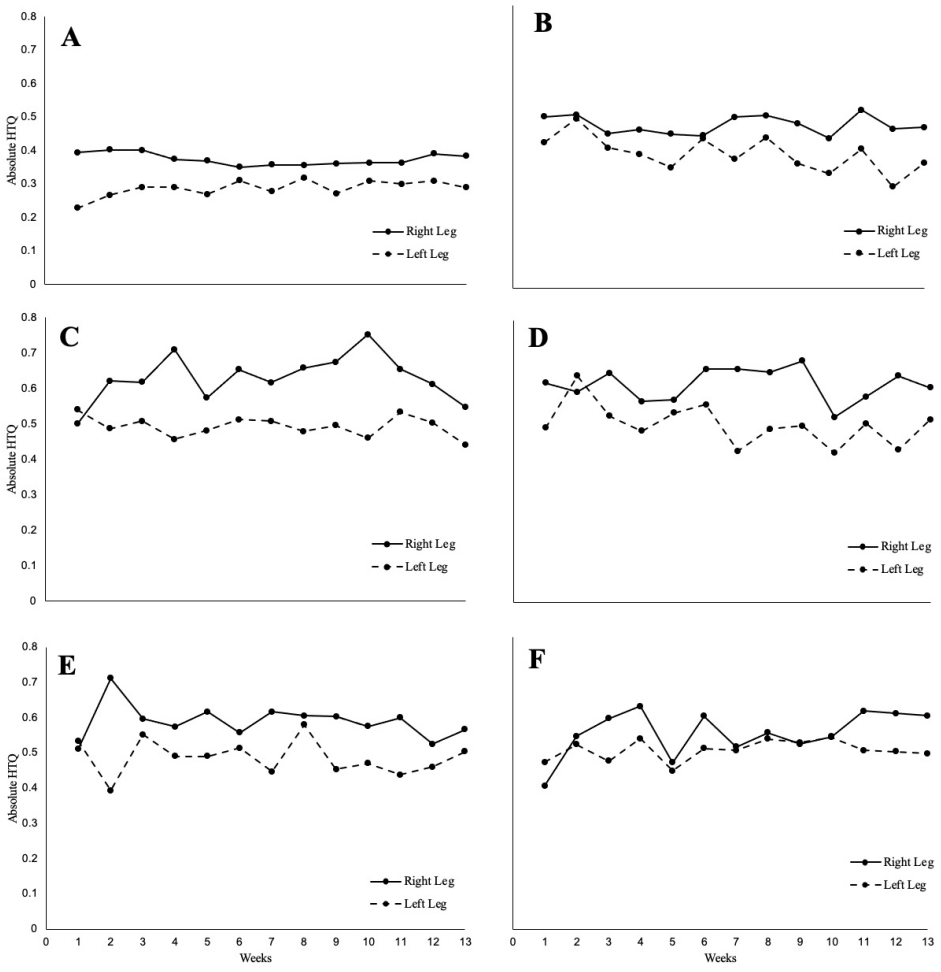
Discussion

Although this study is a case study with a sample size of $n = 1$, it is the first we are aware of to examine the effectiveness of isokinetic training on HTQ following knee chondroplasty with BioCartilage. Regardless of the type of knee injury, surgery causes muscular atrophy (Thomas et al., 2016), reducing lower-limb function and creating a critical need for rehabilitation. Rehabilitation programs should focus on improving muscle strength and hypertrophy, as greater muscle strength and mass allow greater force and power production and may mitigate post-surgery strength deficits (Ebert et al., 2014, 2019). In general, this study showed increases in HTQ CSA of approximately 2.29% for the operative leg (Figure 3) and 1.07% for the nonoperative leg (Figure 3), highlighting the potential effectiveness of a concentric and eccentric isokinetic training program for improving muscular imbalances, as seen in previous studies (Hewett et al., 2004, 2005; Kong & Burns, 2010; Ünlü et al., 2020), providing rationale for utilizing isokinetic training following knee chondroplasty with BioCartilage to help improve muscular balance of the thigh musculature. The changes for normalized and absolute HTQ on both legs across all velocity conditions were below the reported MDC values in Searles et al. (2026), emphasizing that the changes in HTQ should be interpreted cautiously, as the observed change week-to-week cannot be fully attributed to performance and may highlight some error within the measurement. Because all changes fell below the MDC values established by Searles et al. (2026), they cannot be distinguished from measurement error. Table 2 presents absolute and normalized HTQ at baseline and Week 12 for comparison with the 0.67 threshold. Notably, on the operative leg, normalized HTQ at 60 and $180^\circ \cdot s^{-1}$ decreased (0.82 to 0.75, and 0.84 to 0.80, respectively) while HTQ at 120, 240, and $300^\circ \cdot s^{-1}$ increased (0.68 to 0.72, 0.69 to 0.75, and 0.53 to 0.77, respectively). On the nonoperative leg, normalized HTQ at 60, 120, and $240^\circ \cdot s^{-1}$ decreased (0.69 to 0.58, 0.72 to 0.58, and 0.71 to 0.66, respectively), while HTQ at $180^\circ \cdot s^{-1}$ increased (0.66 to 0.68). The remaining velocities were below the 0.67 benchmark at baseline testing, suggesting that surgery more detrimentally affected muscle strength at slower velocities on the nonoperative leg, whereas the operative leg showed the opposite. This change may reflect week-to-week variation not accounted for.

The increase in HTQ CSA for both the operative and nonoperative legs suggests more than just training-program effectiveness. However, even with increases in CSA, HTQ did not increase similarly across velocities; instead, absolute and normalized HTQ on the operative leg decreased at MVIC, 60, and $180^\circ \cdot s^{-1}$, and HTQ on the nonoperative leg decreased at 60, 120, and $240^\circ \cdot s^{-1}$. Notably, the decreases at several velocities on both legs could reflect physiological changes not measured in the study or reduced maximal motor unit recruitment at faster velocities, although this was not measured. Historically, HTQ has been cited as the most important factor for knee injury risk because of an imbalance between the hamstrings and quadriceps, wherein the hamstrings are much weaker than the quadriceps, causing compensation of the quadriceps, leading to greater forces being placed

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Figure 1: Means ± 95% confidence intervals for absolute hamstrings-to-quadriceps ratio (HTQ) from peak torque (PT) calculated from hamstrings PT divided by quadriceps PT across the training program for right and left legs for (A) maximal voluntary isometric contractions, (B) $60° \cdot s^{-1}$, (C) $120° \cdot s^{-1}$, (D) $180° \cdot s^{-1}$, (E) $240° \cdot s^{-1}$, and (F) $300° \cdot s^{-1}$.



on the frontal plane of the knee (Coombs & Garbutt, 2002). Following a knee injury and subsequent surgery, there is the potential for permanent or long-lasting imbalances in the injured leg compared to the non-injured leg, manifesting as a bilateral deficit in force production, decreased power production, and a continual gap between the strength of the hamstrings and quadriceps (Coombs & Garbutt, 2002; Lee et al., 2018). This can cause poor motor control and reduced range of motion in the injured leg, which can hinder activities of daily living as a person ages. With muscular imbalances, the body may compensate by activating surrounding muscles to continue participating in activities of daily living (Coombs & Garbutt, 2002). This can cause one muscle or muscle group to absorb more force during landing tasks, which, over time, can injure the musculotendinous structures of the knee and surrounding connective tissues due to poor force absorption and distribution. Historically, this is seen as the quadriceps absorbing more force than the hamstrings when landing in women, which can result in a tear of the anterior cruciate ligament because the quadriceps are absorbing and dissipating an increased amount of force compared to the hamstrings (Hewett et al., 2004; Lee et al., 2018). Specifically, during landing, the quadriceps act eccentrically and pull anteriorly on the tibia. The hamstrings act as antagonists to the quadriceps and pull posteriorly on the tibia. However, with quadriceps dominance, the anterior force on the tibia is not matched by an equal posterior force, placing excessive tensile load on the anterior cruciate ligament to prevent tibial translation, which can result in a sprain when loads exceed its structural limits. Improvements

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Figure 2: Means ± 95% confidence intervals for normalized hamstrings-to-quadriceps ratio (HTQ) peak torque (PT) calculated from hamstrings PT divided by cross-sectional area divided by quadriceps PT divided by cross-sectional area across the training program for right and left legs split by (A) PT maximal voluntary isometric contractions, (B) PT 60° · s^{-1}, (C) PT 120° · s^{-1}, (D) PT 180° · s^{-1}, (E) PT 240° · s^{-1}, and (F) PT 300° · s^{-1}.

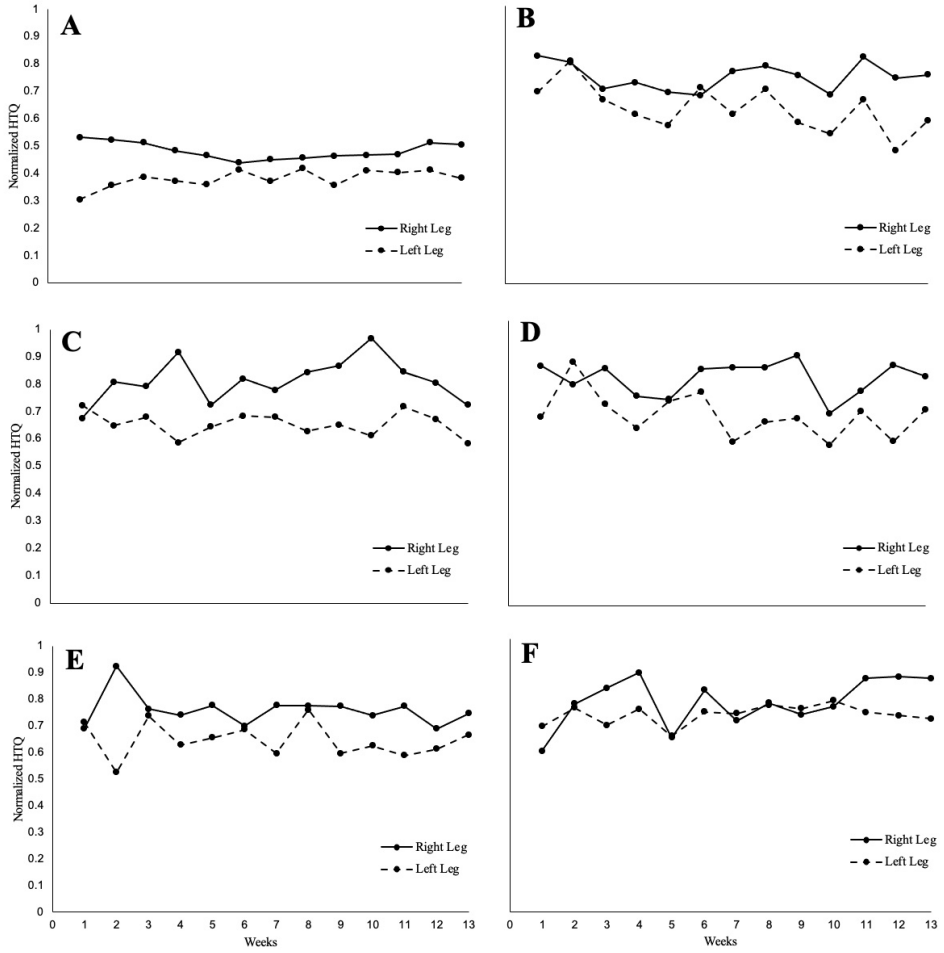
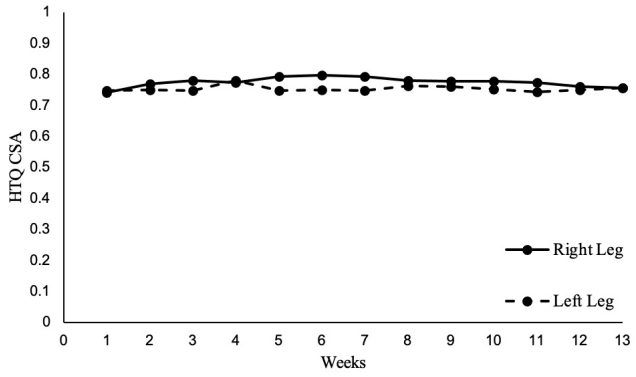


Figure 3: Hamstrings-to-quadriceps ratio (HTQ) from cross-sectional area (CSA) across the training program.



in HTQ may help mitigate these consequences, as increasing muscular strength and size can improve range of motion, force production, and increase motor control of the musculature about the knee and the rate and magnitude in which action potentials are sent to muscles (Hewett et al., 2004, 2005; Horwath et al., 2019).

In addition to traditional physical therapy, the participant opted to use isokinetic training as an additional post-surgery care modality before "return to play." Notably, the isokinetic protocol in this case study resulted in increased HTQ CSA in both legs, suggesting that isokinetic training alongside traditional physical therapy protocols may help reduce the muscular imbalances that result from surgery (Rivera-Brown et al., 2022). Isokinetic training provides velocity-based loading, especially for return-to-play, and can be introduced early to re-

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

train those movement patterns. Additionally, testing quadriceps and hamstring strength at varying intervals post-surgery can help strength coaches and practitioners better understand how to progress other return-to-play tasks for power and strength development (Rivera-Brown et al., 2022). However, because this case study did not include a comparison condition, we cannot determine the independent contribution of isokinetic training to absolute and normalized HTQ, or to HTQ CSA, compared with a traditional physical therapy protocol. HTQ CSA in the injured leg increased more (0.74 to 0.76), possibly because the non-injured leg (0.75 to 0.76) experienced greater atrophy due to limited movement following knee chondroplasty with BioCartilage, allowing greater improvement throughout this program. This limited movement may have resulted from the participant's reluctance to increase movement and risk further injury while healing.

The primary results showed that a 12-week isokinetic training program may improve HTQ CSA in the injured and non-injured leg after knee chondroplasty with BioCartilage. Restoring muscular balance after injury can help the lower leg delay further injury through proper force absorption and production during jumping tasks and activities of daily living, while supporting range of motion and motor control for as long as possible. Thus, rehabilitation practitioners may consider similar isokinetic training programs during rehabilitation.

Conclusions

Within the first 12 weeks of post-operative rehabilitation and after medical clearance following knee chondroplasty with BioCartilage, isokinetic training was accompanied by improvements in HTQ CSA in both the injured and non-injured leg, suggesting it may be a useful rehabilitation tool alongside traditional physical therapy protocols. Further, this case suggests that isokinetic training may be more applicable for increasing HTQ in both the injured and non-injured leg after medical clearance.

The following case study had several limitations. Because the sample size was $n = 1$, the increases in HTQ should be interpreted with caution and cannot be generalized; instead, it can be seen as a proof of concept and a roadmap for future studies. Further, because the dataset includes no comparisons with other participants, it lacks a broader contextual basis and yields a narrower interpretation of the results, in addition to the potential for intra-observer variability. Additionally, weekly testing as the training modality could confound results, as participants may become too familiar with the stimulus and expect what each session will feel like and what the results will be. Lastly, maximal testing every week, in addition to training, could have increased fatigue, as weekly testing itself is a training stimulus that could have dampened maximal force output.

Institutional Review Board Statement

This study was approved by Mississippi State University's Institutional Review Board (IRB) for the protection of human subjects (IRB no. 22-043).

Informed Consent

Informed consent was obtained from the participant involved in the study. Written informed consent has been obtained from the participant to publish this paper.

Data Availability

The data presented in this study are available on request from the corresponding author.

License

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

References

Baumgart, C., Welling, W., Hoppe, M. W., Freiwald, J., & Gokeler, A. (2018). Angle-specific analysis of isokinetic quadriceps and hamstring torques and ratios in patients after ACL reconstruction. *BMC Sports Science, Medicine and Rehabilitation*, *10*, 23. https://doi.org/10.1186/s13102-018-0112-6

Brusalis, C. M., Greditzer, H. G., 4th, Fabricant, P. D., Stannard, J. P., & Cook, J. L. (2020). BioCartilage augmentation of marrow stimulation procedures for cartilage defects of the knee: Two-year clinical outcomes. *The Knee*, *27*(5), 1418–1425. https://doi.org/10.1016/j.knee.2020.07.087

Cole, B. J., Haunschild, E. D., Carter, T., Meyer, J., Fortier, L. A., Gilat, R., & BC (BioCartilage) Study Group. (2021). Clinically significant outcomes following the treatment of focal cartilage defects of the knee with microfracture augmentation using cartilage allograft extracellular matrix: A multicenter prospective study. *Arthroscopy*, *37*(5), 1512–1521. https://doi.org/10.1016/j.arthro.2021.01.043

Coombs, R., & Garbutt, G. (2002). Developments in the use of the hamstring/quadriceps ratio for the assessment of muscle balance. *Journal of Sports Science & Medicine*, *1*(3), 56–62.

Ebert, J. R., Smith, A., Edwards, P. K., & Ackland, T. R. (2014). The progression of isokinetic knee strength after matrix-induced autologous chondrocyte implantation: Implications for rehabilitation and return to activity. *Journal of Sport Rehabilitation*, *23*(3), 244–258.

Ebert, J. R., Smith, A., Janes, G. C., & Wood, D. J. (2019). Association between isokinetic knee strength and perceived function and patient satisfaction with sports and recreational ability after matrix-induced autologous chondrocyte implantation. *Orthopaedic Journal of Sports Medicine*, *7*(12), 2325967119885873.

Gillen, Z. M. (2023). Isokinetic training after a matrix-induced autologous chondrocyte implantation procedure: A case study. *JOSPT Cases*, *3*(3), 150–157.

Hewett, T. E., Myer, G. D., & Ford, K. R. (2004). Decrease in neuromuscular control about the knee with maturation in female athletes. *Journal of Bone and Joint Surgery*, *86*(8), 1601–1608.

Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Jr., Colosimo, A. J., McLean, S. G., van den Bogert, A. J., Paterno, M. V., & Succop, P. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. *American Journal of Sports Medicine*, *33*(4), 492–501.

Horwath, O., Paulsen, G., Esping, T., Seynnes, O., & Olsson, M. C. (2019). Isokinetic resistance training combined with eccentric overload improves athletic performance and induces muscle hypertrophy in young ice hockey players. *Journal of Science and Medicine in Sport*, *22*(7), 821–826.

Kellis, E., & Baltzopoulos, V. (1995). Isokinetic eccentric exercise. *Sports Medicine*, *19*(3), 202–222. https://doi.org/10.2165/00007256-199519030-00005

Kong, P. W., & Burns, S. F. (2010). Bilateral difference in hamstrings to quadriceps ratio in healthy males and females. *Physical Therapy in Sport*, *11*(1), 12–17.

Lee, D. W., Yang, S. J., Cho, S. I., Lee, J. H., & Kim, J. G. (2018). Single-leg vertical jump test as a functional test after anterior cruciate ligament reconstruction. *The Knee*, *25*(6), 1016–1026.

Ong, M. T., Chan, J. S., Man, G. C., Qiu, J., He, X., Wang, Q., & Yung, P. S. (2023). Effect of eccentric isokinetic exercise on muscle strength and functional recovery after anterior cruciate ligament reconstruction. *Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology*, *35*, 20–26. https://doi.org/10.1016/j.asmart.2023.11.002

Rivera-Brown, A. M., Frontera, W. R., Fontánez, R., & Micheo, W. F. (2022). Evidence for isokinetic and functional testing in return to sport decisions following ACL surgery. *PM&R*, *14*(5), 678–690. https://doi.org/10.1002/pmrj.12815

Roig, M., O'Brien, K., Kirk, G., Murray, R., McKinnon, P., Shadgan, B., & Reid, W. D. (2009). The effects of eccentric versus concentric resistance training on muscle strength and mass in healthy adults: A systematic review with meta-analysis. *British Journal of Sports Medicine*, *43*(8), 556–568. https://doi.org/10.1136/bjsm.2008.051417

Ruas, C. V., Pinto, R. S., Haff, G. G., Lima, C. D., Pinto, M. D., & Brown, L. E. (2019). Alternative methods of determining hamstrings-to-quadriceps ratios: A comprehensive review. *Sports Medicine - Open*, *5*(1), 11.

Searles, S., Knight, A., Chander, H., & Gillen, Z. (2026). Reliability of hamstrings-to-quadriceps ratio across the velocity spectrum in females. *Journal of Biomechanics Open*, *1*(1), 100003. https://doi.org/10.1016/j.jbmo.2026.100003

Thomas, A. C., Wojtys, E. M., Brandon, C., & Palmieri-Smith, R. M. (2016). Muscle atrophy contributes to quadriceps weakness after anterior cruciate ligament reconstruction. *Journal of Science and Medicine in Sport*, *19*(1), 7–11.

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness

Thompson, B. J., & Xu, J. (2023). Isokinetic dynamometer leg extensor peak torque measurement: A time-delayed reliability and score selection analysis study. *Journal of Functional Morphology and Kinesiology*, *8*(2), 62. https://doi.org/10.3390/jfmk8020062

Ünlü, G., Çevikol, C., & Melekoğlu, T. (2020). Comparison of the effects of eccentric, concentric, and eccentric-concentric isotonic resistance training at two velocities on strength and muscle hypertrophy. *Journal of Strength and Conditioning Research*, *34*(2), 337–344.

Vincent, K. R., Vasilopoulos, T., Montero, C., & Vincent, H. K. (2019). Eccentric and concentric resistance exercise comparison for knee osteoarthritis. *Medicine and Science in Sports and Exercise*, *51*(10), 1977–1986. https://doi.org/10.1249/MSS.0000000000002010

Warburton, D. E. R., Jamnik, V., Bredin, S. S. D., Shephard, R. J., & Gledhill, N. (2015). The 2015 Physical Activity Readiness Questionnaire for everyone (PAR-Q+) and electronic Physical Activity Readiness Medical Examination (ePARmed-X+). *Canadian Family Physician*, *61*(1), 53–56.

Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.214

© 2026 The Authors | Journal compilation © 2026 Western Society for Kinesiology & Wellness