Differences in torque, H/Q-ratio and left to right leg between adolescent floorball and soccer players

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Abstract
There are similarities between the movement patterns in soccer and floorball. Short sprints and a frequent change of pace and directions. It’s common for an individual practicing a sport with asymmetric kinetic patterns to have strength asymmetries. It’s even more common in athletes with short or intermediate training experience. A low strength ratio between hamstrings and quadriceps has been proven to increase the risk of serious knee injuries, and women have a tendency to impair their ratio during the maturation years. Women compared to men, tend to have a different response to rapid muscle activation, which may prevent a stabilization in the knee joint. It’s not unusual to develop a strength deficit between the legs, especially if one of the legs is more dominant than the other, which also increases the risk of serious injuries. In almost every movement pattern in soccer and floorball, a combination of concentric, eccentric and static movements will occur. This requires good collaboration between agonist and antagonist. The cooperation is trainable, especially during an early age.

The purpose of this study was to determine differences in peak torque, hamstrings/quadriceps ratio and left to right leg between adolescents (age: 16.0 ± 0.3 years), divided into two groups, practicing soccer (S) or floorball (F). A total of 58 athletes, including 18 soccer players (6 females and 12 males) and 40 floorball players (20 females and 20 males), were evaluated using a isokinetic dynamometer.

The result shows no significant difference in peak torque between the groups, but there were a significant difference in one of the legs when peak torque is put in relation to body weight. Hamstrings/quadriceps ratio didn’t differ significantly between the groups, even though some subjects in each group ended up below the recommended value.

The given results barely show any differences in torque, hamstrings to quadriceps ratio and left to right leg between adolescent floorball and soccer players, which may be because of the low age of the participants, or due to all the similarities between the sports.

Key words:
Peak torque, Hamstrings/quadriceps ratio, Soccer, Floorball, Rate of force development
Soccer is a team based game, where eleven players on each team, tries to score as many times as possible during the time allowed (2x45 minutes)(Lees & Nolan, 1998). The field is about 90-110x64-75m (Fifa.com The laws of the game 2013/2014), and the players score by shooting a ball, with a mass of 0.396-0.453kg and a circumference of 68.5-71.1 cm, in the opponents goal (Lees & Nolan, 1998) that’s 7.32m wide and 2.44m high (Fifa.com The laws of the game 2013/2014). During a soccer game, a sprint occurs about every 90 seconds, and lasts for an average of 2-4 seconds. Sprinting constitutes 1-11% of the total distance, and a professional player covers approximately 10-12km during a 90 minutes game. A player performs from 1000 to 1400 short activities during a game, and changes the activity every 4-6 seconds. Activities performed are roughly 10-20 sprints, high intensity running about every 70 seconds, around 15 tackles, 10 headings, 50 involvements with the ball and about 30 passes. In addition to this, the player is constantly changing his/hers pace, sustaining forceful contractions to maintain balance and to control the ball against the opponents. Soccer players need to be able to sprint fast and change directions and pace quickly, which can be provided by high strength and power (Stølen et al. 2005).

Like soccer, floorball is a team based game, but has only six players on the field at the same time. They try to score as many times as possible during the time allowed (3x20 minutes), on a field that’s about 18-20x36-40m (IFF.com Rules of the game 2014). The ball they’re using weighs approximately 23grams and have a diameter of 72mm (IFF.com Material regulations edition 2012), and the goal is 1,6m wide and 1,15m high (Pasanen, et al 2008a). The players use a stick made of plastic, which may be maximal 114cm long and have a total mass of 380 grams (IFF.com Material regulations edition 2012).

Since the studies about floorball are rather limited, where only Maxén, et al. (2011), Pasanen, et al. (2008a, 2008b. 2008c), Snellman, et al. (2001), Wikström and Andersson (1997) have investigated injuries in floorball, and Gomez, et al. (2013) investigated ball possession effectiveness. With no studies on physical requirements, we can only assume they are about the same as in soccer. The sprints may be shorter since the field is quite a bit smaller than a soccer field, and may therefore also appear more frequently. Since floorball players use their upper body for shooting, we can assume there’s a bigger requirement for an upper body strength than in soccer, but since they both consists sprinting, changing pace and directions often, and to resist tackles from other players, we can presume the demands on lower body strength are about the same in both sports.

Strength asymmetries between the lower limbs or reciprocal strength ratio imbalances have been reported in sports with asymmetric kinetic patterns, like soccer (Arnason et al. 2004). According to Fousekis et al. (2010) isokinetic strength asymmetries and reciprocal strength ratio imbalances tend to be more prevalent in players with short and intermediate training-age, while players with high training experience adopt more symmetric use of their lower limbs, which can be associated with adolescents who haven’t had the time to train more than a few years. While men presents a significant increase in peak torque of the hamstrings during maturity, women have a more stable peak torque of the hamstrings during maturation and this weakness in hamstrings creates even more muscular strength imbalances in females’ knees (Dos Santos Andrade et al. 2012). Females also tend to have a lower rate of force development in hamstrings/quadriceps strength ratio (expressed per kilogram of body mass) than males, which can lead to a higher risk for ACL-injuries (Zebis et al. 2011). When it comes to rapid muscle activation, women seem to respond differently than men (Johnson et al., 2012). One reason can be that males have a significantly greater recurrent inhibition, which means a postsynaptic modulator of motor neuron output. Not being able to rapidly activate the muscles, may prevent a stabilization in the knee joint (Johnson et al., 2012). This, considered together with the fact that females also use quadriceps more than hamstrings to stabilize the knee joint (Zebis et al. 2011, Renstrom et al. 2008), may lead to severe knee injuries.

According to Hoshikawa et al. (2009) the quadriceps femoris is important for jumping and ball kicking in soccer, while the hamstrings control these activities and provides joint stabilization. Low muscle strength ratio between hamstrings and quadriceps has been proven to increase the risk of non-contact knee injuries (Zebis et al. 2011) and a hamstrings/quadriceps ratio of at least 50% characterizes a healthy knee (Dos Santos Andrade et al. 2012). Daneshjoo et al., (2013) defines the strength deficit as the difference in strength
between the muscles of opposite extremities. They tested 36 young male soccer players and found out that only 1 of them was in a 10% deficit range between the dominant and non-dominant leg at all angular velocities, which was considered ideal. If the deficit range goes higher than 10%, it contributes to a risk for knee injuries according to the writers. A deficit range less than 10%, between the legs, is an acceptable value.

In almost every movement pattern in soccer, there will occur a combination between concentric, static and eccentric movements. A muscle development in strength is a combination of the agonists’ coordination and the inhibition of the antagonists. All of this is affectable by training, especially in the lower ages (Ekstrand & Karlsson, 1998). Since floorball has almost the same movement patterns as in soccer, this should apply to floorball as well.

Floorball and soccer have some similarities, both being an intermittent sport with similar movement patterns, where you use both legs for sprinting, changing pace and direction frequently and the necessity to be able to resist tackles from opponents. In soccer though, the legs are also used for kicking the ball in different directions, while the arms and upper body are used for shooting in floorball. Since the pitch is smaller in floorball the players might make shorter sprints than in soccer, but they appear more often.

The purpose of the present study was to investigate differences in torque, hamstrings/quadriceps ratio and left to right leg between adolescent, practicing soccer or floorball.

Hypothesis
- Soccer players will have greater values when it comes to peak torque than floorball players.
- Soccer players will have greater average power and total work than the floorball players.
- Hamstrings/quadriceps ratio is expected to be similar between the groups.
- Soccer players are expected to have more players that don’t qualify within the accepted values of deficit between the legs, and also have a bigger deficit than the floorball players.

Material and Methods
Subjects
A total of 58 adolescents (26 females and 32 males; age: 16.0 ± 0.3 years) from a sports high school in Umeå, Sweden, participated in this study. They were distributed in two different groups according to what sport they practiced. Group F consisted of floorball players (20 females & 20 males, body height: 173.1 ± 9.0 cm; body weight: 65.3 ± 9.4kg), while group S consisted of soccer players (6 females and 12 males, body height: 171.8 ± 5.8 cm; body weight: 61.5 ± 6.7kg).

Equipment
A Biodex System 3 (New York, USA) was used to measure isokinetic muscle strength in quadriceps and hamstrings, body weight and body height with Seca (Hamburg, Germany).

Procedure
Each test was performed separately on different times of day and date, which the subjects started up with a light warm up by cycling for five minutes on a cycle ergometer, where they subsequently performed some light stretching and mobility exercises. After the warm up the equipment was adjusted. The subject sat in the chair and the backrest was adjusted to a position that provides the seat in a position where there was a maximal of two fingers distance between the end of the chair and the fold of the knee. The machines' motion axis was then adjusted to mid knee joint or just below. The aim was to get the range of motion to 100°. 0° is the top position of the movement and 100° is the lowest position. By the position of 20° the leg was weighted to amend for the load of the leg. The subject was then strapped by the ankle, thigh, hip and chest. After that, the subject got to try out some kicks at approximately 70% of his/hers maximal force. The subject was then informed how the test would be executed, which includes the machines’ invariabled velocity during all the repetitions on each set, and the subjects maximal push and pull force, during these reps. The test was performed by five repetitions at 90°/s which was followed by a 30 seconds of rest before ten repetitions at 210°/s. The subject had to have his/her arms crossed over the chest during the whole test. The subjects were also instructed to resign from all kinds of heavy training at least 24 hours before the examination.
During the testing, peak torque, time to peak torque, average power and total work, were recorded for both legs.

**Statistical analysis**
The differences between groups were analyzed using t-test. Data are presented as mean values ± standard deviations and deficit is presented in %. The significance level were set as p<0.05.

**Results**
There were no significant differences in height and body mass between the groups (height: p=0.52, body mass: p=0.1).

The isokinetic tests showed a higher peak torque mean value in quadriceps in group S than group F in both legs, but the difference wasn’t significant, p=0.75 for the left leg and p=0.6 for the right leg (Fig 1 and 2).

![Figure 1. Peak torque (Nm) for the left leg quadriceps strength in extension 90°/sec, in both floorball and soccer players.](image1)

![Figure 2. Peak torque (Nm) in the right leg quadriceps strength in extension 90°/sec, for both floorball and soccer players.](image2)

When strength was expressed in relative values (peak torque/body weight) group S performed better in both legs than group F. More specifically in the right leg groups differed significantly (p<0.05), while in the left leg the difference between groups did not reach significant levels (p=0.11) (fig 3 and 4).
Comparing the deficit in the quadriceps strength between the legs, there were no significant differences, but a slightly higher deficit value in F than S. The deficit values within the groups showed no significant differences either, (soccer deficit: p=0.86 and floorball deficit: p=0.64) but both groups presented a higher mean value in the left leg than the right leg (Fig 5 and 6).

Out of the 40 floorball players, there were five that didn’t qualify within the range of the accepted value (less than 10% deficit), and there were six that barely made it (had over 8.5% deficit). Regarding the soccer players, there were 2 out of 18 with a deficit over 10% between the legs, and one that had over 8.5 but less than 10%, and therefore barely made it.
The S group showed a higher mean strength in hamstrings than the F group as well, though the difference wasn’t significant (left leg: p=0.72 and right leg: p=0.71) (Fig 7 and 8).
The relative strength in hamstrings indicated on bigger differences between the groups, as it did in quadriceps. The S group presented higher values in both legs, and showed a significant difference in the left leg (p<0.05), while the difference in the right leg didn’t reach the significant level (p=0.11) (Fig 9 and 10).

Figure 8. Peak torque (Nm) in the right leg hamstrings strength in flexion 90°/sec. for both floorball and soccer players.

Figure 9. Peak torque to Body weight (Nm/Kg) in the left leg hamstrings strength in flexion 90°/sec. for both floorball and soccer players.* (Significant difference between floorball and soccer players).
When measuring the hamstrings to quadriceps ratio the F group presented higher mean values than the S group in the right leg (p=0.76), but lower in the left leg (p=0.86). None of the values were significant. Both groups mean values ended up above the recommended percentage range, with a slightly lower value in the left leg (Fig 11 and 12). There were 10 subjects in the F group and 7 subjects in the S group, who had less than a 50% ratio the left leg, and in the right leg there were 6 subjects in the F group and 2 in the S group. Out of these subjects there were 4 floorball players and 1 soccer player who didn’t end up above the recommended ratio in either of the legs.

![Figure 10. Peak torque to Body weight (Nm/Kg) in the right leg hamstrings strength in flexion 90°/sec, for both floorball and soccer players.](image1)

![Figure 11. Hamstrings to quadriceps ratio (%) in the right leg in extension and flexion 90°/sec, for both floorball and soccer players.](image2)
Table 1 shows differences between S and F regarding mean value for total work. F had higher values in the left leg (p=0.54) while S had higher values the right (p=0.94). There were no significant differences between the groups.

**Table 1. Total work in quadriceps, for both soccer and floorball, and both left and right leg, in extension 210°/sec, in Joule**

<table>
<thead>
<tr>
<th>Total work (Joule)</th>
<th>Floorball</th>
<th>Soccer</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension 210°/sec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left leg</td>
<td>1164.24 ± 228.34</td>
<td>1115.12 ± 304.79</td>
<td>0.54</td>
</tr>
<tr>
<td>Right leg</td>
<td>1141.4 ± 241.58</td>
<td>1137.43 ± 190.03</td>
<td>0.94</td>
</tr>
</tbody>
</table>

For average power the S group had almost no difference in mean value between the legs, while F had slightly higher mean values in the left leg. There were no significant differences between the groups (left leg: p=0.53 and right leg: p= 0.38)(Table 2).

**Table 2. Average power in quadriceps, for both soccer and floorball players, and both left and right leg, in extension 90°/sec, in Watt**

<table>
<thead>
<tr>
<th>Average power (Watt)</th>
<th>Floorball</th>
<th>Soccer</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension 90°/sec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left leg</td>
<td>154.3 ± 28.29</td>
<td>159.47 ± 29.45</td>
<td>0.53</td>
</tr>
<tr>
<td>Right leg</td>
<td>151.49 ± 35.59</td>
<td>159.98 ± 33.5</td>
<td>0.38</td>
</tr>
</tbody>
</table>

When it comes to mean values for time to peak torque in hamstrings, the F group were slower in both left and right leg. The mean values for the left leg were significantly slower than the S group (p<0.05) and the right leg did not have a significant difference (p=0.17)(Table 3).

**Table 3. Time to peak torque in hamstrings, for both soccer and floorball players, and both left and right leg, in flexion 90°/sec, in Milliseconds *(Significant difference between floorball and soccer players)*
### Table 3

<table>
<thead>
<tr>
<th>Time to peak torque (Ms)</th>
<th>Floorball</th>
<th>Soccer</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion 90°/sec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left leg</td>
<td>514.25 ± 134.54*</td>
<td>433.33 ±124.24</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Right leg</td>
<td>458.5 ± 144.05</td>
<td>405.56 ± 130.03</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**Discussion**

The main finding of this study was that a significant difference in strength deficit between the legs were not found in neither the S nor the F group (fig 5 and 6). We expected to see a bigger difference in the S group, since they often have one leg which is more dominant, e.g. for passing and shooting, while the other leg acts more like a supporting leg. Floorball players also have a supporting leg for shooting and passing, but not a dominant leg that perform these actions. Instead they utilize their upper body and extremities to produce the force needed. The F group showed a slightly bigger difference between their legs than the S group, which were not expected according to our hypothesis. They also had more players who didn’t qualify within the deficit range (maximal 10% deficit) or just barely made it. We think the reason for the lack of overall strength differences between the right and the left leg in the groups could be because of their young age (16.0 ± 0.3 years), which means they probably haven’t had the time to develop more strength in one leg than the other, since it’s not possible to develop high levels of strength if the myelination of the nerves isn’t completed (Wilmore et al, 2011). Fousekis et al (2010) indicates that the strength differences, in most cases, are greater amongst people with shorter training age, but will get more balanced the longer the training age. With a professional training age (PTA) of 5-7 years (PTA defines here as 6-7 practices/week and playing in at least the 3rd division), there are bigger strength asymmetries than with a longer PTA. Since our subjects also practices during school hours, they probably practice more than other people their age, which might put them within the definition of PTA. We don’t know for how long they have practiced each sport or if they have practiced multiple sports before or at the same time as soccer or floorball. This means we can’t give any proven statements about the reasons for the lack of strength differences between the legs. It is proven that a big deficit might lead to injuries in the lower extremities, but may be prevented by a more balanced strength, since that leads to better joint stabilization (Nilstad et al, 2014).

There was a difference between the groups regarding time to peak torque (table 3). Group F was slower in the activation of hamstrings in both legs, and had a significant difference in the left leg. The reason for this is indistinct. The movement patterns are very similar, as stated earlier, and since a floorball pitch is much smaller than a soccer pitch, the floorball players should perform more and shorter sprints, which should make their muscle activation more rapid (Thorlund et al, 2009). Being able to rapidly activate the hamstrings is partly important for knee joint stabilization during a powerful knee extension (Cheung el al, 2012) and since knee injuries is the most common injury amongst floorball players (Pasanen et al, 2008a), this might be one reason behind it.

There wasn’t any difference between the groups in peak torque in extension 90°/sec (fig 1 and 2), but there were big differences in peak torque to body weight in extension, with a significance in the right leg (fig 3 and 4). Peak torque in flexion 90°/sec didn’t show any difference either (fig 7 and 8), while it differed to a bigger extent in peak torque to body weight in flexion in both legs, with a significance in the left (fig 9 and 10). The reason for this, could be due to the groups’ body mass values. S weighs a few kg less than F, which will affect the value for relative strength, even if there were no significant statistical differences.

Several subjects from each group (a few more from the F group than the S group) ended up below the recommended value for hamstrings/quadriceps ratio (hamstrings having at least 50% of quadriceps strength)(fig 11 and 12). A low hamstrings/quadriceps ratio will result in greater risks being injured in both the hamstrings muscle and the knee joint (Delextrat et al, 2009). Seeing the results, it’s easy to generalize the F group as inferior, since there were more players who didn’t qualify, though they are considerably more subjects in the F group (40 subjects) than the S group (18 subjects). Both groups showed a mean value greater than the recommended values, but the differences between the legs did not reach a significant level.
Seeing total work as a measure of muscle endurance (Gleeson & Mercer, 1992), we were expecting group S to perform better than group F, since group S is active during a longer period of time, with fewer substitutions and also perform longer sprints. Though the difference wasn’t significant, group F did perform better than group S (table 1). This could be due to floorball players’ performance of more high-intensive/maximal sprints during a game, which may improve the muscular endurance (Wilmore et al, 2011).

The soccer players achieved a better result regarding average power, even if the difference didn’t show any significance (table 2). As we thought the peak torque would be higher within the S group than the F group, we also thought average power would be higher since there is a strong relationship between maximal strength and power (Stølen et al, 2005). It’s important to be able to withstand tackles and other kinds of rough play effectively in soccer, which requires both strength and power. Simultaneously, a soccer player needs to have the energy to change pace and directions regularly during a long period of time, which also calls for both strength and power (Stølen et al, 2005). These requirements also exist in floorball, though we thought the S group would perform better in peak torque and average power, due to longer games and limited substitutions.

Since we know nothing about the subjects’ background, for how long they have practiced each sport, if they practice another sport at the same time, if some of them practice both soccer and floorball, or even how much they practice, we can’t say much about the results compared to the already existing physical requirements within each sport or how big the differences actually are between them. This means we can’t exclude the fact that more than one sport may be practiced by the subjects or how one of the sports affect their physical abilities.

**Conclusion**

Based on our findings, it can be concluded that the differences in torque, hamstrings to quadriceps ratio and left to right leg between adolescent floorball and soccer players are barely noticeable. The only significant differences was developed in smaller measurements, but there were no significant findings in neither peak torque nor hamstrings to quadriceps ratio. This could be the result of the not fully developed physical abilities of the subjects or their possibly low training age.
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IFF.com Rules of the game 2014

IFF.com Material regulations edition 2012