# THE CORRELATION BETWEEN KNEE STABILITY AND MOBILITY OF YOUNG FEMALE RHYTHMIC GYMNASTS

**Peter Katona[1,2] and Rita Polakovits[1]**

**Department of Biomechanics, University of Physical Education, Budapest, Hungary[1]**
**Hungarian Canoe Federation, Budapest, Hungary[2]**

The purpose of this study was to examine the relationship between knee joint mobility and stability. Mobility and stability of the knee joint are supported by the surrounding ligament system around the knee and the muscle system, the balance of muscle forces. In rhythmic gymnastics it is important for an athlete to have an increased range of motion in multiple joints to be successful at competitions, but this heightened flexibility can be the cause of injuries as well. One way to prevent injuries is to have a well-balanced muscle strength in the crucial joints. We examined young female rhythmic gymnasts, their knee's range of motion were measured with goniometer and their hamstring-quadriceps muscle force ratio (H/Q ratio) with dynamometer after warmup. We found significant correlation between their knee flexion and H/Q ratio, and also a moderate correlation between knee extension and H/Q ratio.

**KEYWORDS:** H/Q ratio, Range of motion, prevention.

**INTRODUCTION:** Two main categories can be the cause of injuries during sport activities: extrinsic and intrinsic risk factors (Botar and Mohacsi, 1977, Bahr and Krosshaug 2005, Hume et al. 2013). As an external cause one can mention the facility, the equipment or environmental factors (e.g.: temperature or humidity). The lack of warm-up, fatigue or former injuries are the main inner causes. During complex and immensely demanding sport activities – like rhythmic gymnastics – it is very important to keep in mind during the training period: the athlete have not just to be trained in qualities required to be successful at competition like joint mobility but in basic qualities like joint stability (Douda et al. 2014). The hamstring-quadriceps ratio (H/Q ratio) is an acknowledged parameter to investigate the stability of the knee joint (Coombs and Garbutt 2002). Lack of balance between the forces of these two muscle groups can be a risk of injury (Orchard et al. 1997). In the training methods of rhythmic gymnastics the main attention goes to mobility, because it is needed to perform high valued elements of the sports technique, while the balance of joints gets less attention during practice, and that can be the origin of later injuries. The aim of this study was to determine the interrelation of the range of motion and the muscle balance of rhythmic gymnasts' knee. We hypothesise that there is an increased risk of injury because the abilities required to fulfil the sport requirements (namely the increased range of motion of some gymnastic element) are kept in focus during the trainings and others like strength of muscles contributing to joint stability are somewhat neglected.

**METHODS:** Eleven female rhythmic gymnasts (age 15.64±0.81, 153.55±2.58 m, 46.18±2.96 kg) volunteered to participate in this study. This study was approved by the Ethics Committee of the University of Physical Education. The gymnasts and their parents/guardian provided written consent. After a 5 minute warm-up on a cycle ergometer at 50 W (E7, Ketler GmbH, Ense-Parsit, Germany), the range of motion (ROM) of the gymnasts self-reported dominant knee (van Melick et al. 2017) were measured (3 times) with a goniometer. The ROM was described with an extension and flexion value (in degrees), where a positive extension value means the degree of hyperextension and a negative flexion value means the degree of hyperflexion. Then the joint forces (joint torques) were measured using a Multicont II Tihanyi System dynamometer (Mediagnost, Budapest and Mechatronic Ltd, Szeged, Hungary) on the same limb. The torque of the quadriceps (Q) muscle group was measured during concentric contraction with 60°/s angular velocity between 80 and 10 degrees (Willigenburg et al. 2015), then the eccentric and concentric torque of the hamstring (H) muscle group were

measured with the same parameters. The hamstring group had to be measured this way to calculate both the conventional (cH/Q=concentric H/concentric Q) and the functional (fH/Q=excentric H/concentric Q) H/Q ratio. Data were collated and each participant's average score was entered into the spreadsheet for statistical analysis. Spearman's rank correlation were used to determine the connection between the joint torque ratios and the range of motion (Table 1). Statistical analyses were performed using STATISTICA (STATISTICA 13, Tibco Software Inc., Palo Alto, CA, USA) with significance levels set at $P \leq 0.05$.

**RESULTS:** The hyperextension and hyperflexion values are shown in Figure 1 and Figure 2 respectively.

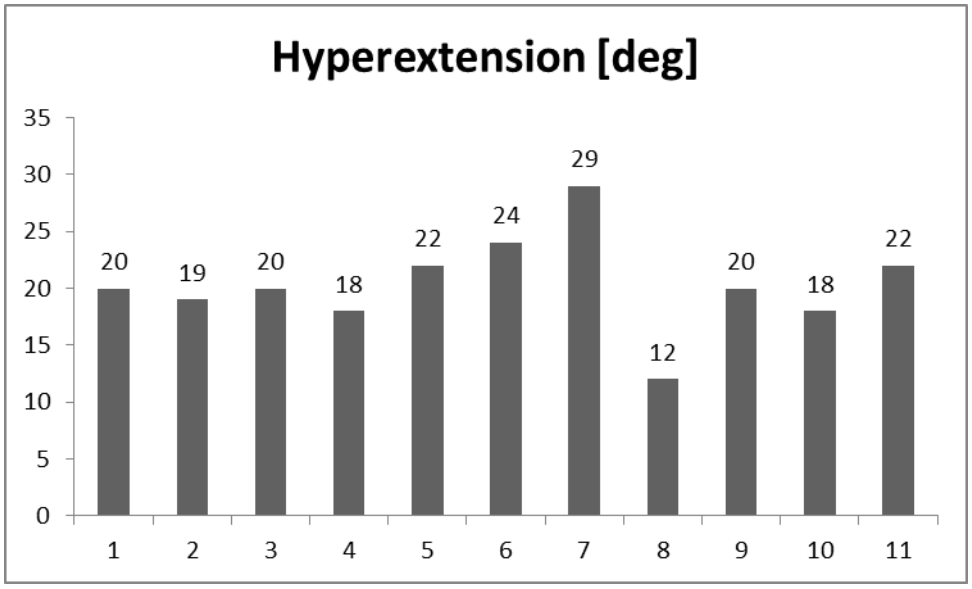


**Figure 1: The hyperextension in degrees measured in the dominant knees of the gymnasts.**

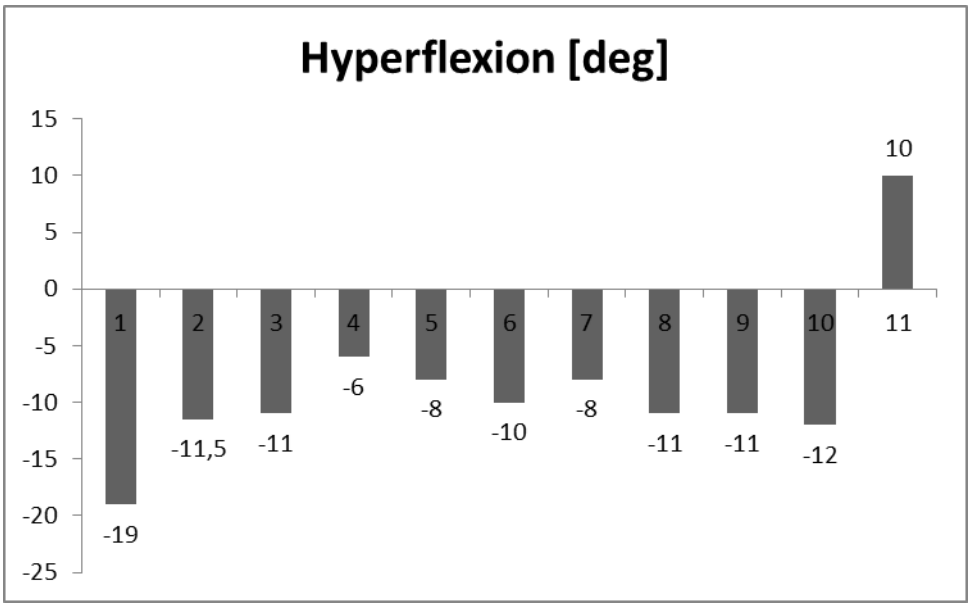


**Figure 2: The hyperflexion in degrees measured in the dominant knees of the athletes.**

The cH/Q and fH/Q values are shown in Figure 3 and Figure 4 respectively.

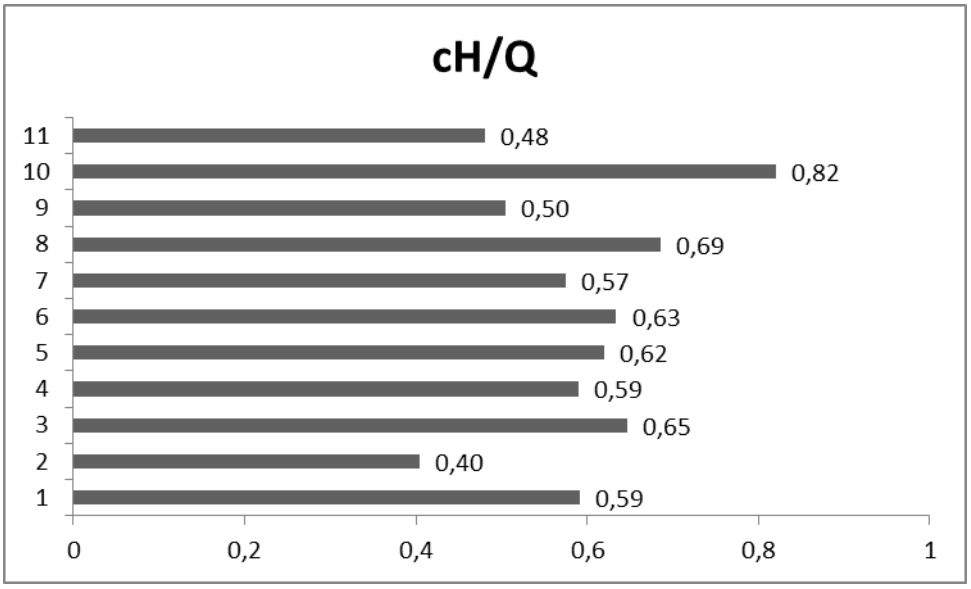


**Figure 3: The cH/Q measured in the dominant knees of the athletes.**

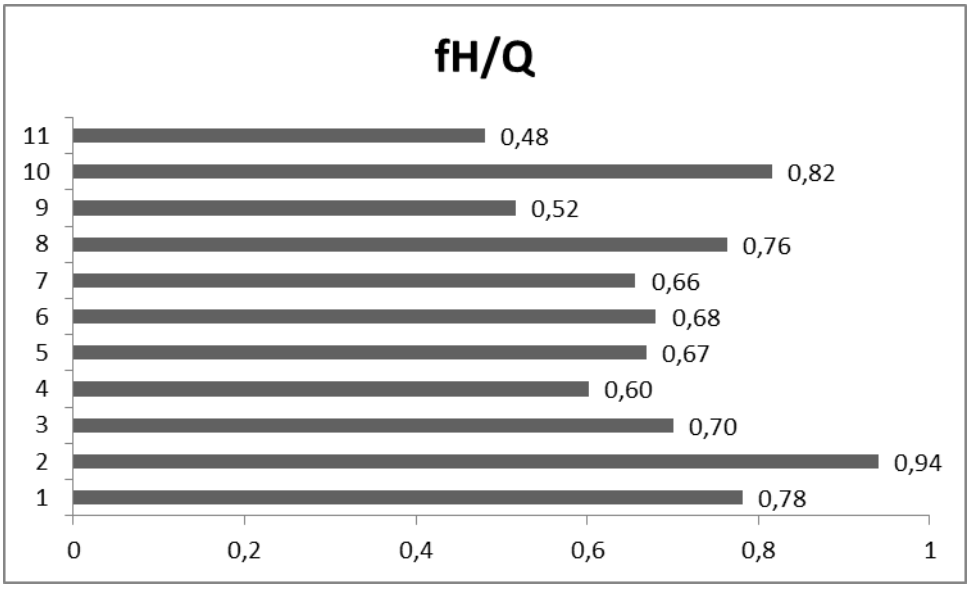


**Figure 4: The fH/Q measured in the dominant knees of the athletes.**

The statistical analysis showed significant correlation between the hyperflexion values and the fH/Q ratio (Table 2).

**Table 1: Results – Spearman's correlation. *-significant correlation**

| Parameters | r |
|---|---|
| 1. cH/Q - hyperflexion | -0.31 |
| 2. cH/Q - hyperextension | -0.31 |
| 3. fH/Q - hyperflexion | -0.82* |
| 4. fH/Q - hyperextension | -0.45 |
| 5. hyperextension - hyperflexion | 0.43 |
| 6. cH/Q – fH/Q | 0.40 |

**DISCUSSION:** The measured athletes have an increased ROM, all of them can achieve hyperextension and all but one of them can achieve hyperflexion. The optimum for the cH/Q ratio is between 0.4-0.6, and 0.5-0.8 for the fH/Q (Rosene et al. 2001). We found 5 athletes with not optimal cH/Q ratio and 4 athletes with not optimal fH/Q ratio – one of them has an fH/Q ratio of 0.91, which means her hamstrings force almost equal to her quadriceps' force. If a H/Q ratio is above optimal, it could mean that the quadriceps is weak or the hamstring is to strong, so the balance of the knee joint is compromised, and an appropriate strengthening should be performed. There is significant correlation only in one case of the statistical analysis: between the rate of hyperflexion and the fH/Q value (r=0.82). It can mean that the increased ability to flex the knee can cause a decrease in the stability of the knee joint through the weakening of the quadriceps muscle. This can be seen as an elevated fH/Q ratio. However, some literature indicates that the upper limit of fH/Q is 0.8 and others report it is 0.6 like the upper limit of cH/Q. The correlation between hyperextension and fH/Q isn't significant but moderate (-0.45), which shows that the effect of hypermobility in the direction of extension has a weaker effect regarding joint stability, what can be explained by the lesser effect of the hamstring muscle group on the stability of the knee joint.

**CONCLUSION:** This study showed that an ability (mobility of the knee) which allow an athlete to be successful in competition can be the cause of his/her increased risk to injure. The ROM of the measured gymnasts' knees is increased to meet the sport requirements, but parallel to this their knee's stability is inadequate. More strengthening of thigh muscles is suggested, to prevent injury in the future. It is still a question, whether the strengthening of the corresponding muscle group would lead only to an increased joint stability or also to a decreased ROM. It is important for trainers to keep well in mind: while achieving higher ROM, the stability of the affected joint can be impaired and through this effect the risk of injury can be elevated. It can be hard to keep the balance between increasing the ROM and keep the risk of injury low, but it is desired, and to have a long and successful sports career, we can say, essential.

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