COMPARISON OF ISOKINETIC STRENGTH IN FEMALE VOLLEYBALL ATHLETES WITH AND WITHOUT KNEE PAIN

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Previous literature indicates that male volleyball players with knee pain have lower quadriceps strength and higher hamstring/quadriceps-ratios (Chantrelle et al., 2022). This has not been investigated in females volleyball players yet. 24 women (71.8 ± 7.6 kg; 1.76± 0.6 m; 24 ± 3.5 years, 11 healthy/13 with chronic knee pain) were examined. The maximum strength and power of the quadriceps and hamstring muscles and their ratio in isokinetic measurement (90°/second) were determined using the ISOMED2000. Maximal quadriceps strength and power in isokinetic measurements is significantly lower in affected legs ($p<0.05$). In contrast the hamstring/quadriceps ratio is significantly increased ($p<0.05$; $\delta=0.34$). Therefore, female volleyball players with chronic knee pain show similar group differences to controls as males.

KEYWORDS: hamstring-quadriceps-ratio, power, torque, isomed2000, concentric

INTRODUCTION: Chronic knee pain (CKP) is a widespread problem in volleyball and is here much more common than in other sports (Ferretti et al., 1984). While only 14% of amateur players suffer from knee pain (Zwerver et al., 2011), the percentage raises up to 45% in elite sport (Lian et al., 2005). Even though there is a lot of information on the association between quadriceps strength and people with knee pain or osteoarthrosis (Coudeyre et al., 2016; Glass et al., 2013), there is less information on this association with patella tendon pain (PT). Currently, only two studies examined the relationship between PT and quadriceps strength in male volleyball players, in which athletes with PT showed lower quadriceps strength (Chantrelle et al., 2022; Dauty et al., 2021) as well as lower hamstring strength (Chantrelle et al., 2022). Due to the significantly reduced quadriceps strength of the chronic knee pain group (CKPG), the hamstring-to-quadriceps ratio (H-Q ratio) is significantly higher for CKPG at 60° and 180°/s than for CG (Chantrelle et al., 2022). In general, volleyball athletes seem to have H-Q ratios of roughly 0.65 ± 0.12, which was investigated in a broad-based study on 127 volleyball players (Hadzic et al., 2010). There is even less information on quadriceps and hamstring strength in female volleyball players. Only one study investigated the H-Q-ratio in healthy collegiate volleyball players so far with 9 athletes (Rosene et al., 2001). Up until now there is no study looking at possible group differences in quadriceps and hamstring strength in female volleyball players with and without PT. Considering that women suffer from patella tendon pain in volleyball as well and former studies only included men, future studies should focus more on the female athlete to close the gender gap in the literature (Harris et al., 2020). Hence, the aim of this study is to investigate group differences in isokinetic measurements for hamstring and quadriceps muscles namely maximal force, maximal power and H/Q-ratio.

METHODS: In a cross-sectional study design, we examined 24 (71.8 ± 7.6 kg; 176 ± 6 cm; 24 ± 3.5 years, 11 controls group (CG)/13 chronic knee pain group (CKPG)) women playing competitive volleyball in higher recreational leagues with 2- 4 trainings per week and regular matches. Inclusion criteria for CG were no injuries to the lower extremity in the last 6 months and unrestricted participation in training and matches. Subjects with structural changes in the knee joint such as partial meniscus removal were excluded. CKPG had to indicate at least a value of 3 on the VAS scale when playing volleyball and subjects had to have pain for at least 3 months on a regular basis. The subjective perception of pain during everyday activities such as climbing stairs, kneeling, jogging and squats were additionally assessed. The CKPG were defined into subjects with patellar tendon pain, anterior knee pain or a combination of both by clinal examination and medical history. All subjects were informed about the examination.

Written consent was obtained. An a priori analysis in G*Power showed that with a group size of 11 and 13 subjects having an abnormal distribution and a desired test power of 0.8, an effect size of δ= 1.07 must be present to reach significant results. Based on results by Chantrelle (Chantrelle et al., 2022) an effect size (cliff's delta = δ) of 1.93 can be expected. The study was previously approved by the local ethics committee (Az. 23-029).
After warming up for about 10-15 minutes with cycling, small jumps and strengthening exercises for the lower extremities, the isokinetic test took place. The isokinetic test was performed on the ISOMED2000 (D&R Ferstel GmbH, Hemau, Germany) which enables torque measurements at specified angular velocities (Holzer et al., 2023). Experiments were performed at 90°/s and included three concentric and eccentric repetitions in a row. Measurements were performed on the injured limb and in healthy athletes on both limbs. Since some athletes had bilateral pain, we could include 18 injured legs and 26 healthy legs in the final analysis. To exclude possible influence from the injured leg on the contralateral leg in unilateral injured athletes, this leg was not included in the final analysis. Measurement was restricted to three repetitions to avoid exhaustion. After a familiarization set, two measurement sets were performed. The torque signal from the ISOMED2000 has been recorded by the MyoSystem1400 (Noraxon USA, Arizona, Scottsdale).
All data were exported from Noraxon to MATLAB (Version: R2023a, MathWorks, Natick, Massachusets, USA), where further processing was conducted. In isokinetic measurements we analysed from the six recorded repetitions (2 sets à 3 repetitions) only the repetition with the highest value in quadriceps or hamstring torque (Mmax). The reason for this approach was that we wanted to have maximal muscle torque of both muscles and no bias from suboptimal repetitions. From the chosen repetition maximal power (Pmax) and total power (Ptotal) was calculated. Hamstring-quadriceps ratio was calculated for all three parameters. All variables were checked for normality in MATLAB. Man-Whitney-U-analysis and calculation of cliff's delta were also performed in MATLAB. Categorization is based on previous literature with δ < 0.147 as negligible, δ < 0.33 as small, δ < 0.474 as moderate and δ > 0.474 as large (Wan et al., 2019).

RESULTS: Mmax and Pmax were significantly reduced in CKPG compared to CG. Maximal hamstring power was also reduced in CKPG compared to CG, but did not reach significance level. Consequently H/Q-Ratio is in CKPG higher compared to CG (Fig.1/Table1).

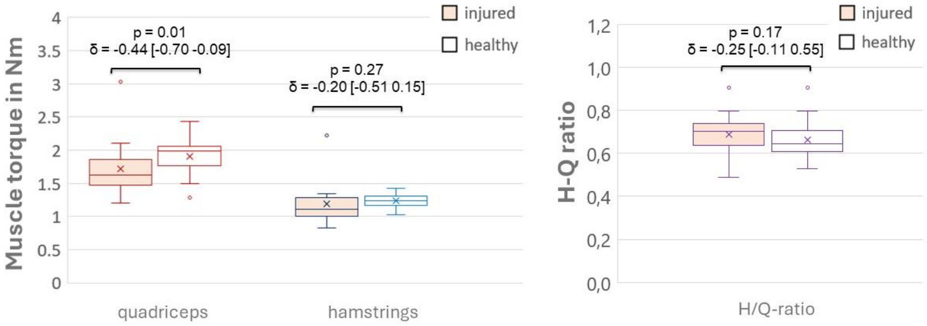

Figure 1: Left: Peak torque of quadriceps and hamstrings in isokinetic measurements at 90°/sec in volleyball athletes with chronic knee pain (red filled boxes) and healthy controls (white filled boxes). Right: Corresponding Hamstring/Quadriceps-ratio (H/Q-ratio).

Table1: Median [IQR] of isokinetic variables with corresponding p-values from Man-Whitney-U Test and cliff's delta (δ) of athletes without (CG) and with chronic knee pain (CKPG).

Variables	CKPG	CG	p	δ
maximal force of quadriceps (N/kg)	1.69 [0.24]	1.99 [0.27]	0.01**	-0.44
maximal force of hamstrings (N/kg)	1.22 [0.19]	1.25 [0.16]	0.27	-0.2
HQ-ratio of maximal force	0.70 [0.09]	0.64 [0.08]	0.17	0.25
maximal power of quadriceps (Watt/kg)	2.66 [0.38]	3.13 [0.43]	0.01**	-0.44
maximal power of hamstrings (Watt/kg)	1.92 [0.30]	1.96 [0.25]	0.27	-0.2
HQ-Ratio of maximal power	0.70 [0.09]	0.64 [0.08]	0.17	0.25
Total power of quadriceps (Watt/kg)	1724.56 [412.06]	1895.73 [387.36]	0.11	-0.29
Total power of hamstrings (Watt/kg)	1436.54 [345.16]	1379.89 [282.32]	0.45	0.14
HQ-ratio of total power	0.82 [0.17]	0.77 [0.31]	0.17	0.25

DISCUSSION: The aim of this study was to analyse group differences in quadriceps and hamstring strength between female athletes with and without chronic knee pain in isokinetic measurements.

The results from the isokinetic measurements are in line with previous literature, which also reported lower Mmax of quadriceps and hamstring in CKPG (Chantrelle et al., 2022). Comparable to former results H/Q-ratio in CKPG is higher than in CG (Chantrelle et al., 2022). Our results with 1.99 Nm/kg for CG and 1.69 Nm/kg for CKPG in isokinetic measurements at 90°/s are lower compared to Chantrelle et al. reporting 3.03 and 2.14 at 60°/s (Chantrelle et al., 2022). Those differences can most probably be explained by different isokinetic velocities as maximal force drops with higher velocity (Siebert et al., 2008)(Siebert et al. 2008) (Chantrelle et al., 2022) and due to gender differences since Chantrelle et al. only investigated male athletes. H/Q-ratio in our investigation is in both groups (P=0.70 [0.09]; C= 0.64 [0.08]) higher compared to previous results with 0.67 for CKPG and 0.56 for CG (Chantrelle et al., 2022). Nevertheless our results from CG are in agreement with reported results from Hadzig et al. (Hadzic et al., 2010), who reported 0.56 as H/Q-Ratio. Since Hadzig (Hadzic et al., 2010) included more healthy subjects (n=127) than Chantrelle (Chantrelle et al., 2022) (n=21) we assume that the reported H/Q-Ratio of 0.65 represents torque ratio in male volleyballers better. Results of this study (H/Q-Ratio 0.64 [0.08]) might imply that those reference values could be applicable to female volleyballers as well. Strength deficits in the thigh muscles seem to be present in athletes with CKP for both genders.

Limitations of this study include that it was a rather small sample size. Nevertheless, we could still show significant differences with moderate effect size. A second limitation might be that pain inhibited full muscle recruitment for the injured athletes.

CONCLUSION: We could show that female athletes have a reduced quadriceps force in isokinetic measurements. These results go in line with previous results on male athletes(Chantrelle et al., 2022). Reported results are important for diagnostic testing in common sporting facilities as reference values.

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