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A psychophysical study on the effect protective equipment has on contact sport athletes

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A psychophysical study on the effect protective equipment has on contact sport athletes

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NOMENCLATURE

HTC	Hampel Tackling Criterion
(m)TBI	(Mild) Traumatic Brain Injury
NINDS	National Institute of Neurological Disorders and Stroke
NFL	National Football League
PCS	Post-Concussion Syndromes
SIS	Second Impact Syndrome

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ABSTRACT

The objective of this research was to determine if the use of helmet and shoulder pads had an impact on overall tackling form, perceived likelihood of getting hurt or injured, and pain levels throughout the body contact sport athletes (American football and rugby). Relationships between overall tackling form and concussion likelihood will be tested to determine whether or not the utilization of football helmets and shoulder pads have an effect on concussion rates.

Using a qualitative design, 18 male rugby players (18-35 years of age) were used as subjects for tackling drills where overall tackling form was analyzed. Surveys determining perceived likelihood of getting hurt or injured, and pain levels, were administered before and after each set of drills respectively. Content analysis was conducted to determine whether the use of helmets and shoulder pads impacted overall tackling form, perceived likelihood of getting hurt or injured, and pain.

There was a significant difference in the scores for overall tackling form for pads (M=5.001, SD=1.099) and without pads (M=2.516, SD=0.433) conditions; $t(17) = 6.314$, $p = .0001$. Specifically, the results suggest that when an athlete wears padding, their overall tackling form decreases. With regards to mindset, there was not statistical significance in the participants' perceived likelihood on getting hurt or injured and their tackling form. A Spearman Rank Test determined there was a positive correlation (.754 and .708) in head pain experienced in both the padded/non-padded tackles respectively meaning that for both padded/non-padded tackles, as form decreased, pain experienced in the head increased.

This study provides an insight into the negative relationship between the use of shoulder pads and helmets, overall tackling form, and pain experienced in participants' heads

for contact sport athletes. It is suggested that removing some protective equipment may improve average tackling form and thus, concussion rates. However, further research needs to be conducted to determine if, what, and how much padding to remove.

Keywords

Rugby; Football; Concussion; Tackling Form; Safety Perception; Injury Research

CHAPTER I: INTRODUCTION

Introduction

United States citizens love sports and are willing to pay for the entertainment of watching them. People spend millions of dollars to watch sports for entertainment purposes each year. In 2005, it was estimated that the American sports industry has grown to a staggering $44 to $73 billion industry based on aggregate supply and demand (Humphreys & Ruseski, 2008). The four largest contributors include football, basketball, baseball and hockey. Football is not only one of the fan favorites to spend money on, but to also participate in. According to a 2012 NCAA study, it was approximated that there are around 1.1 million high school and 70,000 collegiate athletes playing tackle football in the United States (Estimated Probability of Competing in Athletics Beyond the High School Interscholastic Level, 2013).

One of the key attractions that keep fans coming back is the violent aspect of the game. Throughout the course of a game players give and receive many blows to all areas of the body. It is this which keeps so many fans attached to the game, money coming in, and players off the field due to injury. Recently, the National Football League (NFL) has been trying to balance this give and take relationship by figuring out ways to reduce injury rates without losing traction with their revenue intake. The main focus on the injury reduction side is head injuries, specifically concussions and traumatic brain injuries. A concussion can be caused by a bump, blow, or jolt to the head, or any hit that causes cranial whiplash (Concussion in Sports, 2013). According to the United State Center for Disease Control, an estimated 1.7 million people sustain a traumatic brain injury annually; of which 52,000 die (Faul, Xu, Wald & Coronado, 2010). The issue with concussions is the long term health of the victim since traumatic brain injuries can cause epilepsy and increase the risk of developing Alzheimer's disease, Parkinson's disease, and more (National Institute of Neurological Disorders and Stroke (NINDS), 2002, Kontos, Collins, & Russo, 2004). After athletes have sustained their first concussion they become significantly more vulnerable to obtaining second impact (SIS) and post-concussion syndromes (PCS) which increases their likelihood for the neurological diseases previously mentioned (Kontos et al., 2004). Claims stating youth football is dangerous for children have begun to create speculation about whether or not children should even be allowed to play (Kontos, Elbin, Fazio-Sumrock, Burkhart, Swindell, Maroon, & Collins, 2013). This endangerment is not only threatening to youth football, but to the well-being of the sport itself. Many think that if the rising concussion rate is not reduced within the sport, it could potentially lead to the end of football. In 2005, the National Collegiate Athletic Association Injury Surveillance System released statistics showing that per 1000 collegiate athlete exposures there were 3.02 concussions (Gessel, Fields, Collins, Dick, & Comstock, 2007). This number is nearly 40% larger than girls' volleyball, which came in second place with a concussion rate of 1.80 per 1000 exposures (Gessel et al., 2007). In a study by Powell (1999) comparing the number of mild traumatic brain injuries (mTBIs) between football, baseball, basketball, soccer and wrestling; football athletes made up 63.4% (773 total) of reported mTBIs across all five sports. In addition, when comparing strictly collision sports, football, hockey, and rugby; football still had the highest rate of concussions with rates between 4% (Powell & Barber-Foss, 1999) and 6% (McCrea et al., 1998) in an average year of exposure (Kontos et al., 2004).

To combat the high concussion rates, the NFL has implemented many rule changes to lower the amount of exposures per game, as well as creating rules for penalizing players for certain styles of hits, in hopes that the rate decreases. In addition, the NFL has also issued a $10 million incentive program back in 2013 aimed at finding better shock absorbent materials for helmets in addition to other methods or means to protect players' brains from concussions (Mihonces, 2013). As the push for newer and better technologies continues to be a main goal for the NFL, not much research has been done in determining what would happen if the sport took a step backwards in terms of helmet technology.

According to McIntosh & McCrory (2005), "helmets and other devices have been shown to reduce the risk of severe head and facial injury, but current designs appear to make little difference to rates of concussion." This quote clearly shows that one of the primary benefits within the evolution of football helmets was not even tied to what is believed by many to be the main purpose – concussions. It seems to be that helmets have done a tremendous job of reducing lacerations, gouges, and crush injuries, but little with concussions. This study takes a stance against a common trend of assuming that new technologies and better materials will be the best way to reduce concussion rates. By analyzing correlations in pain, perceived likelihood of getting hurt or injured, and overall tackling form (dependent variables), with and without the use of helmet and shoulder pads (independent variable), conclusions can be drawn to determine whether protective gear encourages players to trust equipment for protection rather than proper tackling form.

The theory behind the utilization of rugby players instead of football players is that shoulder pads and helmets could negatively impact the athletes' mindset, tackling form, and thus, overall likelihood of a concussion. Rugby players are taught how to tackle without pads which allows the investigation to test if increasing the amount of protection will encourage athletes to stray from their known tackling form. Despite the many differences between the sports, the overall tackling concepts taught in both football and rugby are similar enough where they can be compared fairly. In an interview of Keven Mealamu (professional rugby player for the New Zealand All-Blacks) and Stephen Paea (professional football player for the Chicago Bears) (2014), the two were asked to discuss some similarities and differences between their respective sports. At one point, Mealamu was asked about how he was trained to tackle. In his response he explains,

"So a lot of our tackling depends on proper footwork, to set up a good shoulder tackle. In rugby you're taught to put your head on the [ball carrier's] right side and get a good shoulder on them, which also helps from a safety point of view."

His explanation is on target with how many football players are taught how to tackle. According to USA Football Heads-Up Tackling (2010), the United States' national initiative to make the sport safer explains how a proper tackle is performed by having the shoulder as the point of contact with the head to the side and away from contact. It is evident that the two sports teach their athletes how to tackle in a very similar manner but it appears to be that football players stray from what is taught in full contact settings more so than rugby.

Currently, there has been no literature that shows how the perceived likelihood of getting hurt or injured and the use of padding/no padding affects overall tackling form of a contact sport athlete. The goal of this study is to add to the pool of concussion mitigation research, to show that potentially the answer to reducing the amount of concussions is by taking a step backwards, not forward.

CHAPTER II: METHODOLOGY

Survey Development

Three surveys were used in this study. The first survey was the Demographics Survey which determined each participants age, weight, height, gender, years of experience, whether or not they had any heart or blood pressure conditions, and if they had a surgically fitted heart pacemaker or automatic defibrillator.

The second survey (known as the "Pre-Trial Survey) was for the determination of the player's mindset before each drill was set to begin. The survey asked four questions that were used to judge how tentative each player was before going into the drill. All participating athletes ranked their answer to each question on a scale of one to five (one being impossible, and five being guaranteed). The four questions that participants were asked for the Pre-Trial Survey were:

1. What do you think the odds are of you getting hurt (requiring little to no medical attention and missing hours/few days) from playing in today's game?
2. What do you think the odds are of you getting injured (requiring medical attention and missing weeks/months) from playing in today's game?
3. What do you think the odds are of you hurting (requiring little to no medical attention and missing hours/few days) someone else from playing in today's game?
4. What do you think the odds are of you injuring (requiring medical attention and missing weeks/months) someone else from playing in today's game?

The third survey (known as the "Post-Trial Survey) was used to determine what areas of the body were in pain. The body parts in question were: head, shoulder, chest, elbow, wrist, hips, thigh, knees, claves, ankles, foot and also two options for listing other body parts that may have been in pain. The pain scale went from 0 to 10, where 0 represented "not consciously aware of any sensation" and 10 represented "unbearable pain that makes activation impossible."

Participants

In order to have participated in this study, each subject must have been at least 18 years old with one or more years of rugby experience. This was required to help minimize the chances of a participant getting injured due to inadequate knowledge of how the game is played and improper tackling form. A total of eighteen participants total (nine separate matchups) were used from the Iowa State University, University of Northern Iowa, and Des Moines Rugby Clubs. Participants ranged from ages 18 to 35. Total experience ranged from 1 to 9 years. As this is the first study of its kind, the sample size seems to be sufficient with the expectation that future studies will explore the Hampel Tackling Criterion's (HTC) validity over a period of time with a larger sample.

Procedure

Each data collection period consisted of two sections. Both sections of each match up consisted of a rugby drill that was set up and played the exact way a real rugby drill would be practiced. The rugby drill being referenced is one that involves one ball carrier and one defender (often referred to as a One-on-One Simulation). The drill was a live tackling situation that pitted a ball carrier against a tackler. It was the ball carrier's objective to score the ball, and was the tackler's objective to prevent it (See **Figure 1**). Each player

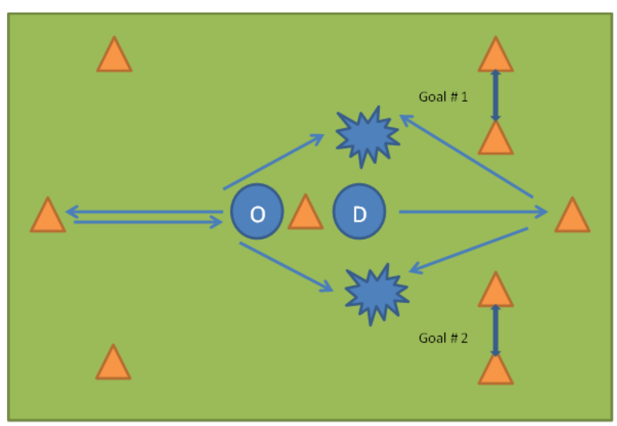

Figure 1: Tackling Drill. The "O" designated the starting position of the offensive player, and the "D" designated the starting position of the defender

stood at the center of the designated drill area with their backs to each other. Once the drill commenced they ran to the cone directly in front of them, turned around and then returned towards each other. The offensive player would then make a cut towards one of two goals that were positioned on the defenders side of the designated area. The purpose of having two separate goals was to keep the defensive player honest by not allowing them to know which direction the offensive player would choose.

Prior to the beginning of the first data collection set, participants read and signed the informed consent form. Then, they were given the Demographics Survey in which they were asked their age, height, weight, gender, the number of years of experience they have playing rugby, and whether or not they have heart or blood pressure conditions, surgically fitted heart pacemakers, or automatic defibrillators. This knowledge was used to verify that each participate was eligible to participate. Following this, the subjects then put on their rugby attire, and warmed up by performing whatever drills they usually performed before their own rugby matches. Following this was the tackling familiarization sheet that all participants had to read. This sheet was composed with the help of a former Iowa State University Rugby captain and president which helped outline the basic steps required to complete a tackle with proper form. The purpose of this was to ensure that all participants know and agreed to perform a proper tackle. The key points addressed were the position of the hips, shoulders, arms, and head throughout the drill as seen in **Figures 2, 3, 4, 5, and 6**.

Figure 2: Tackle preparation stance with lowered center of gravity

Figure 3: Squared hips and shoulder prior to opponent approach

Figure 4: Proper head and arm placement

Figure 5: Legs and hips driving opponent to the ground

Figure 6: Proper head placement at conclusion of tackle

Right before the drill was set to begin; the players took the Pre-Trial Safety Survey which asked them about their perceived likelihood of getting hurt or injured. The first section called for the two athletes to be wearing a helmet and shoulder pads or not. Every match up alternated whether the first section will be performed with or without pads. Participants were involved in twenty total tackles (ten tackles per section x two sections): five tackles with pads, five tackles without pads, five being tackled with pads, and 5 being tackled without pads. Examples of athletes performing padded and non-padded tackles can be seen in **Figures 7 and 8.**

Figure 2: No pads vs. no pads tackling drill

Figure 3: Pads vs. pads tackling drill

Also, during each rugby drill, cameras were set up watching from each side of the drill. At the end of each drill, each participant was instructed to fill out a subjective Post-Trial Survey which rated pain in their shoulder, elbow, wrist, head, legs, and any other additional body part they experienced pain. The second section of data collection was ran the same way as the first meeting except each player was wearing the opposite of what was worn in the first section. If pads were worn for the first section, then no pads will be worn for the second (and vice versa).

Initial contact was made with athletes of each club via email detailing the intent and aim of the study. If they agreed to participate, all surveys were administered during data collection between the sets of drills. All procedures were approved by Institutional Review Board (IRB) at Iowa State University.

Accelerometry Data

During data collection, each athlete was given a Zephyr™ Bioharness (the Bioharness) to record accelerometry data. The purpose behind this was to compare and contrast the levels of acceleration given and received from a tackle with and without pads. The data was to be analyzed with OmniSense, a software provided by Zephyr™. The Bioharness works by recording and saving data directly to itself. The data can be viewed live through the OmniSense Software through a Bluetooth connection. To protect both Bioharnesses, padding was placed with Velcro around the transmitting point of the Bioharness. Unfortunately, all of the accelerometry data had to be discarded due to inadequate connection while at the testing field which provided unreliable data.

Data Analysis

To evaluate the overall form of each tackle, the Hampel Tackling Criterion (HTC) was used (Hampel & Stone, 2014). The HTC is the only known subjective measurement that analyzes and assists in injury and brain injury likelihood based on overall tackling form. The HTC is broken up into two main groups: Striking Player, and Struck Player. The Striking Player group is based off of the tackling player with the player being tackled represented by the Struck Player group. Beneath the Striking Player and Struck Player categories are four sub-categories. Three of these subcategories fall underneath Striking Player, and the other one is under Struck Player. Each of the four total sub-categories are unique qualitative observations with multipliers associated for different levels of each option. The scoring works by taking the subjective multiplier to each of the four categories within the criterion. The highest multiplier (3) is assigned to those behaviors that put players at a higher risk for concussions or mTBI's. The lowest multiplier (1) is for tackles where the striking player has avoided risky maneuvers, and the struck player has been hit other places besides the head/neck. The final score is determined by multiplying each of the multipliers together. Based on this number, the tackle will either be deemed to be low, medium, high, or very high risk of injury. The HTC metric was created as a tool to help coaches, trainers, players, and others involved with the sport, identify potential tackles that could have resulted in head injuries. Twelve participants were shown eleven different videos and asked to analyze them using the HTC. Each video was a replay of a NFL, college, or high school football tackle from a game. Each predetermined very high risk tackle, and all but one of the high risk tackles resulted in concussions. Between the participants, there was 61% overall agreement of where the tackles should be ranked (in terms of risk level). These findings solidified the HTC as a useful tool for people of all backgrounds in identifying tackles that could have resulted in a head injury. Shown in **Table 1** is the table used to analyze each individual tackle. Despite the HTC being a subjective measurement, it was determined that it was a sufficient tool for analyzing what a proper form tackle looks and does not look like.

Table 1: Hampel Tackling Criterion

Hampel Tackling Criterion							
Striking Player						***Struck Player***	
Leads With	**Multiplier**	**Assists with**	**Multiplier**	**Overall Tackle Form**	**Multiplier**	**Areas of Impact**	**Multiplier**
Head	3	Arms	1	Proper Form	1	Head/Neck	3
Shoulder	2	Other	1	Projectile	3	Torso	1
Other	1	None	2	Other	1	Other	1

CHAPTER III: RESULTS

Eighteen male rugby athletes (nine total matchups) agreed to complete the drills, be videotaped for tackling form analysis (HTC score), and complete each survey. Of the eighteen male athletes, ten of them had four years or less of competitive rugby experience and were 19-24 years of age (mean ± SD, 20.9 ± 1.5). The other eight participants had more than four years of experience and were 19-35 years of age (mean ± SD, 23.6 ± 4.9).

HTC Scores

There were a total of 360 tackles performed between the nine matchups. Of the 360 total tackles, half of them were performed where neither player was wearing pads and the other half where both players were wearing pads. A paired-samples t-test was conducted to compare the overall tackling form with and without pads being worn. There was a significant difference in the scores for overall tackling form for pads (M=5.001, SD=1.099) and without pads (M=2.516, SD=0.433) conditions; $t(17)=6.314$, $p=.0001$. To elaborate, these results suggest that padding use does have an effect on overall tackling form. Specifically, the results suggest that when an athlete wears padding, their overall tackling form decreases.

Pre-Trial Survey/Mindset

The distribution results of the Pre Trial Survey can be seen in **Tables 2 and 3.** Shown is the amount of people who felt less likely to get hurt with and without wearing helmet and shoulder pads.

Table 2: Breakdown of perceived likelihood of getting hurt

Likelihood of Getting Hurt		
Mindset	**No. of People**	**Percentage**
Felt less likely to get hurt tackling WITH pads	6	33%
Felt less likely to get hurt tacking WITHOUT pads	4	22%
Felt no difference	8	44%
Total	18	100%

Table 3: Breakdown of perceived likelihood of getting injured

Likelihood of Getting Injured		
Mindset	**No. of People**	**Percentage**
Felt less likely to get injured tackling WTH pads	5	28%
Felt less likely to get injured tacking WITHOUT pads	3	17%
Felt no difference	10	56%
Total	18	100%

Post-Trial Survey

Table 4 shows how many total body parts had a score either higher, lower, the same while comparing with and without pads.

Table 4: Post-trial survey results

Overall Body Part Pain		
Pain Description	**No. of body parts reported**	**Percentage**
Felt more pain WITH pads	63	13%
Felt more pain WITHOUT pads	61	13%
Felt no difference in pain with or without pads	344	74%
Total	468	100%

Linear Regression – No Padding

A linear regression was performed in an attempt to view if the perceived likelihood of getting hurt or injured in the drill had an overall effect on the athletes tackling form without padding. When crossing the HTC scores without pads being worn, with the number of responses that showed the athletes felt "safer with pads while tackling" a 95% CI of 2.339-2.945 was achieved. Then, by crossing the same HTC scores for without pads being worn, with the number of responses that showed the athletes felt "safer without pads while tackling" a 95% CI of 2.28-2.622 was achieved. Since there is an overlap between the two confidence intervals we know the surveyed mindset on how likely they felt they would get hurt or injured did not have an effect on tackling form.

Linear Regression – Padding

A linear regression was performed to view if the perceived likelihood of getting hurt or injured in the drill had an overall effect on the athletes tackling form with padding. When crossing the padded HTC scores with the number of responses that showed the athletes felt "safer with pads while tackling," a 95% CI of 4.903-5.814 was achieved. When crossing the padded HTC Tackling Form scores with the number of responses that showed the athletes felt "safer without pads while tackling," a 95% CI of 4.369-5.125 was achieved. Similar to the linear regression results for the non-padded section, there is an overlap between to the two confidence intervals telling us the surveyed mindset on how likely they felt they would get hurt or injured did not have an effect on their tackling form while wearing pads.

Spearman Rank Test

The Spearman Rank Test was determined by ranking the median HTC scores for non-padded and padded tackling scores as seen in **Table 5.**

Table 5: Spearman rank test for post-trial survey and HTC Scores

Spearman Rank Test			
Body Part	**Match Up Type**	**Correlation**	**Degree of Positive Correlation**
Head	Non Padded	0.754	Strong
Head	Padded	0.708	Strong
Shoulder	Non Padded	0.075	Very Weak
Shoulder	Padded	0.2208	Weak
Chest	Non Padded	0.3875	Weak
Chest	Padded	0.3375	Weak
Elbow	Non Padded	0.1538	Very Weak
Elbow	Padded	0.375	Weak
Wrist	Non Padded	0.1958	Weak
Wrist	Padded	0.525	Moderate
Hips	Non Padded	0.1958	Weak
Hips	Padded	0.525	Moderate
Thighs	Non Padded	0.1625	Very Weak
Thighs	Padded	0.675	Strong
Knees	Non Padded	0.3958	Weak
Knees	Padded	0.675	Strong
Calves	Non Padded	0.3875	Weak
Calves	Padded	0.3	Weak
Ankles	Non Padded	0.7625	Strong
Ankles	Padded	0.525	Moderate
Feet	Non Padded	0.7625	Strong
Feet	Padded	0.525	Moderate

CHAPTER IV: DISCUSSION

The purpose of our study was to evaluate the effects the use of shoulder pads and helmets had on overall tackling form, perceived likelihood of getting hurt or injured, and pain levels throughout the body. No known studies to date have evaluated the effect of padding on overall tackling form. Our main findings show that overall tackling form decreased with the utilization of padding, supporting the initial hypothesis. As the participating rugby players added protection to their head and shoulders, they subconsciously lowered their standards for proper tackling technique and strayed from how they had been coached. Despite the overall form decreasing with the addition of padding, prior mindset of how likely they felt they would get hurt or injured was not a factor. However, previous studies have shown that the use of helmets and shoulder pads increase the insulation as well as the amount of energy required to perform each exercise due to added weight and altered biomechanics (McCullough & Kenney, 2003, Kulka & Kenney, 2002) which may have been a reason for the decrease in form.

From the Spearman Rank Test, the head, ankles, and feet had the strongest overall correlation with the median HTC scores for both pads and no pads. This means that as HTC score increased, and tackling form decreased, pain in those respective body parts increased as well for both the padded and non-padded tackles.

As stated earlier, HTC score increases due to overall form decreasing. One of the main factors of the HTC scoring system deals with what body part the tackling player led with. If the player led with their shoulder as they were taught, they would receive a score of one for that category, which does not impact the overall score. However, if they lead with their head a multiplier of three will then be applied which greatly raises the overall score.

The transition from the shoulder to head becoming the 'tip of the spear' in many of these tackles may explain despite the use of the helmet, more pain being felt in the athletes' heads. This conclusion may be able to be explained by a study which showed that the head was the most sensitive part of the body (Cotter, Zeyl, Keizer, Taylor & Epstein, 1996). This mixed with the head becoming more a tool in improper form tackles helps justify the increase in pain with decrease in form. Since the studied athletes experienced more pain in their heads even with helmets on during tackling, this supports a growing argument that helmets may actually be the problem, not the solution to football's concussion epidemic. Ainissa Ramirez, author of *Newton's Football: The Science Behind America's Game* (2013) even states in her book that helmets should potentially be banned all together, and noted that sports like rugby and Australian rules football have much lower concussion rates than American football.

With current professional and collegiate athletes potentially stuck in their ways from years and years of improper tackling deployments, reducing the level of equipment may be best suited elsewhere. A proactive approach to finding a solution instead of a reactive approach may be where the answer lies. For instance, youth football athletes that are just trying out the sport could potentially benefit greatly from the reduction of padding. As the results show, the addition of padding decreases overall tackling form so reducing padding at a younger age could lead to improved form in later years and higher skilled playing levels.

Limitations

This study had several limitations. Our small and localized sample size was sufficient for the study, but is not large enough to guarantee that the use of helmets and shoulder pads should be removed from football. Also, the subjective HTC scores were calculated by the PI who understands without multiple people scoring each tackle, it is impossible to entirely eliminate bias.

Another limitation of the study involves the type of concussion being tested for. Many concussions come from the act of tackling or being tackled, but not all of them do. This study does not incorporate the likelihood or impact padding has on concussions caused by head to ground impact.

Equipment availability was another limitation. The local high school was able to lend 7 pairs of helmets and shoulder pads of many sizes for the study. Having a wide range of sizes allowed for the experiment to include athletes of many sizes, but it was not possible to guarantee perfect fit, which could have affected mindset, overall tackling form, and pain.

Prior to conducting the experiment, the main plan was to conduct full contact rugby matches and not just tackling drills. Due to scarcity of eligible athletes this was not possible. That being said, having athletes in a full contact game, simulating real “game speed,” could have had an impact.

CHAPTER V: CONCLUSION

In conclusion, for padded and non-padded tackles, there was statistical significance showing how as form decreased the level of pain experienced in the head, ankles and feet also increased. Also, that as the athletes transitioned from non-padded to padded tackles, their overall form had worsened. This leads to the recommendations of potentially removing helmets or solely just facemasks from football. If done so, the potential reduction in improper tackles may lead to the decrease in concussion rates in football. However despite the recommendation and speculation, further research is needed. Future studies will need to continue to determine the exact threshold for concussions, and determine if any correlations exist within figuring out how much equipment to remove, if any.

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