



MSc in Clinical Psychology

Concussions Among Icelandic Female Athletes: Self-Reported Prevalence With and Without Definition of Concussion

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Forewords and acknowledgments

Submitted in partial fulfillment of the requirements of the MSc Clinical Psychology degree, Reykjavík University. This thesis is presented in the style of an article for submission to a peer-reviewed journal. The groundwork for the current study had already been carried out by the research team at the time I joined the team. This thesis is a product of the work that went on for the last three semesters of the Master's program. During the first semester I wrote a literature review of the subject as I assisted with the distribution of the study-questionnaire. Processing of the data took place during the second semester along with writing the first draft of the thesis. The third semester involved in writing the final draft of this thesis.

This study is the first part of larger study on sports-related concussions among Icelandic top-division athletes, managed by Dr. María K. Jónsdóttir, Dr. Hafrún Kristjánsdóttir and Dr. Helga Ágústa Sigurjónsdóttir. The work of this thesis will be submitted to a peer-reviewed journal where María, Hafrún, Helga and Ingunn Unnsteinsdóttir Kristensen will be co-authors of the article. The main purpose of this study was to examine whether female athletes base their self-reported concussion history on currently accepted medical definition of concussion.

For the last two years, during my studies, I have had the opportunity to develop as an individual and learn more than ever before. That would not have been possible without the support of great professionals, friends and family. Therefore, there are numerous of people that I want to extend my gratitude towards. Firstly, I would like to thank my supervisors, María K. Jónsdóttir and Hafrún Kristjánsdóttir, for their guidance and support in completing this work as allowing me to be part of their magnificent research team. I also want to thank the rest of the team, especially Silja Runólfssdóttir and Ingunn for the successful cooperation. Secondly, I would like to show my gratitude towards the women that spent their time participating in this study. For a long time there has been lack of information and researches

about sportswomen, and I believe that this study as those that will follow will be groundbreaking in the fields of female athletes. Thirdly, I would like to thank my fellow students, family and friends (you know who you are) for assistance, support and encouragement throughout the last two years. Especially my mom, Dagbjört Hrönn Leifsdóttir, for always being there for me. I would probably never had turned to psychology if it were not for her advice and encouragement to study psychology. Mom always knows best. To my brilliant cousin, Svandís, and friends, María, Aldís and Rakel, I want to say thank you for always being willing to assist me. I am forever grateful for all of your ideas and opinions. At last, love and gratitude to my partner Pavel, that has been with me through thick and thin. Thank you for all the support, tolerance and patience during my studies.

Abstract

Purpose: The current study aims to examine whether female athletes base their self-reported concussion history on currently accepted medical definitions. Moreover, this study seeks to gather information about sports related concussion (SRC) prevalence among Icelandic top-division female athletes. It was hypothesized that athletes' estimates of SRCs would significantly increase after being provided with a current medical definition, compared to their previous estimates. **Method:** A questionnaire was distributed through relevant Facebook pages (snowball sampling). Participants (M age = 26.9) were 508 former and current sportswomen hailing from soccer, handball, basketball, ice hockey and martial arts. Participants self-reported SRCs before and after being provided with a current medical definition of a concussion. **Results:** The rate of concussion reporting increased from 45% to 65% after a definition was given. Moreover, of those athletes that reported having sustained a concussion, 61.9% increased their estimation of the number of concussions from pre- to post-definition. This indicates that numerous participants lacked knowledge about the current medical definition. The SRCs prevalence among participants in this study was 65%. **Conclusions:** The current understanding of the definition of a concussion among current and former Icelandic female athletes is not consistent with the current accepted medical definition. However, our results indicate that Icelandic female athletes' understanding of concussions is better than preexisting results from other countries that are mainly focused on male athletes. It is essential that a definition is used when self-reported concussion history is assessed in a clinical setting just as in research.

Keywords: concussion, mild traumatic brain injury, sports-related concussion, self-reporting, female athletes

Concussions Among Icelandic Female Athletes: Self-reported Prevalence With and Without Definition of Concussion

In recent years, interest in sports-related concussions (SRCs) has been on the rise (Carroll et al., 2004), with concussions being the most common form of head injuries among athletes (Moser, 2007). SRCs have been described as a public health issue, with athletes at all levels (professional, elite and amateur) suffering from SRCs worldwide (Johnson, Partridge, & Gilbert, 2015). Moreover, athletes are thought to be at greater risk of having multiple concussions compared to those who do not participate in organized sports (Burman, Lysholm, Shahim, Malm, & Tegner, 2016; Johnson et al., 2015). There are concerns that recurrent concussions can increase the risk of post-concussion syndrome (PCS) (Williams, Potter, & Ryland, 2010), vestibular disorders (Davies & Luxon, 1995), long-term behavioral changes (Stern et al., 2013), chronic traumatic encephalopathy (CTE) (Gavett, Stern, & McKee, 2011; Johnson et al., 2015; Stern et al., 2013) and that they can even be fatal (Kelly, 1991; Langlois, Rutland-Brown, & Wald, 2006).

The rate of SRCs has increased gradually in recent years (Daneshvar, Nowinski, McKee, & Cantu, 2011; Hootman, Dick, & Agel, 2007). It is estimated that the incidence of SRCs in various sports stretches from 0.1 to 21.5 per 1000 athletic exposures (Clay, Glover, & Lowe, 2013). Official prevalence and incidence numbers of SRCs in Iceland are missing. However, there are a few BA/BS studies on the matter (Gunnar Örn Jónsson & Jón Benjamín Halldóruson, 2013; Ragnar Hjörvar Hermannsson, Sonja Dögg Jónsdóttir, & Tryggvi Kaspersen, 2014). According to these studies, about 40% to 50% of athletes (males and females) in basketball, handball and soccer have experienced SRCs (Gunnar Örn Jónsson & Jón Benjamín Halldóruson, 2013; Ragnar Hjörvar Hermannsson et al., 2014). No prevalence numbers for SRCs exist in other than the aforementioned contact sports in Iceland.

Concussions often go unrecognized (Moser, 2007) and one of the reasons might be that the term "concussion" is not well defined (Bodin, Yeates, & Klamar, 2012; DeMatteo et al., 2010; Ryu, Feinstein, Colantonio, Streiner, & Dawson, 2009). Concussions go by many names in the clinical context, which can lead to confusion among health-care workers as well as among the general public (Bodin et al., 2012). Frequently used alternative terms for concussions are for example mild traumatic brain injury (mTBI), mild head trauma (DeCuyper & Klimo, 2012), mild closed head injury and minor closed head injury (Bodin et al., 2012). As specified in McKinlay, Bishop, and McLellan (2011) those terms describe the same type of injury. Another reason, for the underdiagnoses of concussions could be that the definition has developed and been revised numerous times over the last decades by the medical community. Early descriptions of concussions have a common thread of characterizing them as injuries that are long-lasting, severe and with loss of consciousness as a primary symptom (Bodin et al., 2012; Cantu, 1986; Denny-Brown, 1943; Guay et al., 2016; Gurdjian & Voris, 1966). In 1965, the committee to study head injury nomenclature proposed the use of a grading scale to define a concussion which was based on the duration of the loss of consciousness (Gurdjian & Voris, 1966). This was later revised by Cantu (1986) who suggested that post-traumatic amnesia was a sign of concussion and Kelly et al. (1991) who added general confusion as a potential symptom of a concussion. At the third international conference on concussion in sport in 2008 the definition of a concussion was expanded to include a wide range of post-head impact symptoms as indicators of a concussion, including somatic (e.g. headache), cognitive (e.g. feeling "like in a fog", slow reaction time), emotional (e.g. lability), physical (e.g. loss of consciousness), behavioral (e.g. irritability), and sleep disturbance symptoms (e.g. drowsiness) (McCrory et al., 2009). It was stated that if any (one or more) of these symptoms are present a concussion should be suspected.

Despite many attempts to define a concussion, a consensus has yet to emerge, and there is still much confusion about the concept (DeMatteo et al., 2010; Lovell, Collins, & Bradley, 2004; Ryu et al., 2009). In an article by Seichepine et al. (2013) the definition of a concussion and the leading misconceptions are rounded up:

Some people have the misconception that concussions only happen when you black out after a hit to the head or when the symptoms last for a while. In reality, a concussion has occurred anytime you have had a blow to the head that caused you to have symptoms for any amount of time. These include: blurred or double vision, seeing stars, sensitivity to light or noise, headache, dizziness or balance problems, nausea, vomiting, trouble sleeping, fatigue, confusion, difficulty remembering, difficulty concentrating, or loss of consciousness. Whenever anyone gets a ding, or their bell rung that too is a concussion. (Seichepine et al., 2013, p. 1301).

Recent guidelines have added that concussion "may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head" (Benson et al., 2018, p. 1).

In general, asking athletes to self-report their concussion history has been deemed unreliable as they often lack knowledge about the current medical definition (Alosco et al., 2017; Robbins et al., 2014). Robbins et al. (2014), asked former and current athletes (417 males, 55 females) in various sports how many concussions they had sustained, once before and then again after receiving the definition of a concussion. The results showed that following the definition participants' estimation increased by 73%, while 25% of participants retained the same estimation and 2% decreased their estimation. In a similar study conducted by Alosco et. (2017), 95 former male American football players were asked to estimate the number of concussions and their symptoms before and after hearing a definition. Just over 90% of participants increased their estimations after being given the definition, while around 10% maintained the same estimation. Both studies suggest that the sample lacked an understanding of the current medical definition of a concussion. Interestingly, both studies research sample was mostly based on male athletes and to date there appears that no comparable information focusing on female athletes has been collected.

Gathering information about concussions in female athletes is however of great importance. Not only do female athletes tend to report higher rates of concussions than male athletes when playing the same sport (Dick, 2009), but it has also been suggested that women are in general more vulnerable to the effects of concussions (Bazarian, Blyth, Mookerjee, He, & McDermott, 2010; Dick, 2009; Elleberg, Leclerc, Couture, & Daigle, 2007; Halldorsson et al., 2012; Meares et al., 2008). Possible reasons behind the observed gender difference include men having stronger neck muscles than women, hormonal differences which render women's brains more sensitive to a concussion, or anatomical difference in the brains of men and women (Webbe, 2011). Another possible reason, that is a well-known reason for gender differences, is that females are more truthful when it comes to self-reporting injuries than males (Dick, 2009) as they are more likely than males to seek medical assistance (Magnúsdóttir et al., 2010).

According to published material from the National Olympic and Sports Association of Iceland (ÍSÍ) and the Football Association of Iceland (KSÍ) (Íþrótta- og ólympíusamband Íslands, n.d.; Reynir Björnsson, 2017) awareness of SRCs has risen in Iceland in the last few years through an emphasis on education for coaches and players (Íþrótta- og ólympíusamband Íslands, n.d.; Reynir Björnsson, 2017). However, it is unclear if the shift of understanding has reached the sports community in Iceland, and for example, resulted in less underreporting of concussions.

The current study aims to examine whether female athletes base their self-reported concussion history on currently accepted medical definitions, by assessing change in concussion estimates before and after a definition of concussion is provided. It was hypothesized that athletes' estimates of concussion would significantly increase after being provided with a current definition of a concussion, compared to their previous estimates. An increase from pre to post-definition will suggest that the athletes are unaware of the currently

accepted medical definition of a concussion. Additionally, this study seeks to gather information about concussion prevalence among former and current Icelandic top-division female athletes in contact sports (soccer, basketball, handball, ice hockey and martial arts). A comparable study on female athletes has not been conducted before.

Method

Participants

To be included in the study, participants had to answer a minimum of nine questions in the survey and meet the inclusion criteria. As Figure 1 demonstrates, 508 participants were in the final sample. The study population was Icelandic female athletes, aged 18 to 45 ($M_{age} = 26.97$, $SD = 7.15$, missing values = 69), that had retired from their sport or were currently training/competing at the highest level in Iceland in soccer (41%), handball (30.6%), basketball (19.1%), ice hockey (4.5%) and martial arts (4.7%) (karate, taekwondo, boxing and mixed martial arts) (Table 1). Former players were 34.5% and current players 65.5% (missing values = 7). On average the women had played their sport for 15.33 years ($SD = 4.5$, range 3 to 30 years).

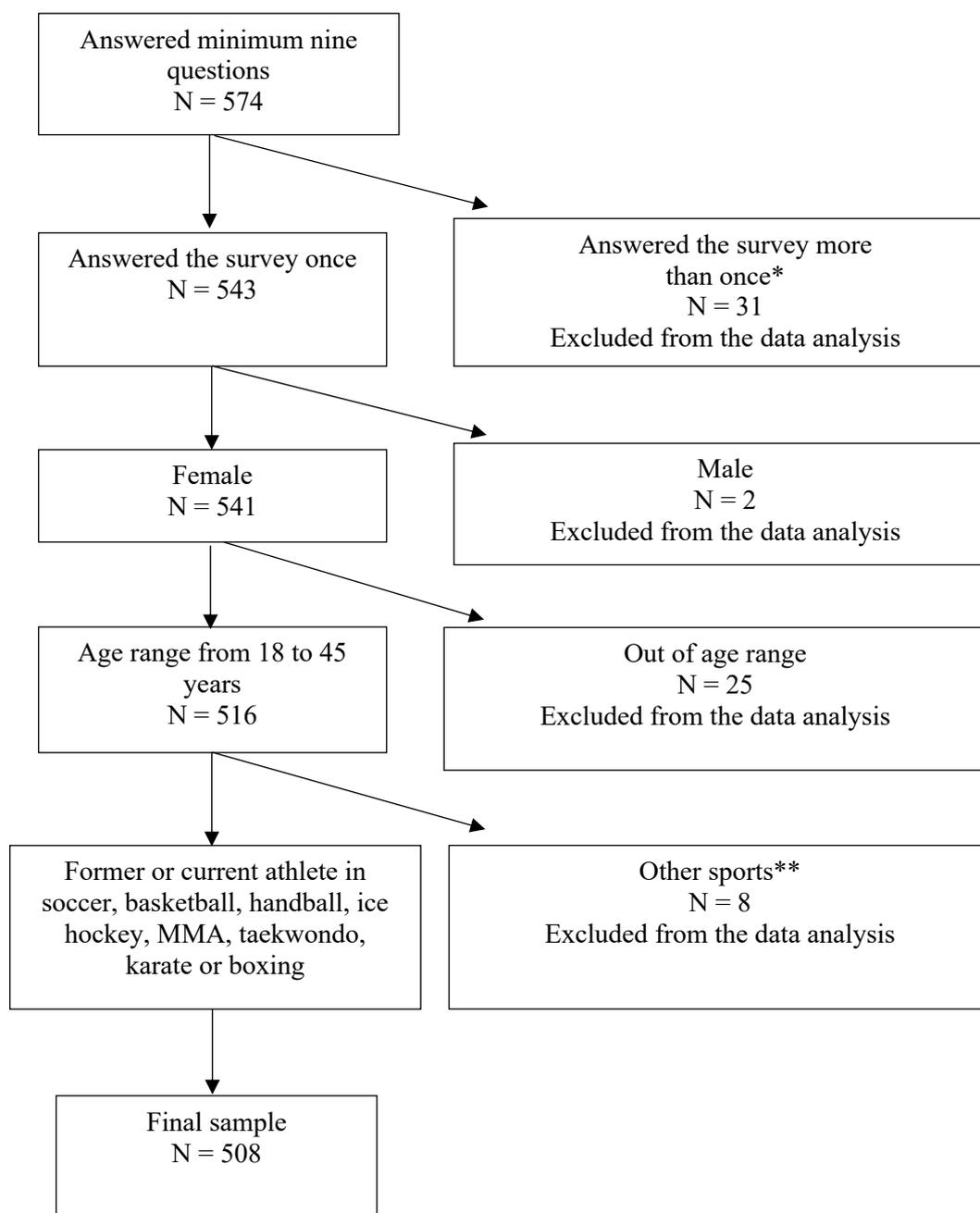
Measures and Materials

Background questions and concussion history. Nine questions were used to provide information about the participants' background. The questions were concerning age, education and marital status. Of the nine questions, three addressed the participants' athletic career; which sport and position they played along with years played in the top league. To address the participants' concussion history participants were asked two questions before- and after they were given a currently accepted medical definition of concussion. The first question was "Have you ever sustained a concussion during a practice or a game?" which participants answered with either a "yes" or "no". The second question was "How often have

you sustained a concussion?" which was answered on a four-point scale from 1= one time, 2 = two to three times, 3 = four to five times and 4 = six times or more.

Figure 1.

Flowchart of inclusion-exclusion process



**If a participant answered the survey more than once, the trial that the participant spent more time on was chosen. **If participant stated playing more than one sport, the sport that met the inclusion criteria was used, or if both sports were inclusive the first sport mentioned was used.*

Table 1

Sample characteristics of 508 former and current elite Icelandic female athletes

Variables	N	%
Primary sport		
Soccer	208	40.9
Defense	91	17.9
Goalkeeper	24	4.7
Midfielder/ Forward	93	18.3
Missing values	0	-
Basketball	97	19.1
Center/ Power forward	39	7.7
Point guard	18	3.5
Small forward/ Shooting guard	39	7.7
Missing value	1	0.1
Handball	155	30.5
Center / Back player	69	13.6
Goalkeeper	26	5.1
Wing/ Pivot player	58	11.4
Missing values	2	0.4
Ice hockey	23	4.5
Defense	7	1.4
Goalkeeper	3	0.6
Midfielder /Forward	13	2.5
Missing values	0	-
Martial arts	24	4.7
Boxing	3	0.6
Karate	11	2.1
Mixed Martial Arts	4	0.8
Taekwondo	6	1.2
Missing values	0	-
Missing values	1	0.2
Highest education level		
Elementary school	97	19.1
Secondary education	166	32.7
Vocational education	16	3.1
Bachelor's degree	146	28.7
Master's degree	76	15.0
Doctorate degree	5	1.0
Missing values	2	0.4
Marital status		
Single	202	39.8
Married/ Cohabitation	185	36.4
In a relationship	116	22.8
Other	1	0.2
Missing values	4	0.8

Definition of a Concussion. A translated definition based on the aforementioned definition by Seichepine et al. (2013) and the consensus statements on concussion in sport from international conferences on concussion in sport (McCrory et al., 2017, 2013, 2009) was used. Added to the statement by Seichepine was "whenever anyone gets dazed after a blow that too is a concussion. Note that a direct blow anywhere on the head and the body with an impulsive force may cause a concussion" (Benson et al., 2018; McCrory et al., 2017, 2013, 2009).

Procedure

An online questionnaire was distributed through the project's Facebook page and other sports-related Facebook pages (snowball sampling) at the end of January 2018. It remained open until the end of April the same year. First, participants were presented with general information about the study and electronically signed an informed consent form. After that participants answered background questions and questions concerning their concussion history. Participants were asked to report the total number of concussions they had experienced in their sport without being provided with a definition of a concussion. Thus, participants' pre-definition answers were based on their previous knowledge of what constitutes a concussion. Afterward, participants were provided with a definition of a concussion and subsequently were asked to once again report the total number of concussions they had experiences. Participants were not able to correct their previous answers. The study protocol was approved by the National Bioethics Committee (no: 17-183-S1).

Design and Data Analysis

Since only categorical variables were in the study, Pearson's Chi-square test of independence was used was to assess group differences. First, the participants' concussion report before and after they were given a definition of a concussion was compared. Secondly the background characteristics of athletes that had and had not sustained a concussion were

compared, thirdly the background characteristics of participants that had sustained concussion and had changed their answer before and after being given a definition was compared to those athletes that did not change their answer and fourthly the number of sustained concussions before and after a definition was given was compared. Statistical analyses and calculations were conducted using the software IBM SPSS Statistics, version 25. The level of significance was set at $p < .05$ in all analyses.

Results

Change in Concussions Estimates Pre- to Post-Definition

Around 40% of the participants reported that they had sustained SRCs pre-definition, but nearly 65% of participants reported having sustained SRCs post-definition (Table 2). A quarter of the participants ($n = 125$, 24.6%) changed their answer from having not sustained SRCs (pre-definition) to having sustained SRCs (post-definition) while the rest of the athletes ($n = 383$, 75.4%) maintained the same answer before and after reading the definition. No participant changed their answer from sustained SRCs (pre-definition) to not having sustained SRCs (post-definition).

Based on their primary sport, there was a significant difference between those that changed their answer from no to yes when asked about sustaining SRCs before and after reading the definition and those that did not change their answer, $X^2(4) = 20.25$, $p < 0.00$. Participants that played basketball (60%) or practiced martial arts (66.7%) were about twice as likely to change their answer from pre- to post definition, than athletes in other sports (Table 3). A significant difference was between the number of sustained SRCs before and after participants were given definition, $\chi^2(12) = 158.68$, $p < 0.01$ (Table 4).

Table 2

Primary sport frequency and changes of sustained concussions pre- and post-definition

Primary sport	Pre-definition	Post-definition	Increase / decrease
Soccer (n = 208)	% (n)	% (n)	
Not sustained concussion	53.4 (111)	31.1 (66)	-22.3%
Sustained concussion	46.6 (97)	68.3 (142)	22.3%
1*	39.2 (38)	30.3 (43)	-8.9 %
2-3*	43.3 (42)	32.4 (46)	-10.9%
4-5*	9.3 (9)	19.7 (28)	10.4%
6 or more*	7.2 (7)	16.2 (23)	9%
Missing	0.1 (1)	1.0 (2)	-
Handball (n = 155)			
Not sustained concussion	55.5 (86)	31.6 (66)	-23.9 %
Sustained concussion	44.5 (69)	68.4 (106)	23.9 %
1*	43.5(30)	31.1 (33)	-12.3%
2-3*	43.5 (30)	32.1 (34)	- 11.4%
4-5*	11.6 (8)	17.9 (19)	6.3%
6 or more*	1.4 (1)	14.2 (15)	12.7%
Missing	0 (0)	4.7 (5)	-
Basketball (n = 97)			
Not sustained concussion	81.4 (79)	53.6 (52)	-27.8%
Sustained concussion	18.6 (18)	46.4 (45)	27.8%
1*	61.1 (11)	40.0 (18)	-21.1 %
2-3*	22.2 (4)	42.2 (19)	20.0%
4-5*	16.7 (3)	11.1 (5)	-5.6%
6 or more*	0 (0)	4.4 (2)	4.4%
Missing	0 (0)	2.2 (1)	-
Martial arts** (n = 24)			
Not sustained concussion	75.0 (18)	25.0 (6)	-50%
Sustained concussion	25.0 (6)	75.0 (18)	50.0%
1*	83.3 (5)	33.3 (6)	-50%
2-3*	0 (0)	33.3 (6)	33.3%
4-5*	16.7 (1)	16.7 (3)	0 %
6 or more*	0 (0)	16.7 (3)	16.7%
Missing	0 (0)	0 (0)	-
Total (n = 508)			
Not sustained concussion	59.8 (304)	35.2 (179)	-24.6%
Sustained concussion	40.2 (204)	64.8 (329)	24.6%
1*	43.6 (89)	30.7 (101)	-12.9%
2-3*	40.7 (83)	36.2 (119)	-4.5%
4-5*	10.8(22)	17.3(57)	6.5%
6 or more*	3.9(8)	13.1(43)	9.1%
Missing	1.0 (2)	2.7 (9)	-

*Sustained concussions, ** Mixed martial arts, karate, boxing, and taekwondo

Of the 318 participants that had sustained SRCs, 61.9% (n= 197) increased their estimate of the number of SRCs from pre- to post-definition. Participants that maintained the same estimation were 37.1% (n=118) and three participants, 0.9%, decreased their estimate. Out of the participants that reported not having sustained SRCs before given the definition, 10.8% reported having sustained four to five SRCs after reading the definition.

Table 3

Changes in self-report between pre-post definition, with participants who reported concussion

Primary sport (n)	Did not change answer post-definition % (n)	Changed answer post-definition % (n)
Soccer (142)	68.3 (97)	31.7 (45)
Handball (106)	65.1 (69)	34.9 (37)
Basketball (45)	40.0 (18)	60.0 (27)
Ice Hockey (18)	77.8 (14)	22.2 (4)
Martial arts* (18)	33.3 (6)	66.7 (12)
Total	62.0 (329)	38.0 (178)

*Martial arts = Mixed martial arts, karate, boxing, and taekwondo

Prevalence of SRCs among participants

Of the 508 participants, 329 (64.8%) had sustained SRCs in practice or competition, based on participants' answers post-definition (Table 2). The likelihood of having sustained a SRC varied according to sport, ($\chi^2(4) = 19.32, p < 0.01$). In all sports, excluding basketball (46.4%), over 50% of participants had sustained SRCs. Women that played and practiced ice-hockey (78%) or martial arts (75%) had the highest rate of self-reported SRCs compared to women in other sports. Of those that claimed to have had a concussion, 68% (n = 217) reported more than one concussion post-definition (Table 4). Moreover, of those participants that reported not to have sustained SRCs pre-definition, 15.8% reported having sustained four or more SRCs post-definition.

Table 4

Changes of participants number of sustained concussions before and after given the definition

Number of concussions pre-definition	Number of concussions post-definition				Total (n)
	1 % (n)	2-3 % (n)	4-5 % (n)	6+ % (n)	
Not sustained concussion	42.5 (51)	41.7 (50)	10.8 (13)	5.0 (6)	(120)
1	57.0 (49)	20.9 (18)	11.6 (10)	10.5 (9)	(86)
2-3	1.2 (1)	59.8 (49)	23.2 (19)	15.9 (13)	(82)
4-5	- (0)	4.5 (1)	59.1 (13)	36.4 (8)	(22)
6+	- (0)	- (0)	12.7 (1)	87.5 (7)	(8)
Total % (n)	31.8 (101)	37.1 (118)	17.6 (56)	13.5 (43)	(318)

Discussion

The results supported this study's hypothesis that athletes' estimate of sustained concussions would increase after being provided with a current medically accepted definition of a concussion. Nearly 25% of the participants changed their answer from not having sustained SRCs to having sustained SRCs after being provided with such a definition. Likewise, the majority (61.9%) of the 318 participants that reported SRCs increased their estimation of number of SRC's from pre- to post-definition. These results are consistent with previous studies (Alosco et al., 2017; Robbins et al., 2014) where participants increased their estimation of sustained concussions after having been provided with a definition of a concussion. In previous studies (Alosco et al., 2017; Robbins et al., 2014), it was mentioned that one possible explanation for the increase of self-reported SRCs post-definition, could be a lack of understanding of what a concussion is. That same reason could also apply to the increase of stated SRCs post-definition in this study. This indicates that the information given to athletes about concussions, i.e. whether they are provided with a current definition or not, and appropriate questioning of their injuries is important in order to determine whether they have sustained a concussion or not.

When the results in the studies by Alosco et al. (2017) and Robbins et al. (2014) are compared to the results of this study it can be seen that a lower percentage of participants in

this study increased their estimation of the number of SRCs after receiving the definition. The increase in the present study was 61.9% while in the study by Alosco et al. it was 91.6% and 73% in the study by Robbins et al. Furthermore, there was a higher percentage of participants in the present study that did not change their estimation of the number of received concussions pre- to post-definition. Although more than half of the participants changed their answer from no to yes post-definition, more than one-third of the participants (37%) did not change their estimation of the number of SRCs they had sustained, which is considerably higher than in the studies by Alosco et al. (8.4%) and in Robbins et al. (25%).

The exact reason for less underreporting of SRCs in this study compared to others is likely multifaceted. The most significant difference between these studies is that this study sample was based on female athletes. Another explanation could be the increased awareness of SRCs the last few years (Guay et al., 2016; Íþróttá- og ólympíusamband Íslands, n.d.; Reynir Björnsson, 2017).

The results of this study reveal that 65% of the participants reported having sustained SRCs. The likelihood of having experienced SRCs varied significantly depending on the participants' sport. Ice hockey and martial arts had the highest rate of concussions. These findings need to be interpreted with caution since the sample sizes were small in both groups. It was expected that highest rate of concussions would be among players in soccer and basketball based on the results of other studies that identified high concussion frequency (Clay et al., 2013; Daneshvar et al., 2011). Our results therefore contradict their findings. The prevalence numbers in this study were higher with respect to previous studies of SRCs prevalence in Iceland, in which around 40% to 50% of the participants had sustained SRCs (Gunnar Örn Jónsson & Jón Benjamín Halldóruson, 2013; Ragnar Hjörvar Hermannsson et al., 2014). Those rates are based on studies that did not provide a definition of a concussion. Interestingly, when the pre-definition prevalence numbers in our study are compared to the

older studies the numbers are similar (previous prevalence numbers: 40- 50%, our unprompted prevalence numbers: 45%). Therefore, it can be assumed that the difference between the prevalence numbers of this study and existing prevalence numbers in Iceland can be traced to prompting participants with a definition when reporting SRCs.

Of the participants that reported SRCs, there was a significant difference between those that changed their answer of having sustained SRCs, to those that retained the same answer post-definition based on the primary sport. Athletes that practiced basketball and martial arts were about twice as likely to change their answers from not having sustained SRCs to stating that they had sustained SRCs after being provided with the definition. This could indicate differing levels of knowledge of concussions between the different sports and consequently mean that the basketball and martial arts movements in Iceland should educate their players more on concussions. It must however be noted that the samples from these sports are relatively small and further research is needed.

The current study has several limitations. Firstly, it is known that self-report measures are often limited and therefore the concussion prevalence could be exaggerated or underestimated. The study sample was collected using a snowball method that could produce a bias in which individuals who have sustained concussions were more likely to participate than others. Secondly, when assessing numbers of SRCs among athletes we are relying on how well an athlete recalls the incidence of SRC through their sports career. Consequently, recall bias could be a contributor to the findings. However, current findings are not dissimilar to previous results (Alosco et al., 2017; Gunnar Örn Jónsson & Jón Benjamín Halldóruson, 2013; Ragnar Hjörvar Hermannsson et al., 2014; Robbins et al., 2014), suggesting that potential biases were not present.

This study also has some important strengths, the most pronounced strength is perhaps the information that the study gives us on the knowledge that female athletes have on

the definition of a concussion. The current study is the first known study that focuses on female athletes and measure the athletes' understanding of what a concussion is. Also, a high proportion of former and current Icelandic female athletes within a wide age range in various sports participated. It was estimated that the target population was 1178 female athletes (calculated from information provided on the sport federations' webpages) when the data collection was conducted. The response rate turned out to be 43.1%. Lastly, the results of this study are essential for Icelandic sports federations and associations to shed light on athletes' understanding of concussions, or lack thereof, so they are able to provide appropriate education and give proper guidance to athletes. It is important for the athletes themselves to recognize the symptoms of a concussion since not all of them have access to healthcare staff at all times, which would leave the athlete responsible for recognizing the symptoms of a concussion (Copp, Lininger, & Warren, 2017). On the other hand, relying on a self-diagnosis from a concussed athlete is questionable. It can be argued that it is unwise to rely on the decision-making of an individual that could be experiencing concussion symptoms like loss of memory, altered consciousness, visual disturbances and so on. It is also important to consider that the athletes' desire to win and do their best for their team may outweigh sensible decision-making concerning their own safety (Cusimano, Chipman, Volpe, & Donnelly, 2009). Nevertheless it can be reasoned that increased knowledge is always power and even though athletes may not be able to judge their own concussed condition, they can assist a teammate in such a situation if they have the knowledge of concussion-symptoms.

Further studies that focus on female athletes are needed to establish whether there is a difference in the understanding of a concussion definition between female and male athletes. Additionally, further research on the same matter should aim to include other sports that are played in Iceland that have been listed as high concussion risk sports, such as gymnastics, volleyball, skiing, cycling, and pole vault (Benson et al., 2018). It is also important to study

the knowledge that coaches and teams staff members have about the definition of concussions.

In summary, this study shows that the current understanding of concussions among current and former Icelandic female athletes is not consistent with the currently accepted medical definition of a concussion. Nevertheless, the results in this study suggest that the understanding of concussions among Icelandic female athletes is better than preexisting results, which are mainly focused on male athletes. Furthermore, the results indicate that unprompted reporting of concussions produces results that differ from results produced after a definition is given, which increases the reporting. It can be argued that providing athletes, coaches and others involved in sports with a definition of a concussion can improve the reliability of self-reported sustained concussions.

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