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REVIEW PAPER

Isokinetic Hamstrings-to-Quadriceps Peak Torque Ratio in Combat Sports: A Systematic Review and Meta-analysis

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Abstract

Combat sports are very demanding in terms of physical fitness as well as the risk of injury. Elite athletes during daily training due to specific movements can develop significant muscle asymmetry that can affect injury. The aim of this study was to systematically review the existing literature with respect to total average value of hamstrings-to-quadriceps (H/Q) 60°·s-1 and H/Q 180°·s-1 in judo, karate, taekwondo and wrestling. We placed special emphasis on sex-based differences and possible asymmetries between legs in terms of isokinetic performance. This document was developed and reported in accordance with the Guidelines for Preferred Reports for Systematic Reviews and Meta-Analyzes (PRISMA). Web of Science, PubMed and Google Scholar were searched for the relevant studies. Studies were included in the review if they were original and written in English and had to have H/Q ratio measured as an outcome. In total, data from 243 athletes from eleven studies included studies was analysed. The Mean of H/Q 60°·s-1 for all sports were: 58.33% for the right leg and 58.91% for the left leg. Women had higher values: 59.38% vs. 57.42% for the right leg and 61.35% vs. 56.56% for the left leg. The Mean of H/Q 180°·s-1 for all sports were: 71.44% for the right leg and 71.35% for the left leg. Women had higher values: 75.76% vs. 69.04% for the right leg and 73.39% vs. 70.33% for the left leg. All these values, combined for all sports, and divided into subgroups according to gender, show that they are within the recommended values. Combined results for all included studies showed that there was no asymmetry between the left and right leg. According to the results of the balance of the mentioned agonists and antagonists, which are crucial for knee joint stabilization during dynamic muscle contractions, we can conclude that athletes in combat sports do not represent a risk group.

Keywords: *H/Q ratio, biomechanics, judo, taekwondo, wrestling, karate combat sports*

Introduction

Modern combat sports are very demanding in terms of physical fitness not only to achieve sporting success, but also to reduce the risk of injury. For instance, during high-intensity action in judo, competitors try to throw each other on their backs or control the opponent in the ground phase (Thomas et al., 1989; Franchini et al., 2005). Similarly, wrestling (Greco-Roman style) is one of the most demanding

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sports from a metabolic standpoint, in which superior strength and power are critical (Kraemer, 2002; Drid & Dokmanac, 2007). In Taekwondo, muscle functions such as muscle strength and endurance of the lower extremities are important factors for performing a strong and precise blow (Cools et al., 2007; Markovic et al., 2008; Kim et al., 2015). According to the rules imposed by the World Karate Federation, the main goal of an athlete is to score a point by touching the opponent; therefore, high-intensity actions in striking and shooting techniques are required before the opponent's response (Mori et al., 2002). Also, karate practitioners spend a lot of time training in positions that could put a lot of stress on joints such as the hips, ankles, and especially the knees (Sorensen et al., 1996; Probst et al., 2007).

The hamstrings to quadriceps H/Q peak torque ratios have received much attention in connection with their use to quantify muscle imbalance, as well as in rehabilitation and physical fitness (Rosene et al., 2001; Kong & Burns, 2010). The H/Q peak tork ratio is critical for providing muscle stability in the knee and for preventing anterior cruciate ligament (ACL) injuries (Aagard et al., 1998). Low back muscle strength relative to the quadriceps increases the risk of non-contact knee injuries (Hewett et al., 2008), and some studies have also shown that asymmetries between dominant and non-dominant limbs may also be associated with an increased risk of injury in athletes (Knapik et al., 1991). Posterior contraction helps prevent excessive quadriceps contraction, thus improving the stability of the knee joint (Weiss et al., 2015). Thus, deficiencies in posterior locus strength and activation limit the potential for muscle contraction to protect ligaments (Hewett et al., 2008).

Elite athletes can develop significant muscle asymmetry during daily training, and the specificity of sports movements can lead to muscle imbalance that could affect injuries (Magalhães et al., 2004). As a result of repeating the same movement patterns over a number of years, a negative adaptation of the body to a particular sport can occur, which often manifests as a contralateral and ipsilateral imbalance of strength and flexibility (Nofal, 2003). Indicators that show the occurrence of contralateral and ipsilateral imbalance are as follows: the ratio of the maximum torque of the hamstrings-to-quadriceps and bilateral deficit (BD). Maintaining a balance between the hamstrings and the quadriceps is necessary for the general stabilization of the knee joint (Croisier et al., 2008). Balance exercises are quite effective in terms of neuromuscular and functional performance (Polat et al., 2018). The risk of injury decreases with increasing leg muscle strength (U˘gur et al., 1999).

The H/Q ratio is particularly significant in acyclic sports, as well as in sports in which there is a dominant muscle group in terms of strength (Scoville et al., 1997). Steindler (1955) was the first to suggest that the absolute muscle strength of the knee extensor should be greater than the strength of the knee flexor at 3:2 (66%). In the 1960s, the introduction of isokinetic dynamometers began (Hislop & Perrine, 1967). Isokinetic reports published up to the 1980s assessed only concentric muscle actions and recommended an optimal H/Q ratio in the range of 50 to 80% (Kannus, 1994). The limit value is 60% (Klein & Allman, 1969; Kellis & Baltzopoulos, 1995). This value has become normative and has been widely used to identify muscle imbalance through the so-called "H/Q conventional relationship" (Heiser et al., 1984). Andrade et al. (2012) reach 57% of average values, while Struzik and Pietraszevski (2015) reach results from 48.8% to 58.8%, depending on the angular velocity.

It is complex to assess whether higher or lower H/Q values are more desirable, because those that are within the mentioned limits can be there most often due to quadriceps weakness. The study was conducted in order to combine the results of several studies, which is a great advantage when we draw conclusions, then on the basis of only one study. Individual studies often have limitations due to the small number of respondents, so we combined the results of several studies to obtain a reference number of respondents. Therefore, the obtained results will represent a better picture of the research subject, and we will be able to conclude whether the obtained values are within the recommended framework. This is the uniqueness of this study in relation to those published so far. The aim of this study was to systematically review the total average value of H/Q 60°·s-1 and H/Q 180°·s-1 of the conventional ratio for judo, karate, taekwondo, and wrestling, and also to compare the values by gender and to compare the values of the left and right leg in order to determine whether there is an asymmetry in the muscle strength of the thighs.

Materials and Methods

Study Design

This document was developed and reported in accordance with the Guidelines for Preferred Reports for Systematic Reviews and Meta-Analyzes (PRISMA) (Moher et al. 2009).

Data sources and searches

The search strategy was developed to identify all relevant studies that measure the H/Q ratio in sports: Judo, Karate, Taekwondo, and Wrestling. Our systematic search included Web of Science, PubMed, and Google Scholar databases. The date limit for the publication period was set from the year 2005 until August 2022. The inclusion/exclusion of studies was done by two investigators by consultation and consensus. We used the following combinations of the search terms via the Boolean operator: ("Hamstring" OR "Posterior Thigh Muscles" OR "Quadriceps") AND ("Ratio" OR "Peak Torque" OR "Torque Ratios" OR "Strength Ratios") AND ("Martial Arts" OR "Judo" OR "Karate" OR "Taekwondo" OR "Wrestling"). The search strategy is shown in Fig. 1. We also manually searched for reference citations of identified studies and selected original research that met our inclusion criteria. Two investigators (V. D. and B. R).

Study selection

To be included in our analysis, the original study had to meet the following criteria: 1) H/Q ratio had to be measured as an outcome 2) athletes had to be from one of four combat sports: Judo, Karate, Taekwondo, and Wrestling. The inclusion of studies in our analysis was limited to English only. Studies excluded were systematic reviews, meta-analyses, study protocols, books, book reviews, and conference publications. Also excluded were those studies that measured dominant and non-dominant leg as an outcome. There was no age limit for the respondents included. The analysis included studies that had both women and men as respondents and athletes elite and non-elite.

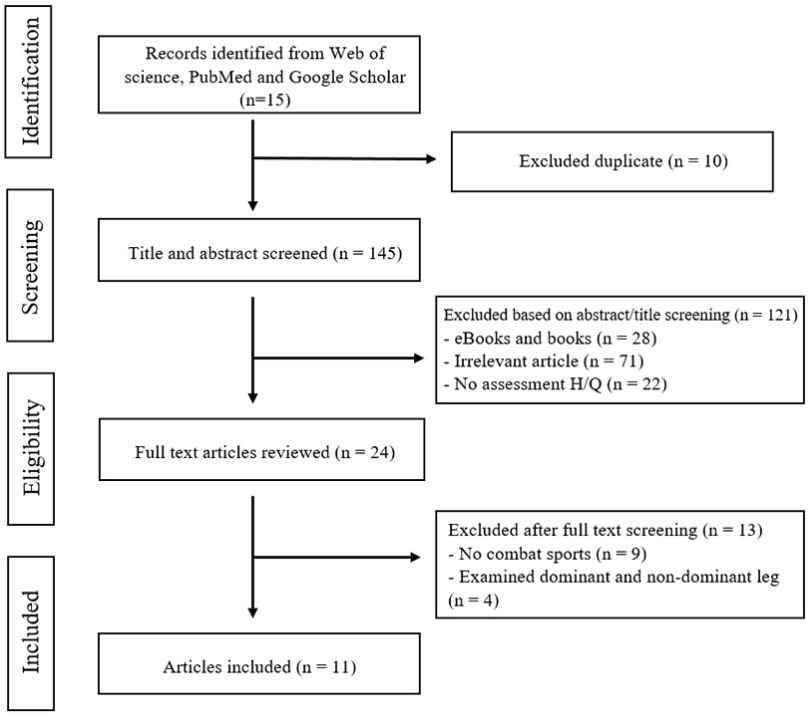

FIGURE 1. Flow diagram of the process of study selection

Data extraction and quality assessment

After selecting studies based on inclusion and exclusion criteria, the two investigators conducted data extraction jointly. The following variables were abstracted into a pre-formatted table: authors, year of publication, characteristics of study participants (number of participants, age), sex, angular velocity, sport, isokinetic dynamometer, H/Q values, and mode.

Two researchers independently assessed the quality of the studies involved, if there were disagreements, they were resolved by consensus. Methodological qualities and risk of bias were evaluated by the methodological index for non-randomized studies (MINORS) (Slim et al., 2003). MINORS score ≥10 was set as the level of inclusion. MINORS involves 12 items: A clearly stated aim, Inclusion of consecutive patients, Prospective collection of data, Endpoints appropriate to the aim of the study, Unbiased assessment of the study endpoint, Follow-up period appropriate to the aim of the study, Loss to follow up less than 5%, Prospective calculation of the study size, An adequate control group, Contemporary groups, Baseline equivalence of groups, and Adequate statistical analyses. Disagreements were resolved by a discussion to reach a consensus.

Statistical analysis

Statistical analysis was performed using MetaAnalyst software version 3.2 (Brown University, USA) (Wallace et al., 2009). For the included studies, the Mean of H/Q ratio 60°·s-

Table 1. Risk of bias for each study

	Methodological items												
Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total score**
Blach 2021	2	2	2	2	0	0	0	0	2	2	2	2	16
Drid 2009	2	1	0	2	0	0	0	0	2	2	2	2	13
Drid 2011	2	2	0	2	0	2	2	0	0	0	0	2	12
Jung 2017	2	2	2	2	0	0	0	0	1	2	2	2	15
Kim 2015	2	1	2	2	0	2	1	0	0	0	0	2	12
Kotrljanović 2016	2	2	2	2	0	0	1	0	2	0	2	2	15
Lisowska 2020	2	2	2	2	0	0	0	0	2	0	2	2	14
Malović 2020	2	2	2	2	0	0	0	0	2	2	2	2	16
Polat 2018	2	2	2	2	0	0	0	0	0	0	0	2	10
Radjo 2011	2	2	1	2	0	0	0	0	2	2	2	2	15
Trajković 2018	2	2	1	2	0	0	0	0	2	2	2	2	15

Note, (MINORS score): 1 - A clearly stated aim, 2 - Inclusion of consecutive patients, 3 - Prospective collection of data, 4 - Endpoints appropriate to the aim of the study, 5 - Unbiased assessment of the study endpoint, 6 - Follow-up period appropriate to the aim of the study, 7 - Loss to follow up less than 5%, 8 - Prospective calculation of the study size, 9 - An adequate control group, 10 - Contemporary groups, 11 - Baseline equivalence of groups, 12 - Adequate statistical analyses.

1 and 180°·s-1 for the right and left leg was measured, and a subgroup analysis by gender was performed. The asymmetry between the left and right legs was estimated using the Mean Difference (MD) and 95% confidence interval (CI) for the measured outcomes H/Q ratio 60°·s-1 and 180°·s-1. Statistical significance was set at $p<0.05$.

Results

Based on the search strategy, a total of 155 studies were selected from the initial database search. Of that number, 10 studies were excluded as duplicates, so 145 studies were selected for further analysis. Following the presentation of the abstract and title, 121 studies were excluded because they did not meet the inclusion criteria. The remaining 24 studies were fully reviewed. When the full-text articles were reviewed, 13 studies were excluded. The remaining 11 studies are included in this review article. The flow diagram of the study selection process is shown in Fig. 1.

Risk of bias

Table 1. shows a summary of the risk of bias for each study included. Of the eleven included studies, no study was randomized, so MINORS was used as a risk of bias assessment tool for non-randomized studies. The maximum possible score for comparative studies is 24, while for non-comparative studies it is 16. The lowest score was the study by Polat et al. (2018) with 10 points, while the highest score was the study by Blash et al. (2021), and Malović et al. (2020) with 16 points.

Table 2 shows the main characteristics of the includ-

Table 2. Characteristics of the included studies

Study	N	Age	Sex	Sport	Isokinetic dynamometer	Angular velocity	H/Q (%) right leg	H/Q (%) left leg	Mode
Blach 2021	25	21.02±3.11	Female	Judo	Humac Norm	60°·s-1	(52kg) 63±1	62±1.4	concentric
							(63kg) 55±1.6	54±2	
							(70kg) 58±1.3	61±1.6	
Drid 2009	20	19.6±2.6	Male	Judo and	Easy-Tech	60°·s-1	(Jud) 47.8±10.8	45.9±9.1	concentric
		20.8±2.8		Wrestling			(W) 39.5±4.9	39.3±6	
Drid 2011	15	22.86±2.8	Female	Judo	Easy-Tech	60°·s-1	47.49±5	47.09±4.2	concentric
Jung 2017	30	19.4 ± 0.99	Male/	Taekwondo	770 Norm;	60°·s-1	(M) 62.8±8.88	59.4±7.52	concentric
		19.1 ± 1.13	Female		Cybex		(F) 52.4±7.1	52.8±5.76	
Kim 2015	12	18.9	Female	Taekwondo	770 Norm;	60°·s-1	(2004) 61.7±3.65	62.2±3.03	concentric
					Cybex		(2005) 63.1±13.89	66.5±9.46	
						180°·s-1	(2004) 69.9±6.45	64.1±5.21	
							(2005) 81.2±11.86	78.3±13.06	
Kotrljanović	18	24.1±3.72	Male/	Karate	Humac Norm	60°·s-1	(M) 68.89±6.81	66.56±12.14	concentric
2016		21.25±2.76	Female				(F) 66.56±9.44	71.22±4.68	
						180°·s-1	(M) 74.89±8.1	76.67±11.44	
							(F) 78.11±11.91	78.67±6.54	
Lisowska	30	25.9±6.9	Male	Karate	Biodex	60°·s-1	(K) 58.63±9.13	54.75±6.9	concentric
2020		22.6±3.8					(Contr) 52.23±6.9	51.59±5.99	
						180°·s-1	(K) 58.95±8.94	59.38±5.94	
							(Contr) 55.66±6.15	53.28±7.77	
Malović	25	22.50 ±1.85	Male	Judo	Humac Norm	60°·s-1	(S) 63.77±9.2	66.4±10.5	concentric
2020		18.33 ±0.50					(J) 65.7±20.6	68±15.9	
		16.50 ±0.53					(C) 69.3±11.1	69.3±9.3	
						180°·s-1	(S) 77.1±14	74.3±12.4	
							(J) 72.7±18.5	77.6±15	
							(C) 78.5±12.6	85.6±15.5	
Polat 2018	18	24.27±3.18	Male	Wrestling	Isomed 2000	60°·s-1	62.85±6.23	60.02±7.98	concentric
Radjo 2011	20	24.8±3.29	Male	Judo	Biodex	60°·s-1	(J-A) 55.67±10.9	55.88±7.2	concentric
		20.95±3.25					(J-B) 44.88±9.15	46.97±10.74	
Trajković	30	21.25±2.76	Female	Karate	Humac Norm	60°·s-1	(S) 61.22±22.33	71±4.47	concentric
2018		16.87±0.99					(J) 62.55±8.05	61.18±9.69	
		15.00±0.81					(C) 70.1±10.44	68.4±9.26	

Note, (Wrest) - Wrestling; (Jud) – Judo; (2004) – season 2004; (2005) – season 2005; (F) – female; (M) – male; (Contr) – control; (K) – karate; (C) – cadet; (J) – junior; (S) – senior; (J-A) – Judo A group; (J-B) – Judo B group

ed studies. A total of 243 respondents participated in the eleven included studies, and the sample size of the included studies ranged from 12 to 30. The age of the respondents ranged between 14 and 29 years. In a study by Blach et al. (2021), we took results from three categories (up to 52 kg, up to 63kg, and up to 70 kg) from seven categories of respond.

Quatitative analysis

All eleven studies measured the H/Q 60°·s-1 ratio. The Mean H/Q 60°·s-1 ratio for the right leg was 58.33% (95% CI = 55.67%, 60.98%, p<0.001) (Fig. 2). The Mean H/Q 60°·s-1 ratio for the right leg for males and females was: Male 57.42% (95% CI = 51.28%, 63.57%, p<0.001); Female 59.38% (95% CI = 56.19%, 62.58%, p<0.001) (Fig. 2).

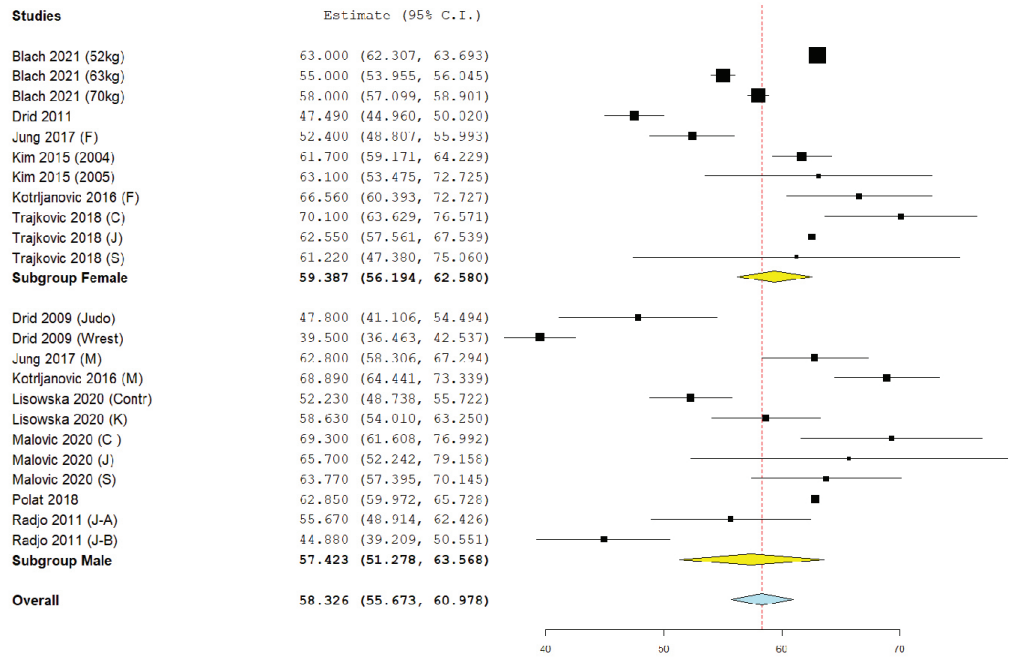

FIGURE 2. H/Q 60°·s-1 Right leg Subgroup Gender: (52kg) – up to 52kg; (63kg) – up to 63kg; (70kg) – up to 70kg; (Wrest) - wrestling; (2004) – season 2004; (2005) – season 2005; (F) – female; (M) – male; (Contr) – control; (K) – karate; (C) – cadet; (J) – junior; (S) – senior; (J-A) – Judo A group; (J-B) – Judo B group.

The Mean H/Q 60°·s-1 ratio for the left leg was 58.91% (95% CI = 56%, 61.81%, p<0.001) (Fig. 3). The Mean H/Q 60°·s-1 ratio for the left leg for males and females was: Male 56.56% (95% CI = 51.63%, 61.49%, p<0.001); Female 61.35% (95% CI = 57.58%, 65.12%, p<0.001) (Fig. 3).

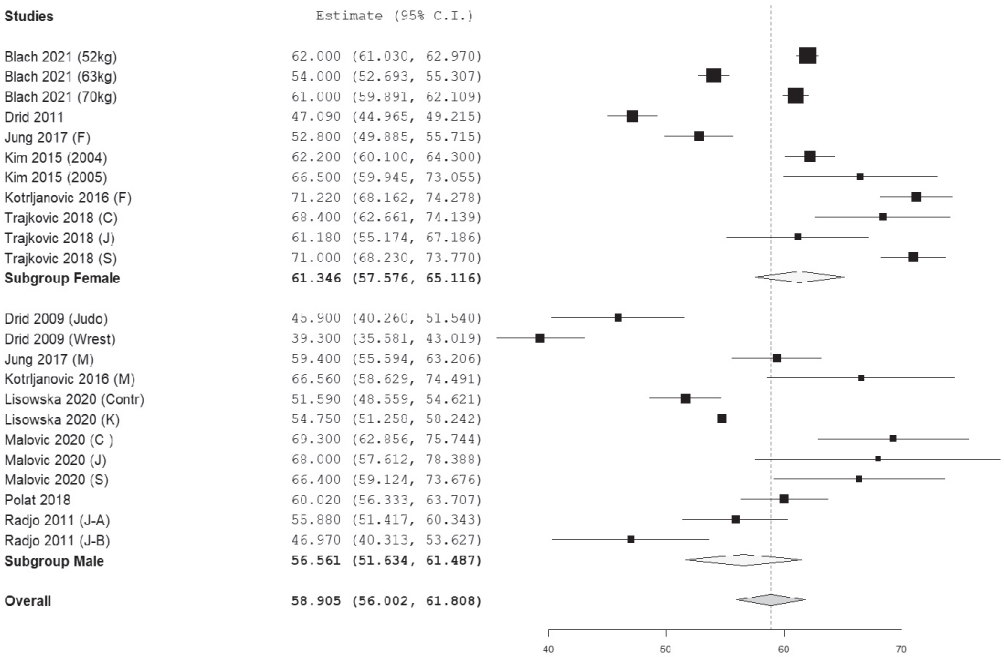

FIGURE 3. H/Q 60°·s-1 Left leg Subgroup Gender: (52kg) – up to 52kg; (63kg) – up to 63kg; (70kg) – up to 70kg; (Wrest) - wrestling; (2004) – season 2004; (2005) – season 2005; (F) – female; (M) – male; (Contr) – control; (K) – karate; (C) – cadet; (J) – junior; (S) – senior; (J-A) – Judo A group; (J-B) – Judo B group.

Four studies measured the H/Q 180°·s-1 ratio. The Mean H/Q 180°·s-1 ratio for the right leg was 71.44% (95% CI = 64.41%, 78.46%, p<0.001) (Fig. 4). The Mean H/Q 180°·s-1 ratio for the right leg for males and females was: Male 69.04% (95% CI = 60.26%, 77.82%, p<0.001); Female 75.76% (95% CI = 68.38%, 83.14%, p<0.001) (Fig. 4).

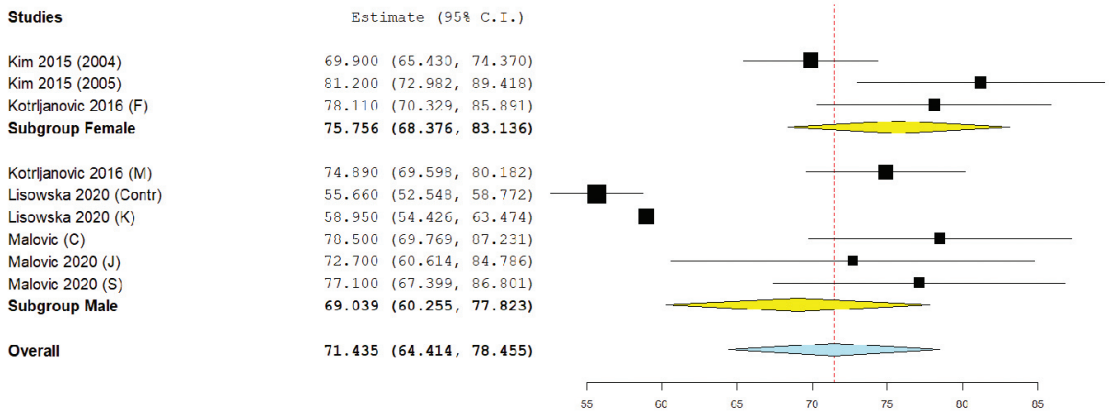

FIGURE 4. H/Q 180 Right leg Subgroup Gender: (2004) – season 2004; (2005) – season 2005; (F) – female; (M) – male; (Contr) – control; (K) – karate; (C) – cadet; (J) – junior; (S) – senior.

The Mean H/Q 180°·s-1 ratio for the left leg was 71.35% (95% CI = 64.22%, 78.48%, p<0.001) (Fig. 5). The Mean H/Q 180°·s-1 ratio for the left leg for males and females was: Male 70.33% (95% CI = 61.12%, 79.54%, p<0.001); Female 73.39% (95% CI = 62.32%, 84.47%, p<0.001) (Fig. 5). The results show that there was no asymmetry, ie a statistically significant difference between the right and left leg, neither for the outcome of H/Q 60°·s-1, nor for the outcome of H/Q 180°·s-1. Outcome H/Q 60°·s-1: (MD= 0.03; 95% CI=-1.04, 1.11, p=0.95); outcome H/Q 180°·s-1: (MD= 1.37; 95% CI=-1.21, 3.95, p=0.3).

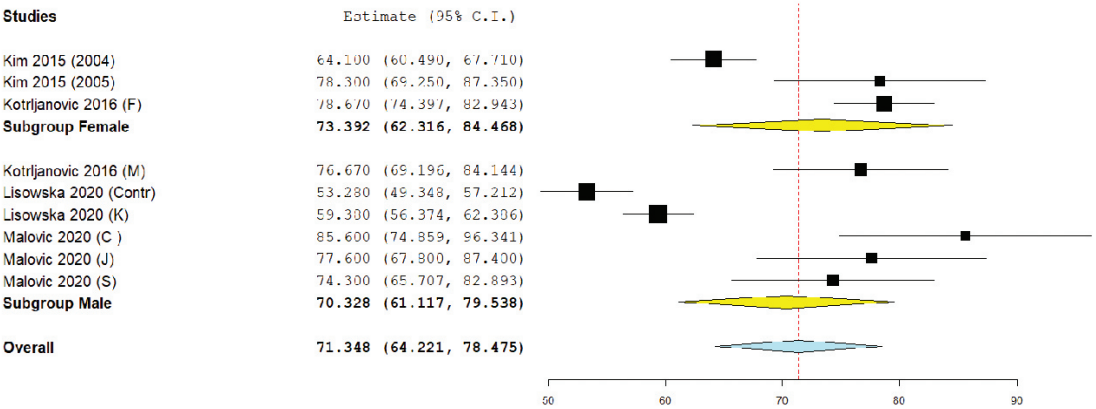

FIGURE 5. H/Q 180 Left leg : (2004) – season 2004; (2005) – season 2005; (F) – female; (M) – male; (Contr) – control; (K) – karate; (C) – cadet; (J) – junior; (S) – senior.

Discussion

The balance between the strength of the muscles of the hamstrings and the quadriceps is an important factor in athletes in combat sports. In this case, the balance of the mentioned agonists and antagonists is crucial for the stabilization of the knee joint during dynamic muscle contractions (DonTigny, 2005). Also important is the symmetry between the opposite legs, whose shortcomings can lead to an increased possibility of injury (Drid et al., 2009; Malović et al., 2020). This systematic review aimed to, based on the results of the included studies, arrive at average values of the conventional H/Q ratio for angular velocities of 60°·s-1 and 180°·s-1 and also to compare the values by gender. Also, based on the obtained results, it was determined whether there is an asymmetry between the left and right leg.

The Mean value of the conventional ratio for an angular velocity of 60°·s-1 for all included studies was 58.33% for the right leg and 58.91% for the left leg (Fig. 2 and 3). From these results, it can be concluded that there is no asymmetry between the left and right leg, and the analysis shows that there is no statistically significant difference: (MD=0.03; p=0.95). These values correspond to a recommended limit of 60% (Klein & Allman, 1969; Kellis & Baltzopoulos, 1995). Women had higher H/Q 60°·s-1 than men, 59.38% vs. 57.42% for the right leg and 61.35% vs. 56.56% for the left leg (Fig. 2 and 3). The Mean H/Q 180°·s-1 for all included studies was 71.44% for the right leg and 71.35% for the left leg. Women had higher H/Q 180°·s-1 than men, 75.76% vs. 69.04% for the right leg and 73.39% vs. 70.33% for the left leg (Fig. 4 and 5). Even at this angular velocity, no asymmetry was observed between the left and right leg, and the analysis shows that there is no statistically significant difference: (MD=1.37; p=0.3).

This is the only systematic review that analyzes the average values of the conventional ratio for angular velocities H/Q 60°·s-1 and H/Q 180°·s-1, in these combat sports. An extensive

systematic review was done by Baroni et al. (2018) including studies that had football players for the respondents. The average value for angular velocities from 12°·s-1 to 180°·s-1 was about 60%, and for speeds from 240°·s-1 to 360°·s-1 was between 70% and 80%. Comparing the results with our study, although we measured only angular velocities of 60°·s-1 and 180°·s-1, we can say that the results are approximate. Aagaard et al. (1998) reported karate athletes showed H/Q ratios greater than 60% at 60°·s-1. Risberg et al. (2018) reach values of 57% -58% for handball players and 59% -60% for football players. Baroni et al. (2018) recommend the use of an angular velocity of 60°·s-1 to examine the conventional H/Q ratio. Our study also came to the result that the values of H/Q increase with increasing angular velocity, as well as the study of Baroni et al. (2018). We did not deal with the differences in the results of the included studies here, but only with the obtained average values.

In combat sports, joint injuries mainly affect the knee (19-28%). Injuries to the meniscus and ligament joints are a major consequence of throwing, grasping, and maneuvering activities that often result in extreme joint positions that cause excessive stretching of muscles and ligaments (Hammani et al., 2017). In judokas, 28% of injuries are knee injuries, in wrestlers 20.5% (Pocecco et al., 2013; Hammani et al., 2017), and in taekwondo, the lower extremities are the most commonly injured part of the body (32%) (Kazemi & Pieter, 2004), while in karate, knee injuries are the most common (Kurland, 1980). As a consequence of hyperextension of the leg during impact and twisting or violent external rotation, the knee is prone to acute injuries of the medial collateral ligament (MCL), anterior cruciate ligament (ACL), meniscus, and patella. Although the most common knee lesions, ACL and MCL injuries, have been reported in all combat sports (Burke, 1981), meniscus injuries are most common in taekwondo (16%), judo (24%), and karate (50%); and patellar instability is common in wrestling (50%) (Nicolini et al., 2014). In general, there is no significant difference between men and women in injuries reported in combat sports, although some studies suggest that female athletes have a much higher risk of ACL injuries than men (Stevenson et al., 2000; Biene, 2011; Koshida et al., 2010). With the increased participation of women in combat sports competitions, similar injury rates and locations are more prevalent in both men and women (Pocecco et al., 2013; Hammani et al., 2017). Isokinetic exercise can significantly improve results in certain sports fields and reduce the frequency of injuries (Shelbourne & Gray, 1997; De Carlo et al., 1999). Moreover, the power imbalance is one of the strongest predictors of injury in highly competitive sports (Croisier et al., 2008; Yeung et al., 2009). The use of isokinetic devices provides an effective tool for assessing power imbalances and applying isokinetic strength exercises. Isokinetic testing is valuable information about strength asymmetry between muscle groups that may be a potential site for injury, but more importantly, for an injury prevention program (Drid et al., 2011; Maly et al., 2017; Blach et al., 2021). Similarly, when the difference in strength between the right and left quadriceps and hamstrings exceeds 10-15%, it is considered that there is an asymmetry between the two sides (Elliott, 1978). According to the Kannus study (1994) the risk of injury is high when this difference exceeds 20%. The results we obtained in our statistical analysis coincide with some recommended values (Steindler, 1955; Klein & Allman, 1969; Kannus, 1994; Kellis & Baltzopoulos, 1995), although Tengman et al. (2014), conclude that it is debatable how useful the value of H/Q, when there are deficits in the quadriceps. Their results show that the injured legs had higher H/Q values than the uninjured ones, which according to them represents a deficit in the strength of the quadriceps.

The results of our research indicate that the subjects from the four included combat sports have values of H/Q 60°·s-1 and H/Q 180°·s-1 within the recommended range and the pooled results from our analysis showed that there is no asymmetry between the left and right leg and that according to studies by Elliott (1978) and Kannus (1994) athletes in combat sports do not represent a risk group. We did not exclude outliers in our analysis. If we did that, the results would confirm the recommended values even more. This study had several limitations. First, a relatively small number of studies had inclusive criteria. Some studies that met the inclusive criteria measured the values of the dominant and non-dominant leg, and could not be included in the statistical processing. Second, all included studies measured only two angular velocities of 60°·s-1 and 180°·s-1. Third, our search included only studies written in English. Future studies can compare H/Q peak torque ratio values of combat sports with team sports and/or water sports, and analyze the percentage occurrence of injuries by different types of sports.

Conclusion

This study examined the H/Q peak torque ratio at two angular velocities in athletes from four combat sports. The results show that their values are within the recommended values, and also show that there is no asymmetry between the thigh muscles of the left and right leg. By analyzing the subgroups, we came to the results by which we were able to compare the values of H/Q according to gender. In both H/Q 60°·s-1 analyzes and H/Q 180°·s-1 analyzes, women had higher values than men for both the right and left leg. This is the first systematic review examining the overall mean hamstring/quadriceps ratio for judo, karate, taekwondo and wrestling, which also compares values by gender and compares left and right leg values to determine asymmetry in the muscle strength of the thighs. The study could raise awareness of the importance of muscle symmetry which is focused on preventing injuries in combat sports and improving performance through strengthening.

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Conflict of Interest
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