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Relationships between Quadriceps:Hamstring Strength Ratio and Lower Extremity Injuries in Netball Players

Henriette Hammill

Physical Activity, Sport and Recreation (PhASRec), North-West University (NWU), Potchefstroom, South Africa
Email: Henriette.hammill@nwu.ac.za

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Abstract

Background: Netball is a popular sport. Due to high impact and quick movement, there is an enormous load on the lower extremities which increases the risk for injury. **Aim:** The aim of this study was to investigate the relationship between the quadricep and hamstring strength and the prevalence of lower extremity injuries in netball players. **Setting:** Twenty-five female netball players (age: 20.8 ± 1.4 years) voluntarily participated. **Methods:** The Cybex Isokinetic dynamometer was used to determine concentric knee torques. Quadriceps:hamstring strength ratio was determined. Occurrence of lower extremity injuries was documented bi-weekly. **Results:** Medium effect sizes were noted for flexion torque:work for the left leg and for the quadriceps:hamstring ratio (≥60%) for the right leg. All the other measured variables have a small effect size. 18.75% of lower extremity injuries and ConQ:ConH of <60% was present. No association between lower extremity injuries and ConQ:ConH. Injuries may not be accurately predicted by this ratio. **Conclusion:** Injuries to the ankle and knee are especially common among netball players. Hamstring and quadriceps muscle asymmetry (>10%) were found to be a potential indicator of lower extremity injury. **Contribution:** This study highlights awareness on lower extremity injuries and the strength ratio between the quadriceps and hamstrings. This can aid coaches and netball players to lower the risk for injuries and thus improve individual- and team performance.

Keywords

Netball, Hamstrings, Quadriceps, Strength Ratio, Lower Extremity Injuries

1. Introduction

During dynamic movement, co-contraction of the quadriceps- and hamstrings muscles play an important role in joint stabilization, which is essential for preventing lower extremity injuries in netball [1]. Netball is a 15-minute quarter-length team sport, consisting of dynamic movements, played on a court that can be indoors or outdoors [2]. Seven players make up a netball team, and each position has a unique set of court constraints and demands during the match through ball catching and throwing, jumping, rapid acceleration and deceleration, and the change of direction which can affect each position's physical requirements [3], during the execution of these actions, netball players must adhere to the "footwork rule" which limits players to land with one step after they catch the ball [4]. Therefore, single-leg landings account for the majority of netball landings, leading to strong vertical ground reaction forces (GRF), skeletal tissue stresses and higher injury risk [4]. The lower extremities, particularly the knees and ankle, are at a greater risk of injury as a result of the sudden decrease in horizontal velocity that occurs during change-of-direction motions and jumps while striving to maintain balance [5]. During netball, injuries to the knee and ankle are said to occur most commonly [5]. One of the strategies is to improve the strength of quadriceps (Q) and hamstring (H) muscles as these muscles are of crucial importance during the safe execution of high-risk landings and for injury prevention [6]. However, uncertainty remains concerning the possible influence of Q:H strength ratios in the prevention of lower extremity injuries in netball players.

Isokinetic testing informs researchers and practitioners about the Q and H absolute- and relative strength, as well as the presence of bilateral strength differences and strength imbalances, and can be presented in the form of a traditional strength ratio (Q concentric (Qcon):H concentric (Hcon)) or in the form of a functional ratio (Q concentric (Qcon):H eccentric (Hecc)) [6]. The Q:H ratio describes the load-bearing capacity of the Q and H muscles which affects the knee joint and serves as an indicator of muscle imbalances [7]. A Q:H ratio of above 0.6 (60%) is regarded to be ideal whereas a Q:H ratio of below 0.6 (60%) indicates an unbalanced strength ratio [1]. Therefore, the risks for non-contact lower extremity injuries, particularly anterior cruciate ligament (ACL) tears and H strains are higher for participants who display a Q:H ratio of less than 0.6 (60%) at an isokinetic testing speed of 60˚/sec [1] [7], these metrics can offer therapists and coaches in especially the most popular team sports, such as netball a measure to ascertain the risk for lower extremity injuries [6].

Netball has a significant high injury rate [8]. During closed kinetic activities such as landing from a jump, running or pivoting, the majority of non-contact lower extremity injuries can occur during these movements [1]. The lower extremity's strength is important for the execution of fundamental sport related movements [9]. In extended positions the H assists with stabilization and deceleration of the knee which explains why a strength imbalance between the Q- and the H muscles serves as a possible risk factor for ACL injuries [9]. It is critical for the agonist and antagonist muscles to co-contract during dynamic motions for joint stabilization and optimal joint placement during pivoting and jumping [1]. As a result, the bi-articulate structure of the leg muscles and the lower extremity joints' neuromuscular compensation in joint stabilization explain the link between lower leg injuries and a low Q to H ratio [1].

The ankle and knee are the most injured structures in netball and the most common activities in netball that cause injuries to the last-mentioned parts are landing, followed by tripping [10]. Furthermore, the wing attack, center and wing defense are the positional groups in netball that got injured the most [10]. Despite the high incidence of lower extremity injuries in netball players and proof that the Q:H ratio may serve as a measure to certain the risk for lower extremity injuries, up until now studies that investigated this theme focused mostly on basketball and soccer players [6], although retrospective studies evaluated the Q:H ratio of both normal and deficient lower extremities, it is unclear whether the strength imbalances existed before the injury occurrence [1]. There is also minimal agreement on whether the Q:H strength ratio can be used to predict non-contact knee injuries or injuries to the surrounding tissue [1]. As a result, well-designed prospective studies could shed light on the link between Q:H ratio and damage to the knee and adjacent tissues [1], especially in team sports such as netball. Therefore, the following research question is posed: What are the relationships between Q:H strength ratio and lower extremity injuries in netball players? Answers to this question may indicate to researchers whether the Q:H strength ratio can be used as an indicator of lower extremity injuries in especially team sport players such as netball players. Furthermore, answers to this question can aid coaches and players on the importance of awareness of lower extremity injuries in netball. The objective of this study is to determine the relationships between Q:H strength ratio and lower extremity injuries in netball players.

2. Methods

2.1. Ethical Consideration

Permission to undertake the research study, was obtained from the Health Research Ethics Committee, Faculty of Health Science, North-West University (NWU) with the number {NWU-00955-19-S1}. The study was conducted according to the ethical guidelines and principles of the international Declaration of Helsinki and the ethical guidelines of the National Health Research Ethics Council of South Africa. Written informed consent was obtained from all participants. Confidentiality of data was obtained by a numerical participation code that was provided to each participant.

The rate of injuries was monitored bi-weekly throughout the season and there were post-data collections at the end of the season. Variables that were collected include the age, GRF, anthropometry (body mass, stature and skinfolds), knee joint strength and isokinetic testing (concentric trails at 60 degrees per second (CON60), concentric trails for 180 degrees per second (CON180) and eccentric trails for 60 degrees per second (ECC60)). In this section, we will only focus on the variables that were used in this specific study.

2.2. Literature

The Academic Search Premier, SPORTDiscus, MEDLINE, Health Source-Nursing/Academic edition, ERIC, Google Scholar, EBSCOhost, Science Direct and the library computer catalogue of a South African University were used to perform a manual search to find data that is relevant to this particular study.

Keywords that were used when searching for the information consisted of the following: quadriceps, hamstrings, strength ratio, lower extremity, injuries, netball, basketball, Q:H ratio, netball positions, isokinetic, concentric, eccentric.

2.3. Empirical Investigation

The design of this study is a single cross-sectional study where the data was collected at the beginning of the season from the participants. Furthermore, the rate of injuries was monitored bi-weekly throughout the netball season and at the end of the season, data was also collected from the participants. The objective of this study which is to determine the relationship between Q:H strength ratio and lower extremity injuries in netball players, fit into the objective of the larger study which was to determine the prevalence, incidence and relationship of lower extremity injuries and GRF during one season in university-level netball players, by determining the Q:H strength ratio through isokinetic testing.

2.4. Participants

A group consisting of twenty-five (N = 25) netball players, all female, from a South African University were used to obtain test data. Pre-season tests were performed on twenty-five (N = 25) participants. However, due to a high dropout, only seventeen (N = 17) participants completed post-season tests successfully. Voluntary written consent was provided by all the participants. The mean age of the participants was 20.9 ± 1.4 years, body mass was 72.6 ± 13.3 kg, stature was 175.3 ± 6 cm and body fat percentage was 22.0% ± 4.9%.

Inclusion criteria

- Only female participants took part in this study.
- The participants must have been registered at a South African University.
- The participants were considered if they were between the ages of 19 to 25 years.
- The participants should have been part of the netball club of a South African Universities' Campus.
- It was also necessary to have at least two years of playing experience.

Exclusion criteria

- All participants who did not fulfill the above mentioned criteria were excluded from the study.

2.5. Measuring Instruments

Injury questionnaire

A customized electronically injury questionnaire was used to obtain information on the participants' demographic and all their injuries. Qualified field workers guided participants in completing the questionnaire electronically every two weeks throughout the netball season and they were accessible to answer any questions or concerns they had about the study and/or questionnaire. The questionnaire was written in English, which all of the participants are fluent in. The questionnaire was an informal questionnaire to document injuries, and it was confirmed by the teams' doctor or biokineticist (clinical exercise therapist).

Body composition testing

Stature

A Stadiometer (Stadiometer Seca 202, Seca Ltd., Hamburg, Germany) was used to measure stature. Stature was measured once the participants arrived at the facility where they were being tested. The participants had to be barefoot for the measurement. They had to remove their shoes as well as their socks. The Frankfort plane was used to place the participant's heads in for accurate measurements. They were asked to inhale while the stature measurement was recorded. The Stadiometer Seca 202 is a reliable and valid measuring instrument for measuring stature because the majority of studies that measured stature made use of the Stadiometer Seca 202 [11]. The participant's stature was measured in centimeters and estimated to the closest 0.1 cm.

4 Body mass

The Seca Scale (Seca Scale, Seca Ltd., Hamburg, Germany) was used to measure body mass. Body mass was measured once the participants arrived at the facility where they were being tested. They were asked to wear minimal clothing to make sure that the minimal value for body mass could be measured. The participants had to stand upright on the scale and their weight had to be spread evenly on both of their feet. The Seca Scale is a reliable and valid measuring instrument for measuring body mass [12]. The participant's body mass was measured in kilograms and estimated to be the closest 0.1 kg.

Warm-up

Cycle ergometer

The cycle ergometers were frequently used in performing research and laboratory experiments, as well as for measuring aerobic power and other physiologic reactions related to maximal effort. A cycling-based warm-up of five-minutes was performed on a stationary cycling ergometer (WattbikePro, Technogym, USA) at a speed of 75 rpm, resulting in a Rating of Perceived Exertion (RPE) of 2 on the modified Borg Scale.

Rate of perceived exertion (RPE) scale

The Borg RPE scale is a measuring tool that has been used for assessing an individual's exertion, effort, dyspnea, and weariness during physical work. It determines how hard the body is working based on bodily feelings such as increased breathing- or heart rate, increased muscle weariness, and sweating [13]. During the warmup, participants were then asked to provide a scale of their exertion that includes all symptoms and feelings of physical tension and weariness.

Participants were instructed to ignore any single element, such as shortness of breath or leg pain, and instead concentrate on the overall impression of exertion. This value indicates the level of activity, enabling the participant to accelerate or slow down their movements. RPE is used to determine the intensity of an exercise where for instance high exercise intensities are indicated at 14 - 16 on the Borg scale (4 - 6 on the 0 - 10 scale), moderate exercise intensities at 12 - 13 (3 - 4 on the 0 - 10 scale), and low exercise intensities are prescribed at 10 - 11 (2 on the 0 - 10 scale) [13].

Cybex isokinetic dynamometer

The isokinetic dynamometer (HUMAC®/Norm™; Computer Sports Medicine, Inc., Stoughton, MA, USA) was used to evaluate all the eccentric and concentric knee torques. The isokinetic dynamometer got an intraclass correlation coefficient (ICC) ranging from 0.74 to 0.89 which indicates a good to exceptional reliability [14]. A protocol that consists of two speeds, firstly 60˚/s (con/ecc) and secondly 180˚/s (con), were applied to determine the H and Q strength profiles (CSMI Humac/Norm testing & rehabilitation system: User's guide, Model 770). In the seated position the participants were assessed with straps over their distal thigh, waist, and shoulders for stabilization purposes during the isokinetic tests. During the test, the participants were required to cross their arms over their chests to make sure force transfer was avoided. The dynamometer's axis of rotation was aligned with the participants' lateral epicondyles on their knees. With the concentric isokinetic trails, the participants were asked to execute five maximal repetitions at 60˚/s (CON60) for each leg, and for each leg at 180˚/s (CON180) for 15 repetitions, with rest that consist of a period of three-minutes between the test modes. After a rest period of five minutes, five repetitions in total for the eccentric isokinetic trails at 60˚/s (ECC60) were performed with each leg. In this study the functional ratio was used to determine the Q:H strength and it was expressed through the Qcon:Hecc ratio because eccentric strength was also measured in the netball players.

Procedures

The participants were given a full description of the study methodology at a briefing session, which was followed by an explanation of the informed consent process. The field workers, researchers and all participants went through the screening process for COVID-19 and filled out the COVID-19 form on the day of testing. Participants were given the option to take the informed consent form home and read it, as well as consult with members of the family if necessary. The briefing took place five days prior to the testing day to prevent any possible contamination of COVID-19 via any surface, like the consent form or person and each participant received the consent form in a zip-lock bag. The participants placed the forms of consent in a box which was stored on site for four days before submission.

Participants were welcomed and went through the COVID-19 screening process and completed the COVID-19 form on the testing day, which took place at the South African University's Centre for Health and Human Performance. The participants were then given a brief overview of the research process and allowed to ask any questions. To keep their identity confidential, each participant was given a numerical indicator that allowed the field personnel to call them to be tested. The participants completed the injury questionnaire electronically every two weeks to ensure that injuries were tracked regularly.

Before the netball season started, the participants' isokinetic knee strength was measured, and the same measurements were conducted at the end of the season. Measurement stations were set up, and each participant went to each one. Field workers with experience in Biokinetics and/or Sport Science oversaw the stations. Before the testing day, all field employees were given a briefing to guarantee their competency and that measurements were taken consistently and uniformly. Throughout the day, refreshments were offered to participants. Each participant was given a sealed bottle with water that could be thrown away after usage. There were two stations where measurements were taken, at each station more information was given about the particular station to the participants. The first station was the body composition station, where body mass and stature were measured. The second station was where the isokinetic testing took place.

Statistical analysis

The Pearson's chi-square test will be used to see if there are any correlations between Cybex data and injury incident rates. The strength of relationships between the Cybex data and injury incidence will be evaluated using Cramer's υ method. The two effect sizes will be interpreted by using the following values as guidelines: values near 0.1 suggest a small practical non-significant difference or effect, 0.3 suggests a medium practical visible difference or effect, and 0.5 suggests a big practical significant difference or effect.

3. Results

Table 1 represents the results of the anthropometric profile of the participants. The participants had an average age of 20.8 ± 1.4 years and a height of 175.3 ± 6 cm. There was no statistical difference ($p = 0.323$) that was significant between the participants' mean body mass of 72.92 kg ± 13.5. This is expected as participants are from a relative same cohort group.

Table 1. Descriptive information.

	N = 25			p-value
	Median	SD	95% CI	
Age	20.77	1.35	0	-
Height (cm)	175.38	5.98	0	-
Weight (kg)	72.92	13.51	−0.76	0.323
Fat %	21.68	4.93	−1.16	0.05

* = Statistical significance level ($p < 0.05$); SD = Standard deviation; CI = Confidence interval.

The body fat mean percentage among participants was 21.7% ± 4.9% during the testing, with a statistical difference of p = 0.045, which was significant. Even though this study does not aim to measure body fat percentage, it is interesring that there exists a significant value within the body fat percentage. This could indicate the variety of body compositions in one cohort of participants.

Table 2 summarizes the relationship between Quadriceps and Hamstring ratio and injuries of the lower extremity in the participants by means of the Concentric/Concentric 60 testings. The cut-off values for each variable in the table were as following: 1) greater than 10% peak flexion and extension torque deficit 2) less than 1.0 for the flexion T:W ratio, less than 1.5 for the extension Torque:Work ratio and 3) less than 60% for the Q:H ratio.

When looking at the extension and flexion deficits, lower extremity injuries were sustained by ten participants. The deficit between the left and right knee flexors and extensors was greater than 10% in each case.

Statistical significance is noted when the p-value is less than 0.05. Effect sizes is indicated as a small, medium or large effect size. The value 0.1 indicates a small effect size, 0.03 indicates a medium effect size and 0.5 indicates a large effect size. There was a small effect size (ES = 0.18) and no statistical significance (p = 0.383) was noted The extension T:W ratio indicated that ten participants has sustained lower extremity injuries due to their left leg's extension T:W ratio being less than 1.5. There were no statistical differences discovered (p = 0.383) and a small effect size was noted (ES = 0.18). As for the right extension T:W ratio nine participants sustained lower extremity injuries. The right leg's extension T:W ratio was greater than 1.5. No statistical differences were discovered (p = 0.610), and a small effect size was noted (ES = 0.10).

Table 2. Quadriceps and Hamstring ratio and injuries.

	Injured		p-value	ES
Con/Con 60	0	1	-	-
Extension deficit (>10%)	6	10	0.383	0.18
Extension Torque: Work ratioi left (>1.5)	10	6	0.383	0.18
Extension Torque: Work ratio right (>1.5)	7	9	0.610	0.1
Flexion deficigt (>10%)	6	10	0.383	0.18
Flexion Torque: Work ratio right (>1.0)	8	8	0.420	0.16
Flexion Torque Work ratio left (>1.0)	8	8	0.174	0.27
Quadriceps:Hamstring ratio left (>60%)	3	13	0.617	0.10
Quadriceps:Hamstring ratio right (>60%)	3	13	0.170	0.28

0 = injured players who did not meet the criteria; 1 = injured players who did meet the criteria; Statistical significance level (p < 0.05); ES = Effect size; 0.1 = small effect size (S); 0.3 = medium effect size (M); 0.5 = large effect size (L).

The flexion T:W ratio indicated that lower extremity injuries were sustained by eight participants, with the left flexion T:W ratio being greater than 1.0. There were no statistical differences discovered ($p = 0.174$), and a medium effect size was noted (ES = 0.27). Lower extremity injuries were sustained by eight participants, with the right flexion T:W ratio being greater than 1.0. There were no statistical differences discovered ($p = 0.420$), and a small effect size was noted (ES = 0.16).

For the right side lower extremity injuries were sustained by 13 participants. The right Q:H ratio was greater than 60%, with 60% being the norm for a good ratio. This value indicates that no statistical differences were discovered ($p = 0.170$), and a medium effect size was noted (ES = 0.28). Meduim effect size means practical significance, which means it has a larger effect to influence aspects and make a difference.

No large effect sizes were noted and there were only two medium effect sizes noted for flexion Torque:Work ratio (Left) and for the Quadriceps:Hamstring ratio (Right).

4. Discussion

This study's objective is to establish the incidence of lower extremity injuries among university netball players across one season. Injuries suffered in the gym, during court practice, and during games are also reported in this study. The participant's height and weight (**Table 1**) are consistent with descriptions of similar population groupings in the literature [3] [9]. According to the ACSM's standards (20.6% - 23.4%) for women who are physically active between the ages of 20 and 29 years, the percentage of body fat of 21.7% is considered fair. An appropriate body fat percentage is classified between 17.61% - 9.8%, and a deficient percentage as falling between 24% - 28.2%. The occurrence of lower extremity injuries was monitored starting at the beginning of the season in this study, which involved 25 female netball players from a university.

Furthermore, this study aims to establish the relationship between Q:H strength ratios by means of isokinetic knee strength testing and the prevalence of lower extremity injuries in netball players throughout a netball season. According to literature it is important to measure the Q:H ratio to identify player at risk for injuries [1].

In this study 62.5% (**Table 2**) of the sustained lower extremity injuries was due to an asymmetry in peak flexion and extension torque values (CON60˚/s) of more than 10%. This shows that there is an association between sustained lower extremity injuries and asymmetry, which further indicates that a lower extremity injury predictor might be muscle asymmetry. Asymmetries of body strength are indicative of potential risks for injuries in elite athletes [1].

The ConQ:ConH ratio may also be a predictor of injury, especially for ACL injuries, and evidence suggests that the ratio should be more than 60% [1]. With the pre-season ratio of 63.68% for the right side and 67.92% for the left side, participants did achieve the required ratio.

It was found that for only 18.75% of lower extremity injuries, a ConQ:ConH ratio of less than 60% was present. This demonstrates that there was no association between the participants' lower extremity injuries and the ConQ:ConH ratio and suggests that injuries may not be accurately predicted by this ratio. It was found that using the ConQ:ConH strength ratio as a predictor of lower extremity injuries there was no predictive relationship with a risk for lower extremity injuries found [1].

The mean T:W ratio (CON60˚) for the knee extensors was 2.3 Nm/kg and the knee flexors were 1.5 Nm/kg [6]. The above-mentioned values are significantly larger than those found in the current study, in which the participants had pre-season mean T:W ratios of 1.0 Nm/kg for the knee flexors and 1.5 Nm/kg for the knee extensors, respectively (CON60˚). To further support the aforementioned finding, it was discovered that 62.5% of the participants who suffered a lower extremity injury failed to reach the target extension T:W ratio of 1.5 Nm/kg (CON60˚/s).

This study creates awareness on the importance of the ratio between the hamstrings and the quadriceps in a high demand sport like netball. This awareness can assist coaches and netball players to lower the risk of lower extremity injuries at university level and therefore improve individual- and team performance.

5. Conclusion

Injuries to the ankle and knee joints are especially common among netball players. Q- and H muscle asymmetry (>10%) is a potential indicator of lower extremity injury. The ConQ:ConH strength ratio measured at 60 degrees per second does not have a significant effect and therefore is not an accurate predictor of injuries in netball players. This study highlights awareness on lower extremity injuries and the strength ration between the quadriceps and hamstrings. This can aid coaches and netball players in order to lower the risk for injuries and thus improve individual- and team performance.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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